PROBABILISTIC ASSESSMENT OF LIQUEFACTION-INDUCED LATERAL GROUND DEFORMATIONS

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ABSTRACT

PROBABILISTIC ASSESSMENT OF LIQUEFACTION-INDUCED LATERAL GROUND DEFORMATIONS

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Due to its critical impact and significant destructive nature during and after seismic events, soil liquefaction and liquefaction-induced lateral ground spreading has been an increasingly important topic in the geotechnical earthquake engineering field during the past four decades. The aim of this research study is the development of both probabilistically and deterministically based semi-empirical methods for the assessment of liquefaction-induced lateral ground spreading.

The scope of this research study includes three main stages: i) the compilation of liquefaction-induced lateral ground spreading data from available earthquake case histories, ii) the identification of the descriptive group of geometrical, geotechnical, seismological, and probabilistic descriptive variables, and iii) the employment of advanced probabilistic assessment techniques for the purpose of developing semi-empirical probabilistic models that best explain the compiled lateral ground spreading case histories.

After careful filtering of the compiled lateral spreading case histories for data quality and completeness points of views, the number of case histories used for this study is reduced down to 526 liquefaction-induced lateral ground spreading data points, compiled from eighteen different earthquakes. By employing maximum likelihood, as well as linear and nonlinear regression assessment techniques, new sets of probabilistic models are developed addressing the effects of: i) site boundary conditions, ii) seismic soil liquefaction triggering, iii) inertial forces acting during the earthquake, and iv) gravitational forces acting before, during, and after the earthquake on the liquefaction-induced lateral ground spreading phenomenon.

Within the maximum likelihood framework, different sources of uncertainties including the model error, errors due to inexact estimations of the descriptive variables were addressed individually. The resultant models were developed for sloping sites with and without free-face, and level sites with free-face boundary conditions enabling to model all sources of uncertainties in the estimation of the magnitude of seismic liquefaction-induced lateral ground deformations. The new probabilistic models were also introduced as a performance-based analysis tool.

Keywords: Earthquakes, lateral spreading, maximum likelihood, nonlinear regression, reliability assessment, soil liquefaction.

ÖZ

SIVILAŞMA SEBEPLİ YANAL ZEMİN YAYILMALARININ OLASILIKSAL DEĞERLENDİRİLMESİ

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Zemin sıvılaşması ve sıvılaşmadan kaynaklanan yanal zemin yayılmaları, sismik aktiviteler sırasında ve sonrasındaki kritik etkisi ve yıkıcı doğasından dolayı, son kırk yıllık dönemde geoteknik deprem mühendisliği alanında önem kazanan bir konu olmuştur. Bu doktora çalışmasının amacı, sıvılaşmadan kaynaklanan yanal zemin yayılmalarının belirlenebilmesi amacıyla olasılık ve deterministik esaslı yarı ampirik yöntemlerin geliştirilmesidir.

Bu çalışma, kapsamı 3 ana ana aşamayı içermekte olup, bunlar: i) mevcut deprem vaka örneklerinden yararlanılarak sıvılaşmaya bağlı zemin oturmalarına ilişkin veri derlenmesi, ii) tanımlayıcı geometrik, geoteknik, sismolojik ve olasılık esaslı parametrelerin belirlenmesi, ve iii) derlenen yanal zemin yayılması vaka örneklerini en iyi şekilde açıklayan yarı ampirik olasılık esaslı modellerinin geliştirilmesi için ileri olasılık değerlendirme yöntemlerinin kullanılmasıdır.

Bu çalışmada kullanılacak vaka örneklerinden oluşan veri tabanı; veri kalitesi ve eksiksizlik ölçütlerine göre dikkatlice araştırıldıktan sonra, 18 farklı depremden derlenen sıvılaşma kökenli veri sayısı 526'ye düşürülmüştür. Yeni olasılık modelleri maksimum olabilirlik, doğrusal ve doğrusal olmayan regresyon analiz teknikleri kullanılarak ve i) saha sınır koşulları, ii) sismik zemin sıvılaşmasının tetiklenmesi,

iii) deprem sırasında etkiyen atalet kuvvetleri ve iv) deprem öncesinde, sırasında ve sonrasında etkiyen yerçekimi kuvvetlerinin sıvılaşmaya bağlı yanal zemin yayılması olayına etkileri göz önünde bulundurularak geliştirilmiştir.

Maksimum olabilirlik yöntemi çerçevesinde model hatası, tanımlayıcı değişkenlerin kesin olmayan tahminlerinden kaynaklanan hatalar ve parametre belirsizliklerini de içeren değişik kökenli hatalar ayrı ayrı belirtilmiştir. Sonuçta serbest yüzeyi olan ve olmayan eğimli sahalar ile serbest yüzeyi olan düz sahalar için geliştirilen modeller sıvılaşmadan kaynaklanan yanal zemin deformasyonlarının tahmininde varolan belirsizlikleri modelleyebilmektedir. Ayrıca, yeni olasılık modelleri performansa dayalı çözümleme metotları olarak ta önerildi.

Anahtar Kelimeler: Depremler, yanal yayılma, maksimum olabilirlik, doğrusal olmayan regresyon, güvenirlik değerlendirmesi, zemin sıvılaşması.

To My Beloved Homeland, PALESTINE

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a_{max}: Maximum ground acceleration

b_i: Model parameter

c': effective soil cohesion strength

CRR: Cyclic resistance ratio

CSR: Cyclic stress ratio

FC: Fines content

g: Gravitational acceleration

IL: Liquefaction potential index

LL: Liquid limit

LSI: Liquefaction severity index

M_W: Moment magnitude of the earthquake

$N_{1,60}$: SPT blow counts corrected for energy and overburden

$N_{1,60,CS}$: SPT blow counts corrected for energy and overburden and fines content

PGA: Peak ground acceleration

PI: Plasticity index

P_L: Probability of liquefaction

r_d: Nonlinear shear mass participation factor

S: Ground surface slope

SPT: Standard penetration test

SPT-N: Standard penetration test blow counts

T_H: Thickness of the potentially liquefiable sub-layer

u: pore water pressure

V_S: Shear wave velocity

V_S^*: Overall equivalent site shear wave velocity

β: Ground surface slope angle

ε: Model correction term

Φ: Normal probability density function

ϕ': effective angle of soil internal friction

$\phi'_{eqv,liq}$: Equivalent angle of internal friction for liquefied soil

θ_i: Model parameter for likelihood analysis

σ: Standard deviation

σ_v: Total vertical stress

σ_v': Vertical effective stress

CHAPTER 1

INTRODUCTION

1.1 Research Statement

The aim of this research study is the development of both probabilistically and deterministically based semi-empirical methods for the assessment of liquefaction-induced lateral ground spreading. The scope of these studies includes three main steps: i) the collection and compilation of liquefaction-induced lateral ground spreading data from different earthquake case histories, ii) the identification of the group of geometrical, geotechnical, and seismological parameters to be considered in the new models, and iii) the employment of advanced probabilistic assessment techniques including maximum likelihood model assessment, linear and nonlinear regression for the purpose of developing models that best match the observed lateral ground spreads with the predicted results. These models are aimed to produce increasingly reliable and accurate lateral ground spreading predictions, but still practical and easy to use.

1.2 Research Significance

Due to its critical impact and significant destructive nature during and after seismic events, soil liquefaction has been an increasingly important topic in the geotechnical earthquake engineering field during the past four decades. Especially starting with the devastating earthquakes in 1964 in Prince William Sound-Alaska and Niigata-Japan, liquefaction-induced lateral ground spreading has been considered as a major potential cause of damage to the overlying structures as well as to the infrastructures during earthquake events. This type of permanent ground deformation has amplitudes ranging from a few centimeters to a couple of meters or even more.

Currently available approaches for predicting the magnitude of lateral ground deformations can be categorized as: i) numerical analyses in the form of finite element and/or finite difference techniques (e.g., Finn et al. (1994), Arulanandan et al. (2000), and Liao et al. (2002)), ii) soft computing techniques (e.g., Wang and Rahman (1999)), iii) simplified analytical methods (e.g., Newmark (1965), Towhata et al. (1992), Kokusho and Fujita (2002), and Elgamal et al. (2003)), and iv) empirical methods developed based on the assessment of either laboratory test data or statistical analyses of lateral spreading case histories (e.g., Hamada et al. (1986), Shamoto et al. (1998), and Youd et al. (2002)). These different approaches are reviewed in Section 2.7.

Due to difficulties in the determination of input model parameters of currently existing numerical and analytical models, empirical and semi-empirical models continue to establish the state of practice for the assessment of liquefaction-induced lateral ground deformations. However, even the best of their kind of these models can not produce, at the moment, reasonably accurate estimates of liquefaction-induced lateral ground deformations. Some of the predictions by currently existing models are documented to be off by more than a factor of two which forms the established limits for use in engineering practice. Therefore, more needs to be done in order to produce more reliable and accurate models that capture the essentials of the liquefaction-induced lateral ground spreading problem.

Within the confines of these research studies, it is intended to develop a set of new models addressing the effects of: i) seismic soil liquefaction triggering, ii) inertial forces acting during the earthquake, iii) gravitational forces acting before, during, and after the earthquake, and iv) site boundary conditions, and also to assess the model formulae and the statistical uncertainties within a probabilistic framework. The resultant models are developed for sloping sites with and without free-face, and level sites with free-face boundary conditions.

1.3 Organization and Scope

Following this introduction, Chapter 2 presents a general literature overview for the: i) soil liquefaction phenomenon, including its definitions and different mechanisms, ii) SPT-based simplified cyclic stress ratio procedure, and different methodologies for the determination of potentially liquefiable soils and soil liquefaction triggering, and iii) seismic soil liquefaction-induced lateral spreading, including the definitions and different approaches for estimating its magnitudes, with particular emphasis on the existing empirical methods.

Chapter 3 demonstrates the employed descriptive variables in the existing empirical models, and also defines the descriptive variables for the proposed models. In this chapter, the compiled database is introduced by discussing old case histories from Youd et al. (2002) database with emphasis on their re-evaluation process, and new case histories mostly from recent earthquakes. This chapter ends with an illustrative example clarifying the procedure developed for processing case histories, and summarizing all output results required for the new models.

Chapter 4 attempts to clarify the essentials of the maximum likelihood analysis employed, and the methodology followed to develop a reliability-based mathematical model for the liquefaction-induced lateral ground spreading problem. Particular emphasis is given to the discussion of the mathematical liquefaction models, with emphasis on formulation of likelihood functions for “exact” and “inexact” observation cases.

Chapter 5 discusses the development of new probabilistically-based seismic soil liquefaction-induced lateral spreading correlations, and their different aspects of use in the engineering practice. Also discussed is the approach used in selecting the mathematical form of the proposed models, and the performance of the controlling factors within each model.

Finally, a comprehensive summary of this research study, its major conclusions, and recommendations for future areas of study are presented in Chapter 6.

CHAPTER 2

LITERATURE REVIEW

2.1 Liquefaction Definitions

As it was originally derived from the Latin verb *liquefacere*, which means to weaken, to melt, or to dissolve, *liquefaction* is an engineering phenomenon referring to the total and sharp loss of soil shear strength due to rapid pore water pressure build up. Seismic soil liquefaction occurs when the structure of a loose and saturated soil breaks down due to some rapidly applied loading. As the soil structure breaks down, the loosely-packed individual soil particles attempt to move into a denser and more stable configuration. During an earthquake event, however, there is not enough time for the water within the pores of the soil to be squeezed out or dissipate, but instead, water is *trapped* in the soil pores and prevents the soil particles moving to a denser state. Simultaneously, this is accompanied by an increase in pore water pressure which reduces the contact forces between the individual soil particles, and consequently resulting in softening and weakening of the soil deposit to a considerable extent. Because of this high pore water pressure, the contact forces become very small or almost zero, and in an extreme case, the excess pore water pressure may increase to a level that may break the particle-to-particle contact. In such cases, the soil will have very little or no resistance to shearing, and will exhibit a behavior more like a viscous liquid than a solid body.

While most frequently associated with saturated cohesionless soil deposits under dynamic loadings, liquefaction phenomenon has also been reported in both mixtures of cohesive and cohesionless soils under both dynamic and static loadings.

If it is expressed in Mohr Columb's soil shear strength formulation, as given by:

$$\tau = c' + \sigma_v' \tan\phi' \quad (2.1)$$

$$\sigma_v' = \sigma_v - u \quad (2.2)$$

where: τ is the soil shear strength, c' is the undrained soil cohesion (equals zero for loose sands and normally consolidated clays), σ_v is the total vertical stress, σ_v' is the effective vertical stress, u is the pore water pressure, and ϕ' is the undrained angle of soil internal friction.

During an earthquake shaking, the applied stresses will generate an increase in the excess pore water pressure, and if pore pressure and total stresses equates and hence leading to the effective vertical stress to be almost zero ($\sigma_v' \cong 0$), the soil will loose its consistency and will "liquefy", resulting in significant deformations. Figure 2.1 demonstrates schematic examples for the possible cases of liquefaction-induced global site instability and/or large displacement lateral ground spreading, while Figures 2.2 and 2.3 show different examples of liquefaction-induced lateral spreading and horizontal and vertical ground deformations observed after the 1999 Kocaeli (Izmit)-Turkey earthquake. (Seed et al., 2003)

High excess pore water pressures leading to soil liquefaction can cause pore water to flow rapidly up to the ground surface. This pore water flow can occur both during and after an earthquake event, and if the flow is strong enough, it can carry sand particles through cracks up to the top surface, where they are deposited in the form of s*and boils*. This type of features is often observed as the surface manifestation of seismic soil liquefaction triggering. Liquefaction-induced failure features have been observed after earthquake events for many years. Due to the fact that liquefaction mostly occurs in saturated soil, its effects are commonly observed in low-lying areas near bodies of water such as rivers, creeks, lakes, bays, and oceans. Therefore, in the past earthquakes, many marine structures such as port and wharf facilities have been subjected to liquefaction-induced damages, since they are often located in areas susceptible to liquefaction. Most ports and wharves have major retaining structures or quay walls, and when the retained and/or underneath soil liquefies, the generated lateral pressure it exerts can increase greatly enough to force these structures to slide and/or tilt toward the water.

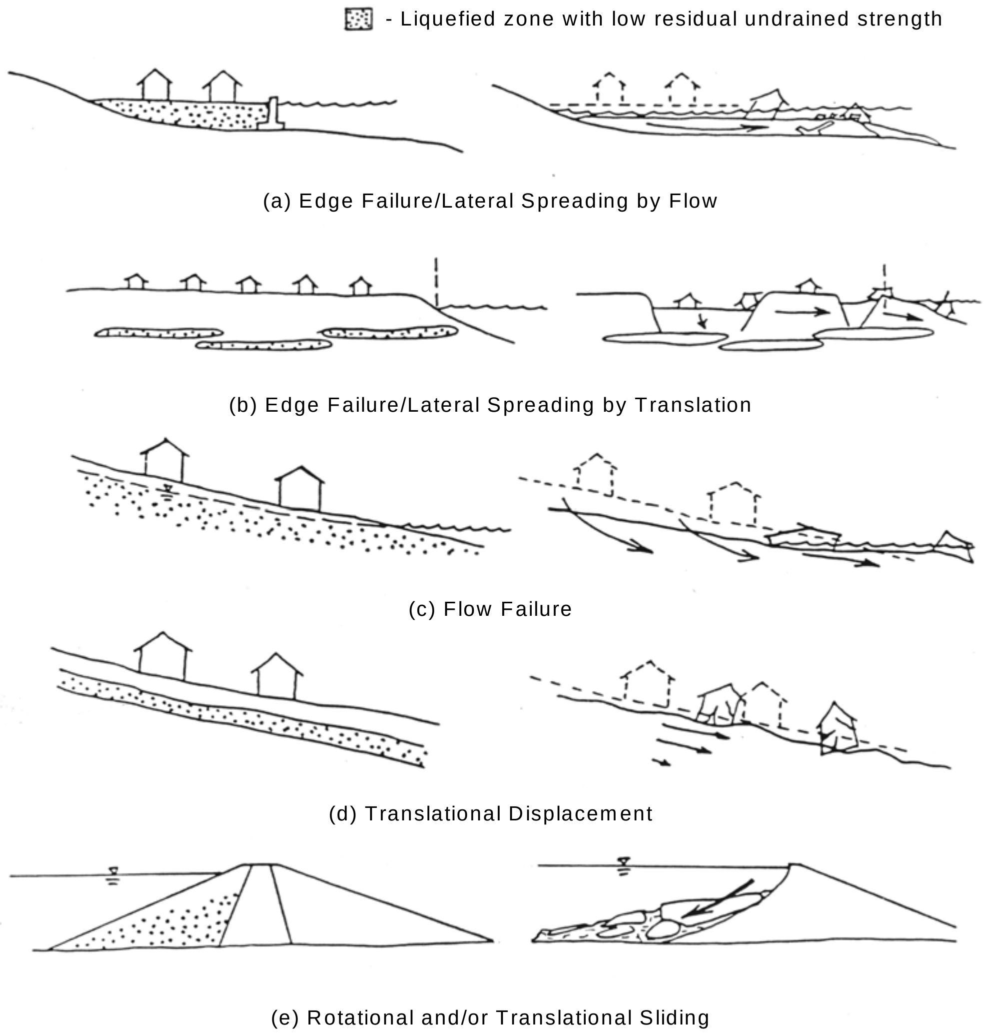


Figure 2.1: Schematic examples of liquefaction-induced global site instability and/or large displacement horizontal deformations. (After Seed et al., 2003)

(a)

(b)

Figure 2.2: Examples of liquefaction-induced lateral spreading after the 1999 Kocaeli (Izmit)-Turkey within the Izmit Bay area, from the sites of: (a) Tea Garden, and (b) Soccer Field. (Source: http://peer.berkeley.edu/turkey/adapazari)

(a)

(b)

Figure 2.3: Examples of liquefaction-induced horizontal and vertical ground deformations after the 1999 Kocaeli (Izmit)-Turkey from the sites of: (a) Hotel Sapanca wall, and (b) Hotel Sapanca south gate. (Source: http://peer.berkeley.edu/turkey/adapazari)

The consequences of seismically-induced liquefaction may include major sliding of soil blocks with associated large ground deformations, or more modest movements that produce limited tension cracks only. The liquefaction resistance of soils is related to numerous geological, compositional, and state factors. Geological factors include the soil deposit age, depositional environment, and hydrological conditions. In general, younger deposits are more susceptible to liquefaction than older ones. Liquefaction occurs in saturated cohesionless soils, therefore, groundwater table depth is an important consideration in the identification of soils that are potentially liquefiable.

The second type factor that influence liquefaction resistance is related to compositional characteristics of soils, which include grain size parameters such as the fines content and fabric-related parameters such as cementation. Finally, state factors such as: density, current state of stress, and stress history have important influences on liquefaction resistance. To the extent that these soil properties vary spatially, the liquefaction resistance will also vary. (Silva et al., 2003)

In this research study, the main motivation is the assessment of liquefaction-induced horizontal ground deformations, or lateral ground spreading. As mentioned before, liquefaction-induced lateral spreading leads to horizontal ground displacements for the whole soil block and/or for the shallow and deep foundations and their base columns for individual structures and/or infrastructures, resulting in partial or total devastation of the buildings and structures they are supporting.

2.2 Liquefaction Mechanisms

In the proceedings of the 1997 NCEER Workshop, P. K. Robertson and C. E. Wride reported that the engineering term of *liquefaction* has been used to define two mainly related but different soil behaviors during earthquakes, namely flow liquefaction and cyclic softening. Since both phenomena can have quite similar consequences, it is difficult to distinguish. However, the mechanisms behind them are rather different, and will be discussed next.

Flow Liquefaction

Flow liquefaction is a phenomenon in which the equilibrium is destroyed by static or dynamic loads in a soil deposit with low residual strength. Residual strength is defined as the strength of soils under large strain levels. Static loading, for example, can be applied by new buildings on a slope that exert additional forces on the soil beneath the foundations. Earthquakes, blasting, and pile driving are all example of dynamic loads that could trigger flow liquefaction. Once triggered, the strength of a soil susceptible to flow liquefaction is no longer sufficient to withstand the static stresses that were acting on the soil before the disturbance. Failures caused by flow liquefaction are often characterized by large and rapid movements which can lead to disastrous consequences. The main characteristics of flow liquefaction are:

- Applies to strain softening soils only, under undrained loading,
- Requires in-situ shear stresses to be greater than the ultimate or minimum soil undrained shear strength,
- Can be triggered by either monotonic or cyclic loading,
- For failure of soil structure to occur, such as a slope, a sufficient volume of the soil must strain soften. The resulting failure can be a slide or a flow depending on the material properties and ground geometry, and
- Can occur in any metastable structured soil, such as loose granular deposits, very sensitive clays, and silt deposits.

Cyclic Softening

Cyclic softening is another phenomenon, triggered by cyclic loading, occurring in soil deposits with static shear stresses lower than the soil strength. Deformations due to cyclic softening develop incrementally because of static and dynamic stresses that exist during an earthquake. Two main engineering terms can be used to define the cyclic softening phenomenon, which applies to both strain softening and strain hardening materials.

Cyclic Mobility

- Requires undrained cyclic loading during which shear stresses are always greater than zero; i.e. no shear stress reversals develops,
- Zero effective stress will not develop,
- Deformations during cyclic loading will stabilize, unless the soil is very loose and flow liquefaction is triggered,
- Can occur in almost any sand provided that the cyclic loading is sufficiently large in size and duration, but no shear stress reversals occurs, and
- Clayey soils can experience cyclic mobility, but deformations are usually controlled by rate effects (creep).

Cyclic Liquefaction

- Requires undrained cyclic loading during which shear stresses reversals occur or zero shear stress can develop; i.e. occurs when in-situ static shear stresses are low compared to cyclic shear stresses,
- Requires sufficient undrained cyclic loading to allow effective stress to reach essentially zero,
- At the point of zero effective stress no shear stress exists. When shear stress is applied, pore water pressure drops as the material tends to dilate, but a very soft initial stress strain response can develop resulting in large deformations,
- Deformations during cyclic loading can accumulate to large values, but generally stabilize when cyclic loading stops,
- Can occur in almost all sands provided that the cyclic loading is sufficiently large in size and duration, and
- Clayey soils can experience cyclic liquefaction but deformations are generally small due to cohesive strength at zero effective stress. Deformations in clays are often controlled by time rate effects (creep).

2.3 Potentially Liquefiable Soils

The first step towards the analysis and assessment of liquefaction-induced lateral spreading is the determination of potentially liquefiable soil layers at a given site. For this purpose, the Chinese criteria have been widely used in the engineering practice for longer than two decades. These criteria were modified and formulated by Seed and Idriss (1982), as shown in Table 2.1. Later, further modifications were applied to these criteria by Andrews and Martin (2000) for silt and clay definitions, as shown in Table 2.2.

Table 2.1: Formulated Chinese Criteria proposed by Seed and Idriss (1982).

Potentially Liquefiable Soils	
Fines Content (< 0.005 mm)	≤ 15%
Liquid Limit (LL)	≤ 35%
Water Content (W)	≥ (0.9xLL)%

Table 2.2: Modified Chinese Criteria proposed by Andrews and Martin (2000).

	Liquid Limit < 32%	Liquid Limit ≥ 32%
Clay Content (< 0.002 mm) < 10%	Potentially Liquefiable	Further studies required considering plastic non-clay sized grains
Clay Content (< 0.002 mm) ≥ 10%	Further studies required considering non-plastic clay sized grains	Non-Liquefiable

Seed et al. (2003) directly related the building penetration case histories that occurred during the 1999 earthquake events in both Kocaeli-Turkey and Chi Chi-Taiwan to soil liquefaction, and recommended new criteria replacing the Chinese criteria, as shown in Figure 2.4. These criteria classify all soils with a plastic index *PI* less than 12 and liquid limit *LL* less than 37 as potentially liquefiable, provided that the soil natural moisture content is greater than (0.8·LL).

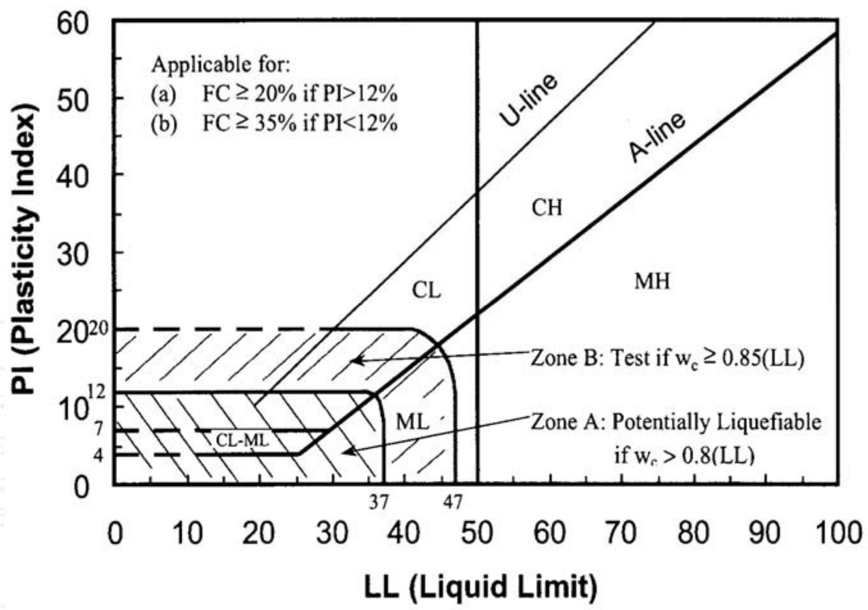


Figure 2.4: Criteria for liquefaction susceptibility of fine-grained sediments proposed by Seed et al. (2003).

The most recent attempt was done by Boulanger and Idriss (2004). They evaluated liquefaction resistance and deformation of granular and fine-grained soils, using cyclic laboratory tests, and recommended the new criteria shown in Figure 2.5, which are also a replacement to the Chinese criteria. This methodology divides the deformation behavior of fine-grained soils into two different types: “Sand-Like” and “Clay-Like”, where soils within the sand-like behavior region are susceptible to liquefaction and have substantially lower values of cyclic resistance ratio, *CRR,* than those within the clay-like behavior region.

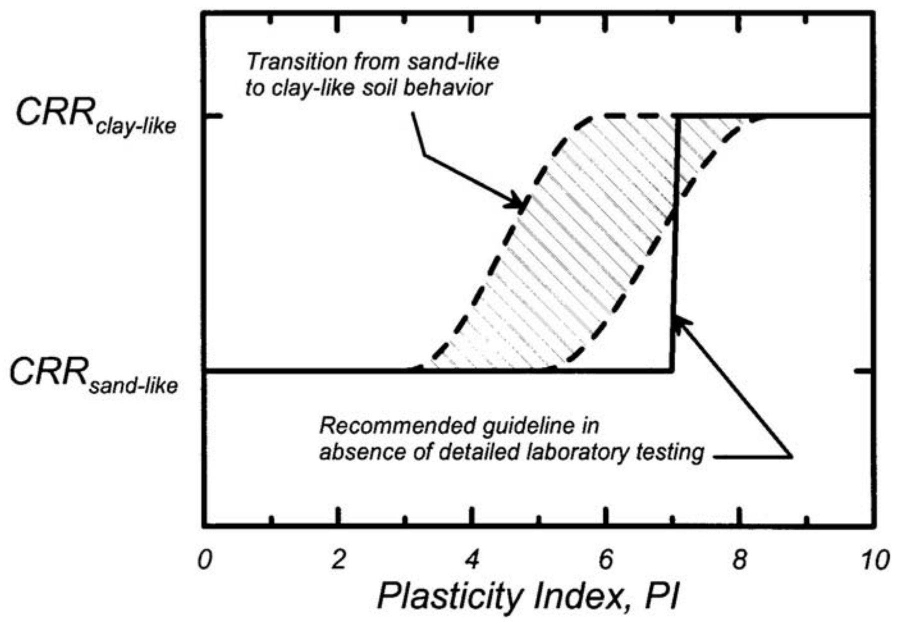


Figure 2.5: Criteria for differentiating between sand-like and clay-like sediment behavior proposed by Boulanger and Idriss (2004).

2.4 Seismic Soil Liquefaction Triggering

The problem of aiming to assess whether a soil sub-layer will liquefy or not will be discussed in the following sections. The discussion includes the definitions of related variables as well as the procedures of analyses.

2.4.1 Simplified Procedure (Seed and Idriss, 1971)

This procedure, proposed and used by Seed and Idriss, 1971, aims to estimate the amplitude of the shear stresses induced by vertically propagating shear waves. Shear stresses developed at a soil column with depth (h) at time (t) due to vertical propagation of shear waves can be calculated as:

$$\tau(t)_{rigid} = \frac{\gamma \cdot h}{g} \cdot a(t) \tag{2.3}$$

where: *a(t)* is the ground surface acceleration at time (t) I terms of (g), γ is the soil unit weight, and *g* is the gravitational acceleration.

As shown in Figure 2.6, due to the fact that soil behaves as a deformable body during an earthquake event, the actual shear stresses developed will be less than those predicted by Equation (2.3) for a given value of ground surface acceleration *a(t)*. Therefore, a stress reduction factor r_d needs to be incorporated as:

$$\tau(t)_{\text{deformable}} = \frac{\gamma \cdot h}{g} \cdot a(t) \cdot r_d \qquad (2.4)$$

where different methodologies have been introduced for the determination of r_d values, and they are overviewed in the next section.

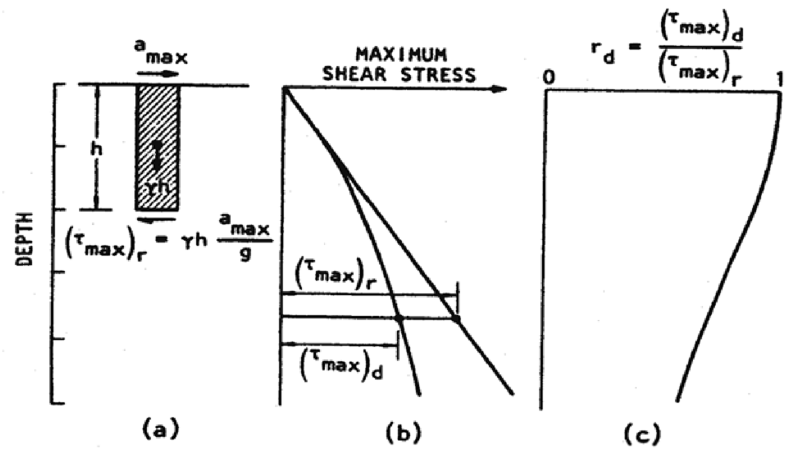


Figure 2.6: Procedure for determining maximum shear stress, $(\tau_{max})_r$. (After Seed and Idriss, 1971)

In order to convert irregular forms of seismic shear stress time histories to a simpler equivalent series of uniform stress cycles, a weighted averaging scheme is required. By an appropriate weighting of the individual stress cycles based on laboratory test data, the amplitude of the average or equivalent uniform stress, τ_{av}, has been estimated to be about (65%) of the maximum shear stress, τ_{max}.

$$\tau_{av} \approx 0.65 \cdot \frac{\gamma \cdot h}{g} \cdot a_{max} \cdot r_d \tag{2.5}$$

where: a_{max} is the maximum ground surface acceleration. A variety of normalization methods can then be applied to convert a series of irregular cyclic shear stress cycles to an equivalent number of uniform cycles with amplitude of τ_{av}.

Cyclic stress ratio *CSR* as defined by Seed and Idriss (1971), is the average cyclic shear stress τ_{av} developed on horizontal soil surface due to vertically propagating shear waves normalized by the initial vertical effective stress σ'_v to incorporate the increase in shear strength due to increase in effective stress. (Cetin, 2000)

$$CSR = \frac{\tau_{av}}{\sigma'_v} = 0.65 \cdot \frac{a_{max}}{g} \cdot \frac{\sigma_v}{\sigma'_v} \cdot r_d \tag{2.6}$$

2.4.2 Determination of r_d Values

Seed and Idriss (1971) recommended a chart solution for relating different ranges of r_d values with soil depth for different soil profiles, as shown in Figure 2.7.

According to Liao and Whitman (1986a), the following equations could be used to estimate average values for r_d as a function of the depth below ground surface z (in meters) by the following equations:

(For $z \leq 9.15$ m) $$r_d = 1.0 - 0.00765 \cdot z \tag{2.7}$$

(For $9.15 \leq z \leq 23.0$ m) $$r_d = 1.174 - 0.0267 \cdot z \tag{2.8}$$

Shibata and Teparaksa (1988) introduced the following formula for estimating the value of r_d as a function of the soil depth Z (in meters) by the following equation:

$$r_d = 1.0 - 0.015 \cdot Z \tag{2.9}$$

In the 1997 NCEER Workshop, T. F. Blake approximated the mean values of r_d as a function of the depth beneath ground surface z (in meters) by the following equation:

$$r_d = \frac{1.0 - 0.4113z^{0.5} + 0.04052z + 0.001753z^{1.5}}{1.0 - 0.4177z^{0.5} + 0.05729z - 0.006205z^{1.5} + 0.00121z^2} \tag{2.10}$$

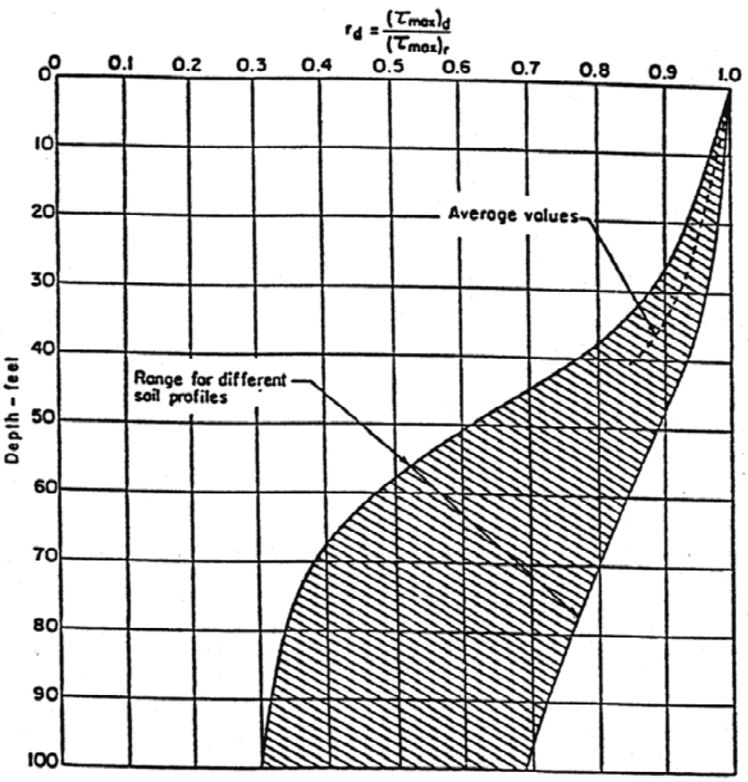


Figure 2.7: Range of r_d values for different soil profiles. (After Seed and Idriss, 1971)

Also Idriss and Golesorkhi (1997) proposed a different chart solution for the determination of r_d values relative to various earthquake magnitudes M_w, as shown in Figure 2.8.

Cetin et al. (2004) introduced a new closed form solution for r_d values as shown in Figure 2.9, and the formulae listed in Equations (2.11), (2.12), (2.13), and (2.14), respectively, as:

(For d < 20 m)

$$r_d = \frac{\left[1 + \frac{-23.013 - 2.949 \cdot a_{max} + 0.999 \cdot M_w + 0.0525 \cdot V^*_{s,12m}}{16.258 + 0.201 \cdot e^{0.341 \cdot (-d + 0.0785 \cdot V^*_{s,12m} + 7.586)}}\right]}{\left[1 + \frac{-23.013 - 2.949 \cdot a_{max} + 0.999 \cdot M_w + 0.0525 \cdot V^*_{s,12m}}{16.258 + 0.201 \cdot e^{0.341 \cdot (0.0785 \cdot V^*_{s,12m} + 7.586)}}\right]} \pm \sigma_{\varepsilon_{r_d}} \quad (2.11)$$

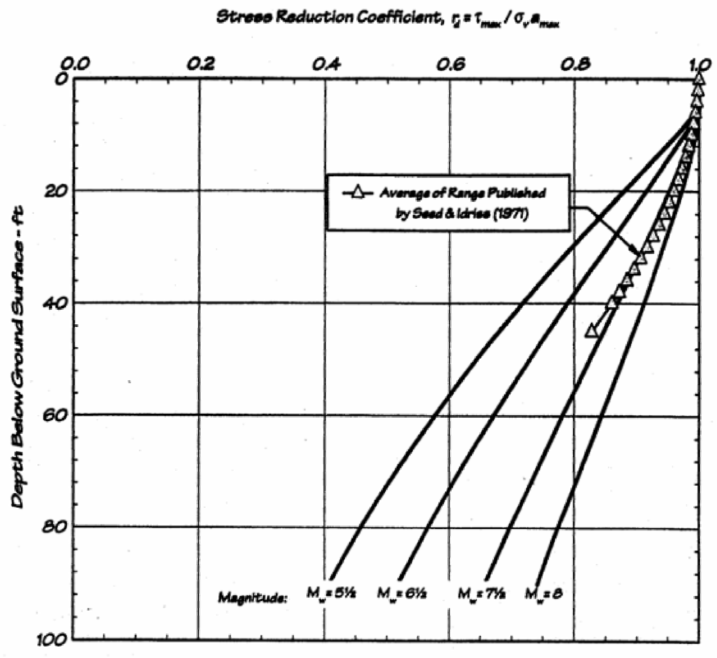


Figure 2.8: Variations of the stress reduction coefficient with depth for various earthquake magnitudes. (After Idriss and Golesorkhi, 1997)

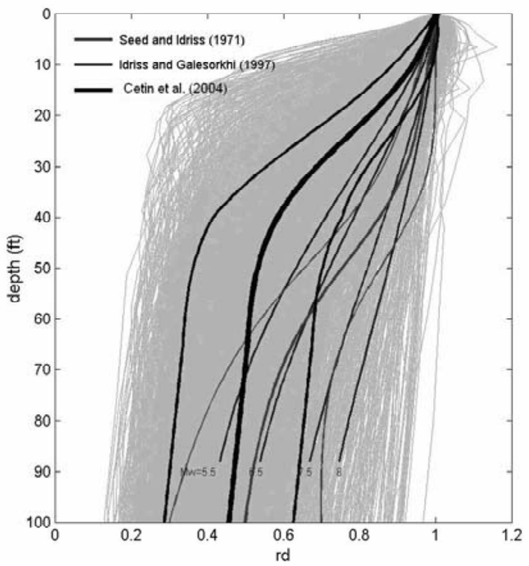


Figure 2.9: Values of r_d for all the sites and all the input motions superimposed with the recommendations of Seed and Idriss (1971) and Idriss and Golesorkhi (1997). (After Cetin et al., 2004)

(For d ≥ 20 m)

$$r_d = \frac{\left[1+\frac{-23.013-2.949\cdot a_{\max}+0.999\cdot M_w+0.0525\cdot V^*_{s,12m}}{16.258+0.201\cdot e^{0.341(-20+0.0785V^*_{s,12m}+7.586)}}\right]}{\left[1+\frac{-23.013-2.949\cdot a_{\max}+0.999\cdot M_w+0.0525\cdot V^*_{s,12m}}{16.258+0.201\cdot e^{0.341(0.0785V^*_{s,12m}+7.586)}}\right]} - 0.0046\cdot(d-20) \pm \sigma_{\varepsilon r_d} \tag{2.12}$$

(For d < 12 m)

$$\sigma_{\varepsilon r_d}(d) = d^{0.850}\cdot 0.0198 \tag{2.13}$$

(For d ≥ 12 m)

$$\sigma_{\varepsilon r_d}(d) = 12^{0.850}\cdot 0.0198 \tag{2.14}$$

where: a_{max} is the peak ground acceleration at ground surface (g), M_w is the earthquake moment magnitude, d is the soil depth beneath ground surface (m), and $V^*_{S,12m}$ is the soil profile equivalent overall shear wave velocity (m/s), defined as:

$$V_S^* = \frac{H}{\sum \frac{h_i}{V_{S,i}}} \tag{2.15}$$

where: H is the total soil profile thickness (m), h_i is the thickness of the i^{th} sub-layer, and $V_{S,i}$ is the shear wave velocity within the i^{th} sub-layer (m/s).

2.4.3 SPT-N Value Corrections

According to Seed et al. (1984), all the measured SPT-N values within the soil profile sub-layers for each case history were corrected for overburden, energy, equipment, and procedural effects as:

$$N_{1,60} = N\cdot C_N\cdot C_R\cdot C_S\cdot C_B\cdot C_E \tag{2.16}$$

where: C_N is a correction for overburden effects, C_R is a correction for the short rod length, C_S is a correction for non standardized sampler configuration, C_B is a correction for borehole diameter, and C_E is a correction for hammer energy efficiency, respectively. These correction factors are employed according to the 1997 NCEER Workshop recommendations, and as summarized in Table 2.3.

Finally, and also as was proposed by Çetin et al. (2004), the SPT-$N_{1,60}$ values are further corrected for the soil fines content (where: $5\% \leq FC \leq 35\%$) as:

$$N_{1,60,CS} = N_{1,60} \cdot (1 + 0.004 \cdot FC) + 0.05 \cdot \left(\frac{FC}{N_{1,60}} \right) \qquad (2.17)$$

where $N_{1,60}$ is the corrected SPT-N value with respect to 60% energy ratio, and FC is the fines content within the soil medium (%).

Table 2.3: Summary of the correction factors for SPT-N values. (NCEER, 1997)

Factor	Term	Equipment Variable	Correction
Overburden Pressure	C_N	-	$(P_a/\sigma'_v)^{0.5}$ $C_N \leq 2$
Energy Ratio	C_E	Safety Hammer	0.60-1.17
		Donut Hammer	0.45-1.00
Borehole Diameter	C_B	65-115 mm	1
		150 mm	1.05
		200 mm	1.15
Rod Length	C_R	3-4 m	0.75
		4-6 m	0.85
		6-10 m	0.95
		10-30 m	1
		> 30 m	< 1.0
Sampling Method	C_S	Standard Sampler	1
		Sampler without liners	1.15-1.30

2.4.4 Liquefaction Triggering Methodologies

Regarding liquefaction triggering methodologies, Seed et al. (1984) recommended the relationship between $N_{1,60}$ and *CSR* for different fines contents *FC* shown in Figure 2.10, in order to define the liquefaction potential boundaries, where $N_{1,60}$ is the corrected *SPT-N* value, and *FC* is the percentage of particles with diameter less than 0.074 mm (or passing sieve # 200).

Cetin et al. (2004) introduced new charts for soil liquefaction triggering, as shown in Figures 2.11 and 2.12, respectively. These charts also allow for the comparison with the proposed approach of Seed et al. (1984).

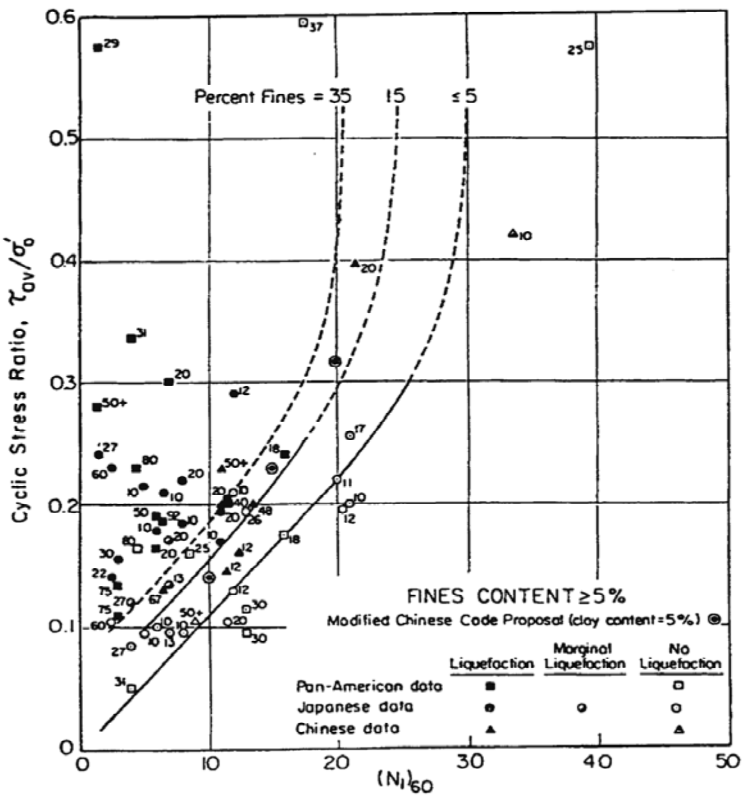


Figure 2.10: Liquefaction boundary curves recommended by Seed et al. (1984).

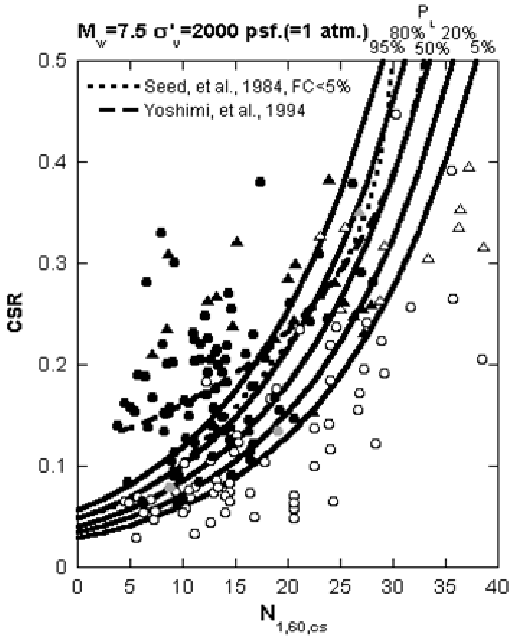


Figure 2.11: Recommended probabilistic SPT-based liquefaction triggering correlation for M_w=7.5 and σ_v'=1.0 atm. (After Cetin et al. 2004)

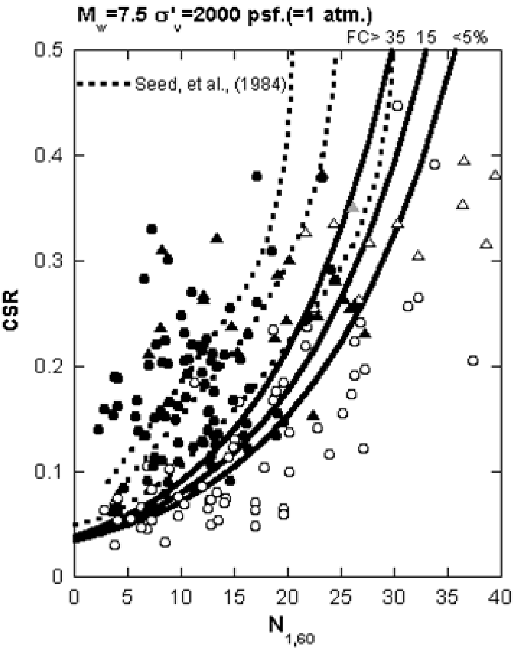


Figure 2.12: Deterministic SPT-based liquefaction triggering correlation for M_w=7.5 and σ_v'=1.0 atm. with adjustments for fines content. (After Cetin et al. 2004)

2.4.5 Liquefaction Severity Index

It is of major importance to estimate the potential of ground failure at a given site rather than potential failure of a particular soil sub-layer. Iwasaki et al. (1982) proposed the engineering Liquefaction Potential Index term, *IL*, for the evaluation of ground failure risk as recommended and discussed in the Japanese Highway Bridge Design Code. This index is defined as:

$$\text{IL} = \int_0^H W(z) \cdot F_1 \cdot dz \qquad (2.18)$$

where:

W(z): a weighting factor = 10-0.5·z, where z is the soil depth (m), and

F_1: a safety factor defined as:

(For $F_s < 1.0$) $\qquad F_1 = 1-F_s \qquad (2.19)$

(For $F_s \geq 1.0$) $\qquad F_1 = 0 \qquad (2.20)$

where F_s is the factor of safety against soil liquefaction and it can be determined from the ratio *CRR/CSR*, where *CSR* is the cyclic stress ratio, and *CRR* is the cyclic resistance ratio for each soil sub-layer, defined by Cetin et al. (2004) as:

$$\text{CRR} = \exp\left(-\frac{N_{1,60} \cdot (1 + 0.004 \cdot FC) - 29.53 \cdot \ln(M_W) - 3.70 \cdot \ln\left(\frac{\sigma'_V}{P_a}\right) + 0.05 \cdot FC + 16.85 + 2.70 \cdot \Phi^{-1}(P_L)}{13.32} \right) \qquad (2.21)$$

where: $N_{1,60}$ is the corrected SPT-N value with respect to 60% energy ratio, *FC* is the fines content of the soil medium (%), M_w is the moment magnitude of the earthquake, σ'_v is the effective overburden pressure, P_a is the atmospheric pressure (in the same units of σ'_v for normalization), $\Phi^{-1}(P_L)$ is the inverse of the standard cumulative normal distribution function for a given probability of liquefaction, (i.e., Mean = 0, and Standard Deviation = 1), and P_L is probability of liquefaction for each sub-layer defined by (Cetin et al., 2004) as:

$$P_L = \Phi\left(-\frac{N_{1,60}\cdot(1+0.004\cdot FC)-13.32\cdot\ln(CSR)-29.53\cdot\ln(M_W) -3.70\cdot\ln\left(\frac{\sigma'_V}{P_a}\right)+0.05\cdot FC+16.85}{2.70} \right) \quad (2.22)$$

where: Φ is the standard cumulative normal distribution function for a given probability of liquefaction, (i.e., Mean = 0, and Standard Deviation = 1), $N_{1,60}$ is the corrected SPT-N value with respect to 60% energy ratio, *FC* is the fines content of the soil medium (%),*CSR* is the cyclic stress ratio, M_w is the moment magnitude of the earthquake, σ'_v is the effective overburden pressure, ad P_a is the atmospheric pressure (in the same units of σ'_v for normalization).

Based on a database composed of 64 liquefied and 23 non-liquefied sites from six different earthquakes, Iwasaki et al. (1992) recommended the following liquefaction risk criteria for different ground failure levels:

- IL = 0, for extremely low liquefaction failure potential,
- 0 < IL ≤ 5, for low liquefaction failure potential,
- 5 < IL ≤ 15, for high liquefaction failure potential, and
- IL > 15, for extremely high liquefaction failure potential.

After slightly modifying the *IL* term, a probabilistic variable for expressing liquefaction severity namely Liquefaction Severity Index, *LSI*, was first adopted and used by Z. Yilmaz (2004). This variable is a function of: i) probability of soil liquefaction, ii) thickness of the potentially liquefiable sub-layer, and iii) depth from ground surface to the potentially liquefiable sub-layer, and is defined as:

$$\text{LSI} = \int_0^H P_L \cdot T_H \cdot W_F \quad (2.23)$$

where: *H* is the total thickness of soil profile starting from the ground water table depth (m), T_H is the thickness of the potentially liquefiable sub-layer (m), W_F is a weighting factor = 1 – 0.05·z, where *z* is the depth to the potentially liquefiable sub-layer (m), and P_L is the probability of liquefaction for each sub-layer.

2.5 Liquefaction-Induced Lateral Ground Spreading

The engineering phenomenon of soil liquefaction by itself may not be hazardous; however, when it is accompanied by different forms of ground deformation, then the consequences are destructive to the surrounding environment. During an earthquake shaking, when a subsurface soil sub-layer liquefies, the intact surface soil blocks will move down a gentle slope and/or towards a vertical free-face. Therefore, due to soil liquefaction during the past earthquake events, large areas and masses of soils were observed to have moved and shifted laterally to new positions, resulting in significant destructive effects for both infrastructures and the overlying surface constructions. The amplitudes of these liquefaction-induced laterals spreading are ranging from a few centimeters to more than couple of meters. Figure 2.13 illustrates a schematic diagram to describe a seismic soil liquefaction-induced lateral spreading case during an earthquake event, and the associated critical consequences.

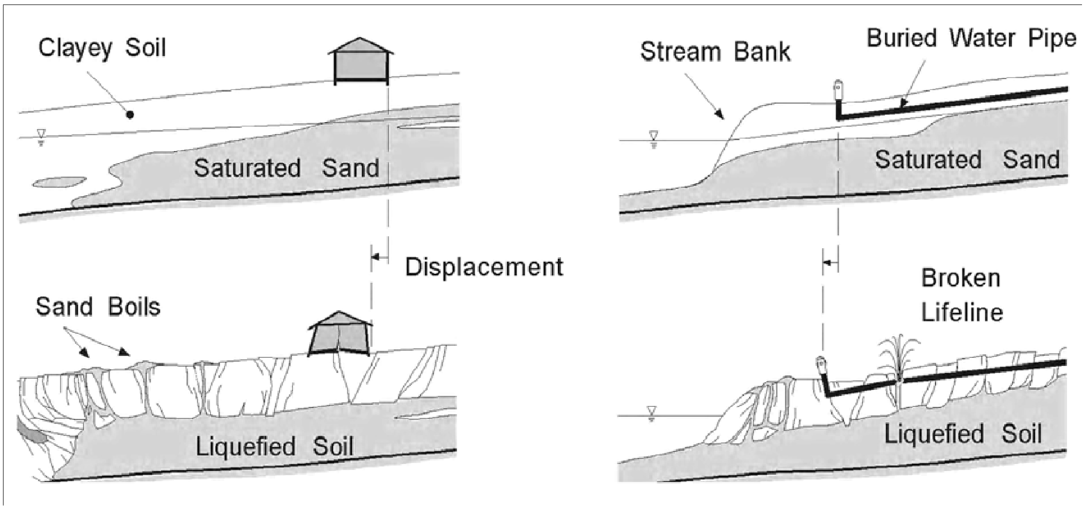


Figure 2.13: Schematic description of liquefaction-induced lateral ground spreading, and the associated destructive effects. (After Rauch, 1997)

When a liquefiable soil sub-layer exists as an underlying stratum, the overlying soil may slide during an earthquake shaking; even though the ground surface is level or gently sloping with couple of degrees. As saturation is required for liquefaction, ground water condition in a soil deposit is one of the major controlling factors that determine whether the soil, when subjected to ground shaking, is susceptible to liquefaction or not. Soils below groundwater table are assumed as saturated and thus susceptible to liquefaction

2.6 Available Methods for Estimating Liquefaction-Induced Lateral Spreading

Several different approaches for predicting the lateral ground deformation magnitudes have been introduced so far, and from the technical point of view, they can be categorized as: i) numerical analyses in the form of finite element and/or finite difference techniques (e.g., Finn et al. (1994), Arulanandan et al. (2000), and Liao et al. (2002)), ii) soft computing techniques (e.g., Wang and Rahman (1999)), iii) simplified analytical methods (e.g., Newmark (1965), Towhata et al. (1992), Kokusho and Fujita (2002), and Elgamal et al. (2003)), and iv) empirical methods developed based on the assessment of either laboratory test data or statistical analyses of lateral spreading case histories (e.g., Hamada et al. (1986), Shamoto et al. (1998), and Youd et al. (2002)). These different approaches are reviewed herein, with particular emphasis on empirical models.

2.6.1 Finite Element and Finite Difference Techniques

Liao et al. (2002) reported that very sophisticated finite element (FEM) and finite difference (FD) methods (e.g., *ABAQUS, FLAC, ADINA, and DIANA*) are required to simulate all aspects of liquefaction and lateral spreading, such as seismic excitation, soil softening, rapid loss of shear strength, redistribution of pore water pressures, and possible progressive failure. Very complex numerical schemes, large computer capabilities, and extensive resources are essentially required in order to obtain a true three dimensional simulations within the real time domains. It should be mentioned that these schemes used in geotechnical practice are all simplified to some extent due to the complexities in accurate modeling and measurement of the in-situ anisotropic state of total and effective stresses due to pore water pressure seismic-induced response, nonlinear stress-strain characteristics, and the inherent variability and heterogeneity of parameters of soil deposits and natural geo-materials. Several well known *FEM* and *FD* software packages for use in seismic-induced ground deformation analyses and earthquake soil dynamic analyses are described herein.

Finn et al. (1994) used the *TARA-3* and *TARA-3FL* codes to calculate the liquefaction-induced lateral ground spreading. The adaptive mesh procedure used in these codes is capable of modifying the finite element grid to track large deformations during the simulation process. Other attempts for finite element models have been proposed, to calculate the lateral ground deformations resulting from earthquakes, by Hamada et al. (1987) and Orense and Towhata (1992).

Gu et al. (1993; 1994) used a plane strain model to predict the deformation resulting from liquefaction. When this method is applied to the Wildlife Site in California (Gu et al., 1994), it correctly estimated the pattern of displacements, but over-estimated the magnitude of displacements by about 30%.

Arulanandan et al. (2000) used fully coupled effective stress-based, nonlinear, finite-element program, *SUMDES,* with a reduced order bounding surface hypo-plasticity model to simulate the stress-strain behavior of non-cohesive soils during 1995 Hyogoken-Nambu earthquake. The results of liquefaction-induced vertical and horizontal ground deformation behavior agree well with the field data observed by the instruments. The initial state parameters and constitutive model constants representative of the site are obtained from nondestructive, in situ electrical and shear wave velocity methods, and they have been proved to be effective.

The finite element software *FLAC* (Fast Lagrangian Analysis of Continua) has a dynamic module that permits the numerical evaluations of complex geo-material construction, including earth and concrete dams, levees, slopes, shallow and deep excavations, retaining walls, and others.

Another internationally popular *FEM* program for geotechnical modeling is *PLAXIS* with full documentation provided at *http://www.plaxis.com/ns.html*.

A complete three dimensional *FEM* formulation that includes effective stress states, plasticity, and nested yield surfaces in the soil constitutive representation has been developed by Jean Prevost at Princeton University-USA.

The US Army Corps of Engineers (USAE) has been involved with geotechnical earthquake engineering research for several decades at the Waterways Experiment Station (WES). They have developed numerical *FEM* models to deal with the analysis of levees, dams, and containment structures in seismic regions, including along the Mississippi River, such as their software program *WESHAKE*.

Yang et al. (2003) employed the computational modeling steps suggested by Elgamal (2002) to introduce a web-based platform for computer numerical simulation of earthquake site response (CYCLIC 1D), including prediction of lateral spreading. *FEM* are employed within an incremental plasticity coupled solid-fluid formulation.

Finally, a relatively new program, entitled *Quake*, for the evaluation and analyses of slopes, earth dams, and reservoirs is available from the *GeoSlope* software company, in addition to some other *USGS* and *GEOENGINEER* software programs related to earthquake-induced lateral ground deformations can be respectively found at their official web sites and publications.

2.6.2 Soft Computing Techniques

Wang, J. and Rahman, M. (1999) reported that a new field of ‘soft computing’ has emerged for solving decision making, modeling, and control problems. Soft computing consists of many complementary tools such as: fuzzy logic, neuro computing, probabilistic reasoning, genetic algorithm, and others. The artificial neural network *ANN* is used to model the seismically induced displacement based on the same database used in the MLR model developed by Bartlet and Youd (1992).

The most frequently used neural-network paradigm is the back propagation learning algorithm. The hidden and output layer neurons process their inputs by multiplying each of their inputs by the corresponding weights, summing the product, and then processing the sum using a nonlinear transfer function to produce a result. The S-shaped sigmoid function is commonly used as the transfer function. The neural-networks "learn" by adjusting the weights between the neurons in response to the errors between actual output values and target output values. At the end of this training phase, the neural network represents a model, which should be able to predict a target value given the input value.

2.6.3 Simplified Analytical Models

<u>Sliding Block Model</u>

In 1965, Newmark proposed this model based on the analogy of a sliding block on frictional sloping plane. He predicted seismically induced ground deformations by integrating the accelerations exceeding the yield acceleration of the sliding block to obtain its velocities. The yield acceleration is related to the slope angle and the factor of safety against sliding. The block is to start sliding when the driving force (the seismic acceleration) reaches or exceeds the resisting force (the yield acceleration). The total accumulated resulting deformations are then determined by integrating the sliding block velocities.

Yegian et al. (1991) used Newmark's concept to introduce their model for predicting the permanent ground displacement expressed as:

$$D = N_{eq} \cdot T^2 \cdot a_p \cdot f(a_y/a_p) \qquad (2.24)$$

where: D is the lateral ground deformation, N_{eq} is the number of cycles equivalent to uniform base motion, T is the period (s), a_y is the yield acceleration (g), a_p is the peak acceleration (g), and f is a dimensionless function depending on base motion.

Baziar et al. (1992) also used Newmark's concept, assuming an equivalent sinusoidal base acceleration record, to propose their model for predicting the permanent ground displacement expressed as:

$$D = N_{eq}(v_{max}^2/a_{max})f(a_y/a_p) \qquad (2.25)$$

where: D is the lateral ground deformation, N_{eq} is the number of cycles equivalent to uniform base motion, v_{max} is the peak velocity, a_y is the yield acceleration, a_p is the peak acceleration, and f is a dimensionless function depending on base motion.

Jibson, R. W. (1994) suggested a relationship for the prediction of lateral spreads as:

$$\text{Log}D = 1.46\ \text{Log}\ I_a - 6.642\ a_y + 1.546 \qquad (2.26)$$

where: D is the lateral ground deformation (cm), I_a is the Aria intensity (m/s), and a_y is the yield acceleration (g).

Minimum Potential Energy Model

This model was developed by Towhata et al. (1991; 1992) based of the observations from laboratory shaking table tests. The final position of the soil layers is determined by the principle of minimum potential energy, using the Lagrangian equations of motion, and assuming the variation of lateral ground deformation with depth as a sine function and with neglecting inertial effects during dynamic loading.

Tokida et al. (1993) used the same principle to develop equations for predicting the maximum lateral displacement at the center of a slide as:

(For 10m ≤ L ≤ 100)

$$D = 1.73 \cdot 10^{-5}\, L^{1.94}\, H^{0.298}\, T^{-0.275}\, \theta^{0.963} \qquad (2.27)$$

(For 100m < L ≤ 1000m)

$$D = 1.29 \cdot 10^{-5}\, L^{1.99}\, H^{0.28}\, T^{-0.243}\, \theta^{0.995} \qquad (2.28)$$

where: D is the horizontal displacement (m), L is the length of the slide (m), H is the average thickness of the liquefied layer (m), T is the average thickness of the liquefied surface layer (m), and θ is the slope of ground surface (%).

Shear Strength Loss and Strain Re-hardening Model

Bardet et al. (1999) reported that in 1997, P. M. Byrne proposed a method to calculate the final position of a slope that liquefies by using the finite difference software package *FLAC*. In the zone of liquefaction, the liquefied material is assumed to be initially free of shear, and to undergo isotropic pressure. Following this instantaneous melting of the liquefied soil, the shear stress τ is assumed to increase with shear strain until it reaches some residual shear strength τ_{ST}. While the liquefied soil regains shear strength, the shear modulus is assumed to take a constant value G_{LIQ}. The final position of the slope is calculated by using the dynamic equation of motion.

Viscous Models

Hadush et al. (2001) reported that in 1995 Aydan, O. has assumed the liquefied subsoil to behave as a visco-elastic body, and calculated the deformation velocities for the liquefied soil sub-layers by using a updated Lagrangian numerical method. They also presented a CIP (Cubic Interpolated Pseudoparticle) based numerical method for the liquefaction-induced lateral spreading analysis within the framework of fluid dynamics.

Liao et al. (2002) reported that Hamada et al. (1994) suggested using viscous models to simulate the liquefaction-induced ground deformation. By measuring the drag force applied to a sphere immersed into liquefied soil layers, the apparent viscosity of these soils can be determined and then used in the liquefaction analysis process.

Kokusho and Fujita (2002) investigated the involvement of water film in lateral flow failure during earthquakes, based on site investigation data obtained from the 1964 Niigata earthquake. It was found that the water films formed beneath fine soil sub-layers have literally no shear resistance, and they are an important factor for the large lateral flow displacement.

Centrifuge Models

Balakrishnan et al. (1998), Manda et al. (1999), Kutter et al. (1999), and Elgamal et al. (2003) numerically analyzed the centrifuge model experiments data to investigate the average shear and volumetric strains for the seismically liquefied soils. The major effective engineering factors that were observed are the thickness of liquefied soil sub-layer and soil relative density.

2.6.4 Empirical Models

Hamada et al.(1986), Youd and Perkins (1987), Rauch (1997), Shamoto et al.(1998), Bardet (1999), and Youd et al. (2002) introduced empirical methods and multi-linear regression *MLR* models for the assessment of liquefaction-induced lateral spreading. The methods of Hamada et al. (1986), Youd and Perkins (1987), Rauch (1997), Bardet (1999), and Youd et al. (2002), Kanibir (2003), are empirical methods based on regression analyses of available lateral spreading case histories. The predictive approach of Shamoto et al. (1998) employs laboratory-based estimates of liquefaction-induced limiting shear strains coupled with an empirical adjustment factor in order to relate these laboratory values to the observed field behavior.

2.6.4.1 Hamada et al. (1986)

In 1986, Hamada et al. introduced a simple empirical equation for predicting the liquefaction induced lateral ground deformations only in terms of ground slope and thickness of liquefied soil layer. This equation was based on the regression analysis of 60 earthquake case histories, mostly from Noshiro-Japan, and it was expressed as:

$$D_h = 0.75\ H^{1/2}\ \theta^{1/3} \qquad (2.29)$$

where: D_h is the predicted horizontal ground displacement (m), H is the thickness of liquefied zone (m), (when more than one sub-layer liquefies, H is measured as the distance from the top-most to the bottom-most liquefied sub-layers including all intermediate sub-layers), and θ is the larger slope of either ground surface or lıquefıed zone lower boundary (%).

It is quite noticable that this model is very simple and easy to use, but it is based on limited number of case histories, and it consists of only two parameters related to the site geometry, with almost no sesmic and/or geotechnical parameters. Therefore, this emperical model is not general and its use is limited to cases with similar conditions.

2.6.4.2 Youd and Perkins (1987)

Based on data collected from western United States and Alaska historical earthquake records, this simple model relates the amplitude of lateral ground spreading (expressed as *LSI*) to the distance from the seismic energy source and the earthquake moment magnitude, where *LSI* stands for: *Liquefaction Severity Index*. The model has similarities to attenuation relation curves for peak accelerations, and expressed as:

$$\text{Log LSI} = -3.49 - 1.86 \text{ Log R} + 0.98 \text{ M}_w \qquad (2.30)$$

where: *LSI* is the general maximum amplitude of lateral ground spread (inch), *R* is the horizontal distance to the seismic energy source (km), and M_w is the earthquake moment magnitude. *LSI* has an upper value of 100 inches (≅2.54 m), and it is assigned for deformations of gently sloping, recent, and fluvial sites of shallow cohesionless soil profiles. Therefore, the use of this two-parameter model is limited to sites with seismic, geotechnical, and topographic conditions similar to those found in the west regions of North America.

2.6.4.3 Rauch (1997)

Rauch, A. F. (1997) considered liquefaction-induced lateral spreading as slides of finite area, instead of individual displacement vectors. Using multiple linear regression methods, Rauch proposed three different equations for estimating the average lateral deformations, which were respectively referred to as regional, site, and geotechnical, and they were expressed as:

<u>Regional Average:</u>

$$D_G = (D_R - 2.21)^2 + 0.149 \quad (2.31)$$

$$D_R = (613\ M_w - 13.9\ R_f - 2420\ A_{max} - 11.4\ T_d)/1000 \quad (2.32)$$

where: D is the average horizontal displacement (m), R_f is the shortest horizontal distance to fault rupture (km), M_w is the earthquake moment magnitude, A_{max} is the peak horizontal ground acceleration at ground surface (g), and T_d is the time duration (in seconds) of the strong earthquake motions (>0.05g).

<u>Site Average:</u>

$$D = (D_R + D_S - 2.44)^2 + 0.111 \quad (2.33)$$

$$D_S = (0.523\ L_{slide} + 42.3\ S_{top} + 31.3\ H_{face})/1000 \quad (2.34)$$

where: L_{slide} is the length of the slide area from head to toe (m), S_{top} is the average slope across the surface of lateral ground spreading (%), and H_{face} is the height of the free face measured vertically from toe to crest (m).

<u>Geotechnical Average:</u>

$$D = (D_R + D_S + D_G - 2.49)^2 + 0.124 \quad (2.35)$$

$$D_S = (50.6\ Z_{FSmin} - 86.1\ Z_{liq})/1000 \quad (2.36)$$

where: Z_{FSmin} is the average depth corresponding to minimum factor of safety (m), and Z_{liq} is the average depth to top of the liquefied layer (m).

This model was based on the MLR analysis for the total of only 78 data points from 16 different earthquakes. The methodology of this model was to subdivide the liquefied area into separate slide zones, and to define the length and area for each slide, and then to consider the average liquefaction-induced displacement vectors and the average borehole soil properties within these slides. The quality of fit results for the three equations of this MLR model was reported as: R^2=50.9% based on 71 data points for regional model, R^2=67.0% based on 58 data points for site model, and R^2=68.8% based on 45 data points for geotechnical model, respectively.

2.6.4.4 Shamoto et al. (1998)

The predictive approach of Shamoto et al. (1998) employed laboratory based estimates of liquefaction-induced limiting shear strains coupled with an empirical adjustment factor to relate these laboratory values to observed field behavior. Predicted lateral displacements, based on laboratory limiting shear strains, are multiplied by a factor of 0.16 in order to predict lateral displacements of non-sloping ground. The tested soils were extracted from twelve earthquake sites in Japan, and the general classification of these soils was clean sands with no fines content (i.e. FC ≅ 0). The model was introduced in a graphical form and also as a mathematical formula expressed as:

$$D_h = C_h x (D_h)_{\max} = C_h x \int_0^H (\gamma_r)_{\max} dz \qquad (2.37)$$

$$(\gamma_r)_{\max} = \frac{e_0 - e^*_{\min}}{1 + e_0} \frac{R^*_0}{M_{CS0}} \gamma^m_{\max} \qquad (2.38)$$

where: D_h is the lateral ground deformation, C_h is the correlation factor between observed and predicted deformations, (0.16 for level sites, and 1.0 for sloping and/or free-face sites), H is the maximum vertical depth under consideration (m), z is the vertical depth below ground surface (m), $(\gamma_r)_{max}$ is the maximum residual shear strain potential, e_0 is the initial void ratio, $e_{min}* = e_{max} - 1.3(e_{max} - e_{min})$, e_{max} is the maximum void ratio, e_{min} is the minimum void ratio, R_0* (= 2.0) is a constant independent of the type of sand, $M_{CS0} = 0.142\ M_{CS}$, M_{CS} is the critical deviator-isotropic stress ratio, m (= 0.76) is a constant independent of the type of sand, and γ_{max} is the maximum double amplitude shear strain.

The obvious limitations of this laboratory based empirical model are: it is derived from very few output results of experimental work, and it is heavily biased towards the Japanese soils of clean sands ad their related seismic and geometric features.

2.6.4.5 Bardet et al. (1999)

Bardet et al. (1999) calibrated six-parameter and four-parameter multi linear regression MLR models for the prediction of liquefaction-induced lateral ground deformations. The models covered both the free-face and ground slope conditions. The four-parameter models are more approximate than the six-parameter models, and are recommended when there is limited borehole data. The MLR models where expressed as:

<u>Six-parameter combined free-face and ground slope model</u>

$$Log\ (D_H+0.01) = -15.034+1.096M-0.873Log\ R-0.014R+0.634Log\ W+0.275Log\ S_{gs} +0.494Log\ T_{15}+4.053Log\ (100-F_{15})-0.814D50_{15} \quad (2.39)$$

<u>Six-parameter free-face model</u>

$$Log\ (D_H+0.01) = -17.372+1.248M-0.923Log\ R-0.014R+0.685Log\ W+0.3Log\ T_{15} +4.826Log\ (100-F_{15})-1.091D50_{15} \quad (2.40)$$

<u>Six-parameter ground slope model</u>

$$Log\ (D_H+0.01) = -14.152+0.988M-1.049Log\ R-0.011R+0.318Log\ S_{gs}+0.619LogT_{15} +4.287Log\ (100-F_{15})-0.705D50_{15} \quad (2.41)$$

<u>Four-parameter combined free-face and ground slope model</u>

$$Log\ (D_H+0.01) = -7.28+1.017M-0.278Log\ R-0.026R+0.497Log\ W+0.454Log\ S_{gs} +0.558Log\ T_{15} \quad (2.42)$$

<u>Four-parameter free-face model</u>

$$Log\ (D_H+0.01) = -6.968+0.972M-0.271LogR-0.027R+0.497LogW+0.584LogT_{15} \quad (2.43)$$

<u>Four-parameter ground slope model</u>

$$Log\ (D_H+0.01) = -7.586+1.109M-0.233LogR-0.025R+ 0.477LogS_{gs}+0.597logT_{15} \quad (2.44)$$

where: D_H is the horizontal ground displacement predicted by the multiple linear regression models (m), M is the earthquake magnitude, where M_w was primarily used whenever reported, R is the horizontal distance to nearest seismic source or nearest fault rupture (km), W is the free-face ratio = H/L (%), H is the height of free-face (m), L is the distance to free-face from the point of displacement (m), S_{gs} is the gradient of surface topography or ground slope (%), T_{15} is the thickness of saturated layers with $N_{1,60}$ < 15 (m), F_{15} is the average fines content, for particles finer than 0.075 mm, in T_{15} (%), and $D50_{15}$ is the average $D50$ in T_{15} (mm).

This model expressly followed the same procedure of Bartlett and Youd's (1992) first proposed model and then revised twice and reintroduced as Youd et al. (2002), which is reviewed in the next section, and applied the same MLR approach but with the use of Bartlett's (1998) database that has slight differences within the ground displacement amplitudes than Youd's. This MLR model has a very similar outline and very close values of coefficients as that of Youd's model except that: the parameter $R*$ was excluded and substituted by R, an equation for sloping sites with a free-face condition was added, and four-parameter equations were proposed as a *first order approximation* for the liquefaction-induced lateral ground deformations.

2.6.4.6 Youd et al. (2002)

The model of Bartlett and Youd was first introduced in (1992) and then it was modified in (1995). After that the model was further revised and modified, and re-introduced as the model of Youd et al. (2002). This model was developed, through multi-linear regression (MLR) of a large case history database compiled from Japan and the United States earthquake events. The model was introduced in the form of two different equations covering the cases of sites with a free-face and others with a sloping ground surface, expressed as follows:

<u>For free face conditions:</u>

$$\text{Log } D_H = -16.713+1.532M-1.406\text{Log } R^*-0.012R+0.592\text{Log } W+0.540\text{Log}T_{15} +3.413\text{Log }(100 - F_{15})-0.795\text{Log }(D50_{15}+0.1 \text{ mm}) \quad (2.45)$$

For gently sloping ground conditions:

$$\text{Log } D_H = -16.213+1.532M-1.406\text{Log } R^*-0.012R+0.338\text{Log } S+0.540\text{Log } T_{15}$$
$$+3.413\text{Log } (100 - F_{15})-0.795\text{Log } (D50_{15}+0.1 \text{ mm}) \quad (2.46)$$

where: D_H is the horizontal ground displacement predicted by the multiple linear regression models (m), M is the earthquake magnitude, where M_w was primarily used whenever reported, R is the horizontal distance to nearest seismic source or nearest fault rupture (km), $R^* = R+10^{(0.89M-5.64)}$, W is the free-face ratio = H/L (%), H is the height of free-face (m), L is the distance to free-face from the point of displacement (m), S is the ground surface slope (%), T_{15} is the thickness of saturated layers with $N_{1,60} < 15$ (m), F_{15} is the average fines content, for particles finer than 0.075 mm, within T_{15} (%), and $D50_{15}$ is the average D50 within T_{15} (mm).

This sophesticated MLR model took into consideration parameters related to the earthquake record, site geometry, and soil properties. The use of this model has many limitations such as: the model is applicable only for widely spread liquefaction cases and not for local spots, the free face equation is used when $5 \leq W \leq 20\%$, while the ground slope equation when $W \leq 1\%$. This bordering system for the values of W is discontinuous, and does not give any explanation for the cases with W values located outside the stated boundaries. In addition, this MLR model is valid only for the ranges of: $6 \leq M_W \leq 8$, $0.1 \leq S \leq 6\%$, and $1 \leq T_{15} \leq 15$ m, and a total depth to the top of the liquefied soil sub-layer ranging from 1 to 10 m. Also, the model is invalid at seismic source distances closer than the following cases:

M_w	6	6.5	7	7.5	8
R (km)	0.5	1	5	10	20-30

Finally, this MLR model is not applicable for gravelly and/or very silty soils, and unpractically, it does not include solutions for sloping ground sites with a free face.

2.6.4.7 Kanibir (2003) Models

A. Kanibir (2003) proposed a set of models for predicting seismic soil liquefaction-induced lateral spreading. The models employed the same group of parameters used in the approach of Youd et al. (2002), but additionally it covered both the free-face and ground surface slope conditions, simultaneously. They were expressed as:

<u>For combined free-face and ground slope condition:</u>

$$\text{Log } D_H = -18.84+23.37M-1.31\text{Log } R^{*}-0.009R+0.06S+0.09W+0.46\text{Log}T_{15} -0.02F_{15}-0.90\text{Log } (D50_{15}+0.1 \text{ mm}) \quad (2.47)$$

<u>For free face condition:</u>

$$\text{Log } D_H = -20.71+25.32\text{Log } M-1.39\text{Log } R^{*}-0.009R+1.15\text{Log } W+0.19T_{15}^{0.5} -0.02F_{15}-0.84\text{Log } (D50_{15}+0.1 \text{ mm}) \quad (2.48)$$

<u>For gently sloping ground condition:</u>

$$\text{Log } D_H = -7.52+8.44\text{Log } M+0.001R^{*}-0.23R+0.11S+0.6\text{Log } T_{15}-0.22F_{15} -0.89\text{Log } D50_{15} \quad (2.49)$$

where: D_H is the predicted horizontal ground displacement (m), M is the earthquake magnitude, R is the horizontal distance to nearest seismic source or nearest fault rupture (km), W is the free-face ratio = H/L (%), H is the height of free-face (m), L is the distance to free-face from the point of displacement (m), S is the gradient of surface topography or ground slope (%), T_{15} is the thickness of saturated layers with $N_{1,60} < 15$ (m), F_{15} is the average fines content, for particles finer than 0.075 mm, within T_{15} (%), and $D50_{15}$ is the average D50 in T_{15} (mm).

This set of models was based on the analysis of liquefaction-induced lateral ground spreading cases from the 1999 Kocaeli (Izmit)-Turkey Earthquake within the Lake Sapanca area. The goodness of fit, R^2, values for these models were reported as: 74.51%, 76.18%, and 72.39%, respectively.

2.7 Comparisons of Different Approaches

The different numerical and analytical procedures reviewed in the previous sections are mechanistic methods which attempt to model, with varying degrees of simplification, the physical behavior of liquefaction-induced lateral spreading. Empirical models, on the other hand, make no attempt to explicitly model the system mechanics; rather, empirical models simply represent the observed relationship between displacements and various site and/or seismic event-related parameters. Due to difficulties in the determination of input model parameters, and given the unsatisfactory aspects of the available mechanistic models, an empirical approach shows considerable promise in terms of both simplicity and reliability. If formulated correctly, an empirical model has the advantage of a direct basis on observed field behavior. Also, empirical methods can be used to validate more complicated mechanistic models or inexpensively identify sites that warrant further study. In developing empirical models, however, truly relevant controlling parameters must be chosen and accurately compiled into a sufficiently large database. For liquefaction-induced ground deformations, this is a difficult but a critical task. (Glaser 1994)

CHAPTER 3

LIQUEFACTION-INDUCED LATERAL GROUND SPREADING CASE HISTORIES

3.1 Introduction

Efforts aiming to develop a semi-empirical or empirical model naturally require the compilation of a high quality data addressing the descriptors of the problem (e.g., liquefaction severity index, *LSI*, moment magnitude of the earthquake, M_W, maximum acceleration, a_{max}, slope of ground surface, *S*, site free-face ratio, *W*, and equivalent angle of internal friction for liquefied soil, $\phi'_{eqv,liq}$); therefore, an intensive and detailed literature survey was performed.

After filtering the compiled lateral spreading case histories from data quality and completeness points of views, a total number of 526 data points from 18 different earthquakes were possible to be used. Reasons lying for filtering out some of the data points can be listed as: i) site and/or seismicity-related information affecting the analysis procedure are not well defined and/or not sufficient, ii) sites with special boundary conditions impeded free liquefaction-induced lateral spreading, and iii) sites with very steep ground slopes.

The resultant database composed of high quality case history data from sites with liquefaction severity index, *LSI*, varying in the range of zero to 9.84, and shaken by the earthquakes producing maximum ground acceleration, a_{max}, in the range of 0.12 to 0.79 g and resulting in observed lateral spreading in the range of 0.0 m to 10.15 m. Compilation and assessment of these 526 case histories, 435 of which were also included in Youd et al. (2002) database, will be discussed, in the next sections. Youd et al. (2002) database, also referred herein as "Old Case Histories", was re-assessed. Additionally, 91 new case histories from 8 different earthquakes, namely; the 1976 Guatemala, 1977 San Juan-Argentina, 1990 Luzon-Philippines, 1994 Northridge-USA, 1995 Hyogoken-Nanbu-Japan, 1999 Kocaeli (Izmit)-Turkey, 1999 Chi Chi-Taiwan, 2003 Tokachi-Oki-Japan, and 2003 San Simeon-USA earthquakes were also analyzed and included in our final database.

3.2 Selection of Descriptive Variables for the Lateral Spreading Models

This section summarizes the variables employed by the existing empirical models for the assessment of seismic soil liquefaction-induced lateral spreading, and it demonstrates the selected variables for the proposed models, which are grouped as seismological, topographical, and geotechnical variables.

3.2.1 Descriptive Variables of the Existing Empirical Models

Hamada et al. (1986), Shamoto et al.(1998), and Youd et al. (2002), as well as others reviewed in Chapter 2, suggested empirical methodologies for the assessment of liquefaction-induced lateral spreading. The methods of Hamada et al. (1986) and Youd et al. (2002) are widely used in the engineering practice. They are empirical methods based on multi-linear regression, *MLR*, analyses of existing lateral spreading case histories.

In addition, Shamoto et al. (1998) proposed a different predictive approach that employs laboratory based estimates of liquefaction-induced limiting shear strains coupled with an empirical adjustment factor in order to relate these laboratory values to the observed field behavior. Table 3.1 summarizes all the parameters employed by these three empirical lateral spreading models, noting that these parameters were reviewed and defined previously in Section 2.6.4.

Table 3.1: Summary of descriptive variables for existing empirical models.

Model	Descriptive Variables
Hamada et al. (1986)	Thickness of liquefied zone, *H*, (m)
	Ground surface slope, θ, (%)
Shamoto et al. (1998)	Maximum vertical depth under consideration, *H*, (m)
	Maximum residual shear strain potential, $(\gamma_r)_{max}$
Youd et al. (2002)	Moment magnitude of the earthquake, M_w
	Horizontal distance to nearest seismic source, *R*, (km)
	Free-face ratio, *W*, (%)
	Ground surface slope, *S*, (%)
	Thickness of saturated sub-layers with $N_{1,60}$ < 15, T_{15}, (m)
	Average fines content, for particles < 0.075 mm, within T_{15}, F_{15}, (%)
	Average D_{50} within T_{15}, $D50_{15}$, (mm)

3.2.2 Descriptive Variables for the Proposed Models

Inspired by available methods regarding the assessment of liquefaction-induced lateral spreading as well as seismic-induced soil liquefaction, descriptive variables, grouped under the titles of: i) seismological, ii) topographical, and iii) geotechnical, are discussed in the following sub-sections.

3.2.2.1 Seismological Variables

This group includes variables that are directly related to durational and intensity-related issues of the strong ground motion shaking. They are listed as:

M_W: Moment magnitude of the earthquake, representing duration of shaking, and
a_{max}: Maximum horizontal ground acceleration (g), representing intensity of shaking.

3.2.2.2 Topographical Variables

The variables of this category describe the site boundary conditions, and define the location of the point where lateral spreading deformations were mapped relative to the boundaries. As show in Figure 3.1, these variables are:

W: Free-face ratio = H/L (%),
L: Distance to the free face from the point of displacement (m),
H: Height of free face (m),
S: Ground surface slope (%), and
β: Ground surface slope angle (degrees) = $\tan^{-1}(S/100)$.

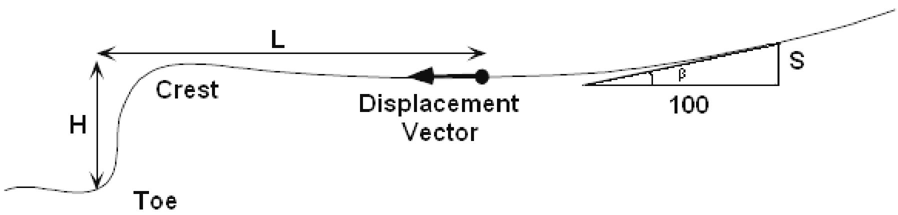


Figure 3.1: Topography-related descriptive variables.

3.2.2.3 Geotechnical Variables

These descriptive variables are subdivided into three main groups addressing the: i) static soil stability, ii) dynamic soil stability with inertial forces, and iii) liquefaction severity-related issues.

<u>Descriptive Variables for Post Liquefaction Static/Dynamic Soil Stability</u>

These variables are adopted as safety measures for the stability of gently sloping sites against sliding under earthquake shaking. They are defined as:

$\tan\phi'_{eqv,liq}/\tan\beta$: Factor of safety measure against gravitational forces for the most critical sub-layer, where

$\phi'_{eqv,liq}$: is the equivalent mobilized angle of internal friction of liquefied or potentially liquefiable soils.

The potentially liquefiable sub-layer having the minimum value of ($\tan\phi'_{eqv,liq}/P_L$) is denoted as the most critical sub-layer, where P_L is the probability of liquefaction for each sub-layer. If the undrained shear strength of the liquefied soil is denoted by S_u, and soil cohesion is assumed to be zero, which is typical for sands, then $S_u/\sigma_v' \cong \tan\phi'_{eqv,liq}$. The values of $\tan\phi'_{eqv,liq}$ can be obtained by using the relationships proposed by Stark and Mesri (1992), as shown in Figure 3.2, where the engineering term $N_{1,60,CS}$ is the corrected SPT-N value with respect to both 60% energy ratio and fines content, as explained in details in Section 2.4.3, noting that if the most critical sub-layer is assessed to have a factor of safety against liquefaction higher than 1.0, then the value of ϕ'_{static} is used instead.

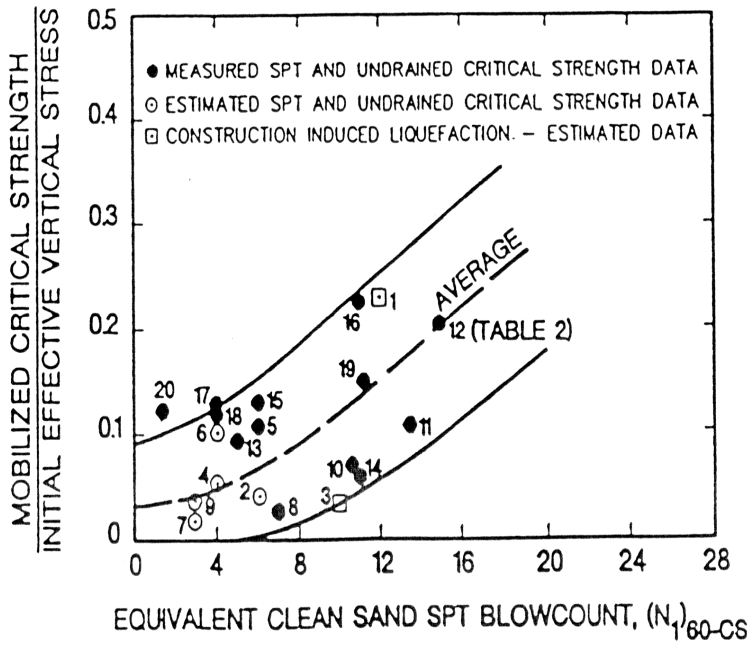


Figure 3.2: Stark and Mesri's (1992) relationship for (S_u/σ_v' vs. $N_{1,60,CS}$).

Descriptive Variables for Inertial Forces

These descriptive variables are safety measures for the resistance of sites against inertial impact effects due to the ground acceleration produced during earthquake shaking. They are defined as:

a_y/a_{max}: Factor of safety against sliding for the most critical sub-layer, where
a_y: Yield acceleration (g) = $\tan(\phi'_{eqv,liq}-\beta)$ with finite slope assumption.

Liquefaction Severity

This probabilistic variable, *LSI*, represents a measure for the seismic-induced liquefaction potential of a given site rather than the potential failure of a particular soil sub-layer. This variable is discussed in detail in Section 2.4.5. The other descriptive variable within this group is the depth from ground surface to the most critical potentially liquefiable soil sub-layer, z_{cr}.

3.3 Re-evaluation of Old Case Histories Data

The pre-existing 435 case history data points, mainly from the database of Youd et al. (2002), were selected from 10 different earthquakes, namely:

1. 1906 San Francisco – USA,
2. 1964 Prince William Sound – Alaska,
3. 1964 Niigata – Japan,
4. 1971 San Fernando – USA,
5. 1979 Imperial Valley – USA,
6. 1983 Borah Peak – USA,
7. 1983 Nihonkai-Chubu – Japan,
8. 1987 Superstition Hills – USA,
9. 1989 Loma Prieta – USA, and
10. 1995 Hyogoken-Nanbu – Japan.

The statistics of some descriptive variables of these case histories are listed in Table 3.2. The distributions for the main characteristics of these case histories are shown in Figure 3.3. As it can be seen in the figures, the majority of the sites included was affected by earthquakes of moment magnitudes ranging from 6.5 to 7.5, and producing maximum ground accelerations less than 0.2 g. In addition, the topographic features for the majority of the sites included ground surfaces with slopes less than 3%, or with free-face ratios less than 10%. Also, the measured lateral spreads for most of the case histories are below 5m, while only a minority are having *LSI* values less than 1.

Table 3.2: Statistics of the descriptive variables of old case histories.

No. of Cases	435		
Variables	Min.	Med.	Max.
LSI	0	5.4	8.8
M_W	6.4	7.5	9.2
a_{max} (g)	0.12	0.19	0.6
S (%)	0	0.36	11.0
W (%)	0	0	56.8
z_{cr} (m)	0.6	4.0	16.8
a_y/a_{max}	0	0.38	3.78
$\tan\beta/\tan\phi'_{eqv,liq}$	0	0.04	1.4

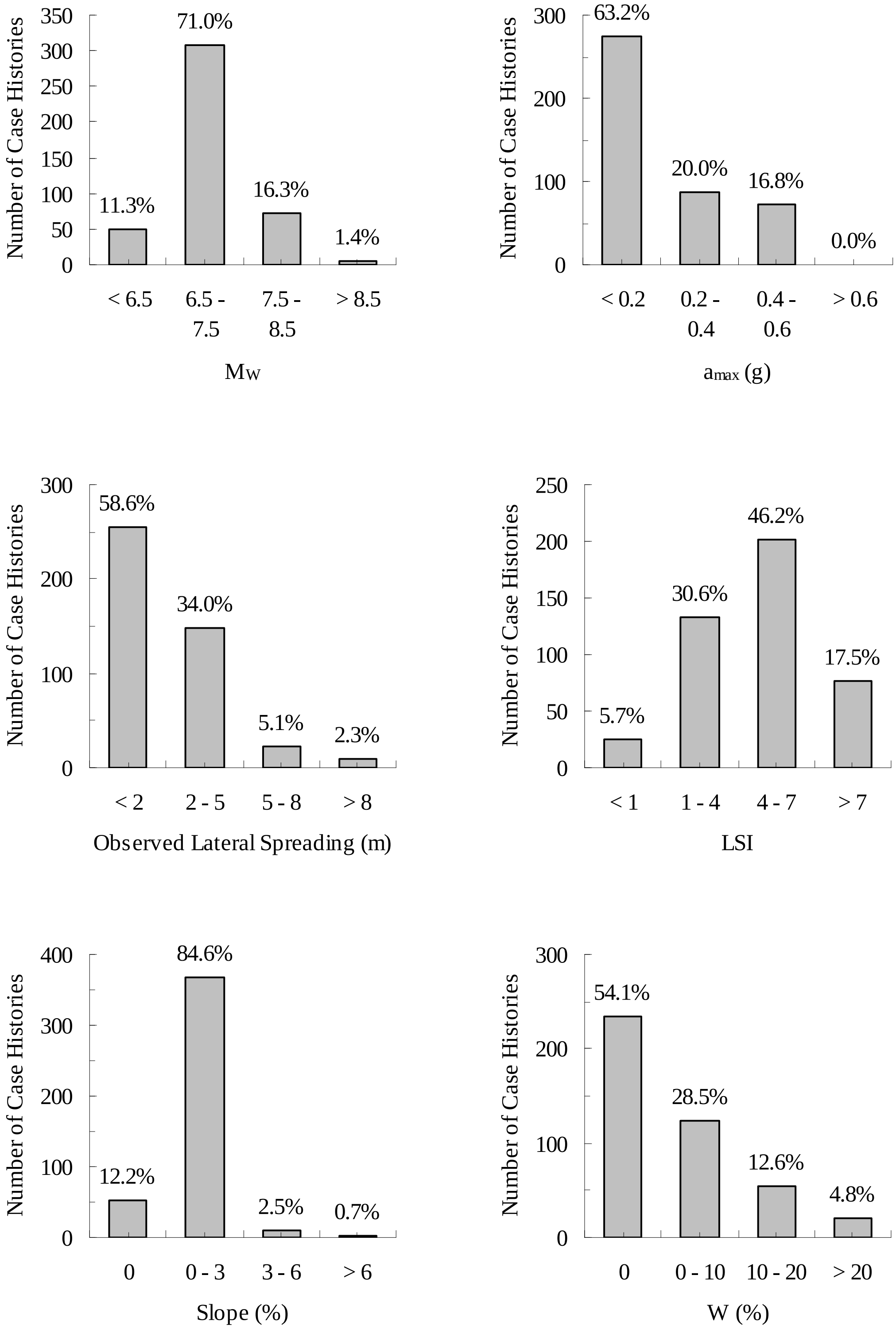


Figure 3.3: Distribution of descriptive variable characterestics for old case histories.

3.4 Evaluation of New Case Histories Data

Intensive literature surveying efforts lead to the addition of 91 new case histories to our lateral spreading database. They were selected from 11 different earthquakes:

1. 1976 Guatemala,
2. 1977 Argentina,
3. 1983 Borah Peak – USA,
4. 1989 Loma Prieta – USA,
5. 1990 Luzon – Phillipines,
6. 1994 Northridge – USA,
7. 1995 Hyogoken-Nanbu – Japan,
8. 1999 Kocaeli-Izmit – Turkey,
9. 1999 Chi-Chi – Taiwan,
10. 2003 San Simeon – USA, and
11. 2003 Tokaci-Oki – Japan.

The distributions for the main characteristics of these case histories are shown in Figure 3.4, while the statistics of the some descriptive variables for these case histories are listed in Table 3.3. As it can be noticed, the characteristics of this group of case histories are differerent from those of the old ones. The majority of the sites included in this part of the overall database were affected by earthquakes having moment magnitudes greater than 7.0, and producing maximum ground accelerations ranging from 0.19 to 0.6 g. In addition, the topographic features for the majority of the sites included ground surface slopes less than 2%, with free-face ratios less than 10%. Also, the measured lateral spreads for most of the case histories are less than 2m, while the *LSI* values for the case histories of this part are distributed within the range from 1 to 7.

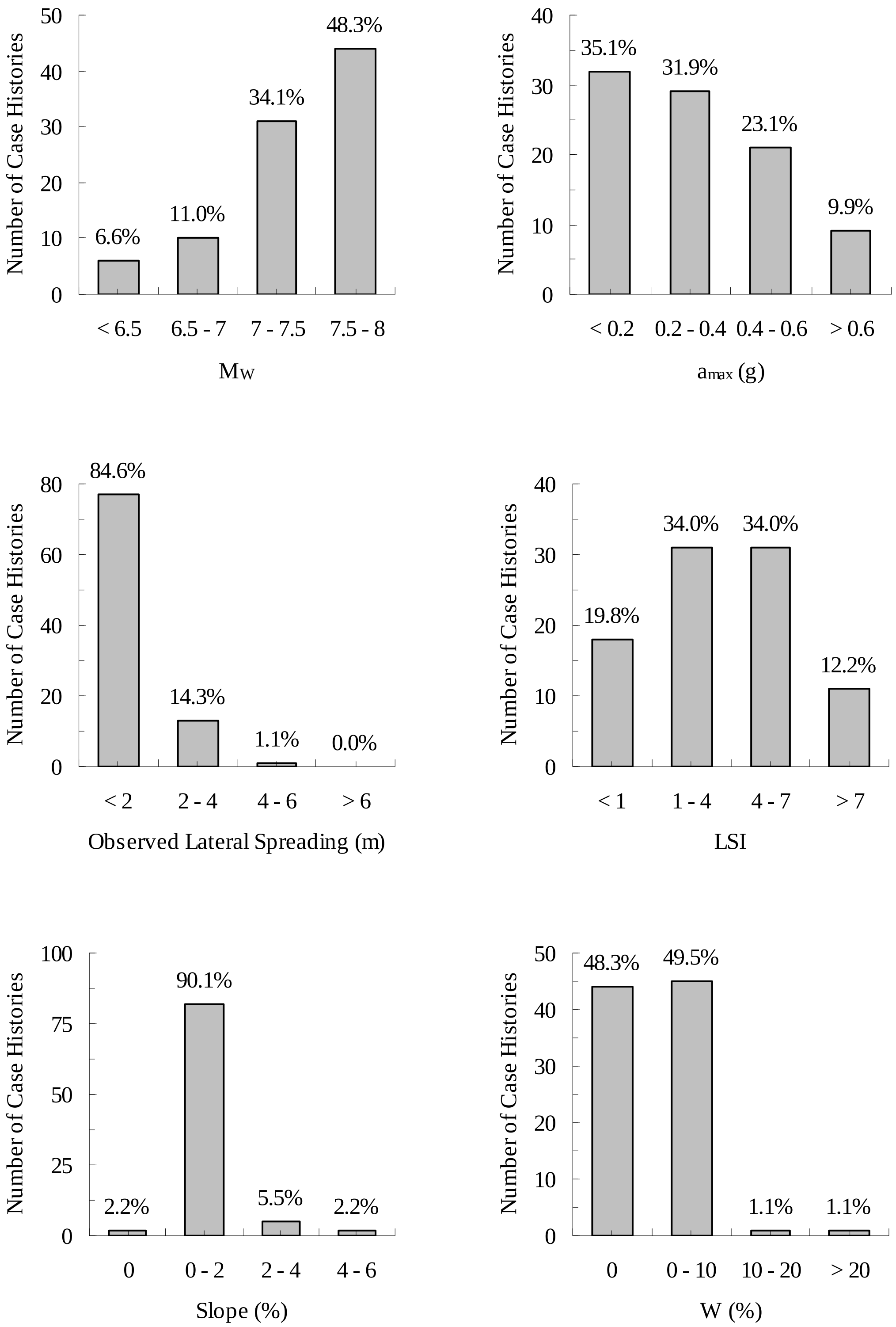


Figure 3.4: Distribution of descriptive variable characterestics for new case histories.

Table 3.3: Statistics of the descriptive variables of new case histories.

No. of Cases	91		
Variables	Min.	Med.	Max.
LSI	0	3.8	7.9
M_W	6.5	7.5	7.9
a_{max} (g)	0.12	0.40	0.79
S (%)	0	1.00	5.24
W (%)	0	0.78	50.0
z_{cr} (m)	0.77	4.40	21.20
a_y/a_{max}	0.06	0.26	6.74
$\tan\beta/\tan\phi'_{eqv,liq}$	0	0.1	0.59

3.5 Overall Case Histories Database

The overall case history database for this study is formed by merging the two data sets, the old and new case history databases, as discussed in the previous sections. The distributions for the main characteristics of these case histories are shown in Figure 3.5, and the statistics of the some descriptive variables of these case histories are listed in Table 3.4. The majority of the sites included in the overall database are shaken by earthquakes having moment magnitudes in the range of 6.5 to 7.5, and with maximumu ground accelerations less than 0.2 g. In addition, the topographic features for the majority of the sites included ground surface slopes less than 3%, with free-face ratios less than 10%. Also, the measured lateral spreads for most of the case histories are below 5m, while the *LSI* values for the overall case histories are distributed within the range from 1 to 7. In addition, and as Table 3.5 illustrates, the resultant overall database is composed of high quality data of 526 liquefaction-induced lateral ground spreading case histories compiled from eighteen different earthquakes, noting that for many cases the observed displacement vector is linked to more than one borehole, denoted in the table by *B.H.i*, and the corresponding distance from each borehole to that vector in denoted by *Di*, where $i \in [1,4]$. For few case histories, the case number is in darkened to indicate cases with uncertainty in the estimated lateral ground deformations due to the major presence of clayey sub-layers within their soil profiles, as discussed in details in Chapter 4. The full detailed case histories database is listed in Appendix A.

Table 3.4: Statistics of the descriptive variables of overall case histories.

No. of Cases	526		
Variables	Min.	Med.	Max.
LSI	0	5.1	8.8
M_W	6.4	7.5	9.2
a_{max} (g)	0.12	0.19	0.79
S (%)	0	0.45	11.0
W (%)	0	0	56.8
z_{cr} (m)	0.6	4.13	21.20
a_y/a_{max}	0	0.36	6.74
$\tan\beta/\tan\phi'_{eqv,liq}$	0	0.05	1.39

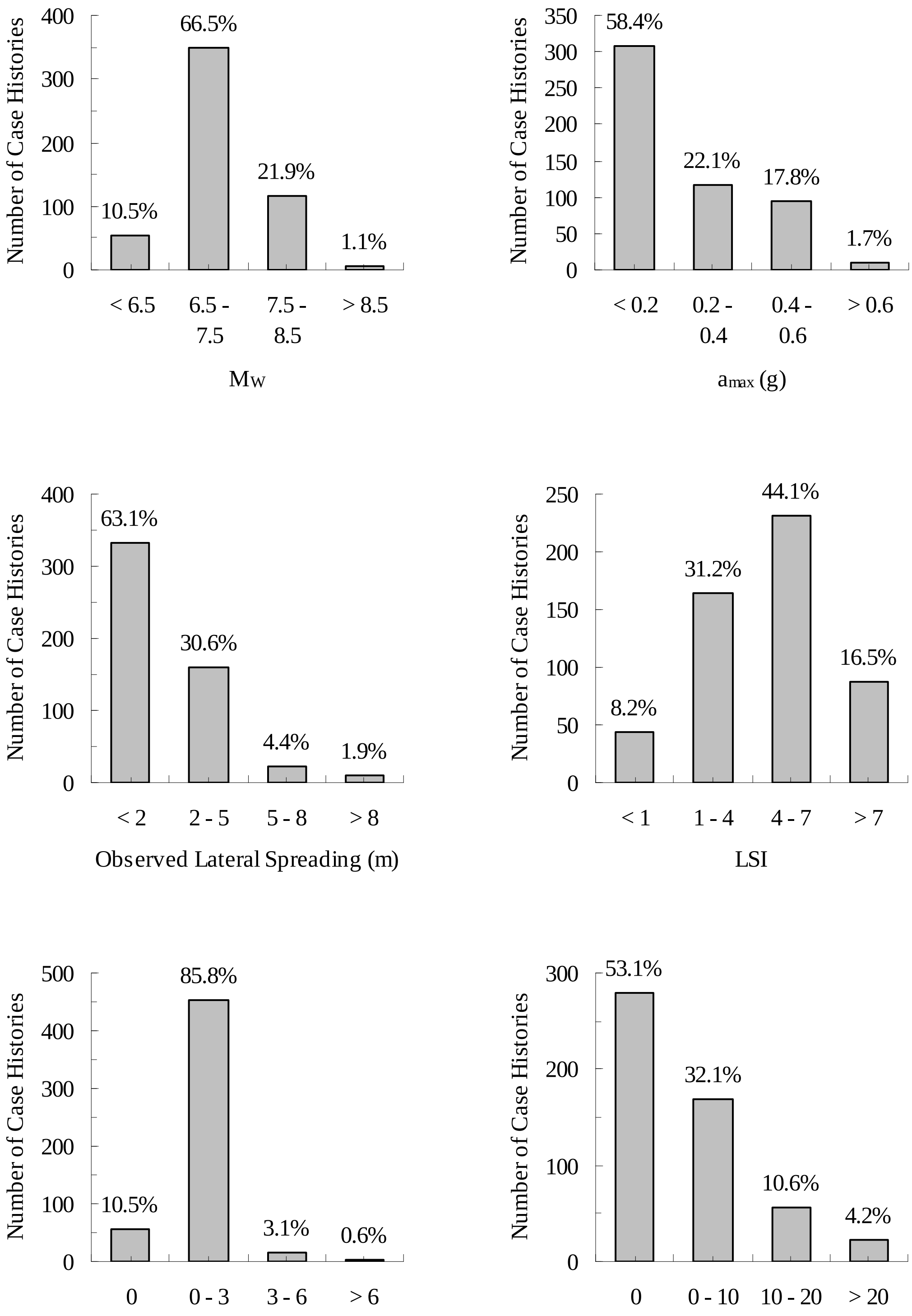


Figure 3.5: Distribution of descriptive variable characterestics for all case histories.

Table 3.5: Summary of Overall Case Histories Database and their Descriptive Variables

Case	Earthquake	Mw	Site Name	Site Location	(B.H. - D(m))1	(B.H. - D(m))2	(B.H. - D(m))3	(B.H. - D(m))4
1	1906 San Francisco - USA	7.9	Mission Creek	15th-20th St., San Francisco	1 - 0.3	-	-	-
2			South of Market	3rd-6th St., San Francisco	2 - 0.3	-	-	-
3			Salinas River	Salinas River Bridge	4 - 45.7	-	-	-
4	1964 Niigata - Japan	7.5	Niigata, Japan	F-10, J-J'	205 - 209.5	210 - 44.5	-	-
5			Niigata, Japan	F-10, J-J'	205 - 222.3	210 - 101.6	-	-
6			Niigata, Japan	F-10, J-J'	205 - 190.5	210 - 241.3	-	-
7			Niigata, Japan	F-10, J-J'	205 - 139.7	206 - 139.7	207 - 139.7	208 - 139.7
8			Niigata, Japan	F-10, J-J'	205 - 82.6	206 - 82.6	207 - 82.6	208 - 82.6
9			Niigata, Japan	F-10, J-J'	205 - 158.8	206 - 158.8	207 - 158.8	208 - 158.8
10			Niigata, Japan	F-10, J-J'	205 - 184.1	206 - 184.1	207 - 184.1	208 - 184.1
11			Niigata, Japan	F-10, J-J'	205 - 133.4	206 - 133.4	207 - 133.4	208 - 133.4
12			Niigata, Japan	F-10, J-J'	205 - 133.4	206 - 133.4	207 - 133.4	208 - 133.4
13			Niigata, Japan	F-10, J-J'	205 - 67.3	206 - 67.3	207 - 67.3	208 - 67.3
14			Niigata, Japan	F-10, J-J'	205 - 120.6	206 - 120.6	207 - 120.6	208 - 120.6
15			Niigata, Japan	F-10, J-J'	205 - 20.3	206 - 20.3	207 - 20.3	208 - 20.3
16			Niigata, Japan	F-10, J-J'	205 - 34.3	206 - 34.3	207 - 34.3	208 - 34.3
17			Niigata, Japan	F-10, J-J'	205 - 190.5	206 - 190.5	207 - 190.5	208 - 190.5
18			Niigata, Japan	F-10, J-J'	205 - 63.5	206 - 63.5	207 - 63.5	208 - 63.5
19			Niigata, Japan	F-10, J-J'	205 - 154.9	206 - 154.9	207 - 154.9	208 - 154.9
20			Niigata, Japan	F-10, J-J'	205 - 196.9	206 - 196.9	207 - 196.9	208 - 196.9
21			Niigata, Japan	F-10, J-J'	205 - 209.5	206 - 209.5	207 - 209.5	208 - 209.5
22			Niigata, Japan	F-10, J-J'	205 - 69.8	206 - 69.8	207 - 69.8	208 - 69.8
23			Niigata, Japan	F-10, J-J'	205 - 105.4	206 - 105.4	207 - 105.4	208 - 105.4
24			Niigata, Japan	F-10, J-J'	205 - 22.9	206 - 22.9	207 - 22.9	208 - 22.9
25			Niigata, Japan	F-10, J-J'	205 - 95.2	206 - 95.2	207 - 95.2	208 - 95.2
26			Niigata, Japan	F-10, J-J'	205 - 80.0	206 - 80.0	207 - 80.0	208 - 80.0
27			Niigata, Japan	F-10, K-K'	211 - 241.3	212 - 101.6	213 - 120.6	214 - 69.8
28			Niigata, Japan	F-10, K-K'	211 - 209.5	212 - 139.7	213 - 139.7	214 - 88.9
29			Niigata, Japan	F-10, K-K'	211 - 222.3	212 - 215.9	213 - 152.4	214 - 190.5
30			Niigata, Japan	F-10, K-K'	211 - 152.4	212 - 190.5	213 - 165.1	214 - 127.0
31			Niigata, Japan	F-10, K-K'	211 - 152.4	212 - 190.5	213 - 158.8	214 - 120.6
32			Niigata, Japan	F-10, K-K'	211 - 177.8	212 - 260.3	213 - 184.1	214 - 222.3
33			Niigata, Japan	F-10, K-K'	211 - 165.1	212 - 133.4	213 - 82.6	214 - 69.8
34			Niigata, Japan	F-10, K-K'	211 - 139.7	212 - 215.9	213 - 146.0	214 - 165.1
35			Niigata, Japan	F-10, K-K'	211 - 171.5	212 - 317.4	213 - 241.3	214 - 273.0
36			Niigata, Japan	F-10, K-K'	211 - 177.8	212 - 133.4	213 - 63.5	214 - 82.6
37			Niigata, Japan	F-10, K-K'	211 - 114.3	212 - 190.5	213 - 120.6	214 - 133.4
38			Niigata, Japan	F-10, K-K'	211 - 158.8	212 - 361.9	213 - 292.1	214 - 311.3
39			Niigata, Japan	F-10, K-K'	211 - 101.6	212 - 254.0	213 - 184.1	214 - 196.9
40			Niigata, Japan	F-10, K-K'	211 - 88.9	212 - 222.3	213 - 152.4	214 - 165.1
41			Niigata, Japan	F-10, K-K'	211 - 108.0	212 - 336.6	213 - 266.7	214 - 279.4
42			Niigata, Japan	F-10, K-K'	211 - 57.2	212 - 241.3	213 - 184.1	214 - 177.8
43			Niigata, Japan	F-10, K-K'	211 - 60.9	212 - 279.4	213 - 215.9	214 - 222.3
44			Niigata, Japan	F-10, K-K'	211 - 50.8	212 - 304.8	213 - 234.9	214 - 241.3
45			Niigata, Japan	F-10, K-K'	211 - 12.7	212 - 292.1	213 - 222.3	214 - 215.9
46			Niigata, Japan	F-10, K-K'	212 - 57.2	215 - 177.8	216 - 196.9	-
47			Niigata, Japan	F-10, K-K'	212 - 44.5	215 - 108.0	216 - 158.8	-
48			Niigata, Japan	F-10, K-K'	212 - 114.3	215 - 247.7	216 - 254.0	-
49			Niigata, Japan	F-10, K-K'	212 - 139.7	215 - 209.5	216 - 177.8	-
50			Niigata, Japan	F-10, K-K'	212 - 101.6	215 - 152.4	216 - 139.7	-
51			Niigata, Japan	F-10, K-K'	212 - 108.0	215 - 69.8	216 - 152.4	-
52			Niigata, Japan	F-10, K-K'	212 - 184.1	213 - 139.7	214 - 190.5	-
53			Niigata, Japan	F-10, K-K'	212 - 146.0	213 - 95.2	214 - 146.0	215 - 165.1
54			Niigata, Japan	F-10, K-K'	212 - 101.6	213 - 25.4	214 - 63.5	-
55			Niigata, Japan	F-10, K-K'	212 - 82.6	213 - 12.7	214 - 63.5	-
56			Niigata, Japan	G-10, A-A'	199 - 81.3	-	-	-
57			Niigata, Japan	G-10, B-B'	135 - 63.5	136 - 135.8	-	-
58			Niigata, Japan	G-10, B-B'	136 - 118.1	146 - 91.4	-	-
59			Niigata, Japan	G-10, B-B'	137 - 12.7	-	-	-
60			Niigata, Japan	G-10, B-B'	138 - 39.3	139 - 39.3	140 - 39.3	141 - 39.3
61			Niigata, Japan	G-10, D-D'	160 - 114.3	155 - 105.4	-	-
62			Niigata, Japan	G-10, D-D'	160 - 146.0	155 - 168.9	-	-
63			Niigata, Japan	G-10, D-D'	160 - 72.4	155 - 116.8	-	-
64			Niigata, Japan	G-10, D-D'	160 - 34.3	155 - 133.3	-	-
65			Niigata, Japan	G-10, D-D'	160 - 17.8	155 - 120.6	-	-
66			Niigata, Japan	G-10, E-E'	161 - 45.7	-	-	-

Table 3.5: (Continued)

Case	Earthquake	Mw	Site Name	Site Location	(B.H. - D(m))1	(B.H. - D(m))2	(B.H. - D(m))3	(B.H. - D(m))4
67	1964 Niigata - Japan	7.5	Niigata, Japan	G-10, E-E'	161 - 35.5	-	-	-
68			Niigata, Japan	G-10, E-E'	161 - 17.8	-	-	-
69			Niigata, Japan	G-10, E-E'	162 - 57.2	164 - 36.8	-	-
70			Niigata, Japan	G-10, E-E'	162 - 22.9	-	-	-
71			Niigata, Japan	G-10, E-E'	163 - 6.3	-	-	-
72			Niigata, Japan	G-10, E-E'	163 - 34.3	167 - 29.2	-	-
73			Niigata, Japan	G-10, E-E'	163 - 26.7	166 - 27.9	-	-
74			Niigata, Japan	G-10, E-E'	163 - 85.1	166 - 50.8	-	-
75			Niigata, Japan	G-10, E-E'	164 - 31.7	-	-	-
76			Niigata, Japan	G-10, E-E'	164 - 116.8	165 - 105.0	-	-
77			Niigata, Japan	G-10, E-E'	164 - 104.1	165 - 88.6	-	-
78			Niigata, Japan	G-10, E-E'	164 - 101.6	165 - 57.0	-	-
79			Niigata, Japan	G-10, E-E'	165 - 73.0	-	-	-
80			Niigata, Japan	G-10, E-E'	166 - 29.2	168 - 41.9	-	-
81			Niigata, Japan	G-10, E-E'	166 - 5.1	-	-	-
82			Niigata, Japan	G-10, E-E'	167 - 2.5	-	-	-
83			Niigata, Japan	G-10, E-E'	168 - 6.3	-	-	-
84			Niigata, Japan	G-10, E-E'	168 - 160.0	170 - 142.2	-	-
85			Niigata, Japan	G-10, E-E'	169 - 176.5	170 - 177.8	-	-
86			Niigata, Japan	G-10, F-F'	36 - 58.4	175 - 63.5	176 - 58.4	-
87			Niigata, Japan	G-10, F-F'	36 - 31.7	175 - 31.7	176 - 25.4	-
88			Niigata, Japan	G-10, F-F'	36 - 10.1	186 - 33.0	-	-
89			Niigata, Japan	G-10, F-F'	166 - 374.7	164 - 323.8	-	-
90			Niigata, Japan	G-10, F-F'	166 - 393.7	164 - 342.9	-	-
91			Niigata, Japan	G-10, F-F'	166 - 393.7	164 - 349.2	-	-
92			Niigata, Japan	G-10, F-F'	166 - 476.3	163 - 419.1	-	-
93			Niigata, Japan	G-10, F-F'	166 - 450.9	163 - 400.1	-	-
94			Niigata, Japan	G-10, F-F'	166 - 520.7	163 - 463.5	-	-
95			Niigata, Japan	G-10, F-F'	166 - 469.9	163 - 419.1	-	-
96			Niigata, Japan	G-10, F-F'	166 - 425.5	163 - 381.0	-	-
97			Niigata, Japan	G-10, F-F'	166 - 431.8	163 - 387.3	-	-
98			Niigata, Japan	G-10, F-F'	166 - 463.5	163 - 419.1	-	-
99			Niigata, Japan	G-10, F-F'	166 - 469.9	163 - 425.5	-	-
100			Niigata, Japan	G-10, F-F'	166 - 476.3	163 - 431.8	-	-
101			Niigata, Japan	G-10, F-F'	172 - 66.0	171 - 63.5	-	-
102			Niigata, Japan	G-10, F-F'	172 - 38.1	171 - 48.3	-	-
103			Niigata, Japan	G-10, F-F'	172 - 44.5	171 - 76.2	-	-
104			Niigata, Japan	G-10, F-F'	176 - 31.7	174 - 38.1	37 - 43.2	-
105			Niigata, Japan	G-10, F-F'	176 - 31.7	-	-	-
106			Niigata, Japan	G-10, F-F'	176 - 35.5	174 - 40.6	-	-
107			Niigata, Japan	G-10, F-F'	177 - 34.3	174 - 50.8	173 - 72.0	-
108			Niigata, Japan	G-10, F-F'	177 - 19.1	174 - 25.4	173 - 51.0	-
109			Niigata, Japan	G-10, F-F'	177 - 41.9	174 - 19.1	173 - 63.0	-
110			Niigata, Japan	G-10, G-G'	180 - 44.4	178 - 152.4	-	-
111			Niigata, Japan	G-10, G-G'	180 - 50.8	178 - 105.4	-	-
112			Niigata, Japan	G-10, G-G'	180 - 62.2	178 - 123.2	-	-
113			Niigata, Japan	G-10, G-G'	180 - 82.5	178 - 111.7	-	-
114			Niigata, Japan	G-10, G-G'	180 - 83.8	178 - 67.3	-	-
115			Niigata, Japan	G-10, G-G'	182 - 92.7	179 - 114.3	-	-
116			Niigata, Japan	G-10, G-G'	182 - 87.6	179 - 76.2	-	-
117			Niigata, Japan	G-10, G-G'	182 - 177.8	179 - 129.0	-	-
118			Niigata, Japan	G-10, G-G'	182 - 177.8	179 - 114.3	-	-
119			Niigata, Japan	G-10, G-G'	182 - 133.3	179 - 81.3	-	-
120			Niigata, Japan	G-10, H-H'	171 - 31.7	183 - 114.3	184 - 130.8	-
121			Niigata, Japan	G-10, H-H'	171 - 40.6	183 - 104.1	184 - 120.6	-
122			Niigata, Japan	G-10, H-H'	171 - 43.2	183 - 110.5	184 - 101.6	-
123			Niigata, Japan	G-10, H-H'	171 - 63.5	183 - 96.5	184 - 92.7	-
124			Niigata, Japan	G-10, H-H'	171 - 64.7	183 - 82.5	184 - 118.1	-
125			Niigata, Japan	G-10, H-H'	171 - 73.6	183 - 133.3	184 - 66.0	-
126			Niigata, Japan	G-10, H-H'	171 - 67.3	183 - 80.0	184 - 110.5	-
127			Niigata, Japan	G-10, H-H'	171 - 73.6	183 - 105.4	184 - 71.1	-
128			Niigata, Japan	G-10, H-H'	171 - 71.1	183 - 72.4	184 - 121.9	-
129			Niigata, Japan	G-10, H-H'	171 - 80.0	183 - 69.8	184 - 139.7	-
130			Niigata, Japan	G-10, H-H'	171 - 77.4	183 - 68.5	184 - 114.3	-
131			Niigata, Japan	G-10, H-H'	171 - 85.1	183 - 68.5	184 - 147.3	-
132			Niigata, Japan	G-10, H-H'	171 - 95.2	183 - 152.4	184 - 50.8	-

Table 3.5: (Continued)

Case	Earthquake	Mw	Site Name	Site Location	(B.H. - D(m))1	(B.H. - D(m))2	(B.H. - D(m))3	(B.H. - D(m))4
133	1964 Niigata - Japan	7.5	Niigata, Japan	G-10, H-H'	171 - 82.5	183 - 63.5	184 - 127.0	-
134			Niigata, Japan	G-10, H-H'	171 - 95.2	183 - 88.9	184 - 66.0	-
135			Niigata, Japan	G-10, H-H'	171 - 78.7	183 - 54.6	184 - 107.9	-
136			Niigata, Japan	G-10, H-H'	171 - 95.2	183 - 102.8	184 - 54.6	-
137			Niigata, Japan	G-10, H-H'	171 - 85.1	183 - 58.4	184 - 119.4	-
138			Niigata, Japan	G-10, H-H'	171 - 101.6	183 - 107.9	184 - 47.0	-
139			Niigata, Japan	G-10, H-H'	171 - 113.0	183 - 85.1	184 - 60.9	-
140			Niigata, Japan	G-10, H-H'	171 - 106.6	183 - 64.7	184 - 82.5	-
141			Niigata, Japan	G-10, H-H'	171 - 114.3	183 - 154.9	184 - 33.0	-
142			Niigata, Japan	G-10, H-H'	171 - 135.8	183 - 173.9	184 - 38.1	-
143			Niigata, Japan	G-10, H-H'	171 - 154.9	183 - 186.6	184 - 44.4	-
144			Niigata, Japan	G-10, H-H'	171 - 162.5	183 - 173.9	184 - 33.0	-
145			Niigata, Japan	G-10, H-H'	171 - 129.5	183 - 123.2	184 - 21.6	-
146			Niigata, Japan	G-10, H-H'	171 - 167.6	183 - 154.9	184 - 27.9	-
147			Niigata, Japan	G-10, H-H'	171 - 125.7	183 - 147.3	184 - 15.2	-
148			Niigata, Japan	G-10, H-H'	171 - 152.4	183 - 154.9	184 - 11.4	-
149			Niigata, Japan	G-10, I-I'	185 - 20.3	-	-	-
150			Niigata, Japan	G-10, I-I'	185 - 43.2	-	-	-
151			Niigata, Japan	G-10, I-I'	185 - 50.8	-	-	-
152			Niigata, Japan	G-10, I-I'	185 - 64.7	-	-	-
153			Niigata, Japan	G-10, I-I'	185 - 107.9	-	-	-
154			Niigata, Japan	G-10, I-I'	185 - 87.6	-	-	-
155			Niigata, Japan	G-10, I-I'	185 - 60.9	-	-	-
156			Niigata, Japan	G-10, I-I'	185 - 52.1	-	-	-
157			Niigata, Japan	G-10, I-I'	185 - 95.2	-	-	-
158			Niigata, Japan	G-10, I-I'	185 - 101.6	-	-	-
159			Niigata, Japan	G-10, I-I'	185 - 148.6	-	-	-
160			Niigata, Japan	G-10, I-I'	185 - 99.0	186 - 81.3	-	-
161			Niigata, Japan	G-10, I-I'	185 - 82.5	186 - 50.8	-	-
162			Niigata, Japan	G-10, I-I'	186 - 101.6	188 - 50.8	-	-
163			Niigata, Japan	G-10, I-I'	188 - 14.0	-	-	-
164			Niigata, Japan	G-10, L-L'	34 - 69.8	33 - 69.8	-	-
165			Niigata, Japan	G-10, L-L'	34 - 139.7	33 - 101.6	-	-
166			Niigata, Japan	G-10, L-L'	34 - 95.2	33 - 82.6	219 - 152.4	-
167			Niigata, Japan	G-10, L-L'	34 - 95.2	33 - 57.2	-	-
168			Niigata, Japan	G-10, L-L'	34 - 95.2	33 - 57.2	-	-
169			Niigata, Japan	G-10, L-L'	34 - 69.8	33 - 31.7	-	-
170			Niigata, Japan	G-10, L-L'	221 - 31.7	219 - 241.3	-	-
171			Niigata, Japan	G-10, L-L'	221 - 25.4	219 - 184.1	-	-
172			Niigata, Japan	G-10, L-L'	221 - 31.7	219 - 215.9	-	-
173			Niigata, Japan	G-10, L-L'	221 - 50.8	219 - 190.5	-	-
174			Niigata, Japan	G-10, L-L'	221 - 69.8	219 - 260.3	-	-
175			Niigata, Japan	G-10, L-L'	221 - 66.0	219 - 241.3	-	-
176			Niigata, Japan	G-10, L-L'	221 - 63.5	219 - 209.5	-	-
177			Niigata, Japan	G-10, L-L'	221 - 69.8	219 - 152.4	-	-
178			Niigata, Japan	G-10, L-L'	221 - 76.2	219 - 165.1	-	-
179			Niigata, Japan	G-10, L-L'	221 - 88.9	219 - 152.4	-	-
180			Niigata, Japan	G-10, L-L'	221 - 95.2	219 - 120.6	-	-
181			Niigata, Japan	G-10, L-L'	221 - 108.0	219 - 127.0	-	-
182			Niigata, Japan	G-10, L-L'	221 - 133.4	219 - 120.6	-	-
183			Niigata, Japan	G-10, L-L'	221 - 114.3	219 - 101.6	-	-
184			Niigata, Japan	G-10, L-L'	221 - 101.6	219 - 120.6	35 - 88.9	-
185			Niigata, Japan	G-10, L-L'	221 - 120.6	219 - 108.0	35 - 95.2	-
186			Niigata, Japan	G-10, L-L'	221 - 152.4	219 - 63.5	35 - 158.8	-
187			Niigata, Japan	G-10, L-L'	221 - 165.1	219 - 44.5	35 - 165.1	-
188			Niigata, Japan	H-10, A-A'	48 - 90.2	-	-	-
189			Niigata, Japan	H-10, A-A'	126 - 57.2	49 - 94.9	-	-
190			Niigata, Japan	H-10, A-A'	126 - 35.5	49 - 88.9	-	-
191			Niigata, Japan	H-10, A-A'	126 - 110.5	48 - 111.7	-	-
192			Niigata, Japan	H-10, A-A'	126 - 128.2	48 - 114.3	-	-
193			Niigata, Japan	H-10, A-A'	128 - 88.9	129 - 88.9	130 - 88.9	131 - 88.9
194			Niigata, Japan	H-10, A-A'	133 - 151.1	48 - 67.3	-	-
195			Niigata, Japan	H-10, A-A'	133 - 139.7	48 - 76.2	-	-
196			Niigata, Japan	H-10, A-A'	133 - 120.6	48 - 127.0	-	-
197			Niigata, Japan	H-10, A-A'	133 - 86.3	48 - 110.5	-	-
198			Niigata, Japan	H-10, A-A'	133 - 97.8	48 - 135.8	-	-

Table 3.5: (Continued)

Case	Earthquake	Mw	Site Name	Site Location	(B.H. - D(m))1	(B.H. - D(m))2	(B.H. - D(m))3	(B.H. - D(m))4
199	1964 Niigata - Japan	7.5	Niigata, Japan	H-10, A-A'	199 - 149.8	-	-	-
200			Niigata, Japan	H-10, A-A'	199 - 121.9	-	-	-
201			Niigata, Japan	H-10, A-A'	199 - 96.5	-	-	-
202			Niigata, Japan	H-10, M-M'	42 - 114.3	43 - 38.1	-	-
203			Niigata, Japan	H-10, M-M'	42 - 57.2	43 - 88.9	-	-
204			Niigata, Japan	H-10, M-M'	42 - 69.8	43 - 127.0	-	-
205			Niigata, Japan	H-10, M-M'	42 - 38.1	43 - 127.0	-	-
206			Niigata, Japan	H-10, M-M'	42 - 29.2	43 - 101.6	-	-
207			Niigata, Japan	H-10, M-M'	194 - 120.6	197 - 38.1	-	-
208			Niigata, Japan	H-10, M-M'	194 - 127.0	197 - 76.2	-	-
209			Niigata, Japan	H-10, M-M'	194 - 108.0	197 - 69.8	-	-
210			Niigata, Japan	H-10, M-M'	194 - 146.0	197 - 108.0	-	-
211			Niigata, Japan	H-10, M-M'	194 - 95.2	197 - 82.6	-	-
212			Niigata, Japan	H-10, M-M'	194 - 127.0	197 - 114.3	-	-
213			Niigata, Japan	H-10, M-M'	194 - 76.2	197 - 69.8	-	-
214			Niigata, Japan	H-10, M-M'	194 - 69.8	197 - 76.2	-	-
215			Niigata, Japan	H-10, M-M'	194 - 133.4	197 - 146.0	-	-
216			Niigata, Japan	H-10, M-M'	194 - 88.9	197 - 101.6	-	-
217			Niigata, Japan	H-10, M-M'	194 - 82.6	197 - 120.6	-	-
218			Niigata, Japan	H-10, M-M'	194 - 57.2	197 - 88.9	-	-
219			Niigata, Japan	H-10, M-M'	194 - 50.8	197 - 101.6	-	-
220			Niigata, Japan	H-10, M-M'	194 - 63.5	197 - 133.4	-	-
221			Niigata, Japan	H-10, M-M'	194 - 50.8	197 - 120.6	-	-
222			Niigata, Japan	H-10, M-M'	194 - 38.1	197 - 120.6	-	-
223			Niigata, Japan	H-10, M-M'	194 - 69.8	197 - 152.4	195 - 133.4	-
224			Niigata, Japan	H-10, M-M'	194 - 19.1	197 - 120.6	-	-
225			Niigata, Japan	H-10, M-M'	194 - 88.9	195 - 38.1	-	-
226			Niigata, Japan	H-10, M-M'	194 - 82.6	195 - 44.5	-	-
227			Niigata, Japan	H-10, M-M'	194 - 57.2	195 - 38.1	-	-
228			Niigata, Japan	H-10, M-M'	194 - 127.0	195 - 101.6	-	-
229			Niigata, Japan	H-10, M-M'	194 - 57.2	195 - 50.8	-	-
230			Niigata, Japan	H-10, M-M'	194 - 57.2	195 - 50.8	-	-
231			Niigata, Japan	H-10, M-M'	194 - 95.2	195 - 101.6	-	-
232			Niigata, Japan	H-10, M-M'	194 - 44.5	195 - 63.5	-	-
233			Niigata, Japan	H-10, M-M'	194 - 19.1	195 - 63.5	-	-
234			Niigata, Japan	H-10, M-M'	197 - 38.1	42 - 158.8	43 - 215.9	-
235			Niigata, Japan	H-10, M-M'	197 - 31.7	42 - 165.1	43 - 222.3	-
236			Niigata, Japan	H-10, M-M'	197 - 25.4	42 - 184.1	43 - 241.3	-
237			Niigata, Japan	H-10, M-M'	197 - 57.2	42 - 158.8	-	-
238			Niigata, Japan	H-10, M-M'	197 - 69.8	42 - 152.4	-	-
239			Niigata, Japan	H-10, M-M'	197 - 82.6	42 - 177.8	-	-
240			Niigata, Japan	H-10, M-M'	197 - 76.2	42 - 133.4	-	-
241			Niigata, Japan	H-10, M-M'	197 - 76.2	42 - 120.6	-	-
242			Niigata, Japan	H-10, M-M'	197 - 114.3	42 - 165.1	-	-
243			Niigata, Japan	H-10, M-M'	197 - 101.6	42 - 146.0	-	-
244			Niigata, Japan	H-10, M-M'	197 - 133.4	42 - 177.8	-	-
245			Niigata, Japan	H-10, M-M'	197 - 88.9	42 - 101.6	-	-
246			Niigata, Japan	H-10, M-M'	197 - 88.9	42 - 203.2	194 - 177.8	-
247			Niigata, Japan	H-10, M-M'	197 - 120.6	42 - 114.3	-	-
248			Niigata, Japan	H-10, M-M'	197 - 152.4	42 - 133.4	-	-
249			Niigata, Japan	H-10, M-M'	197 - 101.6	42 - 88.9	-	-
250			Niigata, Japan	H-10, M-M'	197 - 114.3	42 - 215.9	194 - 190.5	-
251			Niigata, Japan	H-10, M-M'	197 - 120.6	42 - 222.3	194 - 190.5	-
252			Niigata, Japan	H-10, N-N'	43 - 38.1	226 - 120.6	-	-
253			Niigata, Japan	H-10, N-N'	43 - 63.5	226 - 69.8	-	-
254			Niigata, Japan	H-10, N-N'	198 - 165.1	228 - 114.3	-	-
255			Niigata, Japan	H-10, N-N'	198 - 139.7	228 - 139.7	-	-
256			Niigata, Japan	H-10, N-N'	198 - 108.0	228 - 127.0	-	-
257			Niigata, Japan	H-10, N-N'	198 - 108.0	228 - 139.7	-	-
258			Niigata, Japan	H-10, N-N'	198 - 114.3	228 - 165.1	-	-
259			Niigata, Japan	H-10, N-N'	198 - 95.2	228 - 139.7	-	-
260			Niigata, Japan	H-10, N-N'	198 - 105.4	228 - 215.9	-	-
261			Niigata, Japan	H-10, N-N'	198 - 59.7	228 - 165.1	-	-
262			Niigata, Japan	H-10, N-N'	198 - 63.5	228 - 196.9	-	-
263			Niigata, Japan	H-10, N-N'	198 - 50.8	228 - 165.1	-	-
264			Niigata, Japan	H-10, N-N'	198 - 44.5	228 - 196.9	-	-

Table 3.5: (Continued)

Case	Earthquake	Mw	Site Name	Site Location	(B.H. - D(m))1	(B.H. - D(m))2	(B.H. - D(m))3	(B.H. - D(m))4
265	1964 Niigata - Japan	7.5	Niigata, Japan	H-10, N-N'	198 - 38.1	228 - 190.5	-	-
266			Niigata, Japan	H-10, N-N'	225 - 12.7	227 - 76.2	-	-
267			Niigata, Japan	H-10, N-N'	225 - 25.4	227 - 82.6	-	-
268			Niigata, Japan	H-10, N-N'	225 - 19.1	227 - 50.8	-	-
269			Niigata, Japan	H-10, N-N'	225 - 25.4	227 - 44.5	-	-
270			Niigata, Japan	H-10, N-N'	225 - 31.7	227 - 38.1	-	-
271			Niigata, Japan	H-10, N-N'	225 - 50.8	227 - 38.1	-	-
272			Niigata, Japan	H-10, N-N'	225 - 50.8	227 - 19.1	-	-
273			Niigata, Japan	H-10, N-N'	226 - 82.6	225 - 38.1	227 - 50.8	232 - 57.2
274			Niigata, Japan	H-10, N-N'	226 - 38.1	225 - 57.2	227 - 101.6	232 - 67.3
275			Niigata, Japan	H-10, N-N'	226 - 63.5	225 - 38.1	227 - 88.9	232 - 76.2
276			Niigata, Japan	H-10, N-N'	226 - 69.8	225 - 31.7	227 - 76.2	232 - 76.2
277			Niigata, Japan	H-10, N-N'	226 - 69.8	225 - 25.4	227 - 88.9	232 - 82.6
278			Niigata, Japan	H-10, N-N'	226 - 38.1	-	-	-
279	1964 Alaska	9.2	MP 148.3	Matanuska River	15 - 670.7	-	-	-
280			MP 147.4	Matanuska River	17 - 289.6	-	-	-
281			MP 147.5	Matanuska River	18 - 304.9	-	-	-
282			MP 63.0	Portage Creek # 1	25 - 21.3	-	-	-
283			MP 63.5	Portage Creek # 2	27 - 15.2	28 - 30.5	5 - 85.4	-
284			MP 64.7	Twenty Mile River	24 - 54.9	20 - 97.6	23 - 219.5	-
285	1971 San Fernando - USA	6.4	Juvenile Hall	SAN FERNANDO VALLEY, CA.	54 - 0.3	-	-	-
286			Juvenile Hall	SAN FERNANDO VALLEY, CA.	55 - 0.3	-	-	-
287			Juvenile Hall	SAN FERNANDO VALLEY, CA.	56 - 0.3	-	-	-
288			Juvenile Hall	SAN FERNANDO VALLEY, CA.	57 - 0.3	-	-	-
289			Juvenile Hall	SAN FERNANDO VALLEY, CA.	58 - 0.3	-	-	-
290			Jensen Plant	SAN FERNANDO VALLEY, CA.	244 - 124.4	245 - 162.2	248 - 67.7	249 - 91.5
291			Jensen Plant	SAN FERNANDO VALLEY, CA.	246 - 163.7	247 - 160.4	250 - 63.4	251 - 49.4
292			Jensen Plant	SAN FERNANDO VALLEY, CA.	246 - 119.8	247 - 117.4	250 - 98.2	251 - 94.2
293			Jensen Plant	SAN FERNANDO VALLEY, CA.	246 - 78.0	247 - 74.7	250 - 139.9	251 - 136.9
294			Jensen Plant	SAN FERNANDO VALLEY, CA.	246 - 38.4	247 - 33.5	250 - 183.2	251 - 181.7
295			Jensen Plant	SAN FERNANDO VALLEY, CA.	246 - 29.9	247 - 22.0	-	-
296			Jensen Plant	SAN FERNANDO VALLEY, CA.	248 - 206.4	249 - 213.1	252 - 75.9	253 - 81.7
297			Jensen Plant	SAN FERNANDO VALLEY, CA.	248 - 139.6	249 - 150.0	252 - 127.4	253 - 112.8
298			Jensen Plant	SAN FERNANDO VALLEY, CA.	248 - 62.5	249 - 84.5	252 - 200.3	253 - 177.1
299			Jensen Plant	SAN FERNANDO VALLEY, CA.	248 - 19.5	249 - 61.6	252 - 253.4	253 - 227.7
300			Jensen Plant	SAN FERNANDO VALLEY, CA.	250 - 55.5	251 - 46.0	254 - 181.4	255 - 178.7
301			Jensen Plant	SAN FERNANDO VALLEY, CA.	250 - 97.0	251 - 92.7	254 - 134.1	255 - 133.5
302			Jensen Plant	SAN FERNANDO VALLEY, CA.	250 - 137.8	251 - 135.7	254 - 93.0	255 - 90.5
303			Jensen Plant	SAN FERNANDO VALLEY, CA.	250 - 182.3	251 - 180.5	254 - 53.0	255 - 45.7
304			Jensen Plant	SAN FERNANDO VALLEY, CA.	252 - 60.1	253 - 104.6	256 - 164.0	257 - 203.0
305			Jensen Plant	SAN FERNANDO VALLEY, CA.	254 - 223.8	255 - 226.8	258 - 34.1	259 - 14.9
306			Jensen Plant	SAN FERNANDO VALLEY, CA.	254 - 181.1	255 - 180.5	258 - 96.3	259 - 37.2
307			Jensen Plant	SAN FERNANDO VALLEY, CA.	254 - 144.5	255 - 141.2	258 - 135.4	259 - 76.8
308			Jensen Plant	SAN FERNANDO VALLEY, CA.	254 - 103.0	255 - 96.6	258 - 176.5	259 - 122.3
309			Jensen Plant	SAN FERNANDO VALLEY, CA.	254 - 61.0	255 - 46.3	258 - 224.1	259 - 170.7
310			Jensen Plant	SAN FERNANDO VALLEY, CA.	254 - 32.6	255 - 16.8	258 - 264.3	259 - 214.3
311	1976 Guatemala	7.5	La Playa Area	Amatitlan Lake	2 - 0.0	-	-	-
312			La Playa Area	Amatitlan Lake	3 - 0.0	-	-	-
313			La Playa Area	Amatitlan Lake	4 - 0.0	-	-	-
314	1977 Argentina	7.4	San Juan Area	Tulum Valley	1 - 0.0	-	-	-
315			San Juan Area	Tulum Valley	2 - 0.0	-	-	-
316			San Juan Area	Tulum Valley	3 - 0.0	-	-	-
317			San Juan Area	Tulum Valley	6 - 0.0	-	-	-
318	1979 Imperial Valley - USA	6.5	Heber Road	IMPERIAL VALLEY, CA.	61 - 57.9	64 - 52.4	65 - 30.2	66 - 30.2
319			Heber Road	IMPERIAL VALLEY, CA.	61 - 64.0	64 - 58.8	65 - 23.2	66 - 23.2
320			Heber Road	IMPERIAL VALLEY, CA.	61 - 72.3	64 - 66.8	65 - 17.4	66 - 17.4
321			Heber Road	IMPERIAL VALLEY, CA.	61 - 79.6	64 - 76.2	65 - 8.5	66 - 8.5
322			Heber Road	IMPERIAL VALLEY, CA.	61 - 85.7	64 - 80.5	65 - 8.8	66 - 8.8
323			Heber Road	IMPERIAL VALLEY, CA.	65 - 41.5	66 - 41.5	-	-
324			Heber Road	IMPERIAL VALLEY, CA.	65 - 36.0	66 - 36.0	-	-
325			Heber Road	IMPERIAL VALLEY, CA.	65 - 6.7	66 - 6.7	69 - 42.7	68 - 54.0
326			Heber Road	IMPERIAL VALLEY, CA.	65 - 13.4	66 - 13.4	69 - 37.5	68 - 50.3
327			Heber Road	IMPERIAL VALLEY, CA.	65 - 14.6	66 - 14.6	69 - 33.5	68 - 44.8
328			Heber Road	IMPERIAL VALLEY, CA.	65 - 22.3	66 - 22.3	69 - 28.4	68 - 39.3
329			Heber Road	IMPERIAL VALLEY, CA.	65 - 28.4	66 - 28.4	69 - 19.5	68 - 30.5
330			Heber Road	IMPERIAL VALLEY, CA.	65 - 33.2	66 - 33.2	69 - 18.0	68 - 29.0

Table 3.5: (Continued)

Case	Earthquake	Mw	Site Name	Site Location	(B.H. - D(m))1	(B.H. - D(m))2	(B.H. - D(m))3	(B.H. - D(m))4
331	1979 Imperial Valley - USA	6.5	Heber Road	IMPERIAL VALLEY, CA.	65 - 43.6	66 - 43.6	69 - 10.7	68 - 19.5
332			Heber Road	IMPERIAL VALLEY, CA.	65 - 39.3	66 - 39.3	69 - 9.1	68 - 19.8
333			Heber Road	IMPERIAL VALLEY, CA.	65 - 52.1	66 - 52.1	69 - 10.4	68 - 13.4
334			Heber Road	IMPERIAL VALLEY, CA.	65 - 46.0	66 - 46.0	69 - 4.0	68 - 13.4
335			Heber Road	IMPERIAL VALLEY, CA.	65 - 57.6	66 - 57.6	69 - 4.0	68 - 5.5
336			Heber Road	IMPERIAL VALLEY, CA.	69 - 35.1	68 - 24.7	70 - 10.4	71 - 10.4
337			Heber Road	IMPERIAL VALLEY, CA.	69 - 29.6	68 - 18.6	70 - 20.7	71 - 20.7
338			Heber Road	IMPERIAL VALLEY, CA.	69 - 25.9	68 - 16.8	70 - 18.6	71 - 18.6
339			Heber Road	IMPERIAL VALLEY, CA.	69 - 20.7	68 - 10.7	70 - 20.4	71 - 20.4
340			Heber Road	IMPERIAL VALLEY, CA.	69 - 18.9	68 - 12.2	70 - 26.2	71 - 26.2
341			River Park	IMPERIAL VALLEY, CA.	260 - 0.3	-	-	-
342			River Park	IMPERIAL VALLEY, CA.	261 - 0.3	-	-	-
343			River Park	IMPERIAL VALLEY, CA.	263 - 0.3	-	-	-
344			River Park	IMPERIAL VALLEY, CA.	264 - 0.3	-	-	-
345	1983 Borah Peak - USA	6.9	Whiskey Springs	Big Lost River Valley	74 - 0.0	-	-	-
346			Whiskey Springs	Big Lost River Valley	75 - 0.0	-	-	-
347			Whiskey Springs	Big Lost River Valley	76 - 0.0	-	-	-
348			Pence Ranch	Thousand Springs Valley	73 - 0.0	-	-	-
349	1983 Nihonkai-Chubu - Japan	7.7	Noshiro, Japan	N-1, 1	77 - 19.5	-	-	-
350			Noshiro, Japan	N-1, 1	77 - 1.5	-	-	-
351			Noshiro, Japan	N-1, 1	77 - 23.5	-	-	-
352			Noshiro, Japan	N-2, 2	78 - 64.9	79 - 18.0	-	-
353			Noshiro, Japan	N-2, 2	79 - 32.6	80 - 202.1	-	-
354			Noshiro, Japan	N-2, 2	79 - 117.4	80 - 117.4	-	-
355			Noshiro, Japan	N-2, 2	79 - 160.4	80 - 75.0	-	-
356			Noshiro, Japan	N-2, 2	79 - 164.9	80 - 70.1	-	-
357			Noshiro, Japan	N-2, 2	79 - 169.5	80 - 65.9	-	-
358			Noshiro, Japan	N-2, 2	79 - 196.6	80 - 39.0	-	-
359			Noshiro, Japan	N-3, 3	82 - 389.0	83 - 6.1	-	-
360			Noshiro, Japan	N-3, 3	82 - 328.0	83 - 67.1	-	-
361			Noshiro, Japan	N-3, 3	82 - 211.6	83 - 183.5	-	-
362			Noshiro, Japan	N-3, 3	82 - 189.9	83 - 204.9	-	-
363			Noshiro, Japan	N-3, 3	82 - 174.1	83 - 221.0	-	-
364			Noshiro, Japan	N-3, 3	82 - 172.0	83 - 222.9	-	-
365			Noshiro, Japan	N-3, 3	82 - 157.9	83 - 236.9	-	-
366			Noshiro, Japan	N-3, 3	82 - 118.0	83 - 277.1	-	-
367			Noshiro, Japan	N-3, 3	82 - 78.4	83 - 316.5	-	-
368			Noshiro, Japan	N-3, 3	82 - 59.5	83 - 335.4	-	-
369			Noshiro, Japan	N-3, 3	82 - 40.9	83 - 354.0	-	-
370			Noshiro, Japan	N-3, 3	82 - 15.9	83 - 377.4	-	-
371			Noshiro, Japan	N-3, 3	82 - 11.6	-	-	-
372			Noshiro, Japan	N-4, 4	84 - 57.0	85 - 7.6	-	-
373			Noshiro, Japan	N-4, 4	85 - 272.0	86 - 0.6	-	-
374			Noshiro, Japan	N-4, 4	85 - 213.4	86 - 59.1	-	-
375			Noshiro, Japan	N-4, 4	85 - 170.1	86 - 102.4	-	-
376			Noshiro, Japan	N-4, 4	85 - 167.4	86 - 104.9	-	-
377			Noshiro, Japan	N-4, 4	85 - 115.9	86 - 156.4	-	-
378			Noshiro, Japan	N-4, 4	85 - 71.0	86 - 201.5	-	-
379			Noshiro, Japan	N-4, 4	85 - 32.9	86 - 239.9	-	-
380			Noshiro, Japan	N-4, 4	86 - 240.9	87 - 18.6	-	-
381			Noshiro, Japan	N-4, 4	86 - 227.4	87 - 32.0	-	-
382			Noshiro, Japan	N-4, 4	86 - 179.6	87 - 79.9	-	-
383			Noshiro, Japan	N-4, 4	86 - 175.9	87 - 83.5	-	-
384			Noshiro, Japan	N-4, 4	86 - 132.9	87 - 126.5	-	-
385			Noshiro, Japan	N-4, 4	86 - 95.4	87 - 164.0	-	-
386			Noshiro, Japan	N-4, 4	86 - 92.4	87 - 167.1	-	-
387			Noshiro, Japan	N-4, 4	86 - 38.4	87 - 221.0	-	-
388			Noshiro, Japan	N-5, 5	91 - 180.5	92 - 54.6	-	-
389			Noshiro, Japan	N-5, 5	91 - 149.4	92 - 85.4	-	-
390			Noshiro, Japan	N-5, 5	91 - 136.6	92 - 98.5	-	-
391			Noshiro, Japan	N-5, 5	91 - 90.5	92 - 144.5	-	-
392			Noshiro, Japan	N-5, 5	92 - 42.4	93 - 45.7	-	-
393			Noshiro, Japan	N-5, 5	92 - 194.5	93 - 329.6	-	-
394			Noshiro, Japan	N-5, 5	92 - 149.4	93 - 343.9	-	-
395			Noshiro, Japan	N-6, 6	92 - 391.5	93 - 132.6	-	-
396			Noshiro, Japan	N-6, 6	92 - 357.6	93 - 166.5	-	-

Table 3.5: (Continued)

Case	Earthquake	Mw	Site Name	Site Location	(B.H. - D(m))1	(B.H. - D(m))2	(B.H. - D(m))3	(B.H. - D(m))4
397	1983 Nihonkai-Chubu - Japan	7.7	Noshiro, Japan	N-6, 6	92 - 253.0	93 - 271.0	-	-
398			Noshiro, Japan	N-6, 6	92 - 253.0	93 - 271.0	-	-
399			Noshiro, Japan	N-6, 6	92 - 209.1	93 - 314.9	-	-
400			Noshiro, Japan	N-6, 6	92 - 207.0	93 - 317.1	-	-
401			Noshiro, Japan	N-6, 6	92 - 197.0	93 - 327.1	-	-
402			Noshiro, Japan	N-7, 7	94 - 388.1	95 - 89.0	-	-
403			Noshiro, Japan	N-7, 7	94 - 327.1	95 - 150.0	-	-
404			Noshiro, Japan	N-7, 7	94 - 311.9	95 - 164.9	-	-
405			Noshiro, Japan	N-7, 7	94 - 286.0	95 - 190.9	-	-
406			Noshiro, Japan	N-7, 7	94 - 247.6	95 - 229.6	-	-
407			Noshiro, Japan	N-7, 7	94 - 222.6	95 - 254.6	-	-
408			Noshiro, Japan	N-7, 7	94 - 150.0	95 - 327.1	-	-
409			Noshiro, Japan	N-7, 7	94 - 118.0	95 - 359.1	-	-
410			Noshiro, Japan	N-7, 7	94 - 83.5	95 - 393.6	-	-
411			Noshiro, Japan	N-7, 7	94 - 81.1	95 - 396.0	-	-
412			Noshiro, Japan	N-7, 7	94 - 67.4	95 - 409.5	-	-
413			Noshiro, Japan	N-7, 7	94 - 34.5	95 - 442.4	-	-
414			Noshiro, Japan	N-7, 7	95 - 35.4	-	-	-
415			Noshiro, Japan	N-7, 7	95 - 95.1	-	-	-
416			Noshiro, Japan	N-7, 7	95 - 62.5	-	-	-
417	1987 Superstition Hills - USA	6.6	Wildlife	IMPERIAL VALLEY, CA.	110 - 0.3	-	-	-
418			Wildlife	IMPERIAL VALLEY, CA.	110 - 6.1	112 - 14.3	-	-
419			Wildlife	IMPERIAL VALLEY, CA.	110 - 7.9	112 - 6.4	-	-
420			Wildlife	IMPERIAL VALLEY, CA.	111 - 0.3	112 - 0.3	-	-
421			Wildlife	IMPERIAL VALLEY, CA.	113 - 0.3	114 - 0.3	115 - 0.3	-
422			Wildlife	IMPERIAL VALLEY, CA.	117 - 0.3	118 - 0.3	119 - 0.3	-
423	1989 Loma Prieta - USA	7.0	Richmond Hall	Richmond Hall Harbor, CA	R1 - 0.0	-	-	-
424			Mbari Facilities	Sandholdt Road, Moss Landing	E-B3 - 0.0	-	-	-
425			Mbari Facilities	Sandholdt Road, Moss Landing	UC-B10 - 0.0	-	-	-
426			Treasure Island	Treasure Island, CA	T1 - 0.0	-	-	-
427	1990 Luzon - Phillipines	7.6	Pantal River - W. B.	Dagupan City	1 - 0.0	-	-	-
428			Perez Boulevard	Dagupan City	2 - 0.0	-	-	-
429			Perez Boulevard	Dagupan City	3 - 0.0	-	-	-
430			Pantal River - E. B.	Dagupan City	11 - 0.0	-	-	-
431	1994 Northridge - USA	6.7	Malden Street	San Fernando Valley, CA.	15 - 0.0	-	-	-
432			Malden Street	San Fernando Valley, CA.	16 - 0.0	-	-	-
433			Malden Street	San Fernando Valley, CA.	3a - 0.0	-	-	-
434			Malden Street	San Fernando Valley, CA.	5a - 0.0	-	-	-
435	1995 Hyogoken-Nambu - Japan	6.9	The Sea Life Park	Awaji Island, Hyogo Prefecture	22 - 0.0	-	-	-
436			Portopialand Amusement Park	Chou-Ku, Kobe City	20 - 0.0	-	-	-
437			Kobe Area	LP Gas Tank Yard	1 - 0.0	-	-	-
438			Kobe Area	LP Gas Tank Yard	2 - 0.0	-	-	-
439			Kobe Area	LP Gas Tank Yard	3 - 0.0	-	-	-
440			Kobe Area	LP Gas Tank Yard	4 - 0.0	-	-	-
441			Kobe Area	LP Gas Tank Yard	5 - 0.0	-	-	-
442			Nishinomiya East High School	Nishinomiya, Osaka Bay	21 - 0.0	-	-	-
443			Kobe Area	Port Island E-E'	6 - 0.0	-	-	-
444			Kobe Area	Port Island E-E'	7 - 0.0	-	-	-
445			Kobe Area	Port Island E-E'	8 - 0.0	-	-	-
446			Kobe Area	Port Island G-G'	9 - 0.0	-	-	-
447			Kobe Area	Port Island G-G'	10 - 0.0	-	-	-
448			Kobe Area	Port Island N-N'	11 - 0.0	-	-	-
449			Kobe Area	Port Island N-N'	12 - 0.0	-	-	-
450			Kobe Area	Port Island N-N'	13 - 0.0	-	-	-
451			Kobe Area	Rokko Island O-O'	14 - 0.0	-	-	-
452			Kobe Area	Rokko Island P-P'	15 - 0.0	-	-	-
453			Kobe Area	Rokko Island Q-Q'	16 - 0.0	-	-	-
454			Kobe Area	Rokko Island R-R'	17 - 0.0	-	-	-
455			Kobe Area	Rokko Island S-S'	18 - 0.0	-	-	-
456			Kobe Area	Rokko Island T-T'	19 - 0.0	-	-	-
457	1999 Chi Chi - Taiwan	7.6	Caotun - Nantou	Nantou - Taiwan	CN1 - 0.0	-	-	-
458			Caotun - Nantou	Nantou - Taiwan	CN2 - 0.0	-	-	-
459			Caotun - Nantou	Nantou - Taiwan	CN3 - 0.0	-	-	-
460			Caotun - Nantou	Nantou - Taiwan	CN4 - 0.0	-	-	-
461			Nantou Area	Nantou - Taiwan	N1 - 0.0	-	-	-
462			Nantou Area	Nantou - Taiwan	N10 - 0.0	-	-	-

Table 3.5: (Continued)

Case	Earthquake	Mw	Site Name	Site Location	(B.H. - D(m))1	(B.H. - D(m))2	(B.H. - D(m))3	(B.H. - D(m))4
463	1999 Chi Chi - Taiwan	7.6	Nantou Area	Nantou - Taiwan	N12 - 0.0	-	-	-
464	1999 Chi Chi - Taiwan	7.6	Nantou Area	Nantou - Taiwan	N14 - 0.0	-	-	-
465	1999 Chi Chi - Taiwan	7.6	Nantou Area	Nantou - Taiwan	N2 - 0.0	-	-	-
466	1999 Chi Chi - Taiwan	7.6	Nantou Area	Nantou - Taiwan	N-2 - 0.0	-	-	-
467	1999 Chi Chi - Taiwan	7.6	Nantou Area	Nantou - Taiwan	N3 - 0.0	-	-	-
468	1999 Chi Chi - Taiwan	7.6	Nantou Area	Nantou - Taiwan	N4 - 0.0	-	-	-
469	1999 Chi Chi - Taiwan	7.6	Nantou Area	Nantou - Taiwan	N5 - 0.0	-	-	-
470	1999 Chi Chi - Taiwan	7.6	Nantou Area	Nantou - Taiwan	N6 - 0.0	-	-	-
471	1999 Chi Chi - Taiwan	7.6	Nantou Area	Nantou - Taiwan	N7 - 0.0	-	-	-
472	1999 Chi Chi - Taiwan	7.6	Nantou Area	Nantou - Taiwan	N8 - 0.0	-	-	-
473	1999 Chi Chi - Taiwan	7.6	Wufeng Area	Wufeng - Taiwan	W1 - 0.0	-	-	-
474	1999 Chi Chi - Taiwan	7.6	Wufeng Area	Wufeng - Taiwan	W10 - 0.0	-	-	-
475	1999 Chi Chi - Taiwan	7.6	Wufeng Area	Wufeng - Taiwan	W11 - 0.0	-	-	-
476	1999 Chi Chi - Taiwan	7.6	Wufeng Area	Wufeng - Taiwan	W12 - 0.0	-	-	-
477	1999 Chi Chi - Taiwan	7.6	Wufeng Area	Wufeng - Taiwan	W13 - 0.0	-	-	-
478	1999 Chi Chi - Taiwan	7.6	Wufeng Area	Wufeng - Taiwan	W3 - 0.0	-	-	-
479	1999 Chi Chi - Taiwan	7.6	Wufeng Area	Wufeng - Taiwan	W5 - 0.0	-	-	-
480	1999 Chi Chi - Taiwan	7.6	Wufeng Area	Wufeng - Taiwan	W7 - 0.0	-	-	-
481	1999 Chi Chi - Taiwan	7.6	Wufeng Area	Wufeng - Taiwan	W9 - 0.0	-	-	-
482	1999 Chi Chi - Taiwan	7.6	Yuanlin Area	Yuanlin - Taiwan	Y18 - 0.0	-	-	-
483	1999 Chi Chi - Taiwan	7.6	Yuanlin Area	Yuanlin - Taiwan	Y21 - 0.0	-	-	-
484	1999 Chi Chi - Taiwan	7.6	Yuanlin Area	Yuanlin - Taiwan	Y25 - 0.0	-	-	-
485	1999 Chi Chi - Taiwan	7.6	Yuanlin Area	Yuanlin - Taiwan	Y26 - 0.0	-	-	-
486	1999 Chi Chi - Taiwan	7.6	Yuanlin Area	Yuanlin - Taiwan	Y28 - 0.0	-	-	-
487	1999 Chi Chi - Taiwan	7.6	Yuanlin Area	Yuanlin - Taiwan	Y29 - 0.0	-	-	-
488	1999 Chi Chi - Taiwan	7.6	Yuanlin Area	Yuanlin - Taiwan	Y30 - 0.0	-	-	-
489	1999 Chi Chi - Taiwan	7.6	Yuanlin Area	Yuanlin - Taiwan	Y35 - 0.0	-	-	-
490	1999 Chi Chi - Taiwan	7.6	Yuanlin Area	Yuanlin - Taiwan	Y43 - 0.0	-	-	-
491	1999 Chi Chi - Taiwan	7.6	Yuanlin Area	Yuanlin - Taiwan	Y44 - 0.0	-	-	-
492	1999 Chi Chi - Taiwan	7.6	Yuanlin Area	Yuanlin - Taiwan	Y45 - 0.0	-	-	-
493	1999 Chi Chi - Taiwan	7.6	Yuanlin Area	Yuanlin - Taiwan	Y46 - 0.0	-	-	-
494	1999 Chi Chi - Taiwan	7.6	Yuanlin Area	Yuanlin - Taiwan	Y47 - 0.0	-	-	-
495	1999 Kocaeli (Izmit) - Turkey	7.4	Sapanca Lake	Izmit Bay - Sapanca Lake	JS10 - 0.0	-	-	-
496	1999 Kocaeli (Izmit) - Turkey	7.4	Sapanca Lake	Izmit Bay - Sapanca Lake	JS12 - 0.0	-	-	-
497	1999 Kocaeli (Izmit) - Turkey	7.4	Sapanca Lake	Izmit Bay - Sapanca Lake	JS13 - 0.0	-	-	-
498	1999 Kocaeli (Izmit) - Turkey	7.4	Sapanca Lake	Izmit Bay - Sapanca Lake	JS2 - 0.0	-	-	-
499	1999 Kocaeli (Izmit) - Turkey	7.4	Sapanca Lake	Izmit Bay - Sapanca Lake	JS3 - 0.0	-	-	-
500	1999 Kocaeli (Izmit) - Turkey	7.4	Sapanca Lake	Izmit Bay - Sapanca Lake	JS4 - 0.0	-	-	-
501	1999 Kocaeli (Izmit) - Turkey	7.4	Sapanca Lake	Izmit Bay - Sapanca Lake	JS5 - 0.0	-	-	-
502	1999 Kocaeli (Izmit) - Turkey	7.4	Sapanca Lake	Izmit Bay - Sapanca Lake	JS6 - 0.0	-	-	-
503	1999 Kocaeli (Izmit) - Turkey	7.4	Sapanca Lake	Izmit Bay - Sapanca Lake	JS7 - 0.0	-	-	-
504	1999 Kocaeli (Izmit) - Turkey	7.4	Sapanca Lake	Izmit Bay - Sapanca Lake	JS8 - 0.0	-	-	-
505	1999 Kocaeli (Izmit) - Turkey	7.4	Sapanca Lake	Izmit Bay - Sapanca Lake	JS9 - 0.0	-	-	-
506	1999 Kocaeli (Izmit) - Turkey	7.4	Police Station	Izmit Bay - Sapanca Lake	PS2 - 0.0	-	-	-
507	1999 Kocaeli (Izmit) - Turkey	7.4	Sapanca Lake	Izmit Bay - Sapanca Lake	S1/2 - 0.0	-	-	-
508	1999 Kocaeli (Izmit) - Turkey	7.4	Sapanca Lake	Izmit Bay - Sapanca Lake	S1/8 - 0.0	-	-	-
509	1999 Kocaeli (Izmit) - Turkey	7.4	Sapanca Lake	Izmit Bay - Sapanca Lake	S2/1 - 0.0	-	-	-
510	1999 Kocaeli (Izmit) - Turkey	7.4	Sapanca Lake	Izmit Bay - Sapanca Lake	S2/3 - 0.0	-	-	-
511	1999 Kocaeli (Izmit) - Turkey	7.4	Sapanca Lake	Izmit Bay - Sapanca Lake	S4/3 - 0.0	-	-	-
512	1999 Kocaeli (Izmit) - Turkey	7.4	Soccer Field	Izmit Bay - Sapanca Lake	SF5 - 0.0	-	-	-
513	1999 Kocaeli (Izmit) - Turkey	7.4	Soccer Field	Izmit Bay - Sapanca Lake	SF6 - 0.0	-	-	-
514	1999 Kocaeli (Izmit) - Turkey	7.4	Hotel Sapanca	Izmit Bay - Sapanca Lake	SH11 - 0.0	-	-	-
515	1999 Kocaeli (Izmit) - Turkey	7.4	Hotel Sapanca	Izmit Bay - Sapanca Lake	SH4 - 0.0	-	-	-
516	1999 Kocaeli (Izmit) - Turkey	7.4	Hotel Sapanca	Izmit Bay - Sapanca Lake	SH7 - 0.0	-	-	-
517	1999 Kocaeli (Izmit) - Turkey	7.4	Yakin Street	Izmit Bay - Sapanca Lake	YS2 - 0.0	-	-	-
518	1999 Kocaeli (Izmit) - Turkey	7.4	Yakin Street	Izmit Bay - Sapanca Lake	YS4 - 0.0	-	-	-
519	2003 San Simeon - USA	6.5	Coolidge Drive	Oceano, CA.	2 - 0.0	-	-	-
520	2003 San Simeon - USA	6.5	Coolidge Drive	Oceano, CA.	3 - 0.0	-	-	-
521	2003 San Simeon - USA	6.5	Coolidge Drive	Oceano, CA.	4 - 0.0	-	-	-
522	2003 San Simeon - USA	6.5	Juanita Avenue	Oceano, CA.	7 - 0.0	-	-	-
523	2003 San Simeon - USA	6.5	Juanita Avenue	Oceano, CA.	8 - 0.0	-	-	-
524	2003 San Simeon - USA	6.5	Juanita Avenue	Oceano, CA.	9 - 0.0	-	-	-
525	2003 Tokachi-Oki - Japan	7.9	West District - Kushiro Port	Hokkaido Island	P1 - 0.0	-	-	-
526	2003 Tokachi-Oki - Japan	7.9	West District - Kushiro Port	Hokkaido Island	T1 - 0.0	-	-	-

Table 3.5: (Continued)

Case	D_H (m)	a_{max} (g)	S (%)	W (%)	LSI	Zcr. (m)	ϕ' (deg)	a_y/a_{max}	$\tan\beta/\tan\phi'$	Soft Clays?	Reference(s)
1	1.00 ± 0.00	0.60 ± 0.15	0.60	0.00	3.55 ± 0.89	3.50 ± 0.88	2.76 ± 0.67	0.070 ± 0.026	0.124 ± 0.030	Yes	Database of Youd et al., (2002)
2	1.20 ± 0.00	0.56 ± 0.14	0.80	0.00	3.48 ± 0.87	7.00 ± 1.75	4.56 ± 0.95	0.128 ± 0.044	0.100 ± 0.021	No	
3	1.83 ± 0.00	0.28 ± 0.07	2.00	22.02	4.72 ± 1.18	5.18 ± 1.30	4.83 ± 0.95	0.230 ± 0.083	0.236 ± 0.047	No	
4	1.09 ± 0.00	0.19 ± 0.05	0.31	0.00	5.80 ± 0.09	1.09 ± 0.08	3.05 ± 0.67	0.264 ± 0.090	0.058 ± 0.013	No	Database of Youd et al., (2002)
5	1.55 ± 0.00	0.19 ± 0.05	0.59	0.00	5.88 ± 0.09	1.16 ± 0.08	3.16 ± 0.67	0.260 ± 0.089	0.107 ± 0.023	No	
6	2.07 ± 0.00	0.19 ± 0.05	0.65	0.00	6.02 ± 0.09	1.28 ± 0.08	3.36 ± 0.67	0.275 ± 0.092	0.111 ± 0.022	No	
7	1.34 ± 0.00	0.19 ± 0.05	0.29	0.00	6.10 ± 0.68	1.75 ± 0.50	3.49 ± 0.67	0.306 ± 0.098	0.047 ± 0.009	No	
8	1.52 ± 0.00	0.19 ± 0.05	0.36	0.00	6.10 ± 0.68	1.75 ± 0.50	3.49 ± 0.67	0.302 ± 0.097	0.059 ± 0.011	No	
9	0.80 ± 0.00	0.19 ± 0.05	0.27	0.00	6.10 ± 0.68	1.75 ± 0.50	3.49 ± 0.67	0.307 ± 0.098	0.044 ± 0.008	No	
10	0.91 ± 0.00	0.19 ± 0.05	0.26	0.00	6.10 ± 0.68	1.75 ± 0.50	3.49 ± 0.67	0.308 ± 0.098	0.043 ± 0.008	No	
11	0.92 ± 0.00	0.19 ± 0.05	0.24	0.00	6.10 ± 0.68	1.75 ± 0.50	3.49 ± 0.67	0.309 ± 0.099	0.039 ± 0.008	No	
12	1.24 ± 0.00	0.19 ± 0.05	0.28	0.00	6.10 ± 0.68	1.75 ± 0.50	3.49 ± 0.67	0.307 ± 0.098	0.046 ± 0.009	No	
13	1.27 ± 0.00	0.19 ± 0.05	0.38	0.00	6.10 ± 0.68	1.75 ± 0.50	3.49 ± 0.67	0.301 ± 0.097	0.062 ± 0.012	No	
14	1.38 ± 0.00	0.19 ± 0.05	0.28	0.00	6.10 ± 0.68	1.75 ± 0.50	3.49 ± 0.67	0.307 ± 0.098	0.046 ± 0.009	No	
15	1.60 ± 0.00	0.19 ± 0.05	0.27	0.00	6.10 ± 0.68	1.75 ± 0.50	3.49 ± 0.67	0.307 ± 0.098	0.044 ± 0.008	No	
16	1.69 ± 0.00	0.19 ± 0.05	0.32	0.00	6.10 ± 0.68	1.75 ± 0.50	3.49 ± 0.67	0.305 ± 0.098	0.052 ± 0.010	No	
17	1.69 ± 0.00	0.19 ± 0.05	0.34	0.00	6.10 ± 0.68	1.75 ± 0.50	3.49 ± 0.67	0.303 ± 0.098	0.056 ± 0.011	No	
18	1.72 ± 0.00	0.19 ± 0.05	0.47	0.00	6.10 ± 0.68	1.75 ± 0.50	3.49 ± 0.67	0.297 ± 0.096	0.077 ± 0.015	No	
19	2.05 ± 0.00	0.19 ± 0.05	0.81	0.00	6.10 ± 0.68	1.75 ± 0.50	3.49 ± 0.67	0.279 ± 0.093	0.133 ± 0.025	No	
20	2.73 ± 0.00	0.19 ± 0.05	0.81	0.00	6.10 ± 0.68	1.75 ± 0.50	3.49 ± 0.67	0.279 ± 0.093	0.133 ± 0.025	No	
21	0.88 ± 0.00	0.19 ± 0.05	0.24	0.00	6.10 ± 0.68	1.75 ± 0.50	3.49 ± 0.67	0.309 ± 0.099	0.039 ± 0.008	No	
22	1.23 ± 0.00	0.19 ± 0.05	0.24	0.00	6.10 ± 0.68	1.75 ± 0.50	3.49 ± 0.67	0.309 ± 0.099	0.039 ± 0.008	No	
23	1.53 ± 0.00	0.19 ± 0.05	0.29	0.00	6.10 ± 0.68	1.75 ± 0.50	3.49 ± 0.67	0.306 ± 0.098	0.047 ± 0.009	No	
24	1.56 ± 0.00	0.19 ± 0.05	0.32	0.00	6.10 ± 0.68	1.75 ± 0.50	3.49 ± 0.67	0.305 ± 0.098	0.052 ± 0.010	No	
25	1.35 ± 0.00	0.19 ± 0.05	0.29	0.00	6.10 ± 0.68	1.75 ± 0.50	3.49 ± 0.67	0.306 ± 0.098	0.047 ± 0.009	No	
26	1.79 ± 0.00	0.19 ± 0.05	0.25	0.00	6.10 ± 0.68	1.75 ± 0.50	3.49 ± 0.67	0.308 ± 0.099	0.041 ± 0.008	No	
27	3.33 ± 0.00	0.19 ± 0.05	0.75	0.00	7.24 ± 0.95	3.79 ± 1.38	4.32 ± 0.95	0.358 ± 0.125	0.099 ± 0.022	No	
28	2.87 ± 0.00	0.19 ± 0.05	0.78	0.00	7.22 ± 0.93	3.95 ± 1.57	4.25 ± 0.95	0.350 ± 0.124	0.105 ± 0.023	No	
29	2.48 ± 0.00	0.19 ± 0.05	0.92	0.00	7.05 ± 0.75	3.97 ± 1.99	4.30 ± 0.95	0.347 ± 0.123	0.122 ± 0.027	No	
30	3.22 ± 0.00	0.19 ± 0.05	0.78	0.00	7.13 ± 0.86	4.26 ± 2.04	4.17 ± 0.95	0.343 ± 0.123	0.107 ± 0.024	No	
31	3.60 ± 0.00	0.19 ± 0.05	0.78	0.00	7.14 ± 0.86	4.25 ± 2.00	4.17 ± 0.95	0.342 ± 0.122	0.107 ± 0.024	No	
32	3.12 ± 0.00	0.19 ± 0.05	0.99	0.00	7.03 ± 0.71	4.27 ± 2.28	4.21 ± 0.95	0.335 ± 0.121	0.135 ± 0.030	No	
33	2.91 ± 0.00	0.19 ± 0.05	0.90	0.00	7.22 ± 0.87	3.90 ± 1.57	4.21 ± 0.95	0.340 ± 0.122	0.122 ± 0.028	No	
34	3.49 ± 0.00	0.19 ± 0.05	0.94	0.00	7.05 ± 0.74	4.29 ± 2.26	4.18 ± 0.95	0.335 ± 0.121	0.129 ± 0.029	No	
35	3.29 ± 0.00	0.19 ± 0.05	1.09	0.00	7.00 ± 0.67	4.50 ± 2.40	4.15 ± 0.95	0.324 ± 0.119	0.150 ± 0.035	No	
36	4.50 ± 0.00	0.19 ± 0.05	0.89	0.00	7.14 ± 0.77	3.71 ± 1.56	4.29 ± 0.95	0.348 ± 0.123	0.119 ± 0.026	No	
37	3.29 ± 0.00	0.19 ± 0.05	0.90	0.00	7.06 ± 0.74	4.33 ± 2.25	4.15 ± 0.95	0.335 ± 0.121	0.124 ± 0.028	No	
38	1.65 ± 0.00	0.19 ± 0.05	0.99	0.00	6.98 ± 0.63	4.71 ± 2.41	4.09 ± 0.95	0.324 ± 0.119	0.139 ± 0.032	No	
39	3.11 ± 0.00	0.19 ± 0.05	0.90	0.00	6.99 ± 0.63	4.74 ± 2.40	4.06 ± 0.95	0.326 ± 0.120	0.127 ± 0.030	No	
40	3.40 ± 0.00	0.19 ± 0.05	0.90	0.00	7.00 ± 0.64	4.71 ± 2.39	4.06 ± 0.95	0.326 ± 0.120	0.127 ± 0.030	No	
41	2.05 ± 0.00	0.19 ± 0.05	0.81	0.00	6.95 ± 0.55	5.00 ± 2.32	4.00 ± 0.95	0.325 ± 0.120	0.116 ± 0.028	No	
42	2.39 ± 0.00	0.19 ± 0.05	0.87	0.00	6.94 ± 0.50	5.25 ± 2.13	3.91 ± 0.95	0.314 ± 0.118	0.127 ± 0.031	No	
43	2.75 ± 0.00	0.19 ± 0.05	0.89	0.00	6.92 ± 0.44	5.35 ± 2.06	3.89 ± 0.95	0.311 ± 0.117	0.131 ± 0.032	No	
44	2.57 ± 0.00	0.19 ± 0.05	0.77	0.00	6.88 ± 0.37	5.59 ± 1.81	3.82 ± 0.95	0.311 ± 0.117	0.115 ± 0.029	No	
45	2.54 ± 0.00	0.19 ± 0.05	0.77	0.00	6.77 ± 0.13	6.48 ± 0.69	3.56 ± 0.95	0.287 ± 0.113	0.124 ± 0.033	No	
46	1.63 ± 0.00	0.19 ± 0.05	0.42	0.00	5.73 ± 1.14	2.67 ± 0.49	5.14 ± 0.95	0.451 ± 0.143	0.047 ± 0.009	No	
47	1.55 ± 0.00	0.19 ± 0.05	0.54	0.00	5.75 ± 1.08	2.63 ± 0.48	5.02 ± 0.95	0.434 ± 0.139	0.061 ± 0.012	No	
48	1.60 ± 0.00	0.19 ± 0.05	0.40	0.00	5.53 ± 1.43	2.73 ± 0.65	4.99 ± 0.95	0.438 ± 0.140	0.046 ± 0.009	No	
49	1.12 ± 0.00	0.19 ± 0.05	0.27	0.00	5.24 ± 1.74	2.84 ± 0.83	4.85 ± 0.95	0.433 ± 0.139	0.032 ± 0.006	No	
50	1.24 ± 0.00	0.19 ± 0.05	0.25	0.00	5.29 ± 1.69	2.82 ± 0.81	4.84 ± 0.95	0.433 ± 0.139	0.030 ± 0.006	No	
51	1.49 ± 0.00	0.19 ± 0.05	0.48	0.00	5.45 ± 1.23	2.59 ± 0.74	4.34 ± 0.95	0.374 ± 0.128	0.063 ± 0.014	No	
52	1.66 ± 0.00	0.19 ± 0.05	0.58	0.00	7.11 ± 0.82	3.09 ± 1.07	4.60 ± 0.95	0.393 ± 0.132	0.072 ± 0.015	No	
53	1.34 ± 0.00	0.19 ± 0.05	0.65	0.00	6.85 ± 0.84	2.85 ± 0.90	4.26 ± 0.95	0.358 ± 0.125	0.087 ± 0.020	No	
54	2.47 ± 0.00	0.19 ± 0.05	0.84	0.00	7.10 ± 0.59	2.98 ± 0.87	4.46 ± 0.95	0.366 ± 0.127	0.108 ± 0.023	No	
55	1.96 ± 0.00	0.19 ± 0.05	0.75	0.00	6.99 ± 0.35	2.80 ± 0.54	4.51 ± 0.95	0.376 ± 0.128	0.095 ± 0.020	No	
56	1.35 ± 0.00	0.19 ± 0.05	0.12	5.12	7.74 ± 1.93	3.70 ± 0.93	6.73 ± 0.94	0.615 ± 0.177	0.010 ± 0.001	No	
57	6.49 ± 0.00	0.19 ± 0.05	0.11	16.40	6.37 ± 0.20	8.81 ± 1.67	4.31 ± 0.95	0.391 ± 0.131	0.015 ± 0.003	No	
58	1.30 ± 0.00	0.19 ± 0.05	0.11	2.99	6.46 ± 0.21	4.25 ± 0.67	3.40 ± 0.67	0.307 ± 0.098	0.019 ± 0.004	No	
59	2.86 ± 0.00	0.19 ± 0.05	0.12	3.90	5.43 ± 1.36	12.50 ± 3.13	6.78 ± 0.94	0.619 ± 0.178	0.010 ± 0.001	No	
60	2.08 ± 0.00	0.19 ± 0.05	0.00	3.10	6.17 ± 1.16	5.50 ± 4.76	4.13 ± 0.95	0.380 ± 0.129	0.000 ± 0.000	No	
61	3.27 ± 0.00	0.19 ± 0.05	0.45	20.55	5.18 ± 0.31	2.92 ± 0.67	3.34 ± 0.67	0.283 ± 0.094	0.077 ± 0.015	No	
62	3.33 ± 0.00	0.19 ± 0.05	0.39	19.62	5.07 ± 0.31	3.15 ± 0.67	3.39 ± 0.67	0.291 ± 0.095	0.066 ± 0.013	No	
63	1.91 ± 0.00	0.19 ± 0.05	0.45	7.72	4.92 ± 0.31	3.47 ± 0.67	3.46 ± 0.67	0.294 ± 0.096	0.075 ± 0.014	No	
64	1.36 ± 0.00	0.19 ± 0.05	0.45	4.26	4.58 ± 0.31	4.18 ± 0.67	3.61 ± 0.95	0.308 ± 0.117	0.071 ± 0.019	No	
65	0.89 ± 0.00	0.19 ± 0.05	0.45	4.45	4.44 ± 0.31	4.49 ± 0.67	3.67 ± 0.95	0.314 ± 0.118	0.070 ± 0.018	No	
66	4.56 ± 0.00	0.19 ± 0.05	0.00	7.58	6.93 ± 1.73	2.50 ± 0.63	5.61 ± 0.95	0.517 ± 0.156	0.000 ± 0.000	No	

Table 3.5: (Continued)

Case	D_H (m)	a_{max} (g)	S (%)	W (%)	LSI	Zcr. (m)	ϕ' (deg)	a_y/a_{max}	tanβ/tanϕ'	Soft Clays?	Reference(s)
67	4.75 ± 0.00	0.19 ± 0.05	0.00	8.89	6.93 ± 1.73	2.50 ± 0.63	5.61 ± 0.95	0.517 ± 0.156	0.000 ± 0.000	No	Database of Youd et al., (2002)
68	5.34 ± 0.00	0.19 ± 0.05	0.00	13.65	6.93 ± 1.73	2.50 ± 0.63	5.61 ± 0.95	0.517 ± 0.156	0.000 ± 0.000	No	
69	8.72 ± 0.00	0.19 ± 0.05	0.00	12.01	7.40 ± 0.14	4.65 ± 0.92	4.75 ± 0.95	0.437 ± 0.140	0.000 ± 0.000	No	
70	4.76 ± 0.00	0.19 ± 0.05	0.00	8.52	6.89 ± 1.72	8.00 ± 2.00	5.12 ± 0.95	0.472 ± 0.147	0.000 ± 0.000	No	
71	2.90 ± 0.00	0.19 ± 0.05	0.10	11.06	8.43 ± 2.11	6.00 ± 1.50	5.07 ± 0.95	0.462 ± 0.145	0.011 ± 0.002	No	
72	3.53 ± 0.00	0.19 ± 0.05	0.10	7.05	7.48 ± 0.29	4.92 ± 0.50	4.73 ± 0.95	0.430 ± 0.139	0.012 ± 0.002	No	
73	6.01 ± 0.00	0.19 ± 0.05	0.10	9.98	8.34 ± 0.03	3.80 ± 0.25	3.73 ± 0.95	0.338 ± 0.122	0.015 ± 0.004	No	
74	6.29 ± 0.00	0.19 ± 0.05	0.10	12.44	8.32 ± 0.03	3.18 ± 0.25	3.35 ± 0.67	0.303 ± 0.098	0.017 ± 0.003	No	
75	4.57 ± 0.00	0.19 ± 0.05	0.00	5.76	7.72 ± 1.93	2.50 ± 0.63	4.51 ± 0.95	0.415 ± 0.136	0.000 ± 0.000	No	
76	4.84 ± 0.00	0.19 ± 0.05	0.15	2.99	7.98 ± 0.08	2.50 ± 0.00	3.36 ± 0.67	0.301 ± 0.097	0.026 ± 0.005	No	
77	5.19 ± 0.00	0.19 ± 0.05	0.15	3.15	7.99 ± 0.08	2.50 ± 0.00	3.33 ± 0.67	0.298 ± 0.097	0.026 ± 0.005	No	
78	3.45 ± 0.00	0.19 ± 0.05	0.15	3.36	8.04 ± 0.08	2.50 ± 0.00	3.11 ± 0.67	0.278 ± 0.093	0.028 ± 0.006	No	
79	4.75 ± 0.00	0.19 ± 0.05	0.15	4.05	8.22 ± 2.05	2.50 ± 0.63	2.33 ± 0.67	0.206 ± 0.080	0.037 ± 0.011	No	
80	3.65 ± 0.00	0.19 ± 0.05	0.10	4.82	7.65 ± 0.25	2.12 ± 0.08	2.61 ± 0.67	0.235 ± 0.085	0.022 ± 0.006	No	
81	3.60 ± 0.00	0.19 ± 0.05	0.10	6.51	8.25 ± 2.06	1.50 ± 0.38	2.33 ± 0.67	0.209 ± 0.081	0.025 ± 0.007	No	
82	1.85 ± 0.00	0.19 ± 0.05	0.10	4.87	6.68 ± 1.67	4.00 ± 1.00	4.44 ± 0.95	0.403 ± 0.134	0.013 ± 0.003	No	
83	3.25 ± 0.00	0.19 ± 0.05	0.14	3.72	6.78 ± 1.69	3.00 ± 0.75	3.02 ± 0.67	0.270 ± 0.091	0.027 ± 0.006	No	
84	1.26 ± 0.00	0.19 ± 0.05	0.07	2.11	7.21 ± 0.14	5.12 ± 0.67	3.30 ± 0.67	0.300 ± 0.097	0.012 ± 0.002	No	
85	1.55 ± 0.00	0.19 ± 0.05	0.00	2.27	6.99 ± 0.20	4.99 ± 0.67	4.58 ± 0.95	0.422 ± 0.137	0.000 ± 0.000	No	
86	1.24 ± 0.00	0.19 ± 0.05	0.22	2.42	6.18 ± 0.23	3.34 ± 0.28	3.38 ± 0.67	0.299 ± 0.097	0.037 ± 0.007	No	
87	1.81 ± 0.00	0.19 ± 0.05	0.22	2.86	6.17 ± 0.24	3.35 ± 0.28	3.36 ± 0.67	0.297 ± 0.096	0.038 ± 0.007	No	
88	2.70 ± 0.00	0.19 ± 0.05	0.22	3.22	6.58 ± 0.15	3.50 ± 0.00	3.54 ± 0.95	0.314 ± 0.118	0.036 ± 0.010	No	
89	8.38 ± 0.00	0.19 ± 0.05	0.22	17.75	7.97 ± 0.09	2.04 ± 0.00	3.50 ± 0.67	0.310 ± 0.099	0.036 ± 0.007	No	
90	8.51 ± 0.00	0.19 ± 0.05	0.22	16.40	7.97 ± 0.09	2.03 ± 0.00	3.49 ± 0.67	0.310 ± 0.099	0.036 ± 0.007	No	
91	6.66 ± 0.00	0.19 ± 0.05	0.22	4.55	7.97 ± 0.09	2.03 ± 0.00	3.48 ± 0.67	0.309 ± 0.099	0.036 ± 0.007	No	
92	9.48 ± 0.00	0.19 ± 0.05	0.22	17.75	8.35 ± 0.03	3.89 ± 0.25	3.79 ± 0.95	0.337 ± 0.122	0.033 ± 0.008	No	
93	9.28 ± 0.00	0.19 ± 0.05	0.22	17.05	8.35 ± 0.03	3.88 ± 0.25	3.78 ± 0.95	0.336 ± 0.121	0.033 ± 0.008	No	
94	7.69 ± 0.00	0.19 ± 0.05	0.22	19.62	8.35 ± 0.03	3.88 ± 0.25	3.78 ± 0.95	0.336 ± 0.121	0.033 ± 0.008	No	
95	7.30 ± 0.00	0.19 ± 0.05	0.22	7.72	8.35 ± 0.03	3.88 ± 0.25	3.78 ± 0.95	0.336 ± 0.121	0.033 ± 0.008	No	
96	8.36 ± 0.00	0.19 ± 0.05	0.22	7.85	8.35 ± 0.03	3.87 ± 0.25	3.78 ± 0.95	0.336 ± 0.121	0.033 ± 0.008	No	
97	7.35 ± 0.00	0.19 ± 0.05	0.22	4.94	8.35 ± 0.03	3.87 ± 0.25	3.78 ± 0.95	0.336 ± 0.121	0.033 ± 0.008	No	
98	7.20 ± 0.00	0.19 ± 0.05	0.22	5.76	8.35 ± 0.03	3.86 ± 0.25	3.77 ± 0.95	0.335 ± 0.121	0.033 ± 0.008	No	
99	7.18 ± 0.00	0.19 ± 0.05	0.22	5.25	8.35 ± 0.03	3.86 ± 0.25	3.77 ± 0.95	0.335 ± 0.121	0.033 ± 0.008	No	
100	9.14 ± 0.00	0.19 ± 0.05	0.22	17.75	8.35 ± 0.03	3.86 ± 0.25	3.77 ± 0.95	0.335 ± 0.121	0.033 ± 0.008	No	
101	6.17 ± 0.00	0.19 ± 0.05	0.22	17.05	6.04 ± 0.42	2.62 ± 0.45	2.98 ± 0.67	0.263 ± 0.090	0.042 ± 0.009	No	
102	5.38 ± 0.00	0.19 ± 0.05	0.22	17.05	5.87 ± 0.42	2.81 ± 0.45	2.89 ± 0.67	0.254 ± 0.088	0.044 ± 0.010	No	
103	3.74 ± 0.00	0.19 ± 0.05	0.22	7.32	5.69 ± 0.42	3.00 ± 0.45	2.80 ± 0.67	0.246 ± 0.087	0.045 ± 0.011	No	
104	1.95 ± 0.00	0.19 ± 0.05	0.22	3.72	5.73 ± 0.96	3.58 ± 1.81	2.76 ± 0.67	0.242 ± 0.086	0.046 ± 0.011	No	
105	1.22 ± 0.00	0.19 ± 0.05	0.22	2.82	5.94 ± 1.49	3.50 ± 0.88	2.94 ± 0.67	0.259 ± 0.089	0.043 ± 0.010	No	
106	2.47 ± 0.00	0.19 ± 0.05	0.22	3.27	5.34 ± 0.22	4.43 ± 0.33	2.92 ± 0.67	0.257 ± 0.089	0.043 ± 0.010	No	
107	1.88 ± 0.00	0.19 ± 0.05	0.22	2.68	5.67 ± 0.81	4.13 ± 1.09	3.16 ± 0.67	0.279 ± 0.093	0.040 ± 0.008	No	
108	2.67 ± 0.00	0.19 ± 0.05	0.22	3.04	5.59 ± 0.82	4.21 ± 1.15	3.13 ± 0.67	0.276 ± 0.092	0.040 ± 0.009	No	
109	2.40 ± 0.00	0.19 ± 0.05	0.22	3.06	5.31 ± 0.88	4.64 ± 1.14	3.09 ± 0.67	0.272 ± 0.092	0.041 ± 0.009	No	
110	1.31 ± 0.00	0.19 ± 0.05	0.31	2.09	0.94 ± 0.04	1.34 ± 0.25	4.80 ± 0.95	0.425 ± 0.138	0.037 ± 0.007	No	
111	1.24 ± 0.00	0.19 ± 0.05	0.36	3.26	0.97 ± 0.04	1.49 ± 0.25	5.27 ± 0.95	0.466 ± 0.146	0.039 ± 0.007	No	
112	0.68 ± 0.00	0.19 ± 0.05	0.48	3.35	0.97 ± 0.04	1.50 ± 0.25	5.32 ± 0.95	0.464 ± 0.145	0.052 ± 0.009	No	
113	0.67 ± 0.00	0.19 ± 0.05	0.48	4.18	0.99 ± 0.04	1.64 ± 0.25	5.74 ± 0.95	0.504 ± 0.153	0.048 ± 0.008	No	
114	0.87 ± 0.00	0.19 ± 0.05	0.24	4.79	1.02 ± 0.04	1.83 ± 0.25	6.35 ± 0.94	0.573 ± 0.168	0.022 ± 0.003	No	
115	1.37 ± 0.00	0.19 ± 0.05	0.08	2.29	0.77 ± 0.02	2.51 ± 0.37	9.36 ± 0.93	0.863 ± 0.233	0.005 ± 0.000	No	
116	0.81 ± 0.00	0.19 ± 0.05	0.08	2.68	0.78 ± 0.02	2.32 ± 0.37	8.48 ± 0.93	0.780 ± 0.214	0.005 ± 0.001	No	
117	0.85 ± 0.00	0.19 ± 0.05	0.07	3.39	0.78 ± 0.02	2.23 ± 0.37	8.02 ± 0.94	0.738 ± 0.204	0.005 ± 0.001	No	
118	0.71 ± 0.00	0.19 ± 0.05	0.08	4.26	0.78 ± 0.02	2.16 ± 0.37	7.72 ± 0.94	0.709 ± 0.198	0.006 ± 0.001	No	
119	1.09 ± 0.00	0.19 ± 0.05	0.08	3.43	0.79 ± 0.02	2.13 ± 0.37	7.59 ± 0.94	0.697 ± 0.195	0.006 ± 0.001	No	
120	5.02 ± 0.00	0.19 ± 0.05	0.07	29.70	7.36 ± 0.26	4.62 ± 4.67	4.30 ± 0.95	0.392 ± 0.132	0.009 ± 0.002	No	
121	4.27 ± 0.00	0.19 ± 0.05	0.07	19.37	7.38 ± 0.34	5.38 ± 5.45	4.46 ± 0.95	0.407 ± 0.134	0.009 ± 0.002	No	
122	3.77 ± 0.00	0.19 ± 0.05	0.07	11.32	7.36 ± 0.35	5.66 ± 5.66	4.42 ± 0.95	0.403 ± 0.134	0.009 ± 0.002	No	
123	4.39 ± 0.00	0.19 ± 0.05	0.07	9.18	7.39 ± 0.48	6.86 ± 6.05	4.66 ± 0.95	0.425 ± 0.138	0.009 ± 0.002	No	
124	4.87 ± 0.00	0.19 ± 0.05	0.07	16.72	7.45 ± 0.50	6.84 ± 6.04	4.88 ± 0.95	0.446 ± 0.142	0.008 ± 0.002	No	
125	2.96 ± 0.00	0.19 ± 0.05	0.07	5.93	7.29 ± 0.43	7.36 ± 5.80	4.36 ± 0.95	0.397 ± 0.133	0.009 ± 0.002	No	
126	4.82 ± 0.00	0.19 ± 0.05	0.07	12.47	7.45 ± 0.51	7.04 ± 6.00	4.91 ± 0.95	0.448 ± 0.142	0.008 ± 0.002	No	
127	2.50 ± 0.00	0.19 ± 0.05	0.07	6.53	7.34 ± 0.49	7.45 ± 5.80	4.55 ± 0.95	0.415 ± 0.136	0.009 ± 0.002	No	
128	7.05 ± 0.00	0.19 ± 0.05	0.07	16.07	7.49 ± 0.53	7.22 ± 5.91	5.06 ± 0.95	0.462 ± 0.145	0.008 ± 0.001	No	
129	7.66 ± 0.00	0.19 ± 0.05	0.07	35.00	7.52 ± 0.54	7.43 ± 5.76	5.21 ± 0.95	0.476 ± 0.148	0.008 ± 0.001	No	
130	3.20 ± 0.00	0.19 ± 0.05	0.07	12.47	7.50 ± 0.55	7.54 ± 5.72	5.13 ± 0.95	0.469 ± 0.146	0.008 ± 0.001	No	
131	7.12 ± 0.00	0.19 ± 0.05	0.07	55.68	7.54 ± 0.54	7.56 ± 5.66	5.28 ± 0.95	0.483 ± 0.149	0.008 ± 0.001	No	
132	1.83 ± 0.00	0.19 ± 0.05	0.07	4.83	7.23 ± 0.41	8.23 ± 4.88	4.23 ± 0.95	0.386 ± 0.130	0.009 ± 0.002	No	

Table 3.5: (Continued)

Case	D_H (m)	a_{max} (g)	S (%)	W (%)	LSI	Zcr. (m)	ϕ' (deg)	a_y/a_{max}	tanβ/tanϕ'	Soft Clays?	Reference(s)
133	7.39 ± 0.00	0.19 ± 0.05	0.07	16.07	7.53 ± 0.55	7.71 ± 5.55	5.28 ± 0.95	0.483 ± 0.149	0.008 ± 0.001	No	Database of Youd et al., (2002)
134	1.48 ± 0.00	0.19 ± 0.05	0.07	5.76	7.37 ± 0.56	8.24 ± 5.08	4.73 ± 0.95	0.432 ± 0.139	0.008 ± 0.002	No	
135	3.50 ± 0.00	0.19 ± 0.05	0.07	11.32	7.54 ± 0.56	7.94 ± 5.34	5.33 ± 0.95	0.488 ± 0.150	0.007 ± 0.001	No	
136	2.37 ± 0.00	0.19 ± 0.05	0.07	5.36	7.30 ± 0.51	8.36 ± 4.86	4.52 ± 0.95	0.413 ± 0.135	0.009 ± 0.002	No	
137	6.26 ± 0.00	0.19 ± 0.05	0.07	13.73	7.55 ± 0.56	7.94 ± 5.33	5.35 ± 0.95	0.490 ± 0.151	0.007 ± 0.001	No	
138	2.35 ± 0.00	0.19 ± 0.05	0.07	5.01	7.27 ± 0.48	8.64 ± 4.41	4.43 ± 0.95	0.404 ± 0.134	0.009 ± 0.002	No	
139	1.74 ± 0.00	0.19 ± 0.05	0.07	5.01	7.36 ± 0.58	8.68 ± 4.46	4.78 ± 0.95	0.436 ± 0.140	0.008 ± 0.002	No	
140	1.86 ± 0.00	0.19 ± 0.05	0.07	6.23	7.48 ± 0.61	8.54 ± 4.69	5.18 ± 0.95	0.473 ± 0.147	0.008 ± 0.001	No	
141	1.82 ± 0.00	0.19 ± 0.05	0.07	3.98	7.16 ± 0.33	9.14 ± 3.41	4.07 ± 0.95	0.371 ± 0.128	0.010 ± 0.002	No	
142	1.82 ± 0.00	0.19 ± 0.05	0.07	3.38	7.16 ± 0.34	9.19 ± 3.33	4.09 ± 0.95	0.372 ± 0.128	0.010 ± 0.002	No	
143	1.48 ± 0.00	0.19 ± 0.05	0.07	2.97	7.17 ± 0.36	9.18 ± 3.37	4.13 ± 0.95	0.376 ± 0.129	0.010 ± 0.002	No	
144	1.55 ± 0.00	0.19 ± 0.05	0.07	2.88	7.14 ± 0.31	9.59 ± 2.61	4.04 ± 0.95	0.368 ± 0.127	0.010 ± 0.002	No	
145	1.92 ± 0.00	0.19 ± 0.05	0.07	3.86	7.12 ± 0.29	9.79 ± 2.23	4.02 ± 0.95	0.366 ± 0.127	0.010 ± 0.002	No	
146	1.64 ± 0.00	0.19 ± 0.05	0.07	2.90	7.13 ± 0.30	9.80 ± 2.22	4.03 ± 0.95	0.367 ± 0.127	0.010 ± 0.002	No	
147	2.08 ± 0.00	0.19 ± 0.05	0.07	3.68	7.06 ± 0.19	10.04 ± 1.73	3.83 ± 0.95	0.348 ± 0.124	0.010 ± 0.003	No	
148	1.65 ± 0.00	0.19 ± 0.05	0.07	3.09	7.03 ± 0.14	10.37 ± 1.13	3.74 ± 0.95	0.340 ± 0.122	0.011 ± 0.003	No	
149	0.81 ± 0.00	0.19 ± 0.05	0.34	5.36	4.88 ± 1.22	2.50 ± 0.63	4.65 ± 0.95	0.410 ± 0.135	0.042 ± 0.009	No	
150	0.92 ± 0.00	0.19 ± 0.05	0.34	8.78	4.88 ± 1.22	2.50 ± 0.63	4.65 ± 0.95	0.410 ± 0.135	0.042 ± 0.009	No	
151	1.05 ± 0.00	0.19 ± 0.05	0.34	5.15	4.88 ± 1.22	2.50 ± 0.63	4.65 ± 0.95	0.410 ± 0.135	0.042 ± 0.009	No	
152	1.26 ± 0.00	0.19 ± 0.05	0.34	5.76	4.88 ± 1.22	2.50 ± 0.63	4.65 ± 0.95	0.410 ± 0.135	0.042 ± 0.009	No	
153	1.63 ± 0.00	0.19 ± 0.05	0.34	5.29	4.88 ± 1.22	2.50 ± 0.63	4.65 ± 0.95	0.410 ± 0.135	0.042 ± 0.009	No	
154	1.77 ± 0.00	0.19 ± 0.05	0.34	18.49	4.88 ± 1.22	2.50 ± 0.63	4.65 ± 0.95	0.410 ± 0.135	0.042 ± 0.009	No	
155	2.14 ± 0.00	0.19 ± 0.05	0.34	7.14	4.88 ± 1.22	2.50 ± 0.63	4.65 ± 0.95	0.410 ± 0.135	0.042 ± 0.009	No	
156	2.19 ± 0.00	0.19 ± 0.05	0.34	8.19	4.88 ± 1.22	2.50 ± 0.63	4.65 ± 0.95	0.410 ± 0.135	0.042 ± 0.009	No	
157	2.73 ± 0.00	0.19 ± 0.05	0.34	12.86	4.88 ± 1.22	2.50 ± 0.63	4.65 ± 0.95	0.410 ± 0.135	0.042 ± 0.009	No	
158	3.06 ± 0.00	0.19 ± 0.05	0.34	24.02	4.88 ± 1.22	2.50 ± 0.63	4.65 ± 0.95	0.410 ± 0.135	0.042 ± 0.009	No	
159	3.56 ± 0.00	0.19 ± 0.05	0.34	25.93	4.88 ± 1.22	2.50 ± 0.63	4.65 ± 0.95	0.410 ± 0.135	0.042 ± 0.009	No	
160	1.29 ± 0.00	0.19 ± 0.05	0.34	3.06	6.18 ± 0.40	3.05 ± 0.17	4.06 ± 0.95	0.355 ± 0.125	0.048 ± 0.011	No	
161	1.40 ± 0.00	0.19 ± 0.05	0.34	2.86	6.35 ± 0.40	3.12 ± 0.17	3.98 ± 0.95	0.349 ± 0.124	0.049 ± 0.012	No	
162	0.90 ± 0.00	0.19 ± 0.05	0.34	1.85	4.65 ± 0.65	6.83 ± 0.83	5.75 ± 0.95	0.512 ± 0.155	0.034 ± 0.006	No	
163	0.61 ± 0.00	0.19 ± 0.05	0.34	1.64	3.36 ± 0.84	8.50 ± 2.13	6.84 ± 0.94	0.613 ± 0.177	0.028 ± 0.004	No	
164	1.91 ± 0.00	0.19 ± 0.05	0.26	0.00	4.25 ± 0.10	7.75 ± 1.42	6.45 ± 0.94	0.581 ± 0.170	0.023 ± 0.003	No	
165	1.62 ± 0.00	0.19 ± 0.05	0.34	0.00	4.30 ± 0.10	8.42 ± 1.42	6.34 ± 0.94	0.567 ± 0.167	0.031 ± 0.005	No	
166	2.18 ± 0.00	0.19 ± 0.05	0.61	0.00	4.52 ± 0.59	7.59 ± 4.90	5.85 ± 0.95	0.506 ± 0.154	0.060 ± 0.010	No	
167	1.30 ± 0.00	0.19 ± 0.05	0.38	0.00	4.33 ± 0.10	8.81 ± 1.42	6.28 ± 0.94	0.559 ± 0.165	0.035 ± 0.005	No	
168	2.76 ± 0.00	0.19 ± 0.05	0.35	0.00	4.33 ± 0.10	8.81 ± 1.42	6.28 ± 0.94	0.561 ± 0.165	0.032 ± 0.005	No	
169	1.57 ± 0.00	0.19 ± 0.05	0.38	0.00	4.37 ± 0.10	9.35 ± 1.42	6.20 ± 0.94	0.551 ± 0.163	0.035 ± 0.005	No	
170	0.81 ± 0.00	0.19 ± 0.05	0.21	0.00	3.20 ± 0.41	3.35 ± 0.50	5.98 ± 0.94	0.540 ± 0.161	0.020 ± 0.003	No	
171	0.81 ± 0.00	0.19 ± 0.05	0.24	0.00	3.21 ± 0.41	3.36 ± 0.50	5.97 ± 0.94	0.537 ± 0.160	0.023 ± 0.004	No	
172	0.82 ± 0.00	0.19 ± 0.05	0.27	0.00	3.23 ± 0.41	3.38 ± 0.50	5.95 ± 0.94	0.534 ± 0.160	0.026 ± 0.004	No	
173	1.53 ± 0.00	0.19 ± 0.05	0.27	0.00	3.44 ± 0.41	3.63 ± 0.50	5.76 ± 0.95	0.517 ± 0.156	0.027 ± 0.004	No	
174	1.51 ± 0.00	0.19 ± 0.05	0.21	0.00	3.44 ± 0.41	3.63 ± 0.50	5.76 ± 0.95	0.520 ± 0.157	0.021 ± 0.003	No	
175	1.46 ± 0.00	0.19 ± 0.05	0.27	0.00	3.45 ± 0.41	3.64 ± 0.50	5.75 ± 0.95	0.516 ± 0.156	0.027 ± 0.004	No	
176	1.45 ± 0.00	0.19 ± 0.05	0.35	0.00	3.49 ± 0.41	3.70 ± 0.50	5.71 ± 0.95	0.508 ± 0.154	0.035 ± 0.006	No	
177	1.18 ± 0.00	0.19 ± 0.05	0.24	0.00	3.69 ± 0.41	3.94 ± 0.50	5.52 ± 0.95	0.496 ± 0.152	0.025 ± 0.004	No	
178	1.11 ± 0.00	0.19 ± 0.05	0.24	0.00	3.70 ± 0.41	3.95 ± 0.50	5.52 ± 0.95	0.496 ± 0.152	0.025 ± 0.004	No	
179	1.46 ± 0.00	0.19 ± 0.05	0.24	0.00	3.83 ± 0.41	4.11 ± 0.50	5.39 ± 0.95	0.484 ± 0.149	0.025 ± 0.004	No	
180	1.15 ± 0.00	0.19 ± 0.05	0.24	0.00	4.01 ± 0.41	4.32 ± 0.50	5.23 ± 0.95	0.469 ± 0.146	0.026 ± 0.005	No	
181	1.05 ± 0.00	0.19 ± 0.05	0.24	0.00	4.05 ± 0.41	4.38 ± 0.50	5.18 ± 0.95	0.465 ± 0.146	0.026 ± 0.005	No	
182	0.95 ± 0.00	0.19 ± 0.05	0.16	0.00	4.21 ± 0.41	4.58 ± 0.50	5.03 ± 0.95	0.455 ± 0.144	0.018 ± 0.003	No	
183	1.22 ± 0.00	0.19 ± 0.05	0.20	0.00	4.22 ± 0.41	4.59 ± 0.50	5.02 ± 0.95	0.452 ± 0.143	0.023 ± 0.004	No	
184	1.22 ± 0.00	0.19 ± 0.05	0.24	0.00	5.04 ± 2.00	3.66 ± 1.74	4.51 ± 0.95	0.403 ± 0.133	0.030 ± 0.006	No	
185	1.25 ± 0.00	0.19 ± 0.05	0.24	0.00	5.13 ± 1.84	3.80 ± 1.91	4.42 ± 0.95	0.395 ± 0.132	0.031 ± 0.007	No	
186	0.97 ± 0.00	0.19 ± 0.05	0.13	0.00	5.10 ± 1.21	4.54 ± 1.90	4.35 ± 0.95	0.393 ± 0.132	0.017 ± 0.004	No	
187	1.19 ± 0.00	0.19 ± 0.05	0.11	0.00	5.18 ± 0.87	4.86 ± 1.60	4.25 ± 0.95	0.385 ± 0.130	0.015 ± 0.003	No	
188	10.15 ± 0.00	0.19 ± 0.05	0.11	19.62	7.01 ± 1.75	4.50 ± 1.13	3.58 ± 0.95	0.323 ± 0.119	0.018 ± 0.005	No	
189	1.22 ± 0.00	0.19 ± 0.05	0.11	2.76	5.70 ± 0.42	2.62 ± 0.17	4.51 ± 0.95	0.409 ± 0.135	0.014 ± 0.003	No	
190	1.45 ± 0.00	0.19 ± 0.05	0.11	3.59	5.93 ± 0.42	2.71 ± 0.17	4.34 ± 0.95	0.394 ± 0.132	0.014 ± 0.003	No	
191	5.42 ± 0.00	0.19 ± 0.05	0.11	6.03	6.83 ± 0.06	3.75 ± 0.58	3.70 ± 0.95	0.334 ± 0.121	0.017 ± 0.004	No	
192	7.94 ± 0.00	0.19 ± 0.05	0.11	12.01	6.84 ± 0.06	3.79 ± 0.58	3.69 ± 0.95	0.334 ± 0.121	0.017 ± 0.004	No	
193	5.99 ± 0.00	0.19 ± 0.05	0.11	9.12	7.74 ± 0.50	4.13 ± 2.14	2.89 ± 0.67	0.260 ± 0.089	0.022 ± 0.005	No	
194	8.28 ± 0.00	0.19 ± 0.05	0.00	17.05	6.99 ± 0.01	4.35 ± 0.08	3.37 ± 0.67	0.310 ± 0.099	0.000 ± 0.000	No	
195	8.18 ± 0.00	0.19 ± 0.05	0.00	11.06	6.99 ± 0.01	4.32 ± 0.08	3.34 ± 0.67	0.307 ± 0.098	0.000 ± 0.000	No	
196	3.99 ± 0.00	0.19 ± 0.05	0.11	5.54	6.98 ± 0.01	4.24 ± 0.08	3.23 ± 0.67	0.291 ± 0.095	0.019 ± 0.004	No	
197	3.97 ± 0.00	0.19 ± 0.05	0.00	5.06	6.98 ± 0.01	4.22 ± 0.08	3.20 ± 0.67	0.294 ± 0.096	0.000 ± 0.000	No	
198	3.37 ± 0.00	0.19 ± 0.05	0.11	4.45	6.98 ± 0.01	4.21 ± 0.08	3.19 ± 0.67	0.287 ± 0.094	0.020 ± 0.004	No	

Table 3.5: (Continued)

Case	D_H (m)	a_{max} (g)	S (%)	W (%)	LSI	Zcr. (m)	ϕ' (deg)	a_y/a_{max}	$\tan\beta/\tan\phi'$	Soft Clays?	Reference(s)
199	0.95 ± 0.00	0.19 ± 0.05	0.10	3.27	7.74 ± 1.93	3.70 ± 0.93	6.73 ± 0.94	0.616 ± 0.177	0.008 ± 0.001	No	Database of Youd et al., (2002)
200	1.51 ± 0.00	0.19 ± 0.05	0.10	3.82	7.74 ± 1.93	3.70 ± 0.93	6.73 ± 0.94	0.616 ± 0.177	0.008 ± 0.001	No	
201	1.89 ± 0.00	0.19 ± 0.05	0.10	4.87	7.74 ± 1.93	3.70 ± 0.93	6.73 ± 0.94	0.616 ± 0.177	0.008 ± 0.001	No	
202	1.42 ± 0.00	0.19 ± 0.05	0.64	0.00	3.55 ± 0.50	8.50 ± 0.33	7.71 ± 0.94	0.679 ± 0.191	0.047 ± 0.006	No	
203	1.50 ± 0.00	0.19 ± 0.05	0.48	0.00	4.63 ± 0.50	9.22 ± 0.33	5.72 ± 0.95	0.502 ± 0.153	0.048 ± 0.008	No	
204	1.61 ± 0.00	0.19 ± 0.05	0.38	0.00	4.74 ± 0.50	9.29 ± 0.33	5.52 ± 0.95	0.488 ± 0.150	0.039 ± 0.007	No	
205	1.89 ± 0.00	0.19 ± 0.05	0.48	0.00	5.11 ± 0.50	9.54 ± 0.33	4.83 ± 0.95	0.419 ± 0.137	0.057 ± 0.011	No	
206	1.49 ± 0.00	0.19 ± 0.05	0.48	0.00	5.14 ± 0.50	9.55 ± 0.33	4.79 ± 0.95	0.415 ± 0.136	0.057 ± 0.011	No	
207	2.53 ± 0.00	0.19 ± 0.05	0.40	0.00	6.03 ± 0.36	3.68 ± 1.17	4.60 ± 0.95	0.402 ± 0.133	0.050 ± 0.010	No	
208	2.33 ± 0.00	0.19 ± 0.05	0.34	0.00	5.73 ± 0.36	4.63 ± 1.17	4.57 ± 0.95	0.402 ± 0.133	0.043 ± 0.009	No	
209	3.08 ± 0.00	0.19 ± 0.05	0.52	0.00	5.70 ± 0.36	4.75 ± 1.17	4.56 ± 0.95	0.392 ± 0.132	0.065 ± 0.014	No	
210	3.49 ± 0.00	0.19 ± 0.05	0.44	0.00	5.63 ± 0.36	4.98 ± 1.17	4.55 ± 0.95	0.396 ± 0.132	0.055 ± 0.012	No	
211	2.73 ± 0.00	0.19 ± 0.05	0.40	0.00	5.54 ± 0.36	5.25 ± 1.17	4.54 ± 0.95	0.397 ± 0.132	0.050 ± 0.011	No	
212	3.51 ± 0.00	0.19 ± 0.05	0.53	0.00	5.52 ± 0.36	5.32 ± 1.17	4.54 ± 0.95	0.390 ± 0.131	0.067 ± 0.014	No	
213	3.17 ± 0.00	0.19 ± 0.05	0.55	0.00	5.51 ± 0.36	5.35 ± 1.17	4.54 ± 0.95	0.389 ± 0.131	0.069 ± 0.015	No	
214	2.35 ± 0.00	0.19 ± 0.05	0.55	0.00	5.41 ± 0.36	5.65 ± 1.17	4.53 ± 0.95	0.388 ± 0.131	0.069 ± 0.015	No	
215	3.69 ± 0.00	0.19 ± 0.05	0.57	0.00	5.41 ± 0.36	5.66 ± 1.17	4.53 ± 0.95	0.387 ± 0.130	0.072 ± 0.015	No	
216	3.21 ± 0.00	0.19 ± 0.05	0.52	0.00	5.39 ± 0.36	5.73 ± 1.17	4.52 ± 0.95	0.389 ± 0.131	0.066 ± 0.014	No	
217	1.12 ± 0.00	0.19 ± 0.05	0.41	0.00	5.26 ± 0.36	6.15 ± 1.17	4.51 ± 0.95	0.393 ± 0.132	0.052 ± 0.011	No	
218	2.92 ± 0.00	0.19 ± 0.05	0.56	0.00	5.23 ± 0.36	6.26 ± 1.17	4.50 ± 0.95	0.385 ± 0.130	0.071 ± 0.015	No	
219	2.97 ± 0.00	0.19 ± 0.05	0.64	0.00	5.10 ± 0.36	6.67 ± 1.17	4.49 ± 0.95	0.379 ± 0.129	0.082 ± 0.017	No	
220	2.27 ± 0.00	0.19 ± 0.05	0.33	0.00	5.07 ± 0.36	6.74 ± 1.17	4.49 ± 0.95	0.396 ± 0.132	0.042 ± 0.009	No	
221	3.06 ± 0.00	0.19 ± 0.05	0.66	0.00	5.02 ± 0.36	6.93 ± 1.17	4.48 ± 0.95	0.377 ± 0.129	0.084 ± 0.018	No	
222	2.23 ± 0.00	0.19 ± 0.05	0.47	0.00	4.89 ± 0.36	7.32 ± 1.17	4.47 ± 0.95	0.386 ± 0.130	0.060 ± 0.013	No	
223	1.75 ± 0.00	0.19 ± 0.05	0.40	0.00	5.33 ± 1.19	6.59 ± 3.23	4.94 ± 0.95	0.434 ± 0.139	0.046 ± 0.009	No	
224	2.94 ± 0.00	0.19 ± 0.05	0.64	0.00	4.67 ± 0.36	8.04 ± 1.17	4.44 ± 0.95	0.375 ± 0.128	0.082 ± 0.018	No	
225	3.33 ± 0.00	0.19 ± 0.05	0.63	0.00	5.58 ± 0.29	6.90 ± 0.50	5.68 ± 0.95	0.490 ± 0.151	0.063 ± 0.011	No	
226	4.65 ± 0.00	0.19 ± 0.05	0.63	0.00	5.49 ± 0.29	7.05 ± 0.50	5.58 ± 0.95	0.481 ± 0.149	0.064 ± 0.011	No	
227	4.26 ± 0.00	0.19 ± 0.05	0.63	0.00	5.41 ± 0.29	7.20 ± 0.50	5.49 ± 0.95	0.473 ± 0.147	0.065 ± 0.011	No	
228	3.51 ± 0.00	0.19 ± 0.05	0.92	0.00	5.33 ± 0.29	7.33 ± 0.50	5.41 ± 0.95	0.450 ± 0.143	0.097 ± 0.017	No	
229	3.16 ± 0.00	0.19 ± 0.05	0.63	0.00	5.29 ± 0.29	7.41 ± 0.50	5.37 ± 0.95	0.461 ± 0.145	0.067 ± 0.012	No	
230	3.33 ± 0.00	0.19 ± 0.05	0.51	0.00	5.29 ± 0.29	7.41 ± 0.50	5.37 ± 0.95	0.467 ± 0.146	0.054 ± 0.010	No	
231	3.53 ± 0.00	0.19 ± 0.05	0.81	0.00	5.21 ± 0.29	7.55 ± 0.50	5.28 ± 0.95	0.444 ± 0.141	0.088 ± 0.016	No	
232	2.96 ± 0.00	0.19 ± 0.05	0.51	0.00	5.08 ± 0.29	7.76 ± 0.50	5.15 ± 0.95	0.448 ± 0.142	0.057 ± 0.010	No	
233	3.32 ± 0.00	0.19 ± 0.05	0.63	0.00	4.77 ± 0.29	8.31 ± 0.50	4.82 ± 0.95	0.411 ± 0.135	0.075 ± 0.015	No	
234	1.62 ± 0.00	0.19 ± 0.05	0.29	0.00	5.96 ± 0.95	4.10 ± 3.08	5.03 ± 0.95	0.448 ± 0.142	0.033 ± 0.006	No	
235	3.09 ± 0.00	0.19 ± 0.05	0.36	0.00	6.05 ± 0.82	3.79 ± 2.66	4.98 ± 0.95	0.439 ± 0.141	0.041 ± 0.008	No	
236	1.53 ± 0.00	0.19 ± 0.05	0.43	0.00	6.15 ± 0.64	3.40 ± 2.09	4.92 ± 0.95	0.430 ± 0.139	0.050 ± 0.010	No	
237	1.97 ± 0.00	0.19 ± 0.05	0.27	0.00	6.36 ± 0.12	4.12 ± 1.33	4.36 ± 0.95	0.387 ± 0.131	0.035 ± 0.008	No	
238	1.99 ± 0.00	0.19 ± 0.05	0.27	0.00	6.32 ± 0.12	4.51 ± 1.33	4.31 ± 0.95	0.382 ± 0.130	0.036 ± 0.008	No	
239	3.28 ± 0.00	0.19 ± 0.05	0.38	0.00	6.32 ± 0.12	4.54 ± 1.33	4.31 ± 0.95	0.376 ± 0.129	0.050 ± 0.011	No	
240	3.51 ± 0.00	0.19 ± 0.05	0.47	0.00	6.28 ± 0.12	4.91 ± 1.33	4.25 ± 0.95	0.367 ± 0.127	0.063 ± 0.014	No	
241	3.27 ± 0.00	0.19 ± 0.05	0.38	0.00	6.26 ± 0.12	5.10 ± 1.33	4.23 ± 0.95	0.369 ± 0.127	0.051 ± 0.012	No	
242	3.13 ± 0.00	0.19 ± 0.05	0.34	0.00	6.25 ± 0.12	5.27 ± 1.33	4.20 ± 0.95	0.369 ± 0.127	0.046 ± 0.010	No	
243	3.41 ± 0.00	0.19 ± 0.05	0.54	0.00	6.25 ± 0.12	5.28 ± 1.33	4.20 ± 0.95	0.358 ± 0.125	0.074 ± 0.017	No	
244	3.10 ± 0.00	0.19 ± 0.05	0.30	0.00	6.23 ± 0.12	5.43 ± 1.33	4.18 ± 0.95	0.369 ± 0.127	0.041 ± 0.009	No	
245	1.70 ± 0.00	0.19 ± 0.05	0.35	0.00	6.20 ± 0.12	5.73 ± 1.33	4.14 ± 0.95	0.362 ± 0.126	0.048 ± 0.011	No	
246	3.23 ± 0.00	0.19 ± 0.05	0.43	0.00	5.82 ± 1.05	5.61 ± 4.52	4.34 ± 0.95	0.377 ± 0.129	0.057 ± 0.012	No	
247	3.68 ± 0.00	0.19 ± 0.05	0.53	0.00	6.17 ± 0.12	6.11 ± 1.33	4.08 ± 0.95	0.348 ± 0.123	0.074 ± 0.017	No	
248	3.54 ± 0.00	0.19 ± 0.05	0.63	0.00	6.15 ± 0.12	6.27 ± 1.33	4.06 ± 0.95	0.340 ± 0.122	0.089 ± 0.021	No	
249	3.18 ± 0.00	0.19 ± 0.05	0.46	0.00	6.15 ± 0.12	6.27 ± 1.33	4.06 ± 0.95	0.349 ± 0.124	0.065 ± 0.015	No	
250	3.27 ± 0.00	0.19 ± 0.05	0.37	0.00	5.75 ± 1.10	5.96 ± 4.64	4.31 ± 0.95	0.377 ± 0.129	0.049 ± 0.011	No	
251	3.34 ± 0.00	0.19 ± 0.05	0.37	0.00	5.73 ± 1.12	6.03 ± 4.65	4.31 ± 0.95	0.377 ± 0.129	0.049 ± 0.011	No	
252	2.29 ± 0.00	0.19 ± 0.05	0.71	0.00	3.92 ± 0.78	7.52 ± 0.33	8.10 ± 0.94	0.711 ± 0.198	0.050 ± 0.006	No	
253	1.35 ± 0.00	0.19 ± 0.05	0.54	0.00	5.02 ± 0.78	7.05 ± 0.33	7.12 ± 0.94	0.628 ± 0.180	0.043 ± 0.006	No	
254	1.15 ± 0.00	0.19 ± 0.05	0.29	0.00	5.43 ± 0.31	6.00 ± 0.00	3.63 ± 0.95	0.319 ± 0.118	0.046 ± 0.012	No	
255	1.73 ± 0.00	0.19 ± 0.05	0.34	0.00	5.60 ± 0.31	6.00 ± 0.00	3.72 ± 0.95	0.325 ± 0.119	0.052 ± 0.013	No	
256	1.45 ± 0.00	0.19 ± 0.05	0.34	0.00	5.67 ± 0.31	6.00 ± 0.00	3.77 ± 0.95	0.328 ± 0.120	0.052 ± 0.013	No	
257	1.50 ± 0.00	0.19 ± 0.05	0.35	0.00	5.72 ± 0.31	6.00 ± 0.00	3.79 ± 0.95	0.330 ± 0.120	0.053 ± 0.013	No	
258	1.97 ± 0.00	0.19 ± 0.05	0.43	0.00	5.77 ± 0.31	6.00 ± 0.00	3.82 ± 0.95	0.328 ± 0.120	0.064 ± 0.016	No	
259	2.07 ± 0.00	0.19 ± 0.05	0.45	0.00	5.77 ± 0.31	6.00 ± 0.00	3.82 ± 0.95	0.328 ± 0.120	0.067 ± 0.017	No	
260	1.60 ± 0.00	0.19 ± 0.05	0.60	0.00	5.91 ± 0.31	6.00 ± 0.00	3.90 ± 0.95	0.327 ± 0.120	0.088 ± 0.022	No	
261	1.15 ± 0.00	0.19 ± 0.05	0.34	0.00	6.03 ± 0.31	6.00 ± 0.00	3.96 ± 0.95	0.347 ± 0.123	0.049 ± 0.012	No	
262	1.92 ± 0.00	0.19 ± 0.05	0.41	0.00	6.07 ± 0.31	6.00 ± 0.00	3.98 ± 0.95	0.345 ± 0.123	0.059 ± 0.014	No	
263	1.15 ± 0.00	0.19 ± 0.05	0.32	0.00	6.09 ± 0.31	6.00 ± 0.00	3.99 ± 0.95	0.350 ± 0.124	0.046 ± 0.011	No	
264	1.70 ± 0.00	0.19 ± 0.05	0.39	0.00	6.18 ± 0.31	6.00 ± 0.00	4.04 ± 0.95	0.352 ± 0.124	0.055 ± 0.013	No	

Table 3.5: (Continued)

Case	D_H (m)	a_{max} (g)	S (%)	W (%)	LSI	Zcr. (m)	ϕ' (deg)	a_y/a_{max}	tanβ/tanϕ'	Soft Clays?	Reference(s)
265	1.30 ± 0.00	0.19 ± 0.05	0.36	0.00	6.21 ± 0.31	6.00 ± 0.00	4.06 ± 0.95	0.355 ± 0.125	0.051 ± 0.012	No	Database of Youd et al., (2002)
266	1.00 ± 0.00	0.19 ± 0.05	0.37	0.00	6.26 ± 0.14	1.86 ± 1.00	2.93 ± 0.67	0.250 ± 0.088	0.072 ± 0.016	No	
267	1.37 ± 0.00	0.19 ± 0.05	0.48	0.00	6.18 ± 0.14	2.41 ± 1.00	2.90 ± 0.67	0.242 ± 0.086	0.095 ± 0.022	No	
268	1.20 ± 0.00	0.19 ± 0.05	0.42	0.00	6.15 ± 0.14	2.64 ± 1.00	2.89 ± 0.67	0.244 ± 0.086	0.083 ± 0.019	No	
269	1.40 ± 0.00	0.19 ± 0.05	0.38	0.00	6.07 ± 0.14	3.18 ± 1.00	2.86 ± 0.67	0.243 ± 0.086	0.076 ± 0.018	No	
270	1.40 ± 0.00	0.19 ± 0.05	0.37	0.00	6.00 ± 0.14	3.72 ± 1.00	2.83 ± 0.67	0.241 ± 0.086	0.075 ± 0.018	No	
271	1.00 ± 0.00	0.19 ± 0.05	0.46	0.00	5.90 ± 0.14	4.43 ± 1.00	2.80 ± 0.67	0.233 ± 0.085	0.094 ± 0.022	No	
272	1.20 ± 0.00	0.19 ± 0.05	0.33	0.00	5.77 ± 0.14	5.36 ± 1.00	2.75 ± 0.67	0.235 ± 0.085	0.069 ± 0.017	No	
273	1.30 ± 0.00	0.19 ± 0.05	0.37	0.00	5.36 ± 1.97	4.64 ± 3.32	5.05 ± 0.95	0.445 ± 0.142	0.042 ± 0.008	No	
274	1.50 ± 0.00	0.19 ± 0.05	0.51	0.00	5.76 ± 2.23	4.98 ± 2.56	5.41 ± 0.95	0.471 ± 0.147	0.054 ± 0.009	No	
275	1.10 ± 0.00	0.19 ± 0.05	0.46	0.00	5.66 ± 1.86	4.29 ± 3.28	4.96 ± 0.95	0.432 ± 0.139	0.053 ± 0.010	No	
276	1.40 ± 0.00	0.19 ± 0.05	0.46	0.00	5.68 ± 1.67	4.09 ± 3.31	4.76 ± 0.95	0.414 ± 0.136	0.055 ± 0.011	No	
277	1.30 ± 0.00	0.19 ± 0.05	0.46	0.00	5.80 ± 1.40	3.67 ± 3.11	4.55 ± 0.95	0.394 ± 0.132	0.058 ± 0.012	No	
278	2.03 ± 0.00	0.19 ± 0.05	0.54	0.00	7.45 ± 1.86	6.00 ± 1.50	4.93 ± 0.95	0.425 ± 0.138	0.063 ± 0.012	No	
279	1.37 ± 0.00	0.21 ± 0.05	0.70	7.03	6.18 ± 1.55	4.57 ± 1.14	7.51 ± 0.94	0.594 ± 0.168	0.053 ± 0.007	No	Database of Youd et al., (2002)
280	0.30 ± 0.00	0.21 ± 0.05	0.10	0.00	8.78 ± 2.20	1.83 ± 0.46	3.38 ± 0.67	0.277 ± 0.089	0.017 ± 0.003	No	
281	0.30 ± 0.00	0.21 ± 0.05	0.05	0.00	6.62 ± 1.66	1.52 ± 0.38	2.51 ± 0.67	0.206 ± 0.076	0.011 ± 0.003	No	
282	1.91 ± 0.00	0.31 ± 0.08	0.05	48.98	1.90 ± 0.47	16.77 ± 4.19	22.24 ± 0.82	1.317 ± 0.334	0.001 ± 0.000	No	
283	1.85 ± 0.00	0.31 ± 0.08	0.20	24.59	5.73 ± 2.08	2.77 ± 1.41	5.64 ± 0.95	0.312 ± 0.095	0.020 ± 0.003	No	
284	1.57 ± 0.00	0.31 ± 0.08	0.10	16.07	6.46 ± 0.83	6.76 ± 3.04	9.49 ± 0.93	0.536 ± 0.144	0.006 ± 0.001	No	
285	1.68 ± 0.00	0.55 ± 0.14	1.23	0.00	0.01 ± 0.00	11.89 ± 2.97	40.01 ± 0.56	1.488 ± 0.373	0.015 ± 0.000	No	Database of Youd et al., (2002) Housner, G. et al., (1971)
286	0.51 ± 0.00	0.55 ± 0.14	1.23	0.00	0.64 ± 0.16	7.01 ± 1.75	11.76 ± 0.92	0.355 ± 0.094	0.059 ± 0.005	No	
287	1.22 ± 0.00	0.55 ± 0.14	1.23	0.00	0.00 ± 0.00	12.96 ± 3.24	43.55 ± 0.50	1.686 ± 0.423	0.013 ± 0.000	No	
288	1.68 ± 0.00	0.55 ± 0.14	1.23	0.00	0.34 ± 0.09	9.76 ± 2.44	16.70 ± 0.88	0.521 ± 0.134	0.041 ± 0.002	No	
289	1.68 ± 0.00	0.55 ± 0.14	1.23	0.00	0.33 ± 0.08	14.79 ± 3.70	17.96 ± 0.86	0.565 ± 0.144	0.038 ± 0.002	No	
290	0.28 ± 0.00	0.55 ± 0.14	0.00	5.20	2.59 ± 0.64	11.74 ± 1.56	7.42 ± 0.94	0.237 ± 0.067	0.000 ± 0.000	No	
291	2.03 ± 0.00	0.55 ± 0.14	0.00	18.26	2.08 ± 1.45	9.62 ± 7.17	8.48 ± 0.93	0.271 ± 0.074	0.000 ± 0.000	No	
292	1.80 ± 0.00	0.55 ± 0.14	0.00	17.07	1.87 ± 1.23	9.56 ± 7.05	8.52 ± 0.93	0.272 ± 0.074	0.000 ± 0.000	No	
293	2.01 ± 0.00	0.55 ± 0.14	0.00	15.43	1.75 ± 0.80	8.97 ± 6.42	8.43 ± 0.93	0.270 ± 0.074	0.000 ± 0.000	No	
294	2.13 ± 0.00	0.55 ± 0.14	0.00	13.59	1.65 ± 0.36	8.20 ± 5.91	8.27 ± 0.94	0.264 ± 0.073	0.000 ± 0.000	No	
295	1.45 ± 0.00	0.55 ± 0.14	0.00	13.59	1.57 ± 0.05	7.24 ± 1.67	7.99 ± 0.94	0.255 ± 0.071	0.000 ± 0.000	No	
296	0.46 ± 0.00	0.55 ± 0.14	0.00	4.70	2.06 ± 0.36	13.44 ± 1.40	6.29 ± 0.94	0.200 ± 0.059	0.000 ± 0.000	No	
297	0.53 ± 0.00	0.55 ± 0.14	0.00	4.89	2.15 ± 0.38	13.34 ± 1.30	5.89 ± 0.94	0.188 ± 0.056	0.000 ± 0.000	No	
298	0.51 ± 0.00	0.55 ± 0.14	0.00	5.08	2.28 ± 0.37	13.07 ± 0.72	5.60 ± 0.95	0.178 ± 0.054	0.000 ± 0.000	No	
299	0.36 ± 0.00	0.55 ± 0.14	0.00	5.31	2.44 ± 0.25	12.98 ± 0.26	5.44 ± 0.95	0.173 ± 0.053	0.000 ± 0.000	No	
300	3.25 ± 0.00	0.55 ± 0.14	0.00	18.87	2.35 ± 1.55	10.19 ± 7.36	8.00 ± 0.94	0.256 ± 0.071	0.000 ± 0.000	No	
301	1.98 ± 0.00	0.55 ± 0.14	0.00	19.26	2.41 ± 1.77	10.29 ± 7.34	7.55 ± 0.94	0.241 ± 0.067	0.000 ± 0.000	No	
302	2.77 ± 0.00	0.55 ± 0.14	0.00	19.61	2.54 ± 1.98	10.03 ± 7.16	7.04 ± 0.94	0.225 ± 0.064	0.000 ± 0.000	No	
303	2.62 ± 0.00	0.55 ± 0.14	0.00	19.96	2.76 ± 2.09	9.46 ± 6.98	6.43 ± 0.94	0.205 ± 0.060	0.000 ± 0.000	No	
304	0.25 ± 0.00	0.55 ± 0.14	0.00	5.47	1.50 ± 0.57	14.15 ± 1.80	6.37 ± 0.94	0.203 ± 0.059	0.000 ± 0.000	No	
305	0.99 ± 0.00	0.55 ± 0.14	0.00	20.27	1.99 ± 1.03	7.77 ± 6.22	13.43 ± 0.90	0.434 ± 0.113	0.000 ± 0.000	No	
306	2.44 ± 0.00	0.55 ± 0.14	0.00	20.41	2.17 ± 1.05	7.77 ± 6.08	12.48 ± 0.91	0.402 ± 0.105	0.000 ± 0.000	No	
307	3.15 ± 0.00	0.55 ± 0.14	0.00	20.47	2.21 ± 1.56	8.81 ± 7.05	10.46 ± 0.92	0.336 ± 0.089	0.000 ± 0.000	No	
308	3.17 ± 0.00	0.55 ± 0.14	0.00	20.34	2.38 ± 1.96	9.19 ± 7.10	8.83 ± 0.93	0.283 ± 0.077	0.000 ± 0.000	No	
309	3.15 ± 0.00	0.55 ± 0.14	0.00	20.30	2.75 ± 2.10	8.82 ± 6.81	7.23 ± 0.94	0.231 ± 0.065	0.000 ± 0.000	No	
310	2.92 ± 0.00	0.55 ± 0.14	0.00	19.96	3.24 ± 1.87	7.75 ± 6.00	5.98 ± 0.94	0.190 ± 0.056	0.000 ± 0.000	No	
311	0.00 ± 0.00	0.12 ± 0.03	3.50	1.03	1.25 ± 0.31	5.56 ± 1.39	7.92 ± 0.94	0.864 ± 0.256	0.252 ± 0.030	No	Seed, H. B. et al., (1979)
312	0.00 ± 0.00	0.12 ± 0.03	5.24	0.78	0.04 ± 0.01	15.32 ± 3.83	36.16 ± 0.62	5.445 ± 1.367	0.072 ± 0.002	No	
313	0.00 ± 0.00	0.12 ± 0.03	5.24	0.76	0.32 ± 0.08	15.01 ± 3.75	10.72 ± 0.92	1.130 ± 0.314	0.277 ± 0.024	No	
314	1.00 ± 0.00	0.20 ± 0.05	1.00	0.00	0.96 ± 0.24	12.19 ± 3.05	6.71 ± 0.94	0.537 ± 0.158	0.085 ± 0.012	No	Rojahn, C. et al., (1977)
315	2.00 ± 0.00	0.20 ± 0.05	1.00	0.00	2.49 ± 0.62	10.98 ± 2.75	4.41 ± 0.95	0.335 ± 0.118	0.130 ± 0.028	No	
316	1.00 ± 0.00	0.20 ± 0.05	1.00	0.00	1.76 ± 0.44	7.00 ± 1.75	3.03 ± 0.67	0.215 ± 0.079	0.189 ± 0.042	No	
317	1.00 ± 0.00	0.20 ± 0.05	1.00	0.00	1.24 ± 0.31	5.13 ± 1.28	5.38 ± 0.95	0.420 ± 0.134	0.106 ± 0.019	No	
318	0.86 ± 0.00	0.51 ± 0.13	2.00	4.69	1.65 ± 0.16	3.36 ± 1.55	12.86 ± 0.91	0.406 ± 0.107	0.088 ± 0.006	No	Database of Youd et al., (2002)
319	0.66 ± 0.00	0.51 ± 0.13	1.64	4.80	1.82 ± 0.16	3.26 ± 1.23	11.35 ± 0.92	0.360 ± 0.096	0.082 ± 0.007	No	
320	1.12 ± 0.00	0.51 ± 0.13	1.67	6.67	1.98 ± 0.16	3.17 ± 0.95	9.95 ± 0.93	0.310 ± 0.084	0.095 ± 0.009	No	
321	1.09 ± 0.00	0.51 ± 0.13	1.79	6.15	2.19 ± 0.16	3.05 ± 0.66	8.00 ± 0.94	0.240 ± 0.068	0.127 ± 0.015	No	
322	2.03 ± 0.00	0.51 ± 0.13	1.82	7.89	2.19 ± 0.16	3.04 ± 0.65	7.96 ± 0.94	0.238 ± 0.068	0.130 ± 0.016	No	
323	0.46 ± 0.00	0.51 ± 0.13	2.13	3.52	2.39 ± 0.02	2.92 ± 0.16	6.13 ± 0.94	0.169 ± 0.053	0.198 ± 0.031	No	
324	0.46 ± 0.00	0.51 ± 0.13	2.04	3.68	2.39 ± 0.02	2.92 ± 0.16	6.13 ± 0.94	0.170 ± 0.054	0.190 ± 0.029	No	
325	1.40 ± 0.00	0.51 ± 0.13	1.96	6.35	2.52 ± 0.22	2.86 ± 0.56	5.68 ± 0.95	0.156 ± 0.051	0.197 ± 0.033	No	
326	2.11 ± 0.00	0.51 ± 0.13	1.85	8.05	2.64 ± 0.39	2.81 ± 0.56	5.27 ± 0.95	0.144 ± 0.049	0.201 ± 0.036	No	
327	1.52 ± 0.00	0.51 ± 0.13	1.69	6.45	2.69 ± 0.45	2.79 ± 0.56	5.13 ± 0.95	0.143 ± 0.048	0.188 ± 0.035	No	
328	2.62 ± 0.00	0.51 ± 0.13	1.41	8.57	2.82 ± 0.58	2.73 ± 0.53	4.66 ± 0.95	0.132 ± 0.046	0.173 ± 0.035	No	
329	1.50 ± 0.00	0.51 ± 0.13	1.30	6.15	2.96 ± 0.59	2.66 ± 0.44	4.15 ± 0.95	0.117 ± 0.044	0.179 ± 0.041	No	
330	3.81 ± 0.00	0.51 ± 0.13	1.43	9.16	3.02 ± 0.56	2.63 ± 0.40	3.95 ± 0.95	0.107 ± 0.042	0.207 ± 0.050	No	

Table 3.5: (Continued)

Case	D_H (m)	a_{max} (g)	S (%)	W (%)	LSI	Zcr. (m)	ϕ' (deg)	a_y/a_{max}	tanβ/tanϕ'	Soft Clays?	Reference(s)
331	3.99 ± 0.00	0.51 ± 0.13	2.17	9.60	3.18 ± 0.38	2.56 ± 0.24	3.37 ± 0.67	0.073 ± 0.029	0.368 ± 0.073	No	
332	2.29 ± 0.00	0.51 ± 0.13	1.85	6.78	3.17 ± 0.36	2.56 ± 0.24	3.38 ± 0.67	0.079 ± 0.030	0.314 ± 0.062	No	
333	4.24 ± 0.00	0.51 ± 0.13	2.70	9.38	3.26 ± 0.34	2.53 ± 0.18	3.15 ± 0.67	0.055 ± 0.027	0.490 ± 0.104	No	
334	2.01 ± 0.00	0.51 ± 0.13	2.44	6.56	3.27 ± 0.18	2.50 ± 0.11	2.94 ± 0.67	0.053 ± 0.026	0.475 ± 0.108	No	
335	1.47 ± 0.00	0.51 ± 0.13	5.26	6.56	3.37 ± 0.21	2.48 ± 0.07	3.01 ± 0.67	0.000 ± 0.023	1.093 ± 0.222	No	
336	1.02 ± 0.00	0.51 ± 0.13	4.17	8.05	2.76 ± 0.45	3.54 ± 0.68	11.85 ± 0.91	0.327 ± 0.088	0.199 ± 0.016	No	
337	0.71 ± 0.00	0.51 ± 0.13	5.26	6.78	2.98 ± 0.63	3.22 ± 0.89	9.20 ± 0.93	0.212 ± 0.062	0.325 ± 0.033	No	Database of Youd et al., (2002)
338	2.62 ± 0.00	0.51 ± 0.13	4.35	9.84	2.98 ± 0.63	3.22 ± 0.89	9.17 ± 0.93	0.230 ± 0.066	0.269 ± 0.028	No	
339	1.42 ± 0.00	0.51 ± 0.13	5.00	7.02	3.10 ± 0.61	3.05 ± 0.83	7.72 ± 0.94	0.167 ± 0.053	0.369 ± 0.045	No	
340	3.20 ± 0.00	0.51 ± 0.13	2.78	10.08	3.14 ± 0.57	2.98 ± 0.78	7.12 ± 0.94	0.190 ± 0.057	0.223 ± 0.030	No	
341	0.00 ± 0.00	0.21 ± 0.05	0.56	0.00	0.00 ± 0.00	5.20 ± 1.30	38.72 ± 0.58	3.775 ± 0.947	0.007 ± 0.000	No	
342	0.00 ± 0.00	0.21 ± 0.05	0.56	0.00	0.09 ± 0.02	5.00 ± 1.25	18.09 ± 0.86	1.526 ± 0.390	0.017 ± 0.001	No	
343	0.00 ± 0.00	0.21 ± 0.05	0.56	4.26	0.00 ± 0.00	0.60 ± 0.15	18.61 ± 0.86	1.574 ± 0.401	0.017 ± 0.001	No	
344	0.00 ± 0.00	0.21 ± 0.05	0.56	10.66	0.00 ± 0.00	5.00 ± 1.25	30.21 ± 0.71	2.737 ± 0.689	0.010 ± 0.000	No	
345	0.00 ± 0.00	0.60 ± 0.15	11.00	0.00	2.06 ± 0.52	1.74 ± 0.44	6.28 ± 0.94	0.000 ± 0.027	1.392 ± 0.152	No	
346	0.30 ± 0.00	0.60 ± 0.15	11.00	0.00	2.11 ± 0.53	8.08 ± 2.02	6.28 ± 0.94	0.000 ± 0.027	1.074 ± 0.152	No	Database of Youd et al., (2002)
347	1.00 ± 0.00	0.60 ± 0.15	11.00	0.00	1.69 ± 0.42	11.43 ± 2.86	7.24 ± 0.94	0.028 ± 0.028	0.866 ± 0.114	No	
348	1.00 ± 0.00	0.35 ± 0.09	4.00	0.00	2.89 ± 0.72	2.44 ± 0.61	4.79 ± 0.95	0.125 ± 0.057	0.477 ± 0.095	No	
349	1.14 ± 0.00	0.25 ± 0.06	0.56	0.00	3.01 ± 0.75	3.00 ± 0.75	8.38 ± 0.93	0.567 ± 0.157	0.038 ± 0.004	No	
350	1.23 ± 0.00	0.25 ± 0.06	0.56	0.00	3.01 ± 0.75	3.00 ± 0.75	8.38 ± 0.93	0.567 ± 0.157	0.038 ± 0.004	No	
351	1.28 ± 0.00	0.25 ± 0.06	0.56	0.00	3.01 ± 0.75	3.00 ± 0.75	8.38 ± 0.93	0.567 ± 0.157	0.038 ± 0.004	No	
352	1.31 ± 0.00	0.25 ± 0.06	1.59	0.00	3.34 ± 0.47	5.65 ± 0.50	6.87 ± 0.94	0.417 ± 0.124	0.132 ± 0.018	No	
353	2.21 ± 0.00	0.25 ± 0.06	1.96	0.00	3.82 ± 0.16	5.56 ± 0.67	6.54 ± 0.94	0.379 ± 0.116	0.171 ± 0.025	No	
354	2.34 ± 0.00	0.25 ± 0.06	1.78	0.00	3.47 ± 0.16	7.00 ± 0.67	6.57 ± 0.94	0.389 ± 0.118	0.154 ± 0.022	No	
355	2.28 ± 0.00	0.25 ± 0.06	1.24	0.00	3.30 ± 0.16	7.73 ± 0.67	6.59 ± 0.94	0.412 ± 0.123	0.107 ± 0.015	No	
356	2.26 ± 0.00	0.25 ± 0.06	1.23	0.00	3.28 ± 0.16	7.81 ± 0.67	6.59 ± 0.94	0.413 ± 0.123	0.106 ± 0.015	No	
357	2.34 ± 0.00	0.25 ± 0.06	1.18	0.00	3.27 ± 0.16	7.88 ± 0.67	6.59 ± 0.94	0.415 ± 0.123	0.102 ± 0.015	No	
358	3.10 ± 0.00	0.25 ± 0.06	1.26	0.00	3.16 ± 0.16	8.34 ± 0.67	6.61 ± 0.94	0.412 ± 0.123	0.109 ± 0.016	No	
359	0.97 ± 0.00	0.25 ± 0.06	1.34	0.00	2.67 ± 0.03	4.00 ± 0.33	9.90 ± 0.93	0.643 ± 0.174	0.077 ± 0.007	No	
360	0.79 ± 0.00	0.25 ± 0.06	1.06	0.00	2.69 ± 0.03	4.00 ± 0.33	10.07 ± 0.93	0.667 ± 0.179	0.060 ± 0.006	No	
361	1.03 ± 0.00	0.25 ± 0.06	1.12	0.00	2.74 ± 0.03	4.00 ± 0.33	10.40 ± 0.92	0.688 ± 0.184	0.061 ± 0.006	No	
362	1.22 ± 0.00	0.25 ± 0.06	1.24	0.00	2.75 ± 0.03	4.00 ± 0.33	10.46 ± 0.92	0.687 ± 0.184	0.067 ± 0.006	No	
363	1.28 ± 0.00	0.25 ± 0.06	1.37	0.00	2.75 ± 0.03	4.00 ± 0.33	10.50 ± 0.92	0.685 ± 0.184	0.074 ± 0.007	No	
364	1.58 ± 0.00	0.25 ± 0.06	1.38	0.00	2.75 ± 0.03	4.00 ± 0.33	10.51 ± 0.92	0.685 ± 0.184	0.074 ± 0.007	No	
365	1.31 ± 0.00	0.25 ± 0.06	1.51	0.00	2.76 ± 0.03	4.00 ± 0.33	10.55 ± 0.92	0.682 ± 0.183	0.081 ± 0.007	No	
366	2.31 ± 0.00	0.25 ± 0.06	2.06	0.00	2.77 ± 0.03	4.00 ± 0.33	10.66 ± 0.92	0.668 ± 0.180	0.109 ± 0.010	No	
367	2.77 ± 0.00	0.25 ± 0.06	2.91	0.00	2.79 ± 0.03	4.00 ± 0.33	10.77 ± 0.92	0.641 ± 0.173	0.153 ± 0.013	No	
368	2.66 ± 0.00	0.25 ± 0.06	4.34	0.00	2.80 ± 0.03	4.00 ± 0.33	10.82 ± 0.92	0.586 ± 0.161	0.227 ± 0.020	No	
369	3.02 ± 0.00	0.25 ± 0.06	5.90	0.00	2.81 ± 0.03	4.00 ± 0.33	10.87 ± 0.92	0.526 ± 0.147	0.307 ± 0.027	No	
370	2.23 ± 0.00	0.25 ± 0.06	5.90	0.00	2.82 ± 0.03	4.00 ± 0.33	10.94 ± 0.92	0.531 ± 0.148	0.305 ± 0.026	No	
371	2.28 ± 0.00	0.25 ± 0.06	3.83	0.00	2.82 ± 0.71	4.00 ± 1.00	10.99 ± 0.92	0.619 ± 0.168	0.197 ± 0.017	No	
372	1.63 ± 0.00	0.25 ± 0.06	2.16	0.00	3.88 ± 0.21	5.12 ± 0.17	5.37 ± 0.95	0.289 ± 0.098	0.230 ± 0.041	No	Database of Youd et al., (2002)
373	3.05 ± 0.00	0.25 ± 0.06	4.79	0.00	2.44 ± 0.27	4.00 ± 0.17	11.65 ± 0.92	0.627 ± 0.170	0.232 ± 0.019	No	
374	0.97 ± 0.00	0.25 ± 0.06	2.07	0.00	2.78 ± 0.27	4.22 ± 0.17	10.33 ± 0.92	0.644 ± 0.174	0.114 ± 0.010	No	
375	1.31 ± 0.00	0.25 ± 0.06	1.40	0.00	3.03 ± 0.27	4.38 ± 0.17	9.35 ± 0.93	0.601 ± 0.164	0.085 ± 0.009	No	
376	1.31 ± 0.00	0.25 ± 0.06	1.51	0.00	3.05 ± 0.27	4.39 ± 0.17	9.29 ± 0.93	0.592 ± 0.162	0.092 ± 0.009	No	
377	1.66 ± 0.00	0.25 ± 0.06	1.77	0.00	3.35 ± 0.27	4.57 ± 0.17	8.11 ± 0.94	0.498 ± 0.141	0.124 ± 0.015	No	
378	1.98 ± 0.00	0.25 ± 0.06	2.50	0.00	3.61 ± 0.27	4.74 ± 0.17	7.08 ± 0.94	0.395 ± 0.119	0.201 ± 0.027	No	
379	2.28 ± 0.00	0.25 ± 0.06	2.58	0.00	3.83 ± 0.27	4.88 ± 0.17	6.20 ± 0.94	0.330 ± 0.106	0.238 ± 0.036	No	
380	1.28 ± 0.00	0.25 ± 0.06	1.07	0.00	1.67 ± 0.14	2.14 ± 0.33	11.44 ± 0.92	0.765 ± 0.202	0.053 ± 0.004	No	
381	1.02 ± 0.00	0.25 ± 0.06	1.14	0.00	1.71 ± 0.14	2.25 ± 0.33	11.46 ± 0.92	0.763 ± 0.202	0.056 ± 0.005	No	
382	1.44 ± 0.00	0.25 ± 0.06	1.46	0.00	1.86 ± 0.14	2.62 ± 0.33	11.50 ± 0.92	0.753 ± 0.200	0.072 ± 0.006	No	
383	1.28 ± 0.00	0.25 ± 0.06	1.49	0.00	1.87 ± 0.14	2.64 ± 0.33	11.50 ± 0.92	0.752 ± 0.199	0.073 ± 0.006	No	
384	1.95 ± 0.00	0.25 ± 0.06	1.87	0.00	2.01 ± 0.14	2.98 ± 0.33	11.54 ± 0.92	0.739 ± 0.196	0.092 ± 0.007	No	
385	2.07 ± 0.00	0.25 ± 0.06	2.61	0.00	2.13 ± 0.14	3.26 ± 0.33	11.58 ± 0.92	0.711 ± 0.190	0.127 ± 0.010	No	
386	2.37 ± 0.00	0.25 ± 0.06	2.71	0.00	2.14 ± 0.14	3.29 ± 0.33	11.58 ± 0.92	0.707 ± 0.189	0.132 ± 0.011	No	
387	3.07 ± 0.00	0.25 ± 0.06	5.70	0.00	2.31 ± 0.14	3.70 ± 0.33	11.63 ± 0.92	0.588 ± 0.161	0.277 ± 0.022	No	
388	1.08 ± 0.00	0.25 ± 0.06	0.59	0.00	3.23 ± 0.00	3.23 ± 0.17	3.68 ± 0.95	0.234 ± 0.089	0.092 ± 0.024	No	
389	1.28 ± 0.00	0.25 ± 0.06	0.56	0.00	3.23 ± 0.00	3.36 ± 0.17	3.87 ± 0.95	0.248 ± 0.091	0.083 ± 0.020	No	
390	1.23 ± 0.00	0.25 ± 0.06	0.54	0.00	3.23 ± 0.00	3.42 ± 0.17	3.94 ± 0.95	0.254 ± 0.092	0.078 ± 0.019	No	
391	1.26 ± 0.00	0.25 ± 0.06	0.48	0.00	3.22 ± 0.00	3.61 ± 0.17	4.22 ± 0.95	0.276 ± 0.096	0.065 ± 0.015	No	
392	1.23 ± 0.00	0.25 ± 0.06	2.39	0.00	1.80 ± 0.50	2.52 ± 0.17	7.48 ± 0.94	0.428 ± 0.126	0.182 ± 0.023	No	
393	1.66 ± 0.00	0.25 ± 0.06	0.93	0.00	2.13 ± 0.50	2.63 ± 0.17	6.54 ± 0.94	0.421 ± 0.125	0.081 ± 0.012	No	
394	2.42 ± 0.00	0.25 ± 0.06	1.16	0.00	2.34 ± 0.50	2.70 ± 0.17	5.96 ± 0.94	0.371 ± 0.114	0.111 ± 0.018	No	
395	0.37 ± 0.00	0.25 ± 0.06	0.62	0.00	1.01 ± 0.50	2.25 ± 0.17	9.73 ± 0.93	0.660 ± 0.178	0.036 ± 0.004	No	
396	0.82 ± 0.00	0.25 ± 0.06	0.73	0.00	1.20 ± 0.50	2.32 ± 0.17	9.18 ± 0.93	0.617 ± 0.168	0.045 ± 0.005	No	

Table 3.5: (Continued)

Case	D_H (m)	a_{max} (g)	S (%)	W (%)	LSI	Zcr. (m)	ϕ' (deg)	a_y/a_{max}	tanβ/tanϕ'	Soft Clays?	Reference(s)
397	0.87 ± 0.00	0.25 ± 0.06	0.83	0.00	1.80 ± 0.50	2.52 ± 0.17	7.49 ± 0.94	0.492 ± 0.140	0.063 ± 0.008	No	Database of Youd et al., (2002)
398	1.47 ± 0.00	0.25 ± 0.06	0.83	0.00	1.80 ± 0.50	2.52 ± 0.17	7.49 ± 0.94	0.492 ± 0.140	0.063 ± 0.008	No	
399	1.87 ± 0.00	0.25 ± 0.06	0.91	0.00	2.05 ± 0.50	2.60 ± 0.17	6.78 ± 0.94	0.439 ± 0.128	0.077 ± 0.011	No	
400	1.19 ± 0.00	0.25 ± 0.06	0.93	0.00	2.06 ± 0.50	2.61 ± 0.17	6.74 ± 0.94	0.435 ± 0.128	0.079 ± 0.011	No	
401	1.79 ± 0.00	0.25 ± 0.06	0.95	0.00	2.12 ± 0.50	2.62 ± 0.17	6.58 ± 0.94	0.423 ± 0.125	0.082 ± 0.012	No	
402	1.93 ± 0.00	0.25 ± 0.06	1.35	0.00	1.03 ± 0.37	2.37 ± 0.33	12.84 ± 0.91	0.855 ± 0.224	0.059 ± 0.004	No	
403	1.98 ± 0.00	0.25 ± 0.06	1.35	0.00	1.32 ± 0.37	2.63 ± 0.33	11.74 ± 0.92	0.775 ± 0.205	0.065 ± 0.005	No	
404	2.72 ± 0.00	0.25 ± 0.06	1.35	0.00	1.39 ± 0.37	2.69 ± 0.33	11.46 ± 0.92	0.755 ± 0.200	0.067 ± 0.005	No	
405	1.42 ± 0.00	0.25 ± 0.06	1.35	0.00	1.51 ± 0.37	2.80 ± 0.33	10.99 ± 0.92	0.721 ± 0.192	0.070 ± 0.006	No	
406	1.16 ± 0.00	0.25 ± 0.06	1.07	0.00	1.69 ± 0.37	2.96 ± 0.33	10.29 ± 0.92	0.682 ± 0.183	0.059 ± 0.005	No	
407	1.39 ± 0.00	0.25 ± 0.06	0.94	0.00	1.81 ± 0.37	3.07 ± 0.33	9.83 ± 0.93	0.654 ± 0.177	0.054 ± 0.005	No	
408	1.44 ± 0.00	0.25 ± 0.06	0.67	0.00	2.15 ± 0.37	3.37 ± 0.33	8.49 ± 0.93	0.570 ± 0.157	0.045 ± 0.005	No	
409	0.87 ± 0.00	0.25 ± 0.06	0.67	0.00	2.30 ± 0.37	3.51 ± 0.33	7.90 ± 0.94	0.528 ± 0.148	0.048 ± 0.006	No	
410	1.79 ± 0.00	0.25 ± 0.06	0.67	0.00	2.46 ± 0.37	3.65 ± 0.33	7.26 ± 0.94	0.483 ± 0.138	0.053 ± 0.007	No	
411	1.95 ± 0.00	0.25 ± 0.06	0.61	0.00	2.47 ± 0.37	3.66 ± 0.33	7.22 ± 0.94	0.482 ± 0.138	0.048 ± 0.006	No	
412	1.93 ± 0.00	0.25 ± 0.06	0.53	0.00	2.53 ± 0.37	3.72 ± 0.33	6.96 ± 0.94	0.467 ± 0.134	0.043 ± 0.006	No	
413	1.63 ± 0.00	0.25 ± 0.06	0.44	0.00	2.69 ± 0.37	3.86 ± 0.33	6.35 ± 0.94	0.427 ± 0.126	0.040 ± 0.006	No	
414	0.65 ± 0.00	0.25 ± 0.06	0.78	0.00	0.61 ± 0.15	2.00 ± 0.50	14.42 ± 0.90	0.996 ± 0.258	0.030 ± 0.002	No	
415	0.79 ± 0.00	0.25 ± 0.06	0.58	0.00	0.61 ± 0.15	2.00 ± 0.50	14.42 ± 0.90	1.004 ± 0.260	0.023 ± 0.001	No	
416	0.87 ± 0.00	0.25 ± 0.06	0.67	0.00	0.61 ± 0.15	2.00 ± 0.50	14.42 ± 0.90	1.000 ± 0.259	0.026 ± 0.002	No	
417	0.20 ± 0.00	0.21 ± 0.05	0.47	41.38	1.94 ± 0.48	3.05 ± 0.76	4.41 ± 0.95	0.345 ± 0.117	0.061 ± 0.013	No	Database of Youd et al., (2002) Larsen, S. et al., (1991)
418	0.23 ± 0.00	0.21 ± 0.05	0.47	41.38	1.76 ± 0.10	3.64 ± 0.33	4.73 ± 0.95	0.371 ± 0.122	0.057 ± 0.011	No	
419	0.18 ± 0.00	0.21 ± 0.05	0.47	17.91	1.62 ± 0.10	4.14 ± 0.33	5.00 ± 0.95	0.394 ± 0.126	0.054 ± 0.010	No	
420	0.10 ± 0.00	0.21 ± 0.05	0.47	13.11	0.98 ± 0.12	4.47 ± 0.19	8.48 ± 0.93	0.687 ± 0.189	0.032 ± 0.004	No	
421	0.10 ± 0.00	0.21 ± 0.05	0.47	17.52	0.71 ± 0.66	3.72 ± 0.23	9.99 ± 0.93	0.816 ± 0.219	0.027 ± 0.003	No	
422	0.00 ± 0.00	0.21 ± 0.05	0.47	7.50	0.87 ± 0.66	3.81 ± 0.93	8.82 ± 0.93	0.716 ± 0.196	0.030 ± 0.003	No	
423	0.50 ± 0.00	0.13 ± 0.03	0.00	10.00	1.11 ± 0.28	6.34 ± 1.59	5.32 ± 0.95	0.717 ± 0.220	0.000 ± 0.000	No	Database of Youd et al., (2002) Seed, R. B. et al.,
424	0.28 ± 0.00	0.25 ± 0.06	0.00	32.69	0.95 ± 0.24	1.75 ± 0.44	5.12 ± 0.95	0.359 ± 0.112	0.000 ± 0.000	No	
425	0.25 ± 0.00	0.25 ± 0.06	0.00	29.93	1.97 ± 0.49	11.43 ± 2.86	4.37 ± 0.95	0.306 ± 0.101	0.000 ± 0.000	No	
426	1.00 ± 0.00	0.13 ± 0.03	0.00	10.00	1.77 ± 0.44	13.01 ± 3.25	4.67 ± 0.95	0.654 ± 0.211	0.000 ± 0.000	No	
427	5.00 ± 0.00	0.20 ± 0.05	0.50	50.00	7.73 ± 1.93	9.23 ± 2.31	3.14 ± 0.67	0.249 ± 0.085	0.091 ± 0.019	No	Tokimatsu, K. et al., (1994)
428	2.00 ± 0.00	0.20 ± 0.05	0.50	1.05	7.11 ± 1.78	13.46 ± 3.37	3.37 ± 0.67	0.270 ± 0.089	0.085 ± 0.017	No	
429	1.50 ± 0.00	0.20 ± 0.05	0.50	1.54	7.21 ± 1.80	2.69 ± 0.67	2.79 ± 0.67	0.218 ± 0.080	0.103 ± 0.025	No	
430	4.00 ± 0.00	0.20 ± 0.05	0.50	12.50	4.24 ± 1.06	10.38 ± 2.60	5.09 ± 0.95	0.420 ± 0.134	0.056 ± 0.011	No	
431	1.00 ± 0.00	0.52 ± 0.13	1.00	0.00	0.00 ± 0.00	14.10 ± 3.53	55.30 ± 0.31	2.718 ± 0.680	0.007 ± 0.000	No	Database of Youd et al., (2002) Holzer, T. et al., (1999)
432	1.00 ± 0.00	0.52 ± 0.13	1.00	0.00	0.00 ± 0.00	13.00 ± 3.25	45.50 ± 0.47	1.918 ± 0.481	0.010 ± 0.000	No	
433	1.00 ± 0.00	0.52 ± 0.13	1.00	0.00	0.01 ± 0.00	9.10 ± 2.28	39.89 ± 0.56	1.575 ± 0.395	0.012 ± 0.000	No	
434	1.00 ± 0.00	0.52 ± 0.13	1.00	0.00	0.88 ± 0.22	9.00 ± 2.25	7.29 ± 0.94	0.226 ± 0.065	0.078 ± 0.010	No	
435	0.40 ± 0.00	0.60 ± 0.15	0.10	0.00	5.08 ± 1.27	13.50 ± 3.38	12.17 ± 0.91	0.358 ± 0.094	0.005 ± 0.000	No	Database of Youd et al., (2002) Hausler, E. and sitar, N. (2002) Japanese Geotech-nical Society (1996)
436	0.20 ± 0.00	0.35 ± 0.09	0.10	0.00	0.68 ± 0.17	14.50 ± 3.63	10.88 ± 0.92	0.546 ± 0.145	0.005 ± 0.000	No	
437	1.30 ± 0.00	0.54 ± 0.14	0.00	14.34	6.67 ± 1.67	7.50 ± 1.88	3.75 ± 0.95	0.122 ± 0.043	0.000 ± 0.000	No	
438	1.33 ± 0.00	0.54 ± 0.14	0.00	14.56	6.67 ± 1.67	7.50 ± 1.88	3.75 ± 0.95	0.122 ± 0.043	0.000 ± 0.000	No	
439	1.46 ± 0.00	0.54 ± 0.14	0.00	9.79	6.67 ± 1.67	7.50 ± 1.88	3.75 ± 0.95	0.122 ± 0.043	0.000 ± 0.000	No	
440	2.47 ± 0.00	0.54 ± 0.14	0.00	56.82	6.67 ± 1.67	7.50 ± 1.88	3.75 ± 0.95	0.122 ± 0.043	0.000 ± 0.000	No	
441	2.82 ± 0.00	0.54 ± 0.14	0.00	30.20	6.67 ± 1.67	7.50 ± 1.88	3.75 ± 0.95	0.122 ± 0.043	0.000 ± 0.000	No	
442	0.20 ± 0.00	0.37 ± 0.09	0.10	0.00	0.00 ± 0.00	7.00 ± 1.75	43.37 ± 0.50	2.548 ± 0.639	0.001 ± 0.000	No	
443	0.33 ± 0.00	0.54 ± 0.14	0.00	5.16	6.94 ± 1.74	14.00 ± 3.50	3.88 ± 0.95	0.126 ± 0.044	0.000 ± 0.000	No	
444	1.02 ± 0.00	0.54 ± 0.14	0.00	9.84	6.94 ± 1.74	14.00 ± 3.50	3.88 ± 0.95	0.126 ± 0.044	0.000 ± 0.000	No	
445	1.46 ± 0.00	0.54 ± 0.14	0.00	14.63	6.94 ± 1.74	14.00 ± 3.50	3.88 ± 0.95	0.126 ± 0.044	0.000 ± 0.000	No	
446	1.00 ± 0.00	0.54 ± 0.14	0.00	9.25	6.30 ± 1.58	4.00 ± 1.00	2.90 ± 0.67	0.094 ± 0.032	0.000 ± 0.000	No	
447	1.47 ± 0.00	0.54 ± 0.14	0.00	15.00	6.30 ± 1.58	4.00 ± 1.00	2.90 ± 0.67	0.094 ± 0.032	0.000 ± 0.000	No	
448	0.88 ± 0.00	0.54 ± 0.14	0.00	10.40	6.50 ± 1.63	12.00 ± 3.00	5.86 ± 0.94	0.190 ± 0.057	0.000 ± 0.000	No	
449	1.17 ± 0.00	0.54 ± 0.14	0.00	13.95	6.50 ± 1.63	12.00 ± 3.00	5.86 ± 0.94	0.190 ± 0.057	0.000 ± 0.000	No	
450	1.32 ± 0.00	0.54 ± 0.14	0.00	18.56	6.50 ± 1.63	12.00 ± 3.00	5.86 ± 0.94	0.190 ± 0.057	0.000 ± 0.000	No	
451	0.89 ± 0.00	0.54 ± 0.14	0.00	20.69	6.78 ± 1.70	4.00 ± 1.00	2.95 ± 0.67	0.096 ± 0.032	0.000 ± 0.000	No	
452	0.40 ± 0.00	0.54 ± 0.14	0.00	8.45	6.78 ± 1.70	4.00 ± 1.00	2.95 ± 0.67	0.096 ± 0.032	0.000 ± 0.000	No	
453	0.92 ± 0.00	0.54 ± 0.14	0.00	16.82	6.78 ± 1.70	4.00 ± 1.00	2.95 ± 0.67	0.096 ± 0.032	0.000 ± 0.000	No	
454	0.65 ± 0.00	0.54 ± 0.14	0.00	14.63	6.78 ± 1.70	4.00 ± 1.00	2.95 ± 0.67	0.096 ± 0.032	0.000 ± 0.000	No	
455	0.44 ± 0.00	0.54 ± 0.14	0.00	6.67	6.78 ± 1.70	4.00 ± 1.00	2.95 ± 0.67	0.096 ± 0.032	0.000 ± 0.000	No	
456	0.96 ± 0.00	0.54 ± 0.14	0.00	18.00	6.78 ± 1.70	4.00 ± 1.00	2.95 ± 0.67	0.096 ± 0.032	0.000 ± 0.000	No	
457	5.84 ± 0.29	0.43 ± 0.11	1.00	5.00	3.47 ± 0.87	2.80 ± 0.70	3.46 ± 0.67	0.118 ± 0.040	0.165 ± 0.032	No	Juang, H., Clemson University Website Yuan, H. L., et al. (2003)
458	3.95 ± 0.20	0.43 ± 0.11	1.00	5.00	3.93 ± 0.98	5.80 ± 1.45	6.48 ± 0.94	0.242 ± 0.072	0.088 ± 0.013	No	
459	5.84 ± 0.29	0.43 ± 0.11	1.00	5.00	3.47 ± 0.87	2.80 ± 0.70	3.46 ± 0.67	0.118 ± 0.040	0.165 ± 0.032	No	
460	3.95 ± 0.20	0.43 ± 0.11	1.00	5.00	3.93 ± 0.98	5.80 ± 1.45	6.48 ± 0.94	0.242 ± 0.072	0.088 ± 0.013	No	
461	4.53 ± 0.23	0.43 ± 0.11	1.00	5.00	1.85 ± 0.46	3.20 ± 0.80	12.93 ± 0.91	0.512 ± 0.134	0.044 ± 0.003	No	
462	7.16 ± 0.36	0.43 ± 0.11	1.00	5.00	2.08 ± 0.52	3.00 ± 0.75	5.34 ± 0.95	0.195 ± 0.062	0.107 ± 0.019	No	

Table 3.5: (Continued)

Case	D_H (m)	a_{max} (g)	S (%)	W (%)	LSI	Zcr. (m)	ϕ' (deg)	a_y/a_{max}	tanβ/tanϕ'	Soft Clays?	Reference(s)
463	3.81 ± 0.19	0.43 ± 0.11	1.00	5.00	4.94 ± 1.23	3.50 ± 0.88	3.89 ± 0.95	0.135 ± 0.052	0.147 ± 0.036	No	Juang, H., Clemson University Website Yuan, H. L., et al. (2003)
464	2.28 ± 0.11	0.43 ± 0.11	1.00	5.00	7.25 ± 1.81	10.50 ± 2.63	4.00 ± 0.95	0.140 ± 0.052	0.143 ± 0.034	No	
465	4.98 ± 0.25	0.43 ± 0.11	1.00	5.00	3.75 ± 0.94	2.80 ± 0.70	5.51 ± 0.95	0.202 ± 0.064	0.104 ± 0.018	No	
466	3.31 ± 0.17	0.43 ± 0.11	1.00	5.00	1.56 ± 0.39	5.80 ± 1.45	15.55 ± 0.89	0.625 ± 0.161	0.036 ± 0.002	No	
467	4.85 ± 0.24	0.43 ± 0.11	1.00	5.00	2.92 ± 0.73	5.80 ± 1.45	5.79 ± 0.95	0.213 ± 0.066	0.099 ± 0.016	No	
468	3.82 ± 0.19	0.43 ± 0.11	1.00	5.00	4.26 ± 1.06	5.80 ± 1.45	6.02 ± 0.94	0.223 ± 0.068	0.095 ± 0.015	No	
469	3.55 ± 0.18	0.43 ± 0.11	1.00	5.00	5.06 ± 1.27	4.20 ± 1.05	5.31 ± 0.95	0.194 ± 0.062	0.108 ± 0.019	No	
470	1.92 ± 0.10	0.43 ± 0.11	1.00	5.00	5.63 ± 1.41	21.20 ± 5.30	12.57 ± 0.91	0.497 ± 0.130	0.045 ± 0.003	No	
471	2.12 ± 0.11	0.43 ± 0.11	1.00	5.00	7.21 ± 1.80	2.80 ± 0.70	8.11 ± 0.94	0.309 ± 0.086	0.070 ± 0.008	No	
472	4.24 ± 0.21	0.43 ± 0.11	1.00	5.00	2.03 ± 0.51	7.20 ± 1.80	9.01 ± 0.93	0.346 ± 0.095	0.063 ± 0.007	No	
473	2.08 ± 0.10	0.79 ± 0.20	3.00	0.00	0.67 ± 0.17	1.50 ± 0.38	8.04 ± 0.94	0.140 ± 0.041	0.083 ± 0.025	No	
474	0.96 ± 0.05	0.79 ± 0.20	1.00	5.00	7.34 ± 1.83	3.80 ± 0.95	11.38 ± 0.92	0.242 ± 0.064	0.050 ± 0.004	No	
475	0.45 ± 0.02	0.79 ± 0.20	1.00	5.00	7.94 ± 1.99	1.50 ± 0.38	4.41 ± 0.95	0.085 ± 0.030	0.130 ± 0.028	No	
476	1.00 ± 0.05	0.79 ± 0.20	2.00	0.00	4.78 ± 1.19	6.00 ± 1.50	10.77 ± 0.92	0.215 ± 0.058	0.056 ± 0.009	No	
477	0.56 ± 0.03	0.79 ± 0.20	3.00	5.00	7.95 ± 1.99	1.20 ± 0.30	4.54 ± 0.95	0.062 ± 0.021	0.169 ± 0.079	No	
478	0.16 ± 0.01	0.79 ± 0.20	3.00	0.00	4.67 ± 1.17	2.20 ± 0.55	4.25 ± 0.95	0.056 ± 0.020	0.184 ± 0.090	No	
479	0.59 ± 0.03	0.79 ± 0.20	3.00	0.00	3.03 ± 0.76	4.20 ± 1.05	9.01 ± 0.93	0.162 ± 0.046	0.072 ± 0.020	No	
480	0.60 ± 0.03	0.79 ± 0.20	2.00	0.00	5.83 ± 1.46	10.20 ± 2.55	11.28 ± 0.92	0.227 ± 0.060	0.053 ± 0.008	No	
481	0.51 ± 0.03	0.79 ± 0.20	2.00	0.00	5.85 ± 1.46	6.80 ± 1.70	9.13 ± 0.93	0.178 ± 0.049	0.066 ± 0.013	No	
482	2.96 ± 0.15	0.19 ± 0.05	3.00	5.00	6.78 ± 1.70	4.20 ± 1.05	5.24 ± 0.95	0.324 ± 0.119	0.140 ± 0.059	No	
483	3.83 ± 0.19	0.19 ± 0.05	3.00	5.00	7.50 ± 1.88	1.20 ± 0.30	3.96 ± 0.95	0.206 ± 0.080	0.203 ± 0.104	No	
484	2.21 ± 0.11	0.19 ± 0.05	3.00	5.00	6.35 ± 1.59	4.20 ± 1.05	6.15 ± 0.94	0.408 ± 0.134	0.114 ± 0.043	No	
485	2.72 ± 0.14	0.19 ± 0.05	3.00	5.00	6.64 ± 1.66	1.20 ± 0.30	5.55 ± 0.95	0.353 ± 0.124	0.130 ± 0.053	No	
486	1.58 ± 0.08	0.19 ± 0.05	3.00	5.00	5.38 ± 1.34	2.80 ± 0.70	4.21 ± 0.95	0.229 ± 0.084	0.187 ± 0.092	No	
487	0.73 ± 0.04	0.19 ± 0.05	3.00	5.00	4.00 ± 1.00	4.20 ± 1.05	4.96 ± 0.95	0.298 ± 0.115	0.150 ± 0.066	No	
488	0.97 ± 0.05	0.19 ± 0.05	3.00	5.00	4.57 ± 1.14	2.20 ± 0.55	5.97 ± 0.94	0.391 ± 0.131	0.119 ± 0.046	No	
489	0.49 ± 0.02	0.19 ± 0.05	3.00	5.00	4.03 ± 1.01	2.80 ± 0.70	8.72 ± 0.93	0.647 ± 0.184	0.075 ± 0.021	No	
490	2.48 ± 0.12	0.19 ± 0.05	3.00	5.00	6.41 ± 1.60	1.20 ± 0.30	3.73 ± 0.95	0.185 ± 0.077	0.221 ± 0.117	No	
491	1.47 ± 0.07	0.19 ± 0.05	3.00	5.00	5.61 ± 1.40	8.80 ± 2.20	5.69 ± 0.95	0.366 ± 0.127	0.126 ± 0.050	No	
492	0.89 ± 0.04	0.19 ± 0.05	3.00	5.00	4.60 ± 1.15	4.20 ± 1.05	5.98 ± 0.94	0.392 ± 0.132	0.118 ± 0.046	No	
493	0.99 ± 0.05	0.19 ± 0.05	3.00	5.00	4.70 ± 1.18	8.80 ± 2.20	4.26 ± 0.95	0.234 ± 0.085	0.184 ± 0.090	No	
494	1.70 ± 0.08	0.19 ± 0.05	3.00	5.00	5.66 ± 1.42	4.20 ± 1.05	4.98 ± 0.95	0.300 ± 0.115	0.149 ± 0.066	No	
495	2.20 ± 0.00	0.40 ± 0.10	1.60	0.00	4.54 ± 1.14	9.80 ± 2.45	4.07 ± 0.95	0.138 ± 0.054	0.225 ± 0.053	No	Cetin, K. O. et al. (2002a) Cetin, K. O. et al. (2004) Kanibir, A. (2003) PEER Website
496	1.30 ± 0.00	0.40 ± 0.10	1.76	0.00	1.78 ± 0.45	0.77 ± 0.19	10.48 ± 0.92	0.417 ± 0.112	0.095 ± 0.009	No	
497	2.13 ± 0.00	0.40 ± 0.10	1.88	0.00	3.88 ± 0.97	2.77 ± 0.69	3.86 ± 0.95	0.122 ± 0.051	0.279 ± 0.069	No	
498	1.21 ± 0.00	0.40 ± 0.10	1.02	0.00	3.78 ± 0.95	9.77 ± 2.44	6.42 ± 0.94	0.256 ± 0.076	0.091 ± 0.013	No	
499	1.37 ± 0.00	0.40 ± 0.10	1.38	0.00	4.98 ± 1.25	4.80 ± 1.20	4.09 ± 0.95	0.144 ± 0.055	0.193 ± 0.045	No	
500	2.92 ± 0.00	0.40 ± 0.10	2.02	0.00	4.16 ± 1.04	4.72 ± 1.18	3.75 ± 0.95	0.113 ± 0.050	0.308 ± 0.078	Yes	
501	2.92 ± 0.00	0.40 ± 0.10	1.44	0.00	4.31 ± 1.08	5.57 ± 1.39	11.76 ± 0.92	0.483 ± 0.128	0.069 ± 0.006	Yes	
502	2.74 ± 0.00	0.40 ± 0.10	2.04	0.00	3.56 ± 0.89	5.72 ± 1.43	3.12 ± 0.67	0.085 ± 0.036	0.374 ± 0.080	Yes	
503	2.92 ± 0.00	0.40 ± 0.10	1.32	0.00	5.50 ± 1.38	1.22 ± 0.31	10.57 ± 0.92	0.432 ± 0.116	0.071 ± 0.006	Yes	
504	1.67 ± 0.00	0.40 ± 0.10	2.00	0.00	4.23 ± 1.06	4.42 ± 1.11	4.77 ± 0.95	0.158 ± 0.057	0.240 ± 0.048	No	
505	2.06 ± 0.00	0.40 ± 0.10	1.72	0.00	5.97 ± 1.49	4.22 ± 1.06	4.93 ± 0.95	0.172 ± 0.060	0.199 ± 0.039	No	
506	1.10 ± 0.00	0.40 ± 0.10	1.20	0.00	2.96 ± 0.74	3.10 ± 0.78	5.19 ± 0.95	0.197 ± 0.064	0.132 ± 0.024	No	
507	1.73 ± 0.00	0.40 ± 0.10	1.60	0.00	1.60 ± 0.40	1.72 ± 0.43	11.64 ± 0.92	0.473 ± 0.125	0.078 ± 0.006	No	
508	2.92 ± 0.00	0.40 ± 0.10	1.30	0.00	5.23 ± 1.31	1.80 ± 0.45	3.76 ± 0.95	0.132 ± 0.053	0.198 ± 0.050	Yes	
509	1.37 ± 0.00	0.40 ± 0.10	1.56	0.00	3.32 ± 0.83	1.80 ± 0.45	9.90 ± 0.93	0.396 ± 0.107	0.089 ± 0.009	No	
510	1.47 ± 0.00	0.40 ± 0.10	1.72	0.00	1.60 ± 0.40	7.72 ± 1.93	12.20 ± 0.91	0.496 ± 0.131	0.080 ± 0.006	No	
511	0.78 ± 0.09	0.40 ± 0.10	1.48	0.00	2.41 ± 0.60	4.72 ± 1.18	7.14 ± 0.94	0.276 ± 0.080	0.109 ± 0.016	No	
512	0.33 ± 0.00	0.40 ± 0.10	0.20	0.00	1.65 ± 0.41	1.70 ± 0.43	5.51 ± 0.95	0.236 ± 0.072	0.021 ± 0.004	No	
513	1.20 ± 0.00	0.40 ± 0.10	0.20	0.00	1.74 ± 0.44	1.70 ± 0.43	3.90 ± 0.95	0.165 ± 0.059	0.029 ± 0.007	Yes	
514	0.70 ± 0.38	0.40 ± 0.10	1.20	0.00	6.39 ± 1.60	4.40 ± 1.10	2.67 ± 0.67	0.087 ± 0.036	0.257 ± 0.064	No	
515	1.30 ± 0.28	0.40 ± 0.10	4.00	0.00	7.52 ± 1.88	1.10 ± 0.28	3.86 ± 0.95	0.068 ± 0.045	0.593 ± 0.146	No	
516	0.70 ± 0.38	0.40 ± 0.10	2.00	0.00	7.76 ± 1.94	1.30 ± 0.33	4.13 ± 0.95	0.130 ± 0.053	0.277 ± 0.064	No	
517	0.10 ± 0.04	0.40 ± 0.10	0.30	0.00	0.14 ± 0.04	9.95 ± 2.49	24.74 ± 0.79	1.143 ± 0.289	0.007 ± 0.000	No	
518	0.10 ± 0.04	0.40 ± 0.10	0.30	0.00	0.24 ± 0.06	4.05 ± 1.01	8.40 ± 0.93	0.362 ± 0.100	0.020 ± 0.002	No	
519	0.30 ± 0.00	0.12 ± 0.03	1.00	0.00	0.56 ± 0.14	2.75 ± 0.69	3.12 ± 0.67	0.371 ± 0.134	0.183 ± 0.039	No	Holzer, T., et al. (2004)
520	0.30 ± 0.00	0.12 ± 0.03	1.00	0.00	0.56 ± 0.14	3.60 ± 0.90	2.92 ± 0.67	0.342 ± 0.129	0.196 ± 0.045	No	
521	0.30 ± 0.00	0.12 ± 0.03	1.00	0.00	0.46 ± 0.12	4.10 ± 1.03	2.82 ± 0.67	0.327 ± 0.127	0.203 ± 0.048	No	
522	0.30 ± 0.00	0.12 ± 0.03	0.10	0.00	1.44 ± 0.36	5.50 ± 1.38	2.91 ± 0.67	0.415 ± 0.142	0.020 ± 0.005	No	
523	0.20 ± 0.00	0.12 ± 0.03	0.10	0.00	0.97 ± 0.24	3.80 ± 0.95	4.19 ± 0.95	0.602 ± 0.205	0.014 ± 0.003	No	
524	0.10 ± 0.00	0.12 ± 0.03	0.10	0.00	0.00 ± 0.00	5.60 ± 1.40	39.02 ± 0.58	6.739 ± 1.691	0.001 ± 0.000	No	
525	0.20 ± 0.00	0.31 ± 0.08	0.10	0.00	2.29 ± 0.57	11.00 ± 2.75	6.56 ± 0.94	0.368 ± 0.106	0.009 ± 0.001	No	Sasajima, T., et al. (2003, and 2005)
526	0.14 ± 0.00	0.31 ± 0.08	0.10	0.00	0.92 ± 0.23	11.00 ± 2.75	12.16 ± 0.91	0.692 ± 0.181	0.005 ± 0.000	No	

3.6 Data Processing

The overall case histories database were assessed for the purpose of estimating the controlling variables of the proposed model. Regarding old case histories, some essential modifications to Youd et al. (2002) database processing technique have been adopted. Figure 3.6 shows an illustrative case on how case history data is presented in Youd et al. (2002) database.

The first modification was applied to the estimations of dry and moist soil unit weights. In Youd et al (2002) database, the values of soil unit weights were assumed to be constant throughout the soil depth of interest independent of the density and stress state. Additionally, it was observed that linear interpolation was used to generate pseudo SPT-N values of the starting and ending depths of the liquefied zones. Contrary to this, in the proposed assessment technique, dry and saturated unit weights were assigned as a function of SPT-N values, considering the density and stress state at the depth of interest as shown in Table 3.6.

For each case history, the soil profile was sub-layered starting from the GWT depth, in such a way that each SPT-N value was located in the mid depth of the corresponding sub-layer. These modifications were quite essential for determining the most critical sub-layer and its related characteristics, as a basic step in the analysis procedure applied in this study. An illustrative example for the analysis of one case history is explained in detail in the next section, to clarify the analysis procedure, input data, and output results.

Table 3.6: SPT-N related dry and moist soil unit weights, and shear wave velocities.

SPT- N	γ_{dry}(kN/m^3)	γ_{sat}(kN/m^3)	V_S (m/s)
0 – 4	15.0	15.5	125
5 – 10	16.0	16.5	150
11 – 20	17.5	18.0	175
21 – 30	17.5	18.0	200
> 30	18.5	19.0	225

```
 SUMMARY SHEET OF CASE HISTORY INFORMATION AND LIQUEFACTION ANALYSES
EARTHQUAKE:  1964, NIIGATA
BOREHOLE ID. NO.:    204BORING:  3-6
SITE NAME:   PLOT F-10, SECTION I-I'
LOCATION:    PLOT F-10, SECTION I-I'
SOURCE OF HORIZONTAL DISPLACEMENT DATA:
METHOD: PRE & POST EARTHQUAKE PHOTOS
DOCUMENTATION: UNPUBLISHED MAPS FROM HAMADA
MAGNITUDE, M: 7.5
DIST. TO FAULT, R, (km):  21.0
EPICENTRAL DIST. (km):   50
PEAK ACCEL., A, (g):   0.19
DURATION, D, (s):   20
GEOLOGICAL AND TOPOGRAPHICAL MEASUREMENTS
AGE OF SEDIMENTS (yrs):  RECENT
DEPTH TO GROUNDWATER (m):    0.37
AREA OF FAILURE (sq. m):     NOT ESTIMATED
STANDARD PENETRATION AND SOIL MEASUREMENTS
SPT - 2 IN. SAMPLER ASSUMED
HAMMER ENEGRY RATIO:  67       DONUT, ROPE & PULLEY ASSUMED
FIELD BLOW COUNT DATA, BOUNDARIES AND LIQUEFIABLE ZONES
DEPTH SOIL DESCRIPTION N  N160 %F %C  D50 DRY UNIT WT MOIST UNIT WT
 (m)                                  (mm)  (kN/m3)      (kN/m3)
* 0.00 BOUNDARY      3.0  4.0  15  5  0.100  12.730      14.780
S-0.41 FILL          3.0  4.0  15  5  0.100  12.730      14.780
*-1.00 FILL          3.0  4.0  15  5  0.100  12.730      14.780
*-2.00 FILL          3.0  4.0  15  5  0.100  12.730      14.780
*-3.00 FILL          8.0  10.7 15  5  0.100  12.730      14.780
E-3.66 FILL          9.1  16.3 15  5  0.100  12.730      14.780
*-4.00 FILL          11.0 19.7 15  5  0.100  12.730      14.780
S-4.50 BOUNDARY      10.0 17.9  5  1  0.350  15.720      17.610
*-5.00 MEDIUM SAND   10.0 16.8  5  1  0.350  15.720      17.610
E-5.86 MEDIUM SAND   13.7 21.0  5  1  0.350  15.720      17.610
*-6.00 MEDIUM SAND   15.0 22.6  5  1  0.350  15.720      17.610
S-6.66 MEDIUM SAND   15.0 21.4  5  1  0.350  15.720      17.610
*-7.00 MEDIUM SAND   15.0 20.8  5  1  0.350  15.720      17.610
*-8.00 MEDIUM SAND   14.0 18.0  5  1  0.350  15.720      17.610
*-9.00 MEDIUM SAND   11.0 13.3  5  1  0.350  15.720      17.610
*-10.00MEDIUM SAND   13.0 14.8  5  1  0.350  15.720      17.610
*-11.00MEDIUM SAND   16.0 17.3  5  1  0.350  15.720      17.610
E-11.86MEDIUM SAND   18.2 18.9  5  1  0.350  15.720      17.610
*-12.00MEDIUM SAND   19.0 19.7  5  1  0.350  15.720      17.610
S-12.66MEDIUM SAND   17.9 18.0  5  1  0.350  15.720      17.610
*-13.00MEDIUM SAND   16.0 15.9  5  1  0.350  15.720      17.610
*-14.00MEDIUM SAND   12.0 11.5  5  1  0.350  15.720      17.610
E-14.76MEDIUM SAND   17.6 16.3  5  1  0.350  15.720      17.610
*-15.00MEDIUM SAND   22.0 20.4  5  1  0.350  15.720      17.610
*-16.00MEDIUM SAND   29.0 25.9  5  1  0.350  15.720      17.610
*-16.30BOUNDARY      36.0 31.8  8  1  0.150  15.250      17.140
*-17.00FINE SAND     36.0 31.0  8  1  0.150  15.250      17.140
*-18.00FINE SAND     18.0 15.1  8  1  0.150  15.250      17.140
S-18.20BOUNDARY      12.0 10.1  5  1  0.350  15.720      17.610
*-19.00MEDIUM SAND   12.0 9.8   5  1  0.350  15.720      17.610
E-19.86MEDIUM SAND   16.5 13.1  5  1  0.350  15.720      17.610
*-20.00MEDIUM SAND   18.0 14.3  5  1  0.350  15.720      17.610
S = START OF LIQUEFIED ZONE, E = END OF LIQUEFIED ZONE
```

Figure 3.6: Example of raw data summary sheet from Youd et al. (2002) database.

3.7 Illustrative Example

In this section, a detailed discussion on how individual case histories of the overall database had been processed will be presented. Assumptions and methodologies adopted throughout the assessment will be illustrated.

Site Description

The liquefaction case history of the Hotel Sapanca site SH-11, located on the southern cost line of Sapanca Lake-Turkey, shown in Figures 3.7 and 3.8, is selected as an example to illustrate the procedure adopted in this study for estimating the representative values of the proposed model controlling variables for a typical seismic soil liquefaction-induced lateral spreading case history.

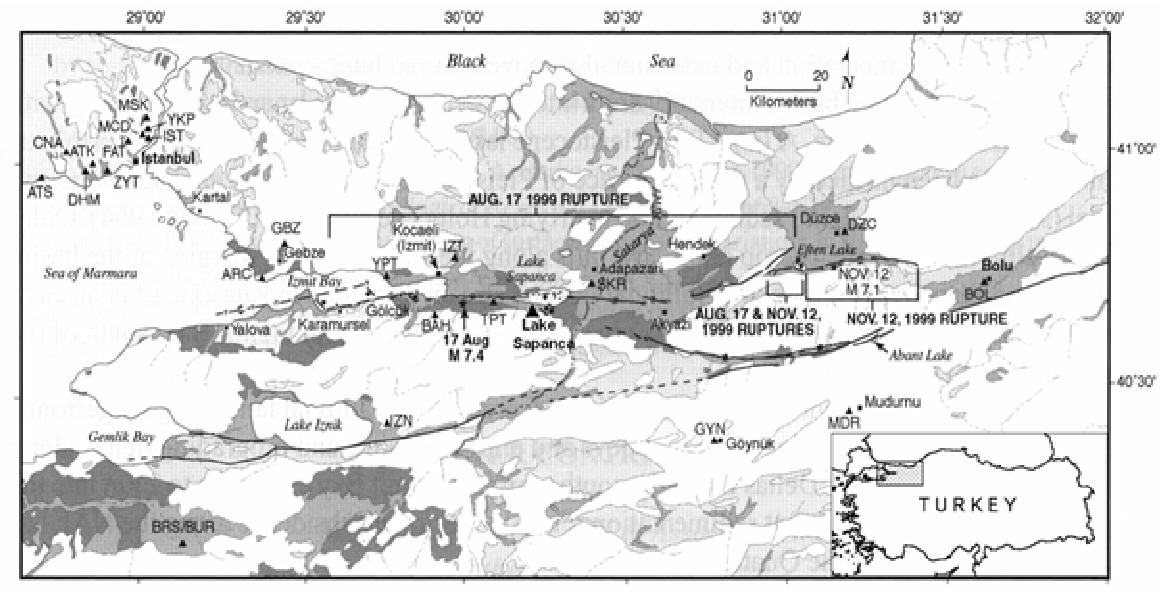


Figure 3.7: General map for the 1999 Kocaeli (Izmit)-Turkey Earthquake. (After Cetin et al., 2002a)

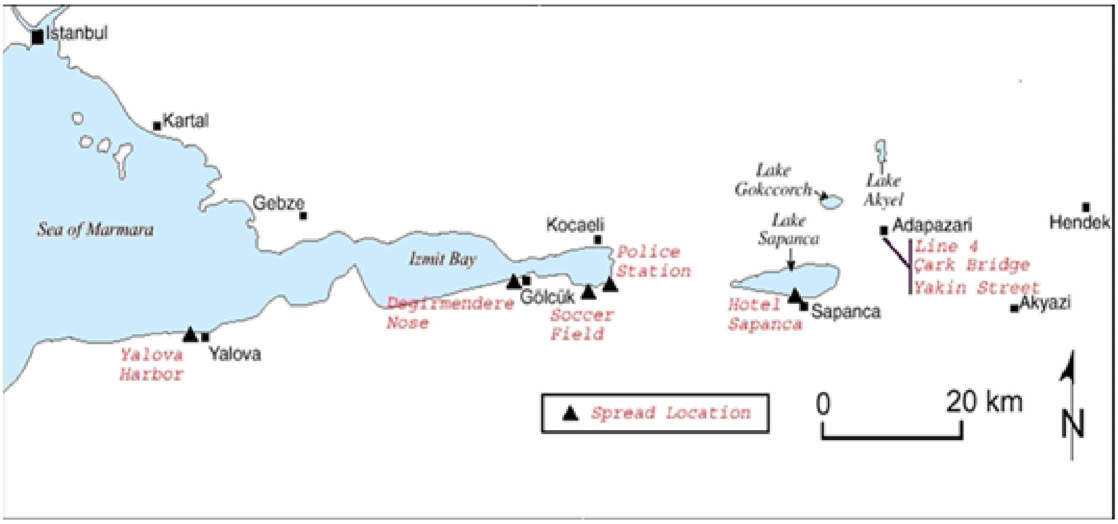


Figure 3.8: Location of Lake Sapanca-Turkey. (Source: http://peer.berkeley.edu/turkey/adapazari)

Immediately after the 17th of August 1999 Kocaeli-Izmit earthquake ($M_w = 7.4$), this site was carefully investigated and mapped for lateral ground deformations, (Cetin et al., 2002a), as shown in Figures 3.9, and 3.10, respectively. The site is underlain by layers of dark gray gravelly silty sand, with uncorrected SPT-N values in the range of 2 to 19, as shown in Figure 3.11.

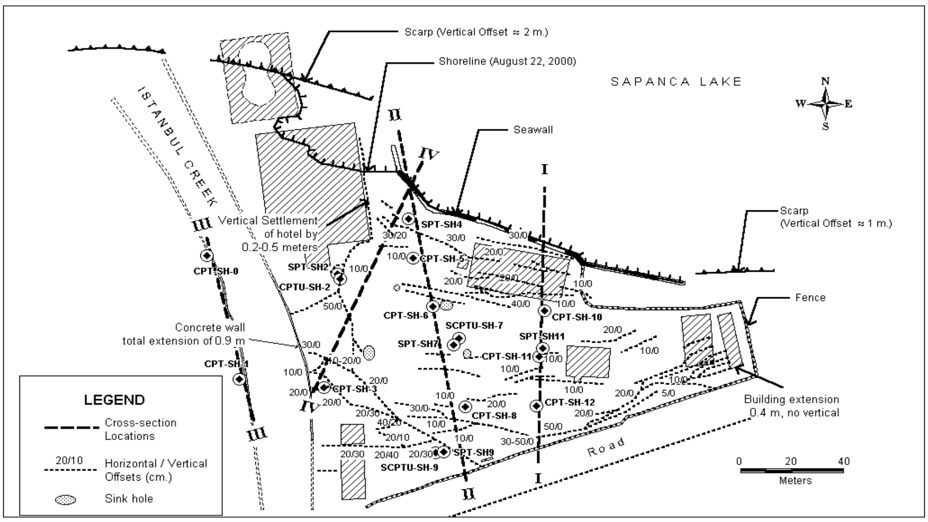


Figure 3.9: Ground deformation map of the Hotel Sapanca site. (Cetin et al., 2002a)

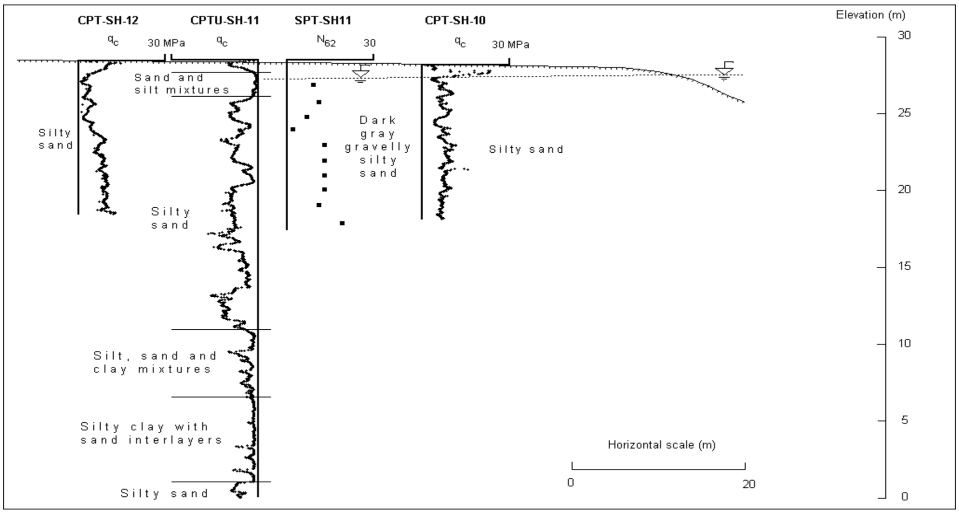
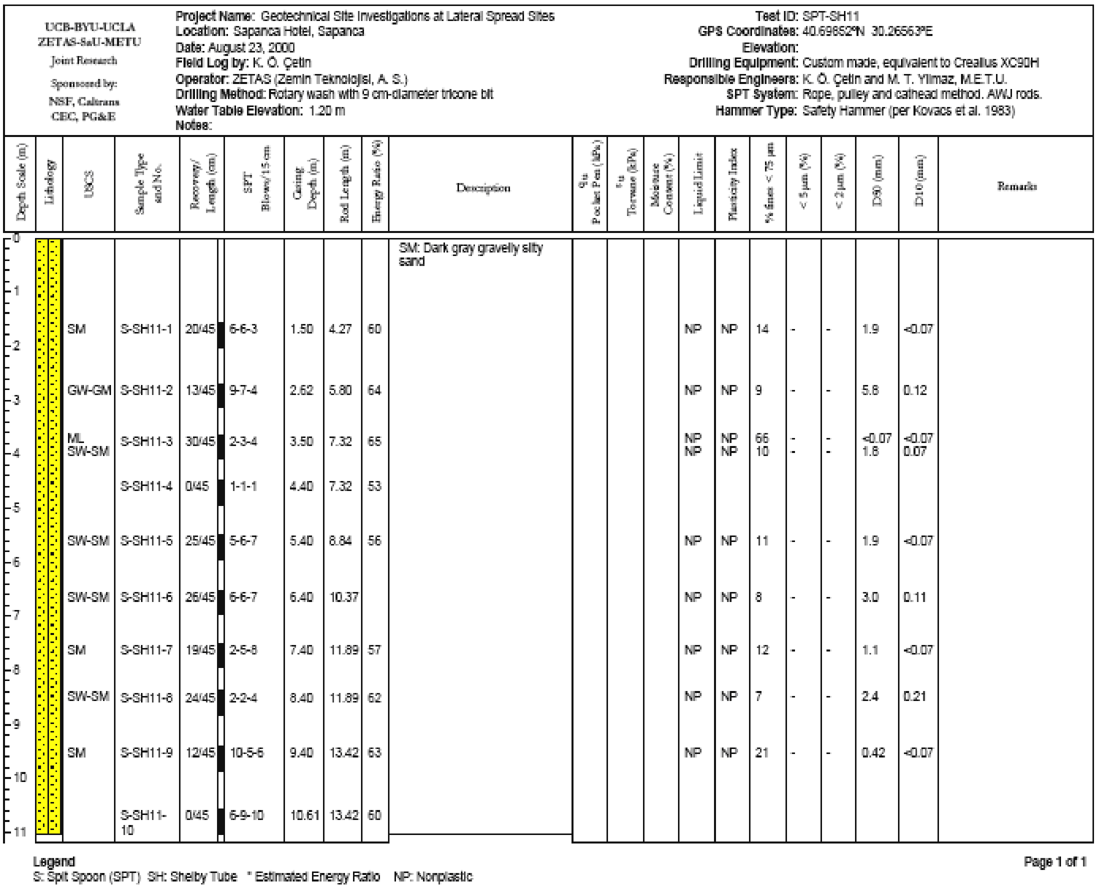


Figure 3.10: Original SH-11 borehole data. (Cetin et al., 2002a)



UCB-BYU-UCLA
ZETAS-SaU-METU
Joint Research
Sponsored by:
NSF, Caltrans
CEC, PG&E

Project Name: Geotechnical Site Investigations at Lateral Spread Sites
Location: Sapanca Hotel, Sapanca
Date: August 23, 2000
Field Log by: K. Ö. Çetin
Operator: ZETAS (Zemin Teknolojisi, A. S.)
Drilling Method: Rotary wash with 9 cm-diameter tricone bit
Water Table Elevation: 1.20 m
Notes:

Test ID: SPT-SH11
GPS Coordinates: 40.69852°N 30.26563°E
Elevation:
Drilling Equipment: Custom made, equivalent to Craelius XC90H
Responsible Engineers: K. Ö. Çetin and M. T. Yilmaz, M.E.T.U.
SPT System: Rope, pulley and cathead method. AWJ rods.
Hammer Type: Safety Hammer (per Kovacs et al. 1983)

USCS	Sample Type and No.	Recovery/ Length (cm)	SPT Blows/15 cm	Casing Depth (m)	Rod Length (m)	Energy Ratio (%)	Description	q_u Pocket Pen (kPa)	s_u Torvane (kPa)	Moisture Content (%)	Liquid Limit	Plasticity Index	% fines < 75 μm	< 5 μm (%)	< 2 μm (%)	D50 (mm)	D10 (mm)	Remarks
							SM: Dark gray gravelly silty sand											
SM	S-SH11-1	20/45	6-6-3	1.50	4.27	60					NP	NP	14	-	-	1.9	<0.07	
GW-GM	S-SH11-2	13/45	9-7-4	2.62	5.80	64					NP	NP	9	-	-	5.8	0.12	
ML SW-SM	S-SH11-3	30/45	2-3-4	3.50	7.32	65					NP NP	NP NP	66 10	- -	- -	<0.07 1.8	<0.07 0.07	
	S-SH11-4	0/45	1-1-1	4.40	7.32	53												
SW-SM	S-SH11-5	25/45	5-6-7	5.40	8.84	56					NP	NP	11	-	-	1.9	<0.07	
SW-SM	S-SH11-6	26/45	6-6-7	6.40	10.37						NP	NP	8	-	-	3.0	0.11	
SM	S-SH11-7	19/45	2-5-8	7.40	11.89	57					NP	NP	12	-	-	1.1	<0.07	
SW-SM	S-SH11-8	24/45	2-2-4	8.40	11.89	62					NP	NP	7	-	-	2.4	0.21	
SM	S-SH11-9	12/45	10-5-6	9.40	13.42	63					NP	NP	21	-	-	0.42	<0.07	
	S-SH11-10	0/45	6-9-10	10.61	13.42	60												

Legend
S: Spit Spoon (SPT) SH: Shelby Tube * Estimated Energy Ratio NP: Nonplastic

Page 1 of 1

Figure 3.11: Processed SH-11 borehole data. (Source: peer.berkeley.edu/turkey/adapazari)

Selection of Input Data

As the basic input data, ground water table was found at a depth of ≅ 1.2 m, ground surface slope was estimated from Figure 3.24 as ≅ 1.2 %, and no free-face boundary conditions were reported. Borehole diameter was presented as 99 mm, and soil dry unit weight ≅ 16 kN/m^3. In order to estimate the site maximum ground acceleration, Cetin et al. (2002a) presented a summary of selected near fault strong ground-motion stations and key characteristics of their records, as shown in Table 3.7. In addition to available strong ground motion records, the results of one-dimensional equivalent linear site response studies performed using SHAKE-91 led to the conclusion that the peak horizontal ground acceleration at the Hotel Sapanca site was on the order of 0.35g to 0.45g. Hence, maximum ground horizontal acceleration for this site was selected as ≅ 0.4 g.

Table 3.7: Summary of selected main shock strong motion records for the stations shown in Figure 3.7. (After Cetin et al., 2002a)

Station	Station Coordinates	Distance to rupture plane (km)	Site Class	Peak Horizontal Acceleration (g) Strong Comp.	Weak Comp.
Sakarya (SKR)	40.737° N 30.384° E	3.3	Stiff Soil	0.407 (E)	N/A (S)
Yarimca (YPT)	40.763° N 29.761° E	4.4	Soft Soil	0.262 (E)	0.298 (N)
Izmit (IZT)	40.790° N 29.960° E	7.7	Rock	0.226 (E)	0.169 (S)
Duzce (DZC)	40.850° N 31.170° E	14.2	Soft Soil	0.368 (W)	0.322 (S)

The soil profile was then sub-layered, starting from the GWT depth, with each SPT-N point located at the mid height of its corresponding sub-layer, as shown in Figure 3.12. The soil moist unit weight and shear wave velocity for each sub-layer were then estimated based on SPT-N value vs. unit weight correlations, shown in Table 3.6. Then the processed soil profile in Figure 3.11 was used to input the rod length, energy ratio, fines content, and mean particle diameter for each sub-layer. After that, for each SPT-N data point the total and effective stress was calculated, the correction factors and consequently $N_{1,60}$ value were calculated based on the procedure discussed in Section 2.4.3.

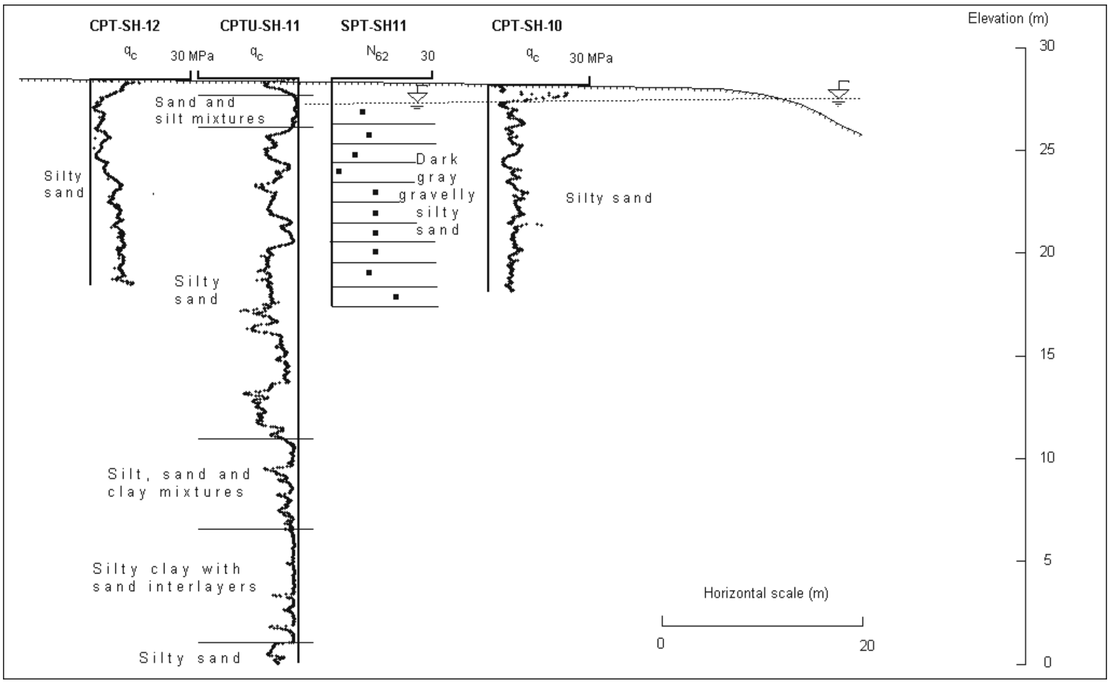


Figure 3.12: SH-11 soil profile after sub-layering according to SPT-N data points.

Data Processing

Microsoft Excel was employed to design the spread sheet shown in Figure 3.13, which was used for analyzing all the compiled liquefaction-induced lateral ground spreading case histories throughout this study. The final calculations of the output

Earthquake	Sub-Layer[a]	Soil Type	Initial Depth (m)	Final Depth (m)	SPT-N Depth (m)	Sub-Layer H (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	$C_N{}^d$	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	$P_{Liq.}$	W_{LSI}	$N_{1,60,CS}$	$\phi'_{eqv,liq}$
Kocaeli	1	Silty Sand	1.20	2.20	1.50	1.00	9	4.27	18.0	24.6	21.7	1.00	1.00	1.00	60	1.00	2.00	18	14	1.9	175	0.98	0.29	0.23	0.78	0.578	0.93	20	15.93
Mw	2	Silty Sand	2.20	3.30	2.62	1.10	11	5.80	18.0	44.8	30.8	1.00	1.00	1.00	64	1.07	1.80	21	9	5.8	200	0.96	0.36	0.25	0.69	0.791	0.87	22	18.35
7.4	3	Silty Sand	3.30	4.20	3.50	0.90	7	7.32	18.0	60.6	38.0	1.00	1.00	1.00	65	1.08	1.62	12	10	1.8	175	0.94	0.39	0.12	0.31	1.000	0.83	13	9.82
Site	4	Silty Sand	4.20	5.00	4.40	0.80	2	7.32	15.5	75.7	44.3	1.00	1.00	1.00	53	0.88	1.50	3	6	1.8	125	0.91	0.40	0.05	0.13	1.000	0.78	3	2.67
Hotel Sapanca	5	Silty Sand	5.00	6.10	5.40	1.10	13	8.84	18.0	92.4	51.2	1.00	1.00	1.00	56	0.93	1.40	17	11	1.9	175	0.88	0.41	0.16	0.39	1.000	0.73	18	14.57
Data Class	6	Silty Sand	6.10	7.10	6.40	1.00	13	10.37	18.0	110.4	59.4	1.00	1.00	1.00	56	0.93	1.30	16	8	3.0	175	0.84	0.40	0.14	0.33	1.000	0.68	17	13.06
	7	Silty Sand	7.10	8.00	7.40	0.90	13	11.89	18.0	128.4	67.6	1.00	1.00	1.00	57	0.95	1.22	15	12	1.1	175	0.80	0.39	0.13	0.32	1.000	0.63	16	12.77
B. H.	8	Silty Sand	8.00	9.00	8.40	1.00	6	11.89	16.5	145.7	75.0	1.00	1.00	1.00	62	1.03	1.15	7	7	2.4	150	0.75	0.38	0.06	0.17	1.000	0.58	8	4.91
SH11	9	Silty Sand	9.00	10.20	9.40	1.20	11	13.42	18.0	162.9	82.5	1.00	1.00	1.00	63	1.05	1.10	13	21	0.4	175	0.71	0.36	0.11	0.30	1.000	0.53	15	11.32
GWT (m)	10	Silty Sand	10.20	11.20	10.61	1.00	19	13.42	18.0	184.7	92.4	1.00	1.00	1.00	60	1.00	1.04	20	15	2.0	175	0.66	0.35	0.17	0.51	0.990	0.47	22	17.77
1.2	11																												
amax (g)	12																												
0.4	13																												
Samplerb	14																												
NA	15																												
B.H. Diam. (mm)	16																												
95	17																												
Energy Ratioc	18																												
	19																												
N (mean)	20																												
10.4	21																												
γ_{dry} (kN/m^3)	22																												
16.0	23																												
Vs* (m/s)	24																												
167	25																												
Observed (cm)	26																												
70	27																												
Distance (m)	28																												
0	29																												
Liquefied ?	30																										LSI		
	SUM					10.00																					6.39		

Figure 3.13: Typical design for the analysis spread sheet used in this study.

data for each sub-layer included: r_d was calculated using Equations 2.11 and 2.13 or Equations 2.12 and 2.14, V_S^* was calculated based on Equation 2.15, *CSR* was calculated using Equation 2.6, *CRR* was calculated using Equation 2.21, *F.S.* = (CRR/CSR), P_L was calculated using Equation 2.22, W_F was calculated using its definition equation in Section 2.4.5, $N_{1,60,CS}$ was calculated using Equation 2.17, $\phi'_{\text{eqv,liq}}$ was determined using Figure 3.2, and finally, the soil profile *LSI* value was calculated based on Equation 2.23.

Output Results

The use of Microsoft Excel eased the analysis process to a great extent, since all the necessary equations were defined in the spread sheet, and consequently all the calculation steps were executed automatically by employing the basic input data. As a result, the final output results for this case history were picked from the spread sheet after defining the fourth sub-layer to be the most critical, as shown in Figure 3.14, since it has the minimum $\phi'_{\text{eqv,liq}}$ value among the potentially liquefiable sub-layers of this soil profile. The output results included: *LSI* = 6.39, $\phi'_{\text{eqv,liq}}$ = 2.67 degrees, z_{cr} = 4.40 m, M_w = 7.4, a_{max} = 0.40 g, *S* = 1.2%, and finally, *W* = 0.

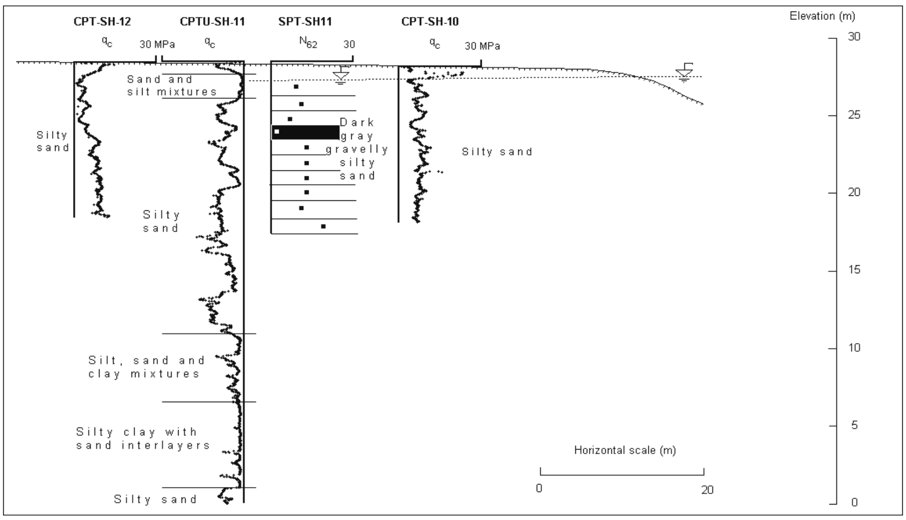


Figure 3.14: The most critical sub-layer for SH-11 site is marked in black.

CHAPTER 4

PROBABILISTIC MODELS FOR LIQUEFACTION-INDUCED LATERAL GROUND SPREADING

4.1 Introduction

This chapter attempts to clarify the essentials of maximum likelihood analysis and the methodology followed to develop a probabilistically-based mathematical model for the problem of seismic soil liquefaction-induced lateral spreading. The philosophical issues as well as the theoretical details regarding the maximum likelihood methodology are beyond the scope of this study. In the maximum likelihood model assessment section, particular attention is given to the discussion of the mathematical liquefaction-induced lateral ground spreading empirical models, with emphasis on the formulation of likelihood functions for exact and inexact observation cases. In addition, the mathematical representations for the uncertainties of the measurable or observable variables, such as *LSI*, $\phi'_{eqv,liq}$, a_{max}, and z_{cr},, are discussed herein.

4.2 Maximum Likelihood Methodology

The procedure of maximum likelihood analyses is one of the most popular methods among statisticians for the derivation of a point estimator for the limit state function parameters directly, (Ang and Tang, 1975). For a given set of independent observations, x_1, x_2,…,x_n, the likelihood function is proportional to the conditional probability of making the observations, given the set of values for the mathematical model parameters, θ’s, as:

$$L(x_1, x_2, ..., x_n|\theta) \propto f(x_1|\theta) \cdot f(x_2|\theta)....f(x_n|\theta) \tag{4.1}$$

Mathematical liquefaction-induced lateral ground spreading models, which will be further implemented in formulating the likelihood function for various cases of error and uncertainty assumptions will be discussed next.

4.3 Sources of Uncertainty

Proper modeling of uncertainties within a probabilistic framework requires understanding the sources of errors for a model. Before discussing the details of the mathematical relationship that will link current knowledge to future predictions, sources of uncertainty, specifically for seismic liquefaction-induced lateral ground spreading empirical models are discussed herein.

4.3.1 Measurement / Estimation Errors

In the process of assessing a model, measurements/estimations of variables under laboratory or field conditions are necessary. Such measurements/estimations are prone to error and this naturally introduces additional uncertainty into the derived model. Specifically, in the liquefaction-induced lateral spreading problem, this kind of uncertainty arises from the errors in the estimation of the values of *LSI*, $\phi'_{eqv,liq}$, z_c, and mapping the observed lateral ground spreading. In addition, predicting or measuring the level of ground shaking, a_{max}, during a seismic event at the site of interest can be prone to measurement/estimation errors.

4.3.2 Simplification Errors (Model Uncertainty)

The nature of modeling implies selection of some, relatively more important aspects of a phenomenon. For the sake of simplicity, and due to lack of data, some of the variables that actually influence the lateral spreading ground deformations such as:

soil gradation, horizontal and vertical permeability of overlying and underlying sub-layers, frequency characteristics of the earthquake shaking, etc. are not incorporated into the proposed liquefaction-induced lateral ground spreading models. Those missing variables may be sources of errors for the resulting predictions. Moreover, incorrect formulation of the variable interactions is a possible source of some additional errors in the estimated behavior. However, the influence of missing parameters and the imperfect functional form of the selected models can be represented by a random model correction term, ε.

4.3.3 Statistical Errors (Model Parameter Uncertainties)

Due to the fuzziness of the boundary between predicted vs. observed lateral ground spreading values, (i.e.: these values do not match perfectly), it is not possible to estimate model parameters defining the lateral spreading boundaries with certainty. The accuracy of the estimated model parameters depends on the size of the available reliable data points. When the database has a limited number of case histories, additional uncertainty is introduced into the model due to statistical errors in estimating the values of model parameters.

4.4 Mathematical Lateral Spreading Models

In general, a mathematical model is a combination of one or more mathematical expressions relating a set of measurable or observable variable quantities, denoted as model descriptive variables, x_i*'s*, and to employ these current variable observations as a future predictive tool, a mathematical formulation with a set of directly unobservable constant values, denoted as model parameters, θ_i*'s*, is needed.

Motivated by the previous empirical lateral spreading models, and series of sensitivity analyses, liquefaction-induced lateral ground deformations may be modeled by employing the predefined controlling descriptive variables, as follows:

Model # 1 (after the model of Hamada et al., 1986),

$$\hat{g}(D_H, H, S, \Theta) = D_H - \theta_1 H^{\theta_2} S^{\theta_3} \tag{4.2}$$

Model # 2 (after the free-face boundary model of Youd et al., 2002)

$$\hat{g}(D_H, M_w, R, W, T15, F15, D5015, \Theta) = \text{Log } D_H - [\theta_1 + \theta_2 M_w + \theta_3 \text{Log } R^* + \theta_4 R + \theta_5 \text{Log } W + \theta_6 \text{Log} T_{15} + \theta_7 \text{Log } (100 - F_{15}) + \theta_8 \text{Log } (D50_{15} + 0.1)] \tag{4.3}$$

Model # 3, (after the sloping ground model of Youd et al., 2002),

$$\hat{g}(D_H, M_w, R, S, T15, F15, D5015, \Theta) = \text{Log } D_H - [\theta_1 + \theta_2 M + \theta_3 \text{Log } R^* + \theta_4 R + \theta_5 \text{Log } S + \theta_6 \text{Log} T_{15} + \theta_7 \text{Log } (100 - F_{15}) + \theta_8 \text{Log } (D50_{15} + 0.1)] \tag{4.4}$$

Model # 4, (the proposed new model)

$$\hat{g}(D_H, LSI, \phi'_{eqv,liq}, z_{cr}, M_W, a_{max}, S, W, \Theta) =$$

$$\text{Log } D_H - [(\theta_1 LSI + \theta_2) a_y / a_{max} + (\theta_3 LSI + \theta_4) \tan\beta / \tan\phi'_{eqv,liq} + (\theta_5 LSI + \theta_6) \text{Log } z_{cr} + (\theta_7 LSI + \theta_8) \text{Log } M_W + (\theta_9 LSI + \theta_{10}) a_{max} + (\theta_{11} LSI + \theta_{12}) \text{Log } S + (\theta_{13} LSI + \theta_{14}) \text{Log } W + (\theta_{15} LSI + \theta_{16})] \tag{4.5}$$

where Θ represents the set of model limit state function parameters, θ_i's. The derivations of the limit state functions given in Equations 4.2 through 4.5 are based on the assumption that seismic soil liquefaction-induced lateral deformations can be sufficiently modeled by the descriptive variables assigned for each limit state function. Even though, the adopted mathematical expression might not have the perfect functional form, therefore, a random model correction term, ε, which represents the uncertainty due to missing descriptive variables and imperfect form of the selected mathematical model, is to be incorporated into the proposed model in a general from as given in Equation 4.6, and in a more specific form for Model # 4 as shown in Equation 4.7.

$$\hat{g}(\ldots) = g(\ldots) + \varepsilon \tag{4.6}$$

$\hat{g}(D_H, LSI, \phi'_{eqv,liq}, , z_{cr}, M_W, a_{max}, S, W, \varepsilon, \Theta) =$

$$\text{Log } D_H - [(\theta_1 LSI+\theta_2)a_y/a_{max} + (\theta_3 LSI+\theta_4)\tan\beta/\tan\phi'_{eqv,liq} + (\theta_5 LSI+\theta_6)\text{Log } z_{cr} + (\theta_7 LSI+\theta_8)\text{Log } M_W + (\theta_9 LSI+\theta_{10})a_{max} + (\theta_{11} LSI+\theta_{12})\text{Log } S + (\theta_{13} LSI+\theta_{14})\text{Log } W + (\theta_{15} LSI+\theta_{16}) + \varepsilon \quad (4.7)$$

4.5 Likelihood Functions

In this section, based on the assumption that all case histories in the database are statistically independent, the likelihood formulations of exact and inexact cases are discussed.

4.5.1 Statistically Independent Exact Observations

If it is assumed that the observed descriptive variables of each lateral ground spreading case history are exact, and each observation are statistically independent, then the likelihood of observing "k" lateral spreading case histories from soil profiles where there is no soft clay sub-layers, and "n-k" lateral spreading case histories from soil profiles with soft clay sub-layers can be simply written as the product of the case histories corresponding probabilities, as follows:

$$L(\underline{\theta}, \eta | \underline{x}_i) \propto \prod_{i=1}^{k} P(g(D_H, LSI_i, \phi'_{eqv,liq,i}, z_{cr,i}, M_{W,i}, a_{\max,i}, S_i, W_i, \varepsilon_i, \underline{\Theta}) = 0) \cdot \prod_{j=k+1}^{n} P(g(D_H, LSI_j, \phi'_{eqv,liq,j}, z_{cr,j}, M_{W,j}, a_{\max,j}, S_j, W_j, \varepsilon_j, \underline{\Theta}) \geq 0) \quad (4.8)$$

For an unbiased model, the random model correction term is required to have a zero mean, i.e., the sum of the prediction errors should be zero for the whole data set. Therefore, the random model correction term ε is assumed to have a zero mean and a standard deviation of σ_ε and it is assumed to be normally distributed, as:

$$f(\varepsilon) = N(0, \sigma_\varepsilon) \quad (4.9)$$

And by using the normal distribution of the error term, ε, the likelihood function given in Equation 4.9 can be rewritten as:

$$L(\underline{\theta}, \sigma_\varepsilon | \underline{x}_i) \propto \prod_{i=1}^{k} \varphi[\frac{\hat{g}(D_H, LSI_i, \phi'_{eqv,liq,i}, z_{cr,i}, M_{W,i}, a_{\max,i}, S_i, W_i, \varepsilon_i, \underline{\Theta})}{\sigma_\varepsilon}] \cdot \prod_{j=k+1}^{n} \Phi[\frac{\hat{g}(D_H, LSI_j, \phi'_{eqv,liq,j}, z_{cr,j}, M_{W,j}, a_{\max,j}, S_j, W_j, \varepsilon_j, \underline{\Theta})}{\sigma_\varepsilon}] \quad (4.10)$$

where φ and Φ are the standard normal cumulative density functions, respectively.

4.5.2 Statistically Independent Inexact Observations

As mentioned before, estimations regarding the descriptive variables for each case history in the overall database are not exact or free from errors, and to model this fact, each estimation or measurement X is written in terms of a mean value μ_X and an error term ε_X, as follows:

$$LSI_i = \widehat{LSI}_i + \varepsilon_{(LSI)i} \quad (4.11)$$

$$(a_y / a_{\max})_i = (a_y \widehat{/} a_{\max})_i + \varepsilon_{(a_y / a_{\max})i} \quad (4.12)$$

$$(\tan \phi'_{eqv,liq} / \tan \beta)_i = (\tan \phi'_{eqv,liq} \widehat{/} \tan \beta)_i + \varepsilon_{(\tan \phi'_{eqv,liq} / \tan \beta)i} \quad (4.13)$$

$$(z_{cr})_i = (\hat{z}_{cr})_i + \varepsilon_{(z_{cr})i} \quad (4.14)$$

where the error term for each estimation or measurement X can be assumed to have zero mean and a standard deviation, $\sigma_{\varepsilon,X}$, and to be also normally distributed, and the total uncertainty in likelihood estimation could be written as the sum of the model error and errors in the observations as explained in the next section, along with the method of estimating the uncertainties in the descriptive variables.

4.5.3 Estimating the Error Terms in Observations

Estimating the Uncertainty in D_H LSI and z_{cr}

The uncertainties in the variables D_H, LSI and z_{cr} were due to applying averaging process for cases where more than one borehole was assigned to a displacement vector or for one borehole location multiple nearby lateral spreading ground deformations were mapped. This averaging procedure was adopted to be similar with Youd et al. (2002) procedure as:

$$\hat{D}_H = \frac{\sum_{i=1}^{n} D_{H\,i}}{d_i \sum_{j=1}^{n} \frac{1}{d_j}} \tag{4.15}$$

$$\widehat{LSI} = \frac{\sum_{i=1}^{n} LSI_i}{d_i \sum_{j=1}^{n} \frac{1}{d_j}} \tag{4.16}$$

$$\hat{z}_{cr} = \frac{\sum_{i=1}^{n} z_{cr\,i}}{d_i \sum_{j=1}^{n} \frac{1}{d_j}} \tag{4.17}$$

where n is the number of boreholes related to the observed displacement vector, and d_i is the distance from the i^{th} borehole to the observed displacement vector. And for these two descriptive variables, their standard deviations, which represent the uncertainty for each of them, was calculated as:

$$\sigma_{LSI} = \left[\left(\frac{n}{n-1} \right) \cdot \frac{\sum_{i=1}^{n} \left(\frac{LSI_{obs} - \widehat{LSI}}{d} \right)_i^2}{\sum_{j=1}^{n} \left(\frac{1}{d} \right)_j^2} \right]^{0.5} \quad (4.18)$$

$$\sigma_{z_{cr}} = \left[\left(\frac{n}{n-1} \right) \cdot \frac{\sum_{i=1}^{n} \left(\frac{z_{cr_{obs}} - \widehat{z}_{cr}}{d} \right)_i^2}{\sum_{j=1}^{n} \left(\frac{1}{d} \right)_j^2} \right]^{0.5} \quad (4.19)$$

Then the uncertainty for the term *log(z_{cr})* in the mathematical model is calculated as:

$$\sigma^2_{\log z_{cr}} = \left(\frac{d(\log z_{cr})}{dz_{cr}} \right)^2 \cdot \sigma^2_{z_{cr}} \Rightarrow \sigma_{\log z_{cr}} = \frac{\sigma_{z_{cr}} \cdot \log e}{z_{cr}} \quad (4.20)$$

where: $e = \ln^{-1}(1) \cong 2.7182818 \Rightarrow \log e \cong 0.4342945$.

Estimating the Uncertainty in $\phi'_{eqv,liq}$

The uncertainty in the variable $\phi'_{eqv,liq}$ was mainly due to uncertainty in Stark and Mesri's (1992) relationship for determining the value of $tan\phi'_{eqv,liq}$, as was discussed in Chapter 3. As shown in Figure 3.2, the relationship is defined by an upper and average and lower boundary curves. For each case history, the uncertainty in the estmation of the average value of $tan\phi'_{eqv,liq}$ is calculated as one sixth of the difference between the upper and lower values for that case, i.e. median ± 3 standard deviation covers both the upper and lower bounds. Hence, the uncertainty for the descriptive variable $\phi'_{eqv,liq}$ calculated as:

$$\sigma^2_{\tan\phi'_{eqv,liq}} = \left(\frac{d\left(\frac{\tan\beta}{\tan\phi'_{eqv,liq}}\right)}{d\phi'_{eqv,liq}} \right)^2 \cdot \sigma^2_{\phi'_{eqv,liq}} \Rightarrow \sigma_{\phi'_{eqv,liq}} = \frac{\sigma_{\tan\phi'_{eqv,liq}} \cdot \sin^2\phi'_{eqv,liq}}{\tan\beta} \qquad (4.21)$$

Estimating the Uncertainty in a_{max}

An upper boundary on the uncertainty of the mean estimates of a_{max} is defined to be less than that predicted by generalized attenuation relationships. Typical attenuation relationships (e.g., Abrahamson and Silva 1997, Idriss, 1991), can estimate peak ground acceleration at soil sites for a wide range of earthquake magnitudes and distances with an error ranging from 30% to 40% of the reported a_{max} values. Any relevant information other than magnitude and distance should improve the accuracy of the estimations, which in turn should decrease the error to a value less than ≅ 35%. Similarly, comparisons of the actual recorded a_{max} values with site response analysis predictions based on adequate site characterization and seismic data revealed that the discrepancy in the matches is more typically in the range of 10% to 20%. Finally, the error in reported a_{max} values reduces to less than 10% for the case history sites where actual strong ground motion recordings are available at the site of interest. (Cetin, 2000)

Estimating the Uncertainty in a_y/a_{max}

Having estimated error values within the $\phi'_{eqv,liq}$ and a_{max} descriptive variables, the uncertainty in the a_y/a_{max} term in the mathematical model is calculated as follows:

$$\sigma^2_{a_y/a_{max}} = \left(\frac{d\left(\frac{\tan(\phi'_{eqv,liq} - \beta)}{a_{max}}\right)}{d\phi'_{eqv,liq}} \right)^2 \cdot \sigma^2_{\phi'_{eqv,liq}} + \left(\frac{d\left(\frac{\tan(\phi'_{eqv,liq} - \beta)}{a_{max}}\right)}{da_{max}} \right)^2 \cdot \sigma^2_{a_{max}} \Rightarrow$$

$$\sigma_{a_y/a_{\max}} = \left[\left(\frac{1}{a_{\max} \cdot \cos^2(\phi'_{eqv,liq} - \beta)} \cdot \right)^2 \cdot \sigma^2_{\phi'_{eqv,liq}} + \left(\frac{-\tan(\phi'_{eqv,liq} - \beta)}{a^2_{\max}} \right)^2 \cdot \sigma^2_{a_{\max}} \right]^{0.5}$$

(4.22)

Then, incorporating the uncertainties in the descriptive variables, the likelihood of observing *k* lateral spreading case histories without soft clay sub-layers and *n-k* lateral spreading case histories with soft clay sub-layers, can be written as:

$$L(\underline{\theta}, \sigma_\varepsilon | \underline{x}_i) \propto \prod_{i=1}^{k} \varphi\left[\frac{\hat{g}(LSI_i, \phi'_{eqv,liq,i}, z_{cr,i}, M_{W,i}, a_{\max,i}, S_i, W_i, \varepsilon_i, \underline{\Theta})}{\sigma_{tot,i}}\right] \cdot$$
$$\prod_{j=k+1}^{n} \Phi\left[\frac{\hat{g}(LSI_j, \phi'_{eqv,liq,j}, z_{cr,j}, M_{W,j}, a_{\max,j}, S_j, W_j, \varepsilon_j, \underline{\Theta})}{\sigma_{tot,j}}\right]$$

(4.23)

Then the total variance, from which the standard deviation is obtained by square rooting, can be written as the sum of the model error, σ_ε^2, and errors in observations, σ_e^2, as follows:

$$\sigma^2_{tot\,i} = \sigma^2_\varepsilon + \sigma^2_{\log(D_H)} + \sigma^2_{LSI_1} \cdot \frac{dM_4}{dLSI_i} + (\theta_1 \cdot LSI_1 + \theta_2) \cdot \sigma^2_{a_y/a_{\max,i}} + (\theta_3 \cdot LSI_i + \theta_4) \cdot \sigma^2_{\tan\beta/\tan\phi'_{eqv,liq,i}}$$
$$+ (\theta_5 \cdot LSI_i + \theta_6) \cdot \sigma^2_{Logz_{cr,i}} + (\theta_7 \cdot LSI_i + \theta_8) \cdot \sigma^2_{LogM_{W,i}} + (\theta_9 \cdot LSI_i + \theta_{10}) \cdot \sigma^2_{a_{\max,i}}$$
$$+ (\theta_{11} \cdot LSI_i + \theta_{12}) \cdot \sigma^2_{LogS,i} + (\theta_{13} \cdot LSI_i + \theta_{14}) \cdot \sigma^2_{Logw,i} \quad (4.24)$$

where;

$$\frac{dM_4}{dLSI_i} = \theta_1 a_y / a_{\max,i} + \theta_3 \cdot \tan\beta \tan/ \phi'_{eqv,liq,i} + \theta_5 \cdot Logz_{cr,i} + \theta_7 \cdot LogM_{w,i} + \theta_9 \cdot a_{\max,i}$$
$$+ \theta_{11} \cdot \log S_i + \theta_{13} \cdot LogW_i + \theta_{15} \quad (4.25)$$

As the last step in the application of maximum likelihood methodology, the model parameters that have maximized the likelihood function were estimated by simply taking derivative of the likelihood function with respect to the parameter of interest and equate it to zero.

4.6 Summary of Uncertainty Sources

As a major step towards a better set of correlations, modeling the error/uncertainty in *LSI*, $\phi'_{eqv,liq}$, a_{max}, and z_{cr} estimations decreases the uncertainty of the model. This is mainly due to separation of estimation errors from those of the model. Also increasing the quantity and quality of informative case histories decreases the uncertainty of model parameters. For a model developed based on a limited amount of data, model parameter uncertainty may be an important source of uncertainty. However, due to the high quantity and quality of data used in the derivation of these correlations, and due to the strong correlation among some of the model parameters, uncertainty of model parameters ended up being insignificantly small for the estimations of seismic soil liquefaction-induced lateral spreading.

The errors in the estimations of major controlling variables *LSI*, $\phi'_{eqv,liq}$, a_{max}, and z_{cr} remains as key sources of uncertainty for the estimation of lateral ground spreading. Therefore several measures are taken to improve the quality of the prior informative data by applying the following rules:

i) Neglecting the equivalent angle of internal friction for liquefied soil term $\phi'_{eqv,liq}$ for low levels of liquefaction risk of the most critical sub-layer (F.S.>1), and employing the static angle of soil internal friction term ϕ'_{Static} instead,

ii) Taking into consideration the possible contribution of soft clay sub-layers for case histories where the soil profile data shows a majority of clayey soils,

iii) Taking into consideration the possible contribution of deeper granular sub-layers for case histories where the soil profile data extends to a shallow depth (<15 m) and the bottom most sub-layer is still liquefiable (granular soil with F.S.<1), and

iv) Taking into consideration the variability in the observed lateral ground spreading values for the same case history reported by different resources or measuring methodologies.

CHAPTER 5

Development of New Correlations

5.1 Introduction

The new correlations developed for the assessment of seismic liquefaction-induced lateral ground spreading are discussed in this chapter. These correlations include the three different possible types of site boundary conditions, i.e., sloping sites with a free-face ($S > 0$ and $W > 0$), sloping sites without a free-face ($W = 0$), and level sites with a free-face ($S = 0$), and explicitly addressing the most important aspects of the problem such as: liquefaction severity index, *LSI*, moment magnitude of the earthquake, M_W, maximum ground acceleration, a_{max}, slope of ground surface, S, site free-face ratio, W, equivalent angle of internal friction for liquefied soil, $\phi'_{eqv,liq}$, and depth from top ground surface to the most critical sub-layer, z_{cr}.

5.2 Development of New Correlations

The identification of the major contributing variables, their internal correlations, and different combinations within a mathematical formation is a very critical step within statistical analysis methodologies. One of the main criteria for selecting these descriptive variables in this study was the attempt to handle the phenomenon of seismic soil liquefaction-induced lateral deformations from all its aspects, mainly: seismological, geotechnical, and topographical (boundary conditions). The steps for applying linear and nonlinear regression analyses and then maximum likelihood methodology are discussed next.

5.2.1 Regression Analyses

The selected new controlling variables for analyzing the overall database and developing the new mathematical models are identified and discussed in details in Chapter 3. Motivated by previous empirical models for liquefaction-induced lateral ground spreading assessment, many trials, employing different possibilities of mathematical formulations and combinations of the descriptive variables, were performed by using the linear and non-linear regression analysis techniques implemented by SPSS, version 13.0 (2004) software.

Unlike the Youd et al. (2002) modeling scheme, which assumes that liquefaction-induced lateral ground deformations are dependent on the free face ratio, in its close proximity and not on ground slope, the descriptive variables free-face ratio, *W*, and ground surface slope, *S*, are used simultaneously in the new developed correlations. In fact, the obvious distinction between the free-face and ground surface slope domination conditions may not always be an easy task. It is still unclear up to which distance from the free face, the free-face condition boundary conditions are still effective, and how these effects combine with a sloping ground surface.

The first few regression trials clearly revealed that introducing the terms: a_y/a_{max}, $tan\beta/tan\phi'_{eqv,liq}$, and z_{cr} in the proposed model instead of the terms: T_{15}, F_{15}, and $D50_{15}$ is a major step forward towards reaching to a more descriptive group of variables and consequently, a powerful representative correlation. To give an idea about the progressive approach of the regression modeling, Table 5.1 lists examples of three different trial models and their corresponding R^2 values.

Then after performing series of trials adopting various mathematical formulations, it was realized from the regression output results that the liquefaction severity index variable, *LSI*, has the most essential role within the new developing correlations. As explained in Equation 2.23, it is represents the probability or potential of liquefaction for a given soil profile under the seismic effects of an assigned earthquake event.

Table 5.1: Examples of trial models and their regression performances.

Trial No.	Model Mathematical Form	R^2 (%)
1	$LogD_H = b_1 \cdot LSI + b_2 \cdot a_y/a_{max} + b_3 \cdot \tan\beta/\tan\phi'_{eqv,liq} + b_4 \cdot z_{cr} + b_5 \cdot M_w + b_6 \cdot W + b_7$	65.8
2	$LogD_H = b_1 \cdot LSI + b_2 \cdot a_y/a_{max} + b_3 \cdot \tan\beta/\tan\phi'_{eqv,liq} + b_4 \cdot z_{cr} + b_5 \cdot M_w + b_6 \cdot LogS + b_7 \cdot LogW + b_8$	71.0
3	$LogD_H = b_1 \cdot LSI + b_2 \cdot a_y/a_{max} + b_3 \cdot \tan\beta/\tan\phi'_{eqv,liq} + b_4 \cdot Logz_{cr} + b_5 \cdot LogM_w + b_6 \cdot a_{max} + b_7 \cdot LogS + b_8 \cdot LogW + b_9$	74.6

Eventually, and as a final result of all the performed linear and nonlinear regression trials, the most reliable mathematical equation for the estimation of lateral ground spreading was expressed in the following form:

$$\text{Log } D_H = b_1 \cdot a_y/a_{max} + b_2 \cdot \tan\beta/\tan\phi'_{eqv,liq} + b_3 \cdot \text{Log } z_{cr} + b_4 \cdot \text{Log } M_W + b_5 \cdot a_{max} + b_6 \cdot \text{Log } S + b_7 \cdot \text{Log } W + b_8 + \varepsilon \qquad (5.1)$$

where D_H is the predicted lateral ground spreading (m), ε is the model error term, and the model parameters, b_i's, are defined as linear function of the liquefaction severity index variable, *LSI*, as:

(For $1 \le i \le 8$) $$b_i = \theta_{2i-1} \cdot LSI + \theta_{2i} \qquad (5.2)$$

Then the final mathematical form of the new developed model is obtained by substituting for the b_i term definitions from Equation 5.2 into Equation 5.1 as:

$$\text{Log } D_H = (\theta_1 \cdot LSI + \theta_2) \cdot a_y/a_{max} + (\theta_3 \cdot LSI + \theta_4) \cdot \tan\beta/\tan\phi'_{eqv,liq} + (\theta_5 \cdot LSI + \theta_6) \cdot \text{Log } z_{cr} + (\theta_7 \cdot LSI + \theta_8) \cdot \text{Log } M_W + (\theta_9 \cdot LSI + \theta_{10}) \cdot a_{max} + (\theta_{11} \cdot LSI + \theta_{12}) \cdot \text{Log } S + (\theta_{13} \cdot LSI + \theta_{14}) \cdot \text{Log } W + (\theta_{15} \cdot LSI + \theta_{16}) + \varepsilon \qquad (5.3)$$

The next step after determining the mathematical model was to employ the nonlinear regression analysis techniques using Equation 5.3 for the three different cases of site conditions to estimate the set of model parameters, θ_i's, and model residual, ε, for each case. With the parameters for Models # 1, 2, and 3, which are listed in Table

5.2, the resultant regression estimations for Model # 4 parameters are listed in Table 5.3. Then by using these parameters and Equation 5.3, the estimated lateral ground spreading for each case history was computed and the overall results were plotted against the observed values of lateral ground spreading, as shown in Figure 5.1, where R^2 value is 80.1%.

Table 5.2: Empirical lateral spreading models.

Model #	Limit State Function
1	After Hamada et al. (1986) model: $D_H = \theta_1 H^{\theta_2} S^{\theta_3}$
2	After Youd et al. (2002) model for free-face conditions: $\text{Log } D_H = [\theta_1+\theta_2 M+\theta_3 \text{Log } R^*+\theta_4 R+\theta_5 \text{Log } W+\theta_6 \text{Log} T_{15} +\theta_7 \text{Log } (100-F_{15})+\theta_8 \text{Log } (D50_{15}+0.1)]$
3	After Youd et al. (2002) model for sloping ground conditions: $\text{Log } D_H = [\theta_1+\theta_2 M+\theta_3 \text{Log } R^*+\theta_4 R+\theta_5 \text{Log } S+\theta_6 \text{Log} T_{15} +\theta_7 \text{Log } (100-F_{15})+\theta_8 \text{Log } (D50_{15}+0.1)]$
4	Proposed Model: $\text{Log } D_H = [(\theta_1 LSI+\theta_2)a_y/a_{max}+(\theta_3 LSI+\theta_4)\tan\beta/\tan\phi'_{eqv,liq} +(\theta_5 LSI+\theta_6)\text{Log } z_{cr}+(\theta_7 LSI+\theta_8)\text{Log } M_W+(\theta_9 LSI+\theta_{10})a_{max} +(\theta_{11} LSI+\theta_{12})\text{Log } S+(\theta_{13} LSI+\theta_{14})\text{Log } W+(\theta_{15} LSI+\theta_{16})]$

Table 5.3: Regression estimations for the model parameters, θ_i's.

				Model # 4		
Parameter	Model #1	Model # 2	Model # 3	W = 0	S = 0	W > 0 & S > 0
θ_1	0.75	-16.713	-16.213	0.029	0.133	0.177
θ_2	1/2	1.532	1.532	-0.108	-1.279	-2.386
θ_3	1/3	-1.406	-1.406	0.012	0.000	-1.751
θ_4	-	-0.012	-0.012	-0.891	0.000	5.542
θ_5	-	0.592	0.338	0.030	0.138	-0.198
θ_6	-	0.540	0.540	0.143	-0.753	1.641
θ_7	-	3.413	3.413	-1.277	-11.350	-9.949
θ_8	-	-0.795	-0.795	2.290	65.661	22.845
θ_9	-	-	-	-0.104	-2.743	-0.621
θ_{10}	-	-	-	0.019	14.634	1.366
θ_{11}	-	-	-	-0.012	0.000	0.240
θ_{12}	-	-	-	0.536	0.000	-1.095
θ_{13}	-	-	-	0.000	-0.117	-0.095
θ_{14}	-	-	-	0.000	1.482	1.182
θ_{15}	-	-	-	1.178	10.638	9.311
θ_{16}	-	-	-	-1.935	-61.411	-22.587
Residual	-	-	-	0.380	0.319	0.496
R^2 (%)	13.2	74.1		80.1		

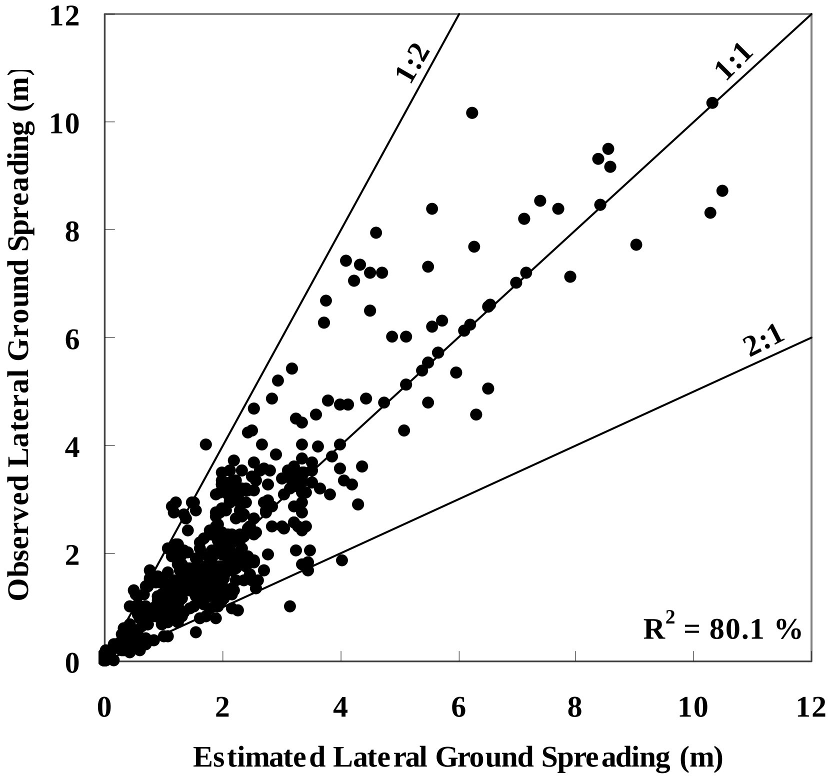


Figure 5.1: Observed vs. estimated lateral spreading values using Model # 4 (proposed model) based on regression estimates of model parameters, θ_i's.

As a starting point towards the development of new correlations, the empirical models of Hamada et al. (1986) and Youd et al. (2002) were applied to our overall database correspondingly, and their overall estimation values for lateral ground spreading were plotted against the observed spreads, as shown in Figures 5.2 and 5.3, respectively. For an ideal result, all data points should lay on the 1:1 line. The 2:1 are 1:2 lines define borders for the observed values equal half of and twice their corresponding estimated values, respectively. R^2 values for the two models are 13.2 and 74.1%, respectively, where R^2 represents a measure for the goodness of fit, and it equals 100% for an ideal case.

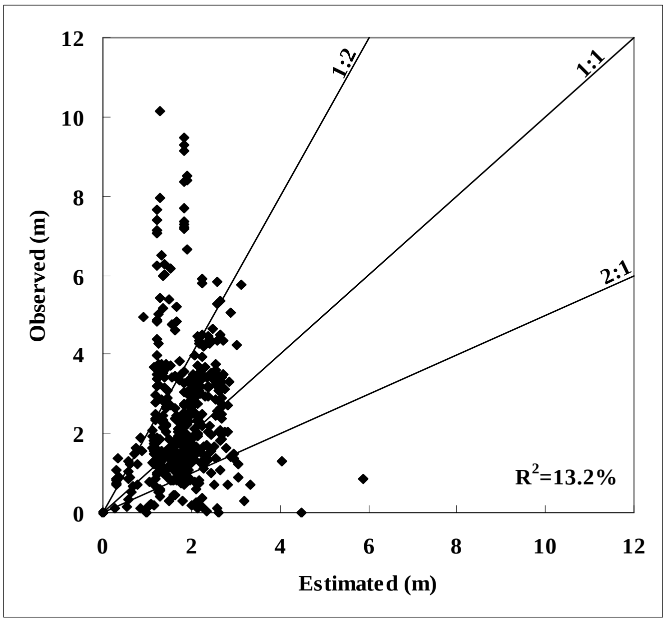


Figure 5.2: Observed vs. estimated lateral spreading values using Model # 1 (after Hamada et al. (1986) model) based on regression estimates of model parameters, θ_i's.

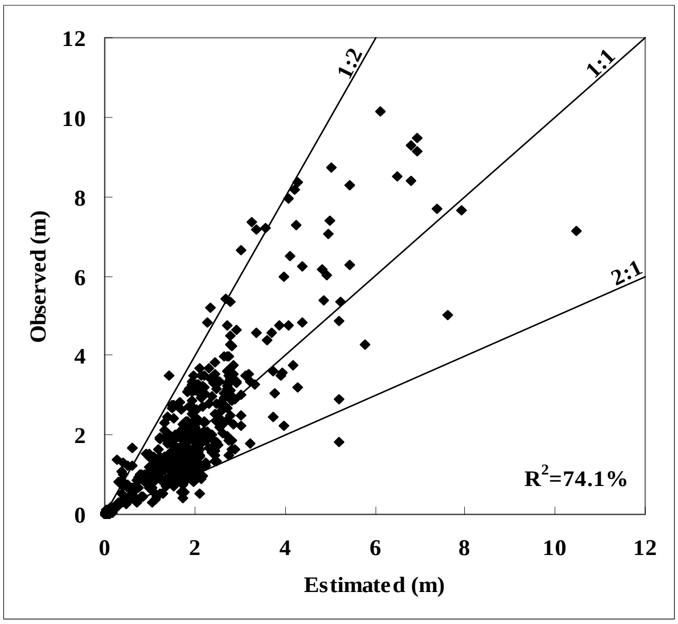


Figure 5.3: Observed vs. estimated lateral spreading values using Models # 2 and 3 (after Youd et al. (2002) models) based on regression estimates of model parameters, θ_i's.

5.2.2 Maximum Likelihood Analyses

As discussed in Chapter 4, all descriptive variables can also be modeled as distributions with variances (e.g. variance in *LSI*, $\phi'_{eqv,liq}$, a_{max}, and z_{cr}) within the maximum likelihood analysis. The maximum likelihood methodology serves much the same purpose as regression analysis techniques, but it is more capable to facilitate separate issues accounting for different contributing sources of variance or uncertainty. It is within the likelihood methodology to assume a normally distributed model error ε term in Equation 5.3, which implies that its mean value is set equal to zero, however, the standard deviation of this term, which is denoted by σ_ε, is still need to be estimated. For this purpose, the Maximum Likelihood analyses were applied to the selected contributing descriptive variables in Equation 5.3 for all cases of the overall database in two different manners: for exact, and inexact descriptive variables/observations.

Exact Observations

The probability of making exact lateral spreading observations is due to the model uncertainty term, σ_ε, which in this case represents all sources of error, since the descriptive variables are considered to be free of measurement/estimation errors. For exact observation assumption, the resultant estimations for the model parameters, θ_i's, and the corresponding model uncertainty term, σ_ε, for each site condition type are listed in Table 5.4, and by using these updated parameters and Equation 5.3, the estimated lateral spreading for each case history was computed and the overall results were plotted against the observed lateral spreads, as shown in Figure 5.4, where R^2 value is estimated as 83.6%.

Table 5.4: Maximum likelihood estimations for the exact observations.

	Site Condition		
Parameter	W = 0	S = 0	W > 0 & S > 0
θ_1	0.070	-0.299	-0.057
θ_2	-0.380	1.797	-0.463
θ_3	0.264	0.000	-0.436
θ_4	-2.347	0.000	1.313
θ_5	0.009	0.091	0.070
θ_6	0.222	-0.339	-0.474
θ_7	-1.521	0.016	-4.830
θ_8	5.516	-30.638	25.021
θ_9	-0.355	-0.896	-1.053
θ_{10}	1.091	0.318	6.507
θ_{11}	-0.049	0.000	0.170
θ_{12}	0.801	0.000	-0.979
θ_{13}	0.000	-0.117	-0.095
θ_{14}	0.000	0.853	0.529
θ_{15}	1.429	0.645	4.632
θ_{16}	-4.869	23.201	-23.961
σ_ε	0.170	0.109	0.135
R^2 (%)	83.6		

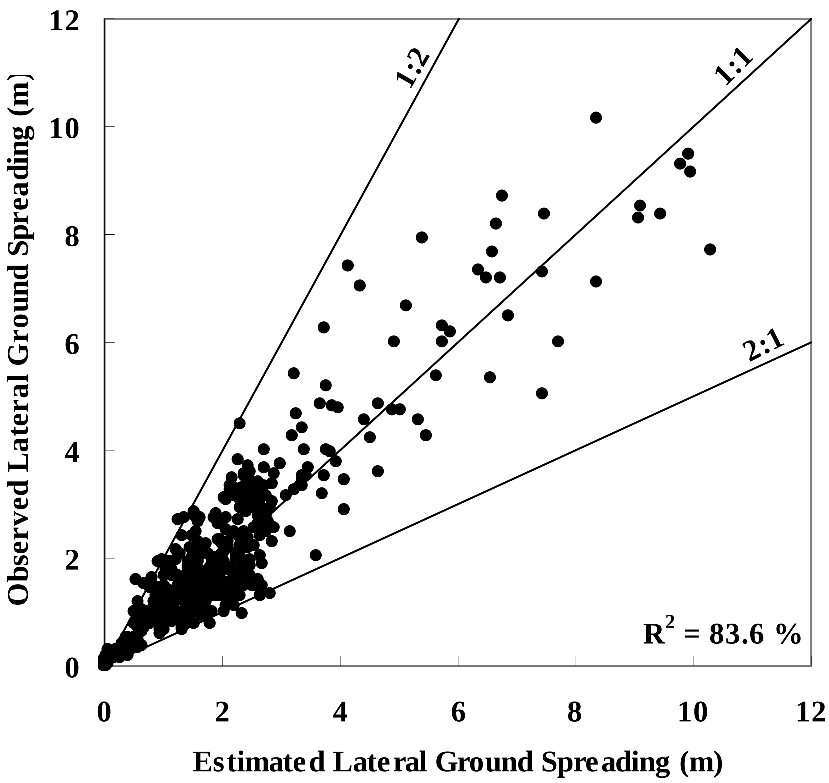


Figure 5.4: Observed vs. Estimated Lateral Spreading values using Model # 4 (proposed model) based on maximum likelihood estimates of model parameters, θ_i's under exact descriptive variable assumption.

Inexact Observations

If the observations as well as descriptive variables are assumed to be uncertain, then the total error due to these as well as model uncertainty term, σ_ε, can be represented by total error term, $\sigma_{total\varepsilon}$, as discussed in Chapter 4. For the inexact observation case, after defining the error term for each descriptive variable in the proposed model, the resultant estimations for the model parameters, θ_i's, and the corresponding model uncertainty, σ_ε, for each site condition type are listed in Table 5.5. Accordingly, the estimated lateral spreading for each case history was computed and the overall results were plotted against the observed lateral spreads, as shown in Figure 5.5, where R^2 value is improved to a value of 85.5%. As it can be seen from the results, the new estimated model parameters are not only significantly different from those produced by regression analyses, but also they led to a more satisfactory model performance and to a reasonable decrease within the model error terms, which is in fact the main advantage and the best justification for employing the maximum likelihood methodology.

Table 5.5: Maximum likelihood estimations for the inexact observations.

	Site Condition		
Parameter	W = 0	S = 0	W > 0 & S > 0
θ_1	0.084	-0.607	-0.056
θ_2	-0.409	3.883	-0.462
θ_3	0.367	0.000	-0.435
θ_4	-2.576	0.000	1.308
θ_5	0.010	0.063	0.070
θ_6	0.255	-0.160	-0.473
θ_7	-1.663	-5.973	-4.832
θ_8	6.435	7.016	25.033
θ_9	-0.505	-1.789	-1.052
θ_{10}	1.452	5.946	6.506
θ_{11}	-0.075	0.000	0.170
θ_{12}	0.869	0.000	-0.979
θ_{13}	0.000	-0.117	-0.095
θ_{14}	0.000	0.846	0.529
θ_{15}	1.561	6.078	4.634
θ_{16}	-5.717	-10.933	-23.972
σ_ε	0.116	0.094	0.106
R^2 (%)	85.5		

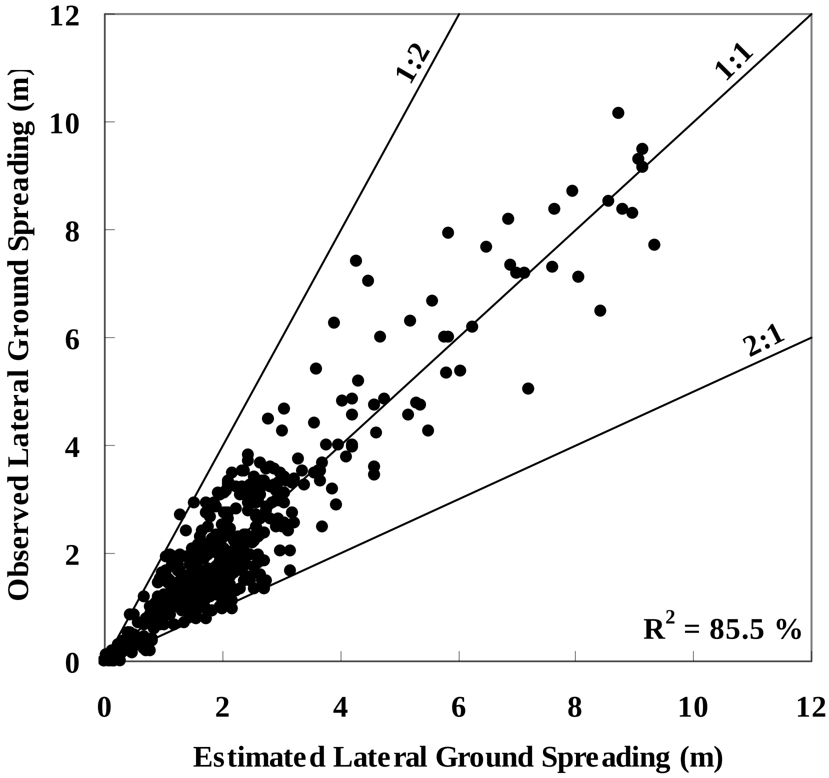


Figure 5.5: Observed vs. Estimated Lateral Spreading values using Model # 4 (proposed model) based on maximum likelihood estimates of model parameters, θ_i's under inexact descriptive variable assumption.

5.3 Probabilistic Use of New Correlations

In this section, the probabilistic use of the proposed model will be illustrated. For this purpose, the probability of the liquefaction-induced lateral ground deformations exceeding the value of 0.5 m will be estimated as a function of ground surface slope, S, and free-face ratio, W, respectively, for a scenario case with the characteristics: M_w = 7.5, a_{max} = 0.2 g, LSI = 1.0, and z_{cr} = 5.0 m. The probability of exceedance values were estimated after applying the mathematical expressions given in Equations 5.4 and 5.5, respectively, by using the model parameters estimated for exact and inexact descriptive variables. The output results are presented in Figures 5.6 ad 5.7.

$$P\left[\log(D_H) \geq \log(0.5)\right] = \Phi[\frac{\hat{g}(LSI, \phi'_{eqv,liq}, z_{cr}, M_W, a_{\max}, S, W, \underline{\Theta}) - \log(0.5)}{\sigma_\varepsilon}] \tag{5.4}$$

$$P\left[\log(D_H) \geq \log(0.5)\right] = \Phi[\frac{\hat{g}(LSI, \phi'_{eqv,liq}, z_{cr}, M_W, a_{\max}, S, W, \underline{\Theta}) - \log(0.5)}{\sigma_{tot}}] \tag{5.5}$$

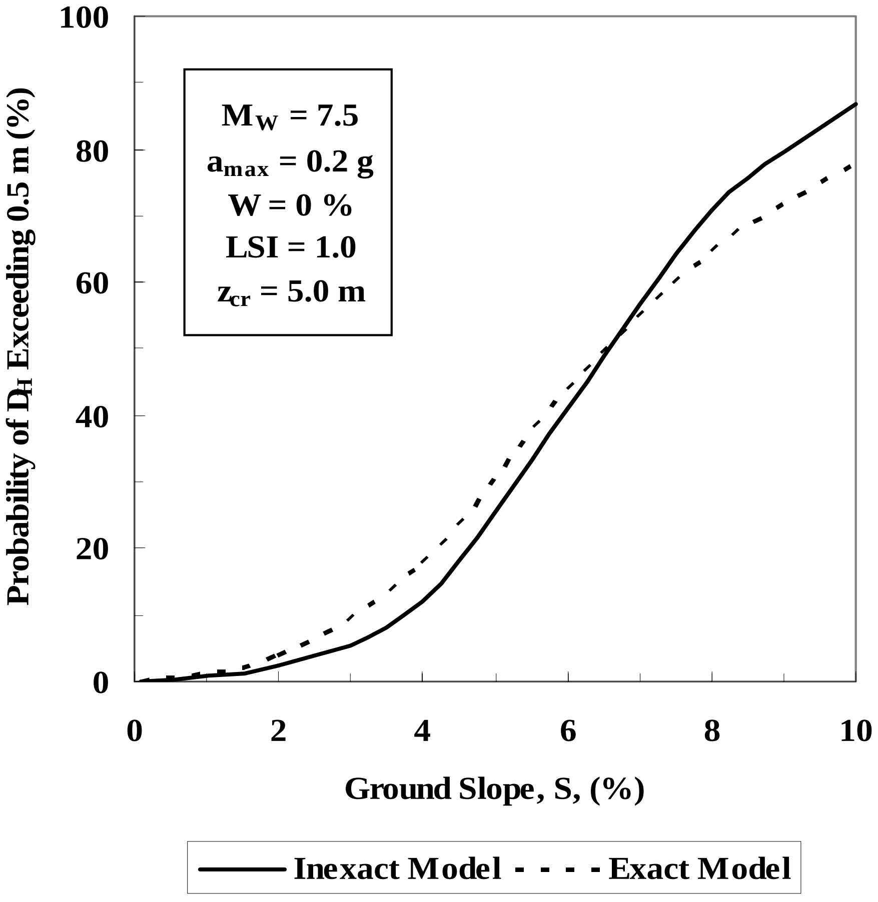


Figure 5.6: Probabilistic distribution of lateral spreading exceeding 0.5 m related to ground slope, S (%).

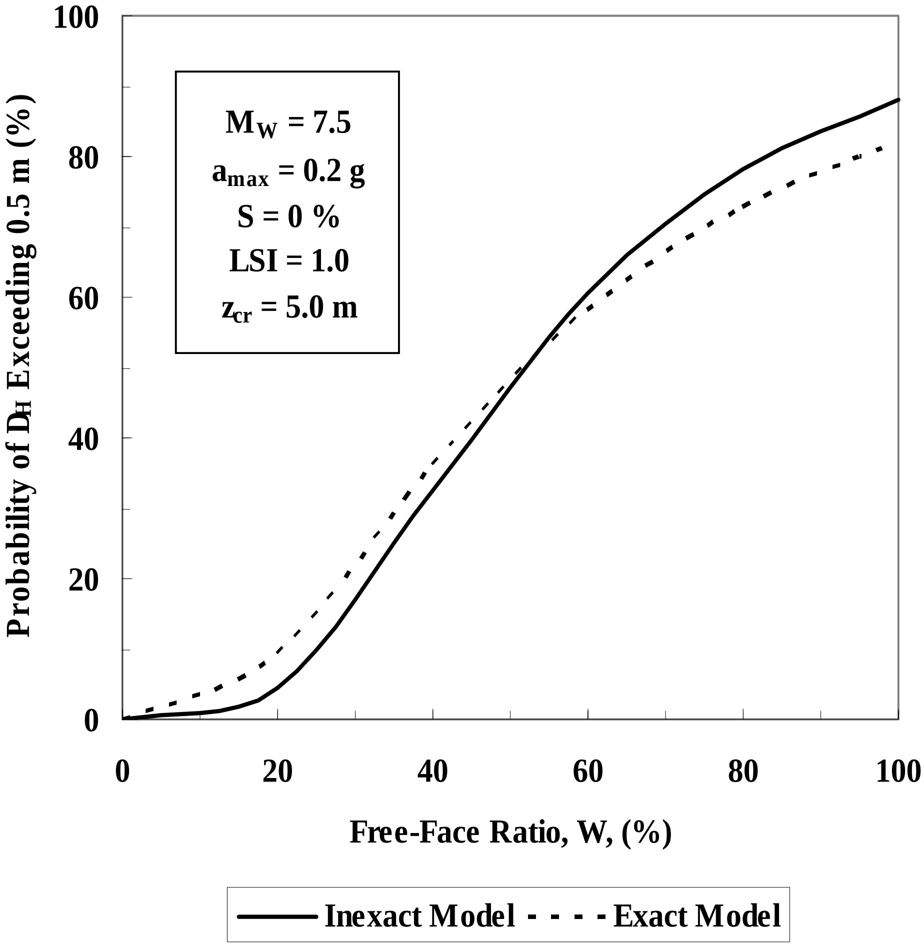


Figure 5.7: Probabilistic distribution of lateral spreading exceeding 0.5 m related to free-face ratio, W (%).

Within the output results of these two figures, the new probabilistic model can be used as a performance- based analysis tool both exact and inexact modeling, where the probability of lateral spreading exceeding 0.5 m can be estimated for an assigned value of site topographical feature. Another procedure for using these probabilistic relationships is to estimate the maximum value of site boundary conditions that corresponds to a predefined design limit for the probability of lateral ground deformations exceeding 0.5m.

CHAPTER 6

SUMMARY AND CONCLUSIONS

6.1 Summary

The aim of these research study is the development of both probabilistically and deterministically based semi-empirical methods for the assessment of liquefaction-induced lateral ground spreading. The scope of this research study includes: i) the compilation of high quality liquefaction-induced lateral ground spreading data from well documented case histories, ii) the identification of the group of seismological geotechnical , and topographical descriptive variables to be considered in the model, and iii) the employment of probabilistic assessment techniques including likelihood model assessment in addition to linear and nonlinear regression analyses for the purpose of developing models that best match the observed lateral ground spreading values with the estimated results.

Currently available approaches for estimating the amplitude of lateral ground deformations can be categorized as: i) numerical analyses in the form of finite element and/or finite difference techniques (e.g., Finn et al. (1990), Arulanandan et al. (2000), and Liao et al. (2002)), ii) soft computing techniques (e.g., Wang and Rahman (1999)), iii) simplified analytical methods (e.g., Newmark (1965), Towhata et al. (1992), Kokusho and Fujita (2002), and Elgamal et al. (2003)), and iv) empirical methods developed based on the assessment of either laboratory test data or statistical analyses of lateral ground spreading case histories (e.g., Hamada et al. (1986), Shamoto et al. (1998), and Youd et al. (2002)).

Due to difficulties in the determination of input model parameters of the existing numerical and analytical models, empirical and semi-empirical models continue to establish the state of practice for the assessment of liquefaction-induced lateral ground deformations. However, these empirical models can not produce reasonably accurate estimates of liquefaction-induced lateral ground spreading deformations. Some of the predictions by these models are documented to be off by more than a factor of two which forms the established limits for use in engineering practice. Thus more needs to be done to produce more reliable and accurate models that capture the essentials of the problem. This is the main motivation of these studies.

Hamada et al.(1986), Youd and Perkins (1987), Rauch (1997), Shamoto et al.(1998), Bardet et al. (1999), Youd et al. (2002), and Kanibir (2003), introduced empirical methods and multi-linear regression *MLR* models for the assessment of liquefaction-induced lateral spreading. Except for the empirical method of Shamoto et al. (1998), all the methods are empirical methods based on regression analyses of previous lateral spreading case histories, while the predictive approach of Shamoto et al. (1998) employs laboratory based estimates of liquefaction-induced limiting shear strains coupled with an empirical adjustment factor in order to relate these laboratory values to the observed field behavior.

The model of Hamada et al. (1986) is very simple and easy to use, but it is based on limited number of case histories, and consists of only two variables defining the site geometry, with almost no emphasis on seismic and/or geotechnical variables. Therefore, this empirical model, even though easy to use, produces limited accuracy predictions.

The model of Youd and Perkins (1987) is assigned for deformations of gently sloping, recent, and fluvial sites of shallow cohesionless soil profiles. Therefore, the use of this two-variable model is limited to sites with seismic, geotechnical, and topographic conditions similar to those found in the west regions of North America.

The model of Rauch (1997) was based on the MLR analysis for the total of only 78 data points from 16 different earthquakes. The methodology of this model was to subdivide the liquefied area into separate slide zones, and to define the length and area for each slide, and then to consider the average liquefaction-induced displacement vectors and the average borehole soil properties within these slides. The quality of fit results for the three equations of this MLR model was reported as: R^2=50.9% based on 71 data points, R^2=67.0% based on 58 data points, and R^2=68.8% based on 45 data points, respectively.

The laboratory based empirical model of Shamoto et al. (1998) is derived from very few output results of experimental work, and it is heavily biased towards the Japanese soils of clean sands and their related seismic and geometric features.

The model of Bardet et al. (1999) expressly followed the same procedure of Bartlett and Youd's (1992) first proposed model and then revised twice and reintroduced as Youd et al. (2002), and applied the same MLR approach but with the use of Bartlett's (1998) database that has slight differences within the ground displacement amplitudes than Youd's. This MLR model has a very similar outline and very close values of model parameters as those of Youd's model except that: the parameter R^* was excluded and substituted by R, an equation for sloping sites with a free-face condition was added, and four-parameter equations were proposed as a *first order approximation* for the liquefaction-induced lateral ground deformations.

The MLR model of Youd et al. (2002) took into consideration parameters related to the earthquake record, site geometry, and soil properties. The use of this model has many limitations such as: the model is applicable only for widely spread liquefaction cases and not for local spots, the free face equation is used only for $5 \leq W \leq 20\%$, while the ground slope equation is used for $W \leq 1\%$. This bordering system for the values of W is discontinuous, and does not give any explanation for the cases with W values located outside the stated boundaries. In addition, this MLR model is valid only for the ranges of: $6 \leq M_W \leq 8$, $0.1 \leq S \leq 6\%$, $1 \leq T_{15} \leq 15$ m, and a total depth to the top of the liquefied soil sub-layer ranging from 1 to 10 m. Finally, this MLR model is not applicable for gravelly and/or very silty soils, and unpractically, it does not include solutions for sloping ground sites with a free face.

All these empirical methods, best of their kind, suffer from a major problem: they do not take into account the uncertainties associated with their model and model descriptive variables, and thus provides no insight regarding the accuracy of the predictions. To be able to eliminate this major problem, a probabilistic assessment methodology was implemented within this study.

After filtering the compiled lateral spreading case histories from data quality and completeness points of views, the total number of case histories used in the final database is reduced down to 526 liquefaction-induced lateral ground spreading data points compiled from 18 different earthquakes. Filtering out some of the data points was mainly due to the following reasons: i) sites with site and/or seismic information affecting the analysis procedure are not well defined and/or not sufficient, ii) sites with special boundary conditions impeded free liquefaction-induced lateral spreading, and iii) sites with very steep ground surface slopes.

Series of models were studied addressing the effects of: i) seismic soil liquefaction triggering, ii) inertial forces acting during the earthquake, iii) gravitational forces acting before, during, and after the earthquake, and iv) site boundary conditions, and within a probabilistic framework which enables the incorporation of the model and variable uncertainties into the model. The resultant models are developed for sloping sites with a free-face, sloping sites without a free-face, and level sites with a free-face.

Due to the high level of complexity, many trials, using different mathematical forms with different descriptive variables were performed by using linear and nonlinear regression analysis techniques, and the most reliable mathematical equation was estimated as in the form:

$$\begin{aligned}\text{Log } D_H = {} & (\theta_1\cdot LSI+\theta_2)\cdot a_y/a_{max} + (\theta_3\cdot LSI+\theta_4)\cdot \tan\beta/\tan\phi'_{eqv,liq} + (\theta_5\cdot LSI+\theta_6)\cdot \text{Log } z_{cr} \\ & + (\theta_7\cdot LSI+\theta_8)\cdot \text{Log } M_W + (\theta_9\cdot LSI+\theta_{10})\cdot a_{max} + (\theta_{11}\cdot LSI+\theta_{12})\cdot \text{Log } S \\ & + (\theta_{13}\cdot LSI+\theta_{14})\cdot \text{Log } W + (\theta_{15}\cdot LSI+\theta_{16}) + \varepsilon \qquad (6.1)\end{aligned}$$

where the set of estimated model parameters, θ_i 's, and the model residual terms, ε's, are listed for the three different cases of site conditions in Table 6.1.

Table 6.1: Regression estimations for the model parameters, θ_i's.

	Site Condition		
Parameter	W = 0	S = 0	W > 0 & S > 0
θ_1	0.029	0.133	0.177
θ_2	-0.108	-1.279	-2.386
θ_3	0.012	0.000	-1.751
θ_4	-0.891	0.000	5.542
θ_5	0.030	0.138	-0.198
θ_6	0.143	-0.753	1.641
θ_7	-1.277	-11.350	-9.949
θ_8	2.290	65.661	22.845
θ_9	-0.104	-2.743	-0.621
θ_{10}	0.019	14.634	1.366
θ_{11}	-0.012	0.000	0.240
θ_{12}	0.536	0.000	-1.095
θ_{13}	0.000	-0.117	-0.095
θ_{14}	0.000	1.482	1.182
θ_{15}	1.178	10.638	9.311
θ_{16}	-1.935	-61.411	-22.587
Residual	0.380	0.319	0.496
R^2 (%)	80.1		

The errors in the estimations of major controlling variables *LSI*, $\phi'_{eqv,liq}$, a_{max}, and z_{cr} remains as key sources of uncertainty for the estimation of lateral ground spreading. Therefore, several measures are taken to improve the quality of the prior informative data by: i) neglecting the equivalent angle of internal friction for liquefied soil term $\phi'_{eqv,liq}$ for low levels of liquefaction risk of the most critical sub-layer (F.S.>1), and employing the static angle of soil internal friction term ϕ'_{Static} instead, ii) taking into consideration the possible contribution of soft clay sub-layers for case histories where the soil profile data shows a majority of clayey soils, iii) taking into consideration the possible contribution of deeper granular sub-layers for case histories where the soil profile data extends to a shallow depth (<15 m) and the bottom most sub-layer is still liquefiable (granular soil with F.S.<1), and iv) taking into consideration the variability in the observed lateral ground spreading values for the same case history reported by different resources or measuring methodologies.

Likelihood analysis methodology was then adopted for the purpose of proper modeling of the uncertainties in the descriptive variables (i.e.: uncertainties in the estimation of *LSI*, a_{max}, $\phi'_{eqv,liq}$, and z_{cr}.). In the formulation of the likelihood functions, different sources of uncertainties including the model error and the errors due to inexact estimations of the descriptive variables were addressed individually.

Finally, probabilistic assessments incorporating the uncertainties in the estimation of descriptive variables produced a reduction within the model error terms and lead to a more reliable set of correlations for the assessment of liquefaction-induced lateral ground spreading, where the set of updated model parameters, θ_i's, and the model error parameters, σ_ε's, for exact and inexact observations are listed for three different site conditions in Tables 6.2 ad 6.3, respectively.

Table 6.2: Maximum Likelihood estimations for the exact observations.

	Site Condition		
Parameter	W = 0	S = 0	W > 0 & S > 0
θ_1	0.070	-0.299	-0.057
θ_2	-0.380	1.797	-0.463
θ_3	0.264	0.000	-0.436
θ_4	-2.347	0.000	1.313
θ_5	0.009	0.091	0.070
θ_6	0.222	-0.339	-0.474
θ_7	-1.521	0.016	-4.830
θ_8	5.516	-30.638	25.021
θ_9	-0.355	-0.896	-1.053
θ_{10}	1.091	0.318	6.507
θ_{11}	-0.049	0.000	0.170
θ_{12}	0.801	0.000	-0.979
θ_{13}	0.000	-0.117	-0.095
θ_{14}	0.000	0.853	0.529
θ_{15}	1.429	0.645	4.632
θ_{16}	-4.869	23.201	-23.961
σ_ε	0.170	0.109	0.135
R^2 (%)	83.6		

Table 6.3: Maximum Likelihood estimations for the inexact observations.

	Site Condition		
Parameter	W = 0	S = 0	W > 0 & S > 0
θ_1	0.084	-0.607	-0.056
θ_2	-0.409	3.883	-0.462
θ_3	0.367	0.000	-0.435
θ_4	-2.576	0.000	1.308
θ_5	0.010	0.063	0.070
θ_6	0.255	-0.160	-0.473
θ_7	-1.663	-5.973	-4.832
θ_8	6.435	7.016	25.033
θ_9	-0.505	-1.789	-1.052
θ_{10}	1.452	5.946	6.506
θ_{11}	-0.075	0.000	0.170
θ_{12}	0.869	0.000	-0.979
θ_{13}	0.000	-0.117	-0.095
θ_{14}	0.000	0.846	0.529
θ_{15}	1.561	6.078	4.634
θ_{16}	-5.717	-10.933	-23.972
σ_ε	0.116	0.094	0.106
R^2 (%)	85.5		

6.2 Conclusions

The new set of correlations for the assessment of liquefaction-induced lateral ground spreading presented in this study have a number of significant advantages over previous empirical relationships currently available, such as:

1. A large number of new case histories data was collected and assessed,

2. Previously available field case history data have been re-evaluated with current knowledge and understanding of seismicity, liquefaction triggering and liquefaction-induced lateral spreading mechanisms,

3. With this greatly enhanced database, higher standards were set for acceptability of case history data, and data not meeting these standards were deleted. The result is an enlarged database of higher overall quality,

4. More advanced probabilistic tools, likelihood analytical methods, were used to develop and evaluate new correlations. These methods allowed for separate treatment of different sources of uncertainty, and also allowed assessment of more contributing variables/parameters than previous studies,

5. Uncertainties within the measurement/estimation of the main descriptive variables were probabilistically assessed and incorporated into the model (i.e.: less accurate case histories had less weight on the overall performance),

6. The probabilistic nature of the proposed model enables an efficient framework in performance-based design decisions (i.e.: at a selected site after a design earthquake, one can estimate the probability of the lateral ground deformations to be greater than a threshold value),

7. The resulting model produced better fits to currently available lateral spreading data. Simply, the goodness of fit, expressed in terms of R^2, is estimated as 85.5% for the proposed model as compared to 13.2% for

Hamada et al. (1986) or 74.1% for Youd et al. (2002) functional forms. Thus, it is concluded that the proposed model as well as the assigned group of descriptive variables are more powerful to explain the observed seismically liquefaction-induced lateral spreading ground deformations than the existing models and the proposed model is a step forward in the assessment of liquefaction-induced ground deformations.

6.3 Recommendations for Future Research

This research study has identified some of the important aspects of seismic soil liquefaction-induced lateral spreading problem within a probabilistic framework, which warrants additional studies. These include the investigation of the other factors affecting liquefaction-induced lateral ground spreading, since the availability of new data and insights in the future may enable to address new aspects of this problem, such as the cap soil layer, soil gradation, soil stratification, etc. In addition, this study was based on correlating the seismic soil liquefaction-induced lateral ground spreading performance to the representative values of standard penetration resistance results. Future studies can be extended to use other in-situ index methods results such as cone penetration resistance and shear wave velocity. Finally, a valuable futuristic contribution would be in the efforts aiming to define the free-face and sloping ground surface effects on the observed lateral ground deformations.

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VITA

Wa’el Mohammad Kh. Al Bawwab was born in Kuwait on April 25, 1967. He was graduated in 1984 from The High School of Abdullah Assalem in Kuwait City-Kuwait. He received his B.S. degree in The Faculty of Engineering and Petroleum, Department of Civil Engineering from Kuwait University-Kuwait in January 1989. He worked in several construction projects as a site engineer for five years. Later in October 1995, he received his M.Sc. degree in Civil Engineering in The Faculty of Engineering, Department of Civil Engineering from Baghdad University-Iraq. His main field of study was in soil mechanics and foundation engineering, and his master’s study was focusing on the buckling of long piles in soft soils. Before he joined the Ph.D. program in METU in 2001, he has been working as an academic instructor in The College of Science and Technology in Gaza-Palestine.

APPENDIX A

DATABASE OF
SEISMIC SOIL LIQUEFACTION-INDUCED
LATERAL SPREADING CASE HISTORIES

SEISMIC EVENT # 1

EARTHQUAKE:	San Francisco
MOMENT MAGNITUDE:	7.9
LOCATION:	USA
DATE:	April 18, 1906
REFERENCE(S):	Database of Youd et al. (2002)

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
San Francisco-1906	1	1.45	Fine Sand	3.50	3	5.00	15.5	55.8	51.4	1.00	0.85	1.00	45	0.75	1.40	3	10	0.15	125	0.87	0.37	0.04	0.12	1.000	0.83	2.76
Mw	2	2.00	Fine Sand	5.50	3	7.00	15.5	86.8	62.7	1.00	0.95	1.00	45	0.75	1.26	3	10	0.15	125	0.76	0.41	0.04	0.10	1.000	0.73	2.77
7.9	3	1.44	Fine Sand	7.50	12	9.00	16.5	118.8	75.1	1.00	0.95	1.00	45	0.75	1.15	10	10	0.15	150	0.65	0.40	0.07	0.18	1.000	0.63	7.34
Site	4	0.88	Silty Clay	8.38	4	9.88	15.5	132.9	80.6	1.00	0.95	1.00	45	0.75	1.11	3	35	0.00	125	0.61	0.39	0.05	0.12	0.000	0.00	Non-Liq.
Mission Creek	5																									
Data Class	6																									
	7																									
B. H.	8																									
1	9																									
GWT (m)	10																									
3.05	11																									
a_{max} (g)	12																									
0.6	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
45	19																									
N (mean)	20																									
5.5	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
137	25																									
Observed (cm)	26																									
150	27																									
Distance (m)	28																									
0.3	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	5.77																							3.55	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
San Francisco-1906	1	2.04	Sand	5.00	11	6.50	16.5	76.6	66.4	1.00	0.95	1.00	45	0.75	1.23	10	10	0.35	150	0.79	0.33	0.07	0.21	1.000	0.75	7.09
Mw	2	3.00	Sand	7.00	8	8.50	16.5	109.6	79.7	1.00	0.95	1.00	45	0.75	1.12	6	10	0.35	150	0.69	0.34	0.05	0.15	1.000	0.65	4.56
7.9	3																									
Site	4																									
South of Market	5																									
Data Class	6																									
	7																									
B. H.	8																									
2	9																									
GWT (m)	10																									
3.96	11																									
a_{max} (g)	12																									
0.56	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
45	19																									
N (mean)	20																									
9.5	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
138	25																									
Observed (cm)	26																									
150	27																									
Distance (m)	28																									
0.3	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	5.04																							3.48	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
San Francisco-1906	1	1.77	Sand	5.18	5	6.68	16.5	79.5	67.8	1.00	0.95	1.00	60	1.00	1.21	6	25	0.25	150	0.82	0.18	0.06	0.33	1.000	0.74	4.83
Mw	2	1.33	Sand	6.34	7	7.84	16.5	98.6	75.6	1.00	0.95	1.00	60	1.00	1.15	8	25	0.25	150	0.77	0.18	0.06	0.36	1.000	0.68	6.32
7.9	3	1.33	Sand	7.84	8	9.34	16.5	123.4	85.6	1.00	0.95	1.00	60	1.00	1.08	8	25	0.25	150	0.70	0.18	0.07	0.36	1.000	0.61	6.88
Site	4	1.07	Sand	8.99	10	10.49	16.5	142.4	93.3	1.00	1.00	1.00	60	1.00	1.04	10	25	0.25	150	0.65	0.18	0.08	0.42	0.999	0.55	9.19
Salinas River	5	1.12	Sand	9.97	12	11.47	18.0	159.3	100.6	1.00	1.00	1.00	60	1.00	1.00	12	25	0.25	175	0.62	0.18	0.09	0.48	0.995	0.50	10.91
Data Class	6	1.25	Sand	11.22	11	12.72	16.5	180.8	109.9	1.00	1.00	1.00	60	1.00	0.95	10	5	0.35	150	0.59	0.18	0.06	0.37	1.000	0.44	7.54
	7																									
B. H.	8																									
4	9																									
GWT (m)	10																									
3.99	11																									
a_{max} (g)	12																									
0.28	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
8.8	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
142	25																									
Observed (cm)	26																									
183	27																									
Distance (m)	28																									
45.7	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	7.86																							4.72	

SEISMIC EVENT # 2

EARTHQUAKE:	Niigata
MOMENT MAGNITUDE:	7.5
LOCATION:	Japan
DATE:	June 16, 1964
REFERENCE(S):	Database of Youd et al. (2002)

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (fps)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	1.86	Medium Sand	3.00	6	4.50	16.5	48.6	37.7	1.00	0.85	1.00	67	1.12	1.63	9	5	0.35	150	0.97	0.15	0.09	0.57	0.956	0.85	6.36
Mw	2	1.50	Medium Sand	4.50	10	6.00	18.0	74.4	48.8	1.00	0.85	1.00	67	1.12	1.43	14	5	0.35	175	0.94	0.18	0.11	0.65	0.869	0.78	10.62
7.5	3	1.50	Medium Sand	6.00	11	7.50	18.0	101.4	61.1	1.00	0.95	1.00	67	1.12	1.28	15	5	0.35	175	0.91	0.19	0.12	0.64	0.874	0.70	11.94
Site	4	1.50	Medium Sand	7.50	17	9.00	18.0	128.4	73.4	1.00	0.95	1.00	67	1.12	1.17	21	5	0.35	200	0.86	0.19	0.18	0.98	0.180	0.63	38.13
G10, L-L'	5	1.50	Medium Sand	9.00	17	10.50	18.0	155.4	85.7	1.00	1.00	1.00	67	1.12	1.08	21	5	0.35	200	0.81	0.18	0.17	0.92	0.265	0.55	17.28
Data Class	6	1.50	Medium Sand	10.50	19	12.00	18.0	182.4	98.0	1.00	1.00	1.00	67	1.12	1.01	21	5	0.35	200	0.76	0.17	0.17	0.99	0.161	0.48	38.24
	7	1.50	Medium Sand	12.00	8	13.50	16.5	208.3	109.1	1.00	1.00	1.00	67	1.12	0.96	9	5	0.35	150	0.71	0.17	0.06	0.37	1.000	0.40	5.78
B. H.	8	1.50	Medium Sand	13.50	23	15.00	18.0	234.2	120.3	1.00	1.00	1.00	67	1.12	0.91	23	5	0.35	200	0.68	0.16	0.19	1.17	0.037	0.33	38.78
33	9	1.50	Medium Sand	15.00	26	16.50	18.0	261.2	132.6	1.00	1.00	1.00	67	1.12	0.87	25	5	0.35	200	0.65	0.16	0.21	1.34	0.007	0.25	39.27
GWT (m)	10	1.50	Medium Sand	16.50	30	18.00	18.0	288.2	144.9	1.00	1.00	1.00	67	1.12	0.83	28	5	0.35	200	0.63	0.16	0.25	1.62	0.000	0.18	39.98
1.89	11	1.50	Medium Sand	18.00	32	19.50	18.0	315.2	157.1	1.00	1.00	1.00	67	1.12	0.80	29	5	0.35	200	0.62	0.15	0.26	1.68	0.000	0.10	40.17
a_{max} (g)	12	1.50	Fine Sand	19.50	34	21.00	18.0	342.2	169.4	1.00	1.00	1.00	67	1.12	0.77	29	8	0.15	200	0.62	0.15	0.28	1.81	0.000	0.03	40.48
0.19	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
67	19																									
N (mean)	20																									
19.4	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
181	25																									
Observed (cm)	26																									
162	27																									
Distance (m)	28																									
101.6	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	18.36																							4.56	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	Φ(x)	PL	WF-L	Φ'mob.
Niigata-1964	1	2.15	Medium Sand	3.50	7	5.00	16.5	56.7	43.0	1.00	0.85	1.00	67	1.12	1.53	10	5	0.35	150	0.95	0.15	0.09	0.59	1.57	0.942	0.83	7.18
Mw	2	1.50	Medium Sand	5.00	13	6.50	18.0	82.6	54.1	1.00	0.95	1.00	67	1.12	1.36	19	5	0.35	175	0.91	0.17	0.17	0.96	-0.86	0.196	0.75	37.51
7.5	3	1.50	Medium Sand	6.50	14	8.00	18.0	109.6	66.4	1.00	0.95	1.00	67	1.12	1.23	18	5	0.35	175	0.86	0.18	0.15	0.86	-0.27	0.395	0.68	15.12
Site	4	2.25	Medium Sand	8.00	23	9.50	18.0	136.6	78.7	1.00	0.95	1.00	67	1.12	1.13	28	5	0.35	200	0.81	0.17	0.29	1.69	-3.62	0.000	0.60	39.89
G-10, L-L'	5	2.25	Medium Sand	11.00	11	12.50	18.0	190.6	103.3	1.00	1.00	1.00	67	1.12	0.98	12	5	0.35	175	0.70	0.16	0.08	0.52	2.17	0.985	0.45	9.13
Data Class	6	1.50	Medium Sand	12.50	18	14.00	18.0	217.6	115.6	1.00	1.00	1.00	67	1.12	0.93	19	5	0.35	175	0.66	0.15	0.13	0.87	-0.36	0.360	0.38	15.58
	7	1.50	Medium Sand	14.00	17	15.50	18.0	244.6	127.8	1.00	1.00	1.00	67	1.12	0.88	17	5	0.35	175	0.63	0.15	0.11	0.75	0.36	0.639	0.30	13.75
B. H.	8	1.50	Medium Sand	15.50	19	17.00	18.0	271.6	140.1	1.00	1.00	1.00	67	1.12	0.84	18	5	0.35	175	0.61	0.15	0.12	0.82	-0.04	0.485	0.23	14.84
34	9																										
GWT (m)	10																										
2.1	11																										
a_{max} (g)	12																										
0.19	13																										
Sampler[b]	14																										
NA	15																										
B.H. Diam. (mm)	16																										
95	17																										
Energy Ratio[c]	18																										
67	19																										
N (mean)	20																										
15.3	21																										
γ_{dry} (kN/m^3)	22																										
16.0	23																										
Vs* (m/s)	24																										
171	25																										
Observed (cm)	26																										
162	27																										
Distance (m)	28																										
139.7	29																									LSI	
Liquefied ?	30																									Lin.	
	SUM	14.15																								3.94	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (fps)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	0.99	Midium Sand	2.50	3	4.00	15.5	39.8	34.9	1.00	0.75	1.00	67	1.12	1.69	4	10	0.35	125	0.97	0.14	0.06	0.46	0.997	0.88	3.42
Mw	2	1.00	Midium Sand	3.50	6	5.00	16.5	55.8	41.1	1.00	0.85	1.00	67	1.12	1.56	9	10	0.35	150	0.95	0.16	0.09	0.54	0.975	0.83	6.37
7.5	3	1.00	Midium Sand	4.50	6	6.00	16.5	72.3	47.8	1.00	0.85	1.00	67	1.12	1.45	8	10	0.35	150	0.93	0.17	0.08	0.46	0.998	0.78	5.85
Site	4	1.00	Midium Sand	5.50	5	7.00	16.5	88.8	54.5	1.00	0.95	1.00	67	1.12	1.35	7	10	0.35	150	0.90	0.18	0.07	0.39	1.000	0.73	5.08
G-10, L-L'	5	0.95	Midium Sand	6.50	6	8.00	16.5	105.3	61.2	1.00	0.95	1.00	67	1.12	1.28	8	10	0.35	150	0.86	0.18	0.07	0.40	1.000	0.68	5.77
Data Class	6	1.00	Midium Sand	7.40	8	8.90	16.5	120.1	67.2	1.00	0.95	1.00	67	1.12	1.22	10	10	0.35	150	0.83	0.18	0.08	0.46	0.997	0.63	7.84
	7	1.05	Coarse Sand	8.50	10	10.00	18.0	139.1	75.4	1.00	0.95	1.00	67	1.12	1.15	12	7	0.60	175	0.79	0.18	0.09	0.52	0.986	0.58	9.45
B. H.	8	1.00	Coarse Sand	9.50	11	11.00	18.0	157.1	83.6	1.00	1.00	1.00	67	1.12	1.09	13	7	0.60	175	0.75	0.17	0.10	0.57	0.959	0.53	10.67
35	9	1.00	Coarse Sand	10.50	15	12.00	18.0	175.1	91.8	1.00	1.00	1.00	67	1.12	1.04	17	7	0.60	175	0.72	0.17	0.13	0.78	0.567	0.48	14.64
GWT (m)	10	1.00	Midium Sand	11.50	11	13.00	18.0	193.1	100.0	1.00	1.00	1.00	67	1.12	1.00	12	5	0.35	175	0.69	0.16	0.09	0.52	0.986	0.43	9.33
2.01	11	1.00	Midium Sand	12.50	10	14.00	18.0	211.1	108.2	1.00	1.00	1.00	67	1.12	0.96	11	5	0.35	175	0.66	0.16	0.07	0.46	0.997	0.38	7.78
a_{max} (g)	12	1.00	Midium Sand	13.50	33	15.00	19.0	229.6	116.9	1.00	1.00	1.00	67	1.12	0.93	34	5	0.35	225	0.64	0.16	0.43	2.79	0.000	0.33	41.69
0.19	13	1.00	Midium Sand	14.50	24	16.00	18.0	248.1	125.6	1.00	1.00	1.00	67	1.12	0.89	24	5	0.35	200	0.62	0.15	0.19	1.28	0.012	0.28	38.92
Sampler[b]	14	1.00	Midium Sand	15.50	33	17.00	19.0	266.6	134.2	1.00	1.00	1.00	67	1.12	0.86	32	5	0.35	225	0.61	0.15	0.35	2.33	0.000	0.23	41.06
NA	15	1.00	Midium Sand	16.50	21	18.00	18.0	285.1	142.9	1.00	1.00	1.00	67	1.12	0.84	20	5	0.35	175	0.60	0.15	0.13	0.91	0.283	0.18	16.44
B.H. Diam. (mm)	16	1.00	Midium Sand	17.50	27	19.00	18.0	303.1	151.1	1.00	1.00	1.00	67	1.12	0.81	25	5	0.35	200	0.60	0.15	0.19	1.31	0.009	0.13	39.08
95	17	1.00	Fine Sand	18.50	32	20.00	18.0	321.1	159.3	1.00	1.00	1.00	67	1.12	0.79	28	11	0.15	200	0.59	0.15	0.27	1.87	0.000	0.08	40.37
Energy Ratio[c]	18	1.00	Fine Sand	19.50	40	21.00	19.0	339.6	168.0	1.00	1.00	1.00	67	1.12	0.77	34	11	0.60	225	0.59	0.15	0.44	2.99	0.000	0.03	42.09
67	19	1.00	Fine Sand	20.50	22	22.00	18.0	358.1	176.7	1.00	1.00	1.00	67	1.12	0.75	18	11	0.15	175	0.58	0.15	0.12	0.85	0.417	0.00	16.06
N (mean)	20																									
17.0	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
171	25																									
Observed (cm)	26																									
122	27																									
Distance (m)	28																									
88.9	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	18.99																							6.65	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	1.09	Coarse Sand	1.50	10	3.00	18.0	25.2	19.4	1.00	0.75	1.00	67	1.12	2.00	17	4	0.60	175	0.99	0.16	0.19	1.18	0.032	0.93	36.96
Mw	2	1.00	Coarse Sand	2.50	8	4.00	18.0	43.2	27.6	1.00	0.75	1.00	67	1.12	1.90	13	4	0.60	175	0.98	0.19	0.13	0.66	0.840	0.88	9.80
7.5	3	1.00	Coarse Sand	3.50	3	5.00	16.5	60.4	35.0	1.00	0.85	1.00	67	1.12	1.69	5	4	0.60	150	0.96	0.20	0.06	0.31	1.000	0.83	3.53
Site	4	1.00	Coarse Sand	4.50	5	6.00	16.5	76.9	41.7	1.00	0.85	1.00	67	1.12	1.55	7	4	0.60	150	0.94	0.21	0.07	0.34	1.000	0.78	4.93
G-10, F-F'	5	1.00	Coarse Sand	5.50	13	7.00	18.0	94.2	49.2	1.00	0.95	1.00	67	1.12	1.43	20	4	0.60	175	0.92	0.22	0.18	0.83	0.452	0.73	16.49
Data Class	6	1.00	Coarse Sand	6.50	7	8.00	16.5	111.4	56.6	1.00	0.95	1.00	67	1.12	1.33	10	4	0.60	150	0.89	0.22	0.08	0.38	1.000	0.68	6.91
	7	1.00	Midium Sand	7.50	11	9.00	18.0	128.7	64.0	1.00	0.95	1.00	67	1.12	1.25	15	5	0.35	175	0.86	0.21	0.11	0.54	0.978	0.63	11.60
B. H.	8	1.00	Fine Sand	8.50	10	10.00	18.0	146.7	72.2	1.00	0.95	1.00	67	1.12	1.18	12	5	0.15	175	0.82	0.21	0.09	0.46	0.998	0.58	9.53
36	9	1.00	Fine Sand	9.50	9	11.00	18.0	164.7	80.4	1.00	1.00	1.00	67	1.12	1.12	11	5	0.15	175	0.79	0.20	0.08	0.42	0.999	0.53	8.25
GWT (m)	10	1.00	Fine Sand	10.50	10	12.00	18.0	182.7	88.6	1.00	1.00	1.00	67	1.12	1.06	12	5	0.15	175	0.76	0.19	0.09	0.44	0.999	0.48	8.91
0.91	11	1.00	Fine Sand	11.50	13	13.00	18.0	200.7	96.8	1.00	1.00	1.00	67	1.12	1.02	15	5	0.15	175	0.72	0.19	0.10	0.56	0.966	0.43	11.77
a_{max} (g)	12	1.00	Fine Sand	12.50	12	14.00	18.0	218.7	105.0	1.00	1.00	1.00	67	1.12	0.98	13	5	0.15	175	0.70	0.18	0.09	0.50	0.992	0.38	10.12
0.19	13	1.00	Fine Sand	13.50	30	15.00	19.0	237.2	113.7	1.00	1.00	1.00	67	1.12	0.94	31	5	0.15	225	0.68	0.17	0.36	2.04	0.000	0.33	40.96
Sampler[b]	14	1.00	Fine Sand	14.50	33	16.00	19.0	256.2	122.9	1.00	1.00	1.00	67	1.12	0.90	33	5	0.15	225	0.66	0.17	0.40	2.36	0.000	0.28	41.46
NA	15	1.00	Fine Sand	15.50	32	17.00	19.0	275.2	132.1	1.00	1.00	1.00	67	1.12	0.87	31	5	0.15	225	0.64	0.17	0.33	2.01	0.000	0.23	40.87
B.H. Diam. (mm)	16	1.00	Fine Sand	16.50	23	18.00	18.0	293.7	140.7	1.00	1.00	1.00	67	1.12	0.84	22	5	0.15	200	0.63	0.16	0.16	0.97	0.186	0.18	38.30
95	17	1.00	Silt	17.50	19	19.00	18.0	311.7	148.9	1.00	1.00	1.00	67	1.12	0.82	17	35	0.03	175	0.63	0.16	0.15	0.91	0.000	0.00	Non-Liq.
Energy Ratio[c]	18	1.00	Fine Sand	18.50	26	20.00	18.0	329.7	157.1	1.00	1.00	1.00	67	1.12	0.80	23	5	0.15	200	0.62	0.16	0.17	1.07	0.082	0.08	38.71
67	19	1.00	Fine Sand	19.50	50	21.00	19.0	348.2	165.8	1.00	1.00	1.00	67	1.12	0.78	43	5	0.15	225	0.62	0.16	0.80	5.00	0.000	0.03	44.21
N (mean)	20	1.00	Fine Sand	20.50	31	22.00	18.0	366.7	174.5	1.00	1.00	1.00	67	1.12	0.76	26	5	0.15	200	0.61	0.16	0.21	1.33	0.007	0.00	39.54
17.8	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
180	25																									
Observed (cm)	26																									
181	27																									
Distance (m)	28																									
31.7	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	20.09																							6.38	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	1.09	Coarse Sand	1.50	1	3.00	15.5	22.8	17.0	1.00	0.75	1.00	67	1.12	2.00	2	6	0.60	125	0.99	0.16	0.06	0.38	1.000	0.93	2.34
Mw	2	1.00	Coarse Sand	2.50	2	4.00	15.5	38.3	22.7	1.00	0.75	1.00	67	1.12	2.00	3	6	0.60	125	0.98	0.20	0.07	0.32	1.000	0.88	2.93
7.5	3	1.00	Coarse Sand	3.50	7	5.00	18.0	55.0	29.6	1.00	0.85	1.00	67	1.12	1.84	12	6	0.60	175	0.96	0.22	0.12	0.54	0.976	0.83	9.34
Site	4	1.00	Coarse Sand	4.50	18	6.00	18.0	73.0	37.8	1.00	0.85	1.00	67	1.12	1.63	28	6	0.60	200	0.94	0.22	0.37	1.65	0.000	0.78	40.01
G-10, F-F'	5	1.00	Midium Sand	5.50	7	7.00	18.0	91.0	46.0	1.00	0.95	1.00	67	1.12	1.47	11	4	0.35	175	0.91	0.22	0.09	0.42	0.999	0.73	7.99
Data Class	6	1.00	Midium Sand	6.50	9	8.00	18.0	109.0	54.2	1.00	0.95	1.00	67	1.12	1.36	13	4	0.35	175	0.89	0.22	0.11	0.48	0.995	0.68	10.01
	7	1.00	Midium Sand	7.50	10	9.00	18.0	127.0	62.4	1.00	0.95	1.00	67	1.12	1.27	13	4	0.35	175	0.85	0.21	0.10	0.49	0.994	0.63	10.46
B. H.	8	1.00	Midium Sand	8.50	8	10.00	16.5	144.3	69.8	1.00	0.95	1.00	67	1.12	1.20	10	4	0.35	150	0.82	0.21	0.08	0.38	1.000	0.58	7.20
37	9	1.00	Fine Sand	9.50	12	11.00	18.0	161.5	77.3	1.00	1.00	1.00	67	1.12	1.14	15	4	0.15	175	0.78	0.20	0.11	0.56	0.964	0.53	12.25
GWT (m)	10	1.00	Fine Sand	10.50	7	12.00	16.5	178.8	84.7	1.00	1.00	1.00	67	1.12	1.09	8	4	0.15	150	0.75	0.19	0.07	0.34	1.000	0.48	5.73
0.91	11	1.00	Fine Sand	11.50	10	13.00	18.0	196.0	92.2	1.00	1.00	1.00	67	1.12	1.04	12	4	0.15	175	0.72	0.19	0.08	0.44	0.999	0.43	8.68
a_{max} (g)	12	1.00	Fine Sand	12.50	44	14.00	19.0	214.5	100.8	1.00	1.00	1.00	67	1.12	1.00	49	4	0.15	225	0.69	0.18	1.38	7.60	0.000	0.38	45.73
0.19	13	1.00	Fine Sand	13.50	41	15.00	19.0	233.5	110.0	1.00	1.00	1.00	67	1.12	0.95	44	4	0.15	225	0.67	0.18	0.90	5.13	0.000	0.33	44.29
Sampler[b]	14	1.00	Fine Sand	14.50	40	16.00	19.0	252.5	119.2	1.00	1.00	1.00	67	1.12	0.92	41	4	0.15	225	0.65	0.17	0.71	4.19	0.000	0.28	43.55
NA	15	1.00	Fine Sand	15.50	36	17.00	19.0	271.5	128.4	1.00	1.00	1.00	67	1.12	0.88	35	4	0.15	225	0.64	0.17	0.46	2.78	0.000	0.23	42.07
B.H. Diam. (mm)	16	1.00	Fine Sand	16.50	43	18.00	19.0	290.5	137.6	1.00	1.00	1.00	67	1.12	0.85	41	4	0.15	225	0.63	0.16	0.69	4.20	0.000	0.18	43.55
95	17	1.00	Fine Sand	17.50	35	19.00	19.0	309.5	146.8	1.00	1.00	1.00	67	1.12	0.83	32	4	0.15	225	0.62	0.16	0.35	2.16	0.000	0.13	41.19
Energy Ratio[c]	18	1.00	Silty Sand	18.50	29	20.00	18.0	328.0	155.5	1.00	1.00	1.00	67	1.12	0.80	26	35	0.07	200	0.61	0.16	0.30	1.90	0.000	0.08	40.71
67	19	1.00	Fine Sand	19.50	33	21.00	18.0	346.0	163.7	1.00	1.00	1.00	67	1.12	0.78	29	8	0.15	200	0.61	0.16	0.27	1.71	0.000	0.03	40.38
N (mean)	20	1.00	Fine Sand	20.50	41	22.00	19.0	364.5	172.4	1.00	1.00	1.00	67	1.12	0.76	35	8	0.15	225	0.61	0.16	0.43	2.72	0.000	0.00	42.05
21.7	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
178	25																									
Observed (cm)	26																									
195	27																									
Distance (m)	28																									
43.2	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	20.09																							6.69	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	0.97	Fine Sand	2.00	8	3.50	18.0	32.2	25.1	1.00	0.75	1.00	67	1.12	2.00	13	8	0.15	175	0.98	0.15	0.14	0.90	0.307	0.90	10.71
Mw	2	0.50	Medium Sand	2.50	9	4.00	18.0	41.2	29.2	1.00	0.75	1.00	67	1.12	1.85	14	5	0.35	175	0.97	0.17	0.14	0.81	0.513	0.88	10.98
7.5	3	0.50	Sandy Silt	3.00	10	4.50	18.0	50.2	33.3	1.00	0.85	1.00	67	1.12	1.73	16	35	0.04	175	0.96	0.18	0.21	1.15	0.000	0.00	Non-Liq.
Site	4	0.50	Medium Sand	3.50	11	5.00	18.0	59.2	37.4	1.00	0.85	1.00	67	1.12	1.64	17	5	0.35	175	0.95	0.19	0.16	0.87	0.368	0.83	14.03
H-10, N-N'	5	0.75	Sandy Silt	4.00	12	5.50	18.0	68.2	41.5	1.00	0.85	1.00	67	1.12	1.55	18	35	0.04	175	0.94	0.19	0.22	1.13	0.000	0.00	Non-Liq.
Data Class	6	1.00	Medium Sand	5.00	4	6.50	16.5	85.4	48.9	1.00	0.95	1.00	67	1.12	1.43	6	5	0.35	150	0.91	0.20	0.06	0.33	1.000	0.75	4.16
	7	1.00	Medium Sand	6.00	4	7.50	16.5	101.9	55.6	1.00	0.95	1.00	67	1.12	1.34	6	5	0.35	150	0.88	0.20	0.06	0.30	1.000	0.70	3.96
B. H.	8	1.00	Medium Sand	7.00	7	8.50	16.5	118.4	62.3	1.00	0.95	1.00	67	1.12	1.27	9	5	0.35	150	0.85	0.20	0.08	0.39	1.000	0.65	6.47
42	9	1.00	Medium Sand	8.00	11	9.50	18.0	135.7	69.7	1.00	0.95	1.00	67	1.12	1.20	14	5	0.35	175	0.81	0.19	0.11	0.55	0.972	0.60	11.00
GWT (m)	10	1.00	Medium Sand	9.00	11	10.50	18.0	153.7	77.9	1.00	1.00	1.00	67	1.12	1.13	14	5	0.35	175	0.77	0.19	0.10	0.55	0.973	0.55	10.94
1.28	11	1.00	Medium Sand	10.00	4	11.50	16.5	170.9	85.4	1.00	1.00	1.00	67	1.12	1.08	5	5	0.35	150	0.74	0.18	0.05	0.28	1.000	0.50	3.54
a_{max} (g)	12	1.00	Medium Sand	11.00	5	12.50	16.5	187.4	92.1	1.00	1.00	1.00	67	1.12	1.04	6	5	0.35	150	0.70	0.18	0.05	0.30	1.000	0.45	4.03
0.19	13	1.00	Medium Sand	12.00	14	13.50	18.0	204.7	99.5	1.00	1.00	1.00	67	1.12	1.00	16	5	0.35	175	0.68	0.17	0.11	0.64	0.874	0.40	12.67
Sampler[b]	14	1.00	Medium Sand	13.00	9	14.50	16.5	221.9	106.9	1.00	1.00	1.00	67	1.12	0.97	10	5	0.35	150	0.65	0.17	0.07	0.41	1.000	0.35	6.76
NA	15	1.00	Medium Sand	14.00	13	15.50	18.0	239.2	114.4	1.00	1.00	1.00	67	1.12	0.94	14	5	0.35	175	0.63	0.16	0.09	0.55	0.971	0.30	10.61
B.H. Diam. (mm)	16	1.00	Medium Sand	15.00	25	16.50	18.0	257.2	122.6	1.00	1.00	1.00	67	1.12	0.90	25	5	0.35	200	0.62	0.16	0.22	1.35	0.006	0.25	39.27
95	17	1.00	Medium Sand	16.00	39	17.50	19.0	275.7	131.3	1.00	1.00	1.00	67	1.12	0.87	38	5	0.35	225	0.61	0.16	0.57	3.58	0.000	0.20	42.76
Energy Ratio[c]	18	1.00	Fine Sand	17.00	27	18.50	18.0	294.2	139.9	1.00	1.00	1.00	67	1.12	0.85	25	8	0.15	200	0.60	0.16	0.22	1.41	0.003	0.15	39.46
67	19	1.00	Fine Sand	18.00	34	19.50	19.0	312.7	148.6	1.00	1.00	1.00	67	1.12	0.82	31	8	0.15	225	0.60	0.15	0.34	2.17	0.000	0.10	41.02
N (mean)	20	1.00	Fine Sand	19.00	46	20.50	19.0	331.7	157.8	1.00	1.00	1.00	67	1.12	0.80	41	8	0.15	225	0.59	0.15	0.70	4.58	0.000	0.05	43.71
16.2	21	1.00	Fine Sand	20.00	38	21.50	19.0	350.7	167.0	1.00	1.00	1.00	67	1.12	0.77	33	8	0.15	225	0.59	0.15	0.37	2.43	0.000	0.00	41.49
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
172	25																									
Observed (cm)	26																									
80	27																									
Distance (m)	28																									
82.6	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	19.22																							5.81	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	0.85	Coarse Sand	2.00	8	3.50	18.0	32.7	29.3	1.00	0.75	1.00	67	1.12	1.85	12	6	0.60	175	0.99	0.14	0.12	0.89	0.323	0.90	9.52
Mw	2	1.00	Coarse Sand	3.00	14	4.50	18.0	50.7	37.5	1.00	0.85	1.00	67	1.12	1.63	22	6	0.60	200	0.98	0.16	0.23	1.42	0.003	0.85	38.35
7.5	3	1.00	Coarse Sand	4.00	13	5.50	18.0	68.7	45.6	1.00	0.85	1.00	67	1.12	1.48	18	6	0.60	175	0.97	0.18	0.17	0.94	0.240	0.80	37.41
Site	4	1.00	Coarse Sand	5.00	14	6.50	18.0	86.7	53.8	1.00	0.95	1.00	67	1.12	1.36	20	6	0.60	175	0.96	0.19	0.19	0.99	0.166	0.75	37.95
H-10, N-N'	5	1.00	Coarse Sand	6.00	14	7.50	18.0	104.7	62.0	1.00	0.95	1.00	67	1.12	1.27	19	6	0.60	175	0.94	0.20	0.16	0.83	0.455	0.70	15.84
Data Class	6	1.00	Coarse Sand	7.00	13	8.50	18.0	122.7	70.2	1.00	0.95	1.00	67	1.12	1.19	16	6	0.60	175	0.92	0.20	0.13	0.66	0.846	0.65	13.54
	7	1.00	Coarse Sand	8.00	10	9.50	18.0	140.7	78.4	1.00	0.95	1.00	67	1.12	1.13	12	6	0.60	175	0.89	0.20	0.09	0.45	0.998	0.60	9.12
B. H.	8	1.00	Coarse Sand	9.00	12	10.50	18.0	158.7	86.6	1.00	1.00	1.00	67	1.12	1.07	14	6	0.60	175	0.86	0.19	0.10	0.54	0.978	0.55	11.52
43	9	1.00	Coarse Sand	10.00	18	11.50	18.0	176.7	94.8	1.00	1.00	1.00	67	1.12	1.03	21	6	0.60	200	0.83	0.19	0.17	0.87	0.374	0.50	17.53
GWT (m)	10	1.00	Coarse Sand	11.00	21	12.50	18.0	194.7	103.0	1.00	1.00	1.00	67	1.12	0.99	23	6	0.60	200	0.80	0.19	0.20	1.05	0.104	0.45	38.73
1.65	11	1.00	Coarse Sand	12.00	29	13.50	19.0	213.2	111.7	1.00	1.00	1.00	67	1.12	0.95	31	6	0.60	225	0.77	0.18	0.34	1.88	0.000	0.40	40.80
a_{max} (g)	12	1.00	Coarse Sand	13.00	36	14.50	19.0	232.2	120.9	1.00	1.00	1.00	67	1.12	0.91	37	6	0.60	225	0.74	0.18	0.53	2.98	0.000	0.35	42.42
0.19	13	1.00	Coarse Sand	14.00	48	15.50	19.0	251.2	130.0	1.00	1.00	1.00	67	1.12	0.88	47	6	0.60	225	0.72	0.17	1.15	6.67	0.000	0.30	45.27
Sampler[b]	14	1.00	Coarse Sand	15.00	55	16.50	19.0	270.2	139.2	1.00	1.00	1.00	67	1.12	0.85	52	6	0.60	225	0.70	0.17	1.66	9.85	0.000	0.25	46.65
NA	15	1.00	Coarse Sand	16.00	53	17.50	19.0	289.2	148.4	1.00	1.00	1.00	67	1.12	0.82	49	6	0.60	225	0.69	0.17	1.25	7.53	0.000	0.20	45.70
B.H. Diam. (mm)	16	1.00	Coarse Sand	17.00	57	18.50	19.0	308.2	157.6	1.00	1.00	1.00	67	1.12	0.80	51	6	0.60	225	0.68	0.16	1.45	8.83	0.000	0.15	46.28
95	17	1.00	Coarse Sand	18.00	71	19.50	19.0	327.2	166.8	1.00	1.00	1.00	67	1.12	0.77	61	6	0.60	225	0.67	0.16	3.24	19.95	0.000	0.10	49.21
Energy Ratio[c]	18	1.00	Coarse Sand	19.00	71	20.50	19.0	346.2	176.0	1.00	1.00	1.00	67	1.12	0.75	60	6	0.60	225	0.66	0.16	2.82	17.46	0.000	0.05	48.76
67	19	1.00	Coarse Sand	20.00	69	21.50	19.0	365.2	185.2	1.00	1.00	1.00	67	1.12	0.73	57	6	0.60	225	0.66	0.16	2.18	13.58	0.000	0.00	47.90
N (mean)	20																									
32.9	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
195	25																									
Observed (cm)	26																									
75	27																									
Distance (m)	28																									
88.9	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	18.85																							2.80	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N^d	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	3.09	Sand	3.50	6	5.00	16.5	57.3	31.9	1.00	0.85	1.00	67	1.12	1.77	10	10	0.20	150	0.96	0.21	0.10	0.48	0.995	0.83	7.57
Mw	2	1.00	Sand	4.50	3	6.00	16.5	73.8	38.6	1.00	0.85	1.00	67	1.12	1.61	5	10	0.20	150	0.94	0.22	0.06	0.28	1.000	0.78	3.58
7.5	3	1.00	Sand	5.50	10	7.00	18.0	91.0	46.0	1.00	0.95	1.00	67	1.12	1.47	16	10	0.20	175	0.91	0.22	0.14	0.64	0.882	0.73	13.17
Site	4	1.00	Sand	6.50	16	8.00	18.0	109.0	54.2	1.00	0.95	1.00	67	1.12	1.36	23	10	0.20	200	0.88	0.22	0.24	1.11	0.063	0.68	38.87
H-10, A-A'	5	1.00	Silty Sand	7.50	5	9.00	16.5	126.3	61.6	1.00	0.95	1.00	67	1.12	1.27	7	10	0.22	150	0.85	0.22	0.07	0.30	1.000	0.63	4.79
Data Class	6	1.00	Silty Sand	8.50	4	10.00	16.5	142.8	68.3	1.00	0.95	1.00	67	1.12	1.21	5	10	0.22	150	0.81	0.21	0.06	0.27	1.000	0.58	3.85
	7	1.00	Midium Sand	9.50	6	11.00	16.5	159.3	75.0	1.00	1.00	1.00	67	1.12	1.15	8	7	0.32	150	0.78	0.20	0.07	0.32	1.000	0.53	5.30
B. H.	8	1.00	Midium Sand	10.50	6	12.00	16.5	175.8	81.7	1.00	1.00	1.00	67	1.12	1.11	7	7	0.32	150	0.74	0.20	0.06	0.32	1.000	0.48	5.07
48	9	1.00	Midium Sand	11.50	10	13.00	18.0	193.0	89.2	1.00	1.00	1.00	67	1.12	1.06	12	7	0.32	175	0.71	0.19	0.09	0.45	0.998	0.43	9.06
GWT (m)	10	1.00	Midium Sand	12.50	15	14.00	18.0	211.0	97.3	1.00	1.00	1.00	67	1.12	1.01	17	7	0.32	175	0.69	0.18	0.12	0.68	0.808	0.38	14.15
0.91	11	1.00	Midium Sand	13.50	19	15.00	18.0	229.0	105.5	1.00	1.00	1.00	67	1.12	0.97	21	7	0.30	200	0.66	0.18	0.16	0.91	0.283	0.33	17.65
a_{max} (g)	12	1.00	Fine Sand	14.50	44	16.00	19.0	247.5	114.2	1.00	1.00	1.00	67	1.12	0.94	46	14	0.18	225	0.65	0.17	1.27	7.31	0.000	0.28	45.49
0.19	13	1.00	Fine Sand	15.50	52	17.00	19.0	266.5	123.4	1.00	1.00	1.00	67	1.12	0.90	52	14	0.18	225	0.63	0.17	2.04	12.07	0.000	0.23	47.27
Sampler[b]	14	1.00	Fine Sand	16.50	49	18.00	19.0	285.5	132.6	1.00	1.00	1.00	67	1.12	0.87	48	14	0.18	225	0.62	0.17	1.37	8.27	0.000	0.18	45.92
NA	15	1.00	Fine Sand	17.50	46	19.00	19.0	304.5	141.8	1.00	1.00	1.00	67	1.12	0.84	43	14	0.18	225	0.62	0.16	0.95	5.82	0.000	0.13	44.69
B.H. Diam. (mm)	16	1.00	Fine Sand	18.50	41	20.00	19.0	323.5	151.0	1.00	1.00	1.00	67	1.12	0.81	37	14	0.18	225	0.61	0.16	0.59	3.63	0.000	0.08	43.03
95	17	1.00	Fine Sand	19.50	40	21.00	19.0	342.5	160.2	1.00	1.00	1.00	67	1.12	0.79	35	14	0.18	225	0.61	0.16	0.49	3.08	0.000	0.03	42.48
Energy Ratio[c]	18	1.00	Fine Sand	20.50	41	22.00	19.0	361.5	169.4	1.00	1.00	1.00	67	1.12	0.77	35	14	0.18	225	0.60	0.16	0.48	3.03	0.000	0.00	42.44
67	19																									
N (mean)	20																									
22.9	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
178	25																									
Observed (cm)	26																									
397	27																									
Distance (m)	28																									
110.5	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	20.09																							7.01	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	1.84	Midium Sand	2.00	5	3.50	16.5	32.5	21.9	1.00	0.75	1.00	67	1.12	2.00	8	5	0.35	150	0.99	0.18	0.10	0.53	0.982	0.90	5.64
Mw	2	1.50	Midium Sand	3.50	8	5.00	18.0	58.4	33.0	1.00	0.85	1.00	67	1.12	1.74	13	5	0.35	175	0.97	0.21	0.12	0.59	0.945	0.83	10.25
7.5	3	1.50	Midium Sand	5.00	14	6.50	18.0	85.4	45.3	1.00	0.95	1.00	67	1.12	1.49	22	5	0.35	200	0.95	0.22	0.22	1.02	0.130	0.75	38.41
Site	4	1.50	Coarse Sand	6.50	16	8.00	18.0	112.4	57.6	1.00	0.95	1.00	67	1.12	1.32	22	6	0.60	200	0.91	0.22	0.22	0.99	0.165	0.68	38.53
H-10, A-A'	5	1.50	Midium Sand	8.00	17	9.50	18.0	139.4	69.9	1.00	0.95	1.00	67	1.12	1.20	22	5	0.60	200	0.87	0.21	0.19	0.89	0.313	0.60	18.27
Data Class	6	1.50	Midium Sand	9.50	19	11.00	18.0	166.4	82.2	1.00	1.00	1.00	67	1.12	1.10	23	5	0.60	200	0.82	0.20	0.21	1.03	0.121	0.53	38.78
	7	1.50	Midium Sand	11.00	22	12.50	18.0	193.4	94.4	1.00	1.00	1.00	67	1.12	1.03	25	5	0.60	200	0.77	0.19	0.23	1.20	0.027	0.45	39.29
B. H.	8	1.50	Midium Sand	12.50	19	14.00	18.0	220.4	106.7	1.00	1.00	1.00	67	1.12	0.97	21	5	0.60	200	0.73	0.19	0.16	0.85	0.416	0.38	17.31
49	9	1.50	Midium Sand	14.00	17	15.50	18.0	247.4	119.0	1.00	1.00	1.00	67	1.12	0.92	17	5	0.60	175	0.69	0.18	0.12	0.67	0.822	0.30	14.34
GWT (m)	10	1.50	Midium Sand	15.50	26	17.00	18.0	274.4	131.3	1.00	1.00	1.00	67	1.12	0.87	25	5	0.60	200	0.67	0.17	0.21	1.24	0.018	0.23	39.30
0.91	11	1.50	Midium Sand	17.00	29	18.50	18.0	301.4	143.6	1.00	1.00	1.00	67	1.12	0.83	27	5	0.60	200	0.65	0.17	0.24	1.40	0.003	0.15	39.76
a_{max} (g)	12	1.50	Midium Sand	18.50	31	20.00	18.0	328.4	155.9	1.00	1.00	1.00	67	1.12	0.80	28	5	0.60	200	0.64	0.17	0.25	1.46	0.002	0.08	39.95
0.19	13	1.50	Midium Sand	20.00	34	21.50	18.0	355.4	168.1	1.00	1.00	1.00	67	1.12	0.77	29	5	0.60	200	0.64	0.17	0.27	1.63	0.000	0.00	40.38
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
67	19																									
N (mean)	20																									
19.8	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
188	25																									
Observed (cm)	26																									
122	27																									
Distance (m)	28																									
94.9	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	19.84																							4.12	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N^d	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	0.59	Midium Sand	1.00	3	2.50	16.5	15.1	14.3	1.00	0.75	1.00	67	1.12	2.00	5	5	0.35	150	0.99	0.13	0.08	0.64	0.871	0.95	3.63
Mw	2	1.00	Midium Sand	2.00	4	3.50	16.5	31.6	20.9	1.00	0.75	1.00	67	1.12	2.00	7	5	0.35	150	0.98	0.18	0.09	0.47	0.997	0.90	4.53
7.5	3	1.00	Midium Sand	3.00	3	4.50	16.5	48.1	27.6	1.00	0.85	1.00	67	1.12	1.90	5	5	0.35	150	0.96	0.21	0.07	0.35	1.000	0.85	3.82
Site	4	1.00	Midium Sand	4.00	5	5.50	16.5	64.6	34.3	1.00	0.85	1.00	67	1.12	1.71	8	5	0.35	150	0.94	0.22	0.08	0.38	1.000	0.80	5.44
H-10, A-A'	5	1.00	Coarse Sand	5.00	9	6.50	18.0	81.9	41.8	1.00	0.95	1.00	67	1.12	1.55	15	6	0.15	175	0.92	0.22	0.13	0.59	0.938	0.75	11.89
Data Class	6	1.00	Coarse Sand	6.00	9	7.50	18.0	99.9	50.0	1.00	0.95	1.00	67	1.12	1.41	14	6	0.15	175	0.89	0.22	0.11	0.52	0.986	0.70	10.64
	7	1.00	Coarse Sand	7.00	4	8.50	16.5	117.1	57.4	1.00	0.95	1.00	67	1.12	1.32	6	6	0.15	150	0.86	0.22	0.06	0.28	1.000	0.65	3.95
B. H.	8	1.00	Clayey Silt	8.00	5	9.50	16.5	133.6	64.1	1.00	0.95	1.00	67	1.12	1.25	7	35	0.02	150	0.82	0.21	0.07	0.35	0.000	0.00	Non-Liq.
126	9	1.00	Clayey Silt	9.00	4	10.50	16.5	150.1	70.8	1.00	1.00	1.00	67	1.12	1.19	5	35	0.02	150	0.79	0.21	0.06	0.31	0.000	0.00	Non-Liq.
GWT (m)	10	1.00	Midium Sand	10.00	12	11.50	18.0	167.4	78.2	1.00	1.00	1.00	67	1.12	1.13	15	5	0.35	175	0.75	0.20	0.11	0.57	0.957	0.50	12.16
0.91	11	1.00	Midium Sand	11.00	14	12.50	18.0	185.4	86.4	1.00	1.00	1.00	67	1.12	1.08	17	5	0.35	175	0.72	0.19	0.13	0.66	0.845	0.45	13.78
a_{max} (g)	12	1.00	Midium Sand	12.00	12	13.50	18.0	203.4	94.6	1.00	1.00	1.00	67	1.12	1.03	14	5	0.35	175	0.69	0.18	0.10	0.53	0.982	0.40	10.81
0.19	13	1.00	Midium Sand	13.00	14	14.50	18.0	221.4	102.8	1.00	1.00	1.00	67	1.12	0.99	15	5	0.35	175	0.66	0.18	0.11	0.61	0.924	0.35	12.42
Sampler[b]	14	1.00	Midium Sand	14.00	25	15.50	18.0	239.4	111.0	1.00	1.00	1.00	67	1.12	0.95	27	5	0.35	200	0.65	0.17	0.25	1.43	0.003	0.30	39.62
NA	15	1.00	Midium Sand	15.00	33	16.50	19.0	257.9	119.7	1.00	1.00	1.00	67	1.12	0.91	34	5	0.35	225	0.63	0.17	0.42	2.48	0.000	0.25	41.58
B.H. Diam. (mm)	16	1.00	Fine Sand	16.00	52	17.50	19.0	276.9	128.9	1.00	1.00	1.00	67	1.12	0.88	51	14	0.15	225	0.62	0.16	1.85	11.23	0.000	0.20	46.95
95	17	1.00	Fine Sand	17.00	59	18.50	19.0	295.9	138.0	1.00	1.00	1.00	67	1.12	0.85	56	14	0.15	225	0.61	0.16	2.68	16.53	0.000	0.15	48.34
Energy Ratio[c]	18	1.00	Fine Sand	18.00	53	19.50	19.0	314.9	147.2	1.00	1.00	1.00	67	1.12	0.82	49	14	0.15	225	0.61	0.16	1.47	9.22	0.000	0.10	46.28
67	19	1.00	Fine Sand	19.00	47	20.50	19.0	333.9	156.4	1.00	1.00	1.00	67	1.12	0.80	42	14	0.15	225	0.60	0.16	0.84	5.33	0.000	0.05	44.36
N (mean)	20	1.00	Fine Sand	20.00	45	21.50	19.0	352.9	165.6	1.00	1.00	1.00	67	1.12	0.78	39	14	0.15	225	0.60	0.16	0.66	4.20	0.000	0.00	43.53
20.6	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
175	25																									
Observed (cm)	26																									
542	27																									
Distance (m)	28																									
110.5	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	19.59																							6.65	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	3.09	Midium Sand	3.00	8	4.50	18.0	52.2	31.7	1.00	0.85	1.00	67	1.12	1.78	13	5	0.35	175	0.97	0.20	0.13	0.65	0.859	0.85	10.53
Mw	2	2.00	Midium Sand	5.00	5	6.50	16.5	86.7	46.6	1.00	0.95	1.00	67	1.12	1.47	8	5	0.35	150	0.93	0.21	0.07	0.35	1.000	0.75	5.21
7.5	3	2.00	Midium Sand	7.00	1	8.50	15.5	118.7	58.9	1.00	0.95	1.00	67	1.12	1.30	1	2	0.35	125	0.87	0.22	0.04	0.19	1.000	0.65	2.24
Site	4	2.00	Midium Sand	9.00	10	10.50	18.0	152.2	72.8	1.00	1.00	1.00	67	1.12	1.17	13	2	0.35	175	0.80	0.21	0.10	0.47	0.997	0.55	10.12
H-10, A-A'	5	2.00	Midium Sand	11.00	10	12.50	18.0	188.2	89.2	1.00	1.00	1.00	67	1.12	1.06	12	2	0.35	175	0.73	0.19	0.08	0.43	0.999	0.45	8.87
Data Class	6	2.00	Midium Sand	13.00	31	14.50	19.0	225.2	106.6	1.00	1.00	1.00	67	1.12	0.97	34	2	0.35	225	0.68	0.18	0.41	2.30	0.000	0.35	41.54
	7	2.00	Midium Sand	15.00	13	16.50	18.0	262.2	124.0	1.00	1.00	1.00	67	1.12	0.90	13	2	0.35	175	0.65	0.17	0.08	0.49	0.993	0.25	10.08
B. H.	8	2.00	Midium Sand	17.00	34	18.50	19.0	299.2	141.3	1.00	1.00	1.00	67	1.12	0.84	32	2	0.35	225	0.62	0.16	0.33	2.05	0.000	0.15	41.10
128	9	2.00	Fine Sand	19.00	44	20.50	19.0	337.2	159.7	1.00	1.00	1.00	67	1.12	0.79	39	9	0.15	225	0.61	0.16	0.61	3.81	0.000	0.05	43.21
GWT (m)	10	2.00	Fine Sand	21.00	37	22.50	19.0	375.2	178.1	1.00	1.00	1.00	67	1.12	0.75	31	9	0.15	225	0.61	0.16	0.32	2.03	0.000	0.00	41.02
0.91	11																									
a_{max} (g)	12																									
0.19	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
67	19																									
N (mean)	20																									
19.3	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
179	25																									
Observed (cm)	26																									
100	27																									
Distance (m)	28																									
45.7	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	21.09																							7.55	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	2.59	Midium Sand	2.50	2	4.00	15.5	38.3	22.7	1.00	0.75	1.00	67	1.12	2.00	3	2	0.35	125	0.97	0.20	0.06	0.32	1.000	0.88	2.91
Mw	2	2.00	Midium Sand	4.50	6	6.00	16.5	70.3	35.1	1.00	0.85	1.00	67	1.12	1.69	10	2	0.35	150	0.92	0.23	0.09	0.40	1.000	0.78	6.65
7.5	3	2.00	Midium Sand	6.50	7	8.00	18.0	104.8	50.0	1.00	0.95	1.00	67	1.12	1.41	11	2	0.35	175	0.86	0.22	0.09	0.40	1.000	0.68	7.55
Site	4	2.00	Midium Sand	8.50	10	10.00	18.0	140.8	66.3	1.00	0.95	1.00	67	1.12	1.23	13	2	0.35	175	0.78	0.20	0.10	0.48	0.995	0.58	10.06
H-10, A-A'	5	2.00	Midium Sand	10.50	14	12.00	18.0	176.8	82.7	1.00	1.00	1.00	67	1.12	1.10	17	2	0.35	175	0.71	0.19	0.13	0.68	0.808	0.48	14.13
Data Class	6	2.00	Midium Sand	12.50	16	14.00	18.0	212.8	99.1	1.00	1.00	1.00	67	1.12	1.00	18	3	0.35	175	0.65	0.17	0.13	0.75	0.661	0.38	14.86
	7	2.00	Midium Sand	14.50	16	16.00	18.0	248.8	115.5	1.00	1.00	1.00	67	1.12	0.93	17	3	0.35	175	0.62	0.16	0.11	0.68	0.804	0.28	13.59
B. H.	8	1.50	Midium Sand	16.50	14	18.00	18.0	284.8	131.9	1.00	1.00	1.00	67	1.12	0.87	14	3	0.35	175	0.60	0.16	0.09	0.54	0.978	0.18	10.65
129	9	1.00	Fine Sand	17.50	47	19.00	19.0	303.3	140.5	1.00	1.00	1.00	67	1.12	0.84	44	3	0.15	225	0.59	0.16	0.87	5.51	0.000	0.13	44.46
GWT (m)	10	1.50	Fine Sand	18.50	50	20.00	19.0	322.3	149.7	1.00	1.00	1.00	67	1.12	0.82	46	3	0.15	225	0.59	0.16	0.94	6.06	0.000	0.08	44.83
0.91	11	2.00	Fine Sand	20.50	50	22.00	19.0	360.3	168.1	1.00	1.00	1.00	67	1.12	0.77	43	3	0.15	225	0.58	0.15	0.75	4.91	0.000	0.00	44.13
a_{max} (g)	12																									
0.19	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
67	19																									
N (mean)	20																									
21.1	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
169	25																									
Observed (cm)	26																									
100	27																									
Distance (m)	28																									
45.7	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	20.59																							8.27	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	2.59	Midium Sand	2.50	3	4.00	16.5	39.9	24.3	1.00	0.75	1.00	67	1.12	2.00	5	5	0.35	150	0.97	0.20	0.07	0.37	1.000	0.88	3.63
Mw	2	2.00	Fine Sand	4.50	3	6.00	16.5	72.9	37.7	1.00	0.85	1.00	67	1.12	1.63	5	5	0.15	150	0.92	0.22	0.06	0.28	1.000	0.78	3.45
7.5	3	2.00	Fine Sand	6.50	5	8.00	16.5	105.9	51.0	1.00	0.95	1.00	67	1.12	1.40	7	5	0.15	150	0.86	0.22	0.07	0.32	1.000	0.68	4.98
Site	4	2.00	Coarse Sand	8.50	6	10.00	16.5	138.9	64.4	1.00	0.95	1.00	67	1.12	1.25	8	10	0.60	150	0.78	0.21	0.07	0.34	1.000	0.58	5.61
H-10, A-A'	5	2.00	Coarse Sand	10.50	11	12.00	18.0	173.4	79.3	1.00	1.00	1.00	67	1.12	1.12	14	10	0.60	175	0.71	0.19	0.11	0.56	0.969	0.48	11.33
Data Class	6	2.00	Coarse Sand	12.50	11	14.00	18.0	209.4	95.7	1.00	1.00	1.00	67	1.12	1.02	13	10	0.60	175	0.65	0.18	0.09	0.52	0.986	0.38	10.09
	7	2.00	Coarse Sand	14.50	24	16.00	18.0	245.4	112.1	1.00	1.00	1.00	67	1.12	0.94	25	10	0.60	200	0.62	0.17	0.24	1.42	0.003	0.28	39.50
B. H.	8	2.00	Coarse Sand	16.50	28	18.00	18.0	281.4	128.4	1.00	1.00	1.00	67	1.12	0.88	28	10	0.60	200	0.60	0.16	0.27	1.69	0.000	0.18	40.13
130	9	2.00	Coarse Sand	18.50	23	20.00	18.0	317.4	144.8	1.00	1.00	1.00	67	1.12	0.83	21	10	0.60	200	0.58	0.16	0.16	1.02	0.126	0.08	38.39
GWT (m)	10	2.00	Fine Sand	20.50	29	22.00	18.0	353.4	161.2	1.00	1.00	1.00	67	1.12	0.79	26	4	0.15	200	0.58	0.16	0.20	1.30	0.010	0.00	39.35
0.91	11																									
a_{max} (g)	12																									
0.19	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
67	19																									
N (mean)	20																									
14.3	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
169	25																									
Observed (cm)	26																									
100	27																									
Distance (m)	28																									
45.7	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	20.59																							8.00	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	2.59	Fine Sand	2.50	2	4.00	15.5	38.3	22.7	1.00	0.75	1.00	67	1.12	2.00	3	8	0.15	125	0.97	0.20	0.07	0.33	1.000	0.88	2.98
Mw	2	2.00	Midium Sand	4.50	3	6.00	16.5	70.3	35.1	1.00	0.85	1.00	67	1.12	1.69	5	7	0.35	150	0.92	0.23	0.06	0.28	1.000	0.78	3.59
7.5	3	2.00	Midium Sand	6.50	7	8.00	18.0	104.8	50.0	1.00	0.95	1.00	67	1.12	1.41	11	7	0.35	175	0.86	0.22	0.09	0.41	1.000	0.68	7.73
Site	4	2.00	Midium Sand	8.50	14	10.00	18.0	140.8	66.3	1.00	0.95	1.00	67	1.12	1.23	18	8	0.35	175	0.78	0.21	0.15	0.75	0.641	0.58	15.48
H-10, A-A'	5	2.00	Midium Sand	10.50	4	12.00	16.5	175.3	81.2	1.00	1.00	1.00	67	1.12	1.11	5	8	0.35	150	0.71	0.19	0.05	0.28	1.000	0.48	3.69
Data Class	6	2.00	Midium Sand	12.50	17	14.00	18.0	209.8	96.1	1.00	1.00	1.00	67	1.12	1.02	19	8	0.35	175	0.66	0.18	0.15	0.86	0.382	0.38	16.56
	7	2.00	Midium Sand	14.50	24	16.00	18.0	245.8	112.5	1.00	1.00	1.00	67	1.12	0.94	25	8	0.35	200	0.62	0.17	0.23	1.38	0.004	0.28	39.41
B. H.	8	2.00	Midium Sand	16.50	52	18.00	19.0	282.8	129.9	1.00	1.00	1.00	67	1.12	0.88	51	8	0.35	225	0.60	0.16	1.62	10.06	0.000	0.18	46.49
131	9	2.00	Fine Sand	18.50	30	20.00	18.0	319.8	147.2	1.00	1.00	1.00	67	1.12	0.82	28	11	0.15	200	0.59	0.16	0.27	1.69	0.000	0.08	40.18
GWT (m)	10	2.00	Fine Sand	20.50	39	22.00	19.0	356.8	164.6	1.00	1.00	1.00	67	1.12	0.78	34	11	0.15	225	0.58	0.16	0.42	2.73	0.000	0.00	41.95
0.91	11																									
a_{max} (g)	12																									
0.19	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
67	19																									
N (mean)	20																									
19.2	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
170	25																									
Observed (cm)	26																									
100	27																									
Distance (m)	28																									
45.7	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	20.59																							7.14	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	0.77	Fine Sand	1.00	6	2.50	16.5	16.1	13.5	1.00	0.75	1.00	67	1.12	2.00	10	8	0.15	175	0.99	0.15	0.13	0.87	0.356	0.95	7.36
Mw	2	1.00	Fine Sand	2.00	5	3.50	16.5	32.6	20.2	1.00	0.75	1.00	67	1.12	2.00	8	8	0.15	150	0.97	0.19	0.10	0.52	0.987	0.90	5.83
7.5	3	1.00	Fine Sand	3.00	2	4.50	15.5	48.6	26.4	1.00	0.85	1.00	67	1.12	1.95	4	8	0.15	125	0.95	0.22	0.06	0.30	1.000	0.85	3.12
Site	4	1.00	Midium Sand	4.00	2	5.50	15.5	64.1	32.1	1.00	0.85	1.00	67	1.12	1.77	3	5	0.35	125	0.93	0.23	0.06	0.26	1.000	0.80	2.91
H-10, A-A'	5	1.00	Midium Sand	5.00	3	6.50	16.5	80.1	38.2	1.00	0.95	1.00	67	1.12	1.62	5	5	0.35	150	0.90	0.23	0.06	0.28	1.000	0.75	3.68
Data Class	6	1.00	Fine Sand	6.00	2	7.50	15.5	96.1	44.4	1.00	0.95	1.00	67	1.12	1.50	3	8	0.15	125	0.87	0.23	0.05	0.23	1.000	0.70	2.91
	7	1.00	Fine Sand	7.00	5	8.50	16.5	112.1	50.6	1.00	0.95	1.00	67	1.12	1.41	7	8	0.15	150	0.83	0.23	0.07	0.32	1.000	0.65	5.16
B. H.	8	1.00	Fine Sand	8.00	10	9.50	18.0	129.4	58.1	1.00	0.95	1.00	67	1.12	1.31	14	8	0.15	175	0.79	0.22	0.11	0.53	0.983	0.60	11.26
133	9	1.00	Fine Sand	9.00	11	10.50	18.0	147.4	66.3	1.00	1.00	1.00	67	1.12	1.23	15	8	0.15	175	0.75	0.21	0.12	0.59	0.944	0.55	12.41
GWT (m)	10	1.00	M to C Sand	10.00	10	11.50	18.0	165.4	74.4	1.00	1.00	1.00	67	1.12	1.16	13	5	0.35	175	0.71	0.20	0.10	0.49	0.993	0.50	9.98
0.73	11	1.00	M to C Sand	11.00	9	12.50	18.0	183.4	82.6	1.00	1.00	1.00	67	1.12	1.10	11	5	0.35	175	0.68	0.19	0.08	0.44	0.999	0.45	8.10
a_{max} (g)	12	1.00	Sandy Silt	12.00	4	13.50	16.5	200.6	90.1	1.00	1.00	1.00	67	1.12	1.05	5	35	0.04	150	0.66	0.18	0.06	0.32	0.000	0.00	Non-Liq.
0.19	13	1.00	Sandy Silt	13.00	4	14.50	16.5	217.1	96.8	1.00	1.00	1.00	67	1.12	1.02	5	35	0.04	150	0.63	0.18	0.06	0.32	0.000	0.00	Non-Liq.
Sampler[b]	14	1.00	Clay	14.00	10	15.50	18.0	234.4	104.2	1.00	1.00	1.00	67	1.12	0.98	11	35	0.01	175	0.62	0.17	0.09	0.55	0.000	0.00	Non-Liq.
NA	15	1.00	Fine Sand	15.00	29	16.50	18.0	252.4	112.4	1.00	1.00	1.00	67	1.12	0.94	30	8	0.15	200	0.60	0.17	0.34	2.06	0.000	0.25	40.83
B.H. Diam. (mm)	16	1.00	Fine Sand	16.00	33	17.50	19.0	270.9	121.1	1.00	1.00	1.00	67	1.12	0.91	33	8	0.15	225	0.59	0.16	0.43	2.60	0.000	0.20	41.67
95	17	1.00	Fine Sand	17.00	31	18.50	18.0	289.4	129.8	1.00	1.00	1.00	67	1.12	0.88	30	8	0.15	200	0.59	0.16	0.33	2.04	0.000	0.15	40.82
Energy Ratio[c]	18	1.00	Fine Sand	18.00	33	19.50	19.0	307.9	138.5	1.00	1.00	1.00	67	1.12	0.85	31	8	0.15	225	0.58	0.16	0.35	2.18	0.000	0.10	41.07
67	19	1.00	Fine Sand	19.00	50	20.50	19.0	326.9	147.7	1.00	1.00	1.00	67	1.12	0.82	46	8	0.15	225	0.58	0.16	1.06	6.73	0.000	0.05	45.11
N (mean)	20	1.00	Fine Sand	20.00	41	21.50	19.0	345.9	156.8	1.00	1.00	1.00	67	1.12	0.80	37	8	0.15	225	0.57	0.16	0.50	3.22	0.000	0.00	42.52
15.0	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
167	25																									
Observed (cm)	26																									
397	27																									
Distance (m)	28																									
86.3	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	19.77																							6.95	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (fps)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	1.46	Midium Sand	2.00	5	3.50	16.5	32.5	23.1	1.00	0.75	1.00	67	1.12	2.00	8	5	0.35	150	0.98	0.17	0.09	0.56	0.967	0.90	5.64
Mw	2	1.00	Silt	3.00	3	4.50	16.5	49.0	29.8	1.00	0.85	1.00	67	1.12	1.83	5	35	0.03	150	0.96	0.19	0.08	0.42	0.000	0.00	Non-Liq.
7.5	3	1.00	Midium Sand	4.00	8	5.50	18.0	66.2	37.2	1.00	0.85	1.00	67	1.12	1.64	12	5	0.35	175	0.94	0.21	0.11	0.55	0.972	0.80	9.49
Site	4	1.00	Midium Sand	5.00	11	6.50	18.0	84.2	45.4	1.00	0.95	1.00	67	1.12	1.48	17	5	0.35	175	0.91	0.21	0.16	0.75	0.656	0.75	14.26
G-10, B-B'	5	1.00	Midium Sand	6.00	13	7.50	18.0	102.2	53.6	1.00	0.95	1.00	67	1.12	1.37	19	5	0.35	175	0.88	0.21	0.17	0.81	0.506	0.70	15.71
Data Class	6	1.00	Midium Sand	7.00	8	8.50	18.0	120.2	61.8	1.00	0.95	1.00	67	1.12	1.27	11	5	0.35	175	0.84	0.20	0.09	0.43	0.999	0.65	7.84
	7	1.00	Midium Sand	8.00	12	9.50	18.0	138.2	70.0	1.00	0.95	1.00	67	1.12	1.20	15	5	0.35	175	0.80	0.20	0.12	0.60	0.932	0.60	12.22
B. H.	8	1.00	Midium Sand	9.00	10	10.50	18.0	156.2	78.1	1.00	1.00	1.00	67	1.12	1.13	13	5	0.35	175	0.77	0.19	0.09	0.49	0.993	0.55	9.67
135	9	1.00	Midium Sand	10.00	9	11.50	18.0	174.2	86.3	1.00	1.00	1.00	67	1.12	1.08	11	5	0.35	175	0.73	0.18	0.08	0.44	0.999	0.50	7.86
GWT (m)	10	1.00	Midium Sand	11.00	7	12.50	16.5	191.5	93.8	1.00	1.00	1.00	67	1.12	1.03	8	5	0.35	150	0.70	0.18	0.06	0.36	1.000	0.45	5.42
1.04	11	1.00	Midium Sand	12.00	7	13.50	16.5	208.0	100.5	1.00	1.00	1.00	67	1.12	1.00	8	5	0.35	150	0.67	0.17	0.06	0.35	1.000	0.40	5.23
a_{max} (g)	12	1.00	Midium Sand	13.00	25	14.50	18.0	225.2	107.9	1.00	1.00	1.00	67	1.12	0.96	27	5	0.35	200	0.65	0.17	0.25	1.53	0.001	0.35	39.72
0.19	13	1.00	Fine Sand	14.00	28	15.50	18.0	243.2	116.1	1.00	1.00	1.00	67	1.12	0.93	29	8	0.15	200	0.63	0.16	0.31	1.88	0.000	0.30	40.44
Sampler[b]	14	1.00	Fine Sand	15.00	44	16.50	19.0	261.7	124.8	1.00	1.00	1.00	67	1.12	0.90	44	8	0.15	225	0.61	0.16	0.95	5.99	0.000	0.25	44.57
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
67	19																									
N (mean)	20																									
13.6	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
170	25																									
Observed (cm)	26																									
224	27																									
Distance (m)	28																									
143.5	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	14.46																							6.00	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N^d	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (fps)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	0.74	Clay	1.00	1	2.50	15.5	15.1	12.8	1.00	0.75	1.00	67	1.12	2.00	2	35	0.01	125	0.99	0.14	0.08	0.53	0.000	0.00	Non-Liq.
Mw	2	1.00	M to C Sand	2.00	1	3.50	15.5	30.6	18.5	1.00	0.75	1.00	67	1.12	2.00	2	5	0.50	125	0.97	0.20	0.06	0.30	1.000	0.90	2.33
7.5	3	1.00	M to C Sand	3.00	1	4.50	15.5	46.1	24.1	1.00	0.85	1.00	67	1.12	2.00	2	5	0.50	125	0.95	0.22	0.06	0.25	1.000	0.85	2.40
Site	4	1.00	M to C Sand	4.00	1	5.50	15.5	61.6	29.8	1.00	0.85	1.00	67	1.12	1.83	2	5	0.50	125	0.92	0.24	0.05	0.23	1.000	0.80	2.35
G-10, B-B'	5	1.00	M to C Sand	5.00	3	6.50	16.5	77.6	36.0	1.00	0.95	1.00	67	1.12	1.67	5	5	0.50	150	0.89	0.24	0.07	0.28	1.000	0.75	3.76
Data Class	6	1.00	M to C Sand	6.00	6	7.50	16.5	94.1	42.7	1.00	0.95	1.00	67	1.12	1.53	10	5	0.50	150	0.86	0.23	0.09	0.38	1.000	0.70	6.78
	7	1.00	M to C Sand	7.00	5	8.50	16.5	110.6	49.4	1.00	0.95	1.00	67	1.12	1.42	8	5	0.50	150	0.82	0.23	0.07	0.32	1.000	0.65	5.06
B. H.	8	1.00	M to C Sand	8.00	5	9.50	16.5	127.1	56.1	1.00	0.95	1.00	67	1.12	1.34	7	5	0.50	150	0.78	0.22	0.07	0.31	1.000	0.60	4.76
136	9	1.00	M to C Sand	9.00	6	10.50	16.5	143.6	62.8	1.00	1.00	1.00	67	1.12	1.26	8	5	0.50	150	0.74	0.21	0.07	0.35	1.000	0.55	5.70
GWT (m)	10	1.00	M to C Sand	10.00	8	11.50	18.0	160.9	70.2	1.00	1.00	1.00	67	1.12	1.19	11	5	0.50	175	0.70	0.20	0.08	0.42	0.999	0.50	7.70
0.76	11	1.00	M to C Sand	11.00	9	12.50	18.0	178.9	78.4	1.00	1.00	1.00	67	1.12	1.13	11	5	0.50	175	0.67	0.19	0.08	0.45	0.998	0.45	8.39
a_{max} (g)	12	1.00	M to C Sand	12.00	8	13.50	16.5	196.1	85.9	1.00	1.00	1.00	67	1.12	1.08	10	5	0.50	150	0.64	0.18	0.07	0.40	1.000	0.40	6.68
0.19	13	1.00	M to C Sand	13.00	32	14.50	19.0	213.9	93.8	1.00	1.00	1.00	67	1.12	1.03	37	5	0.50	225	0.62	0.17	0.57	3.26	0.000	0.35	42.45
Sampler[b]	14	1.00	M to C Sand	14.00	34	15.50	19.0	232.9	103.0	1.00	1.00	1.00	67	1.12	0.99	37	5	0.50	225	0.60	0.17	0.58	3.42	0.000	0.30	42.59
NA	15	1.00	M to C Sand	15.00	35	16.50	19.0	251.9	112.2	1.00	1.00	1.00	67	1.12	0.94	37	5	0.50	225	0.59	0.16	0.54	3.31	0.000	0.25	42.45
B.H. Diam. (mm)	16	1.00	Fine Sand	16.00	49	17.50	19.0	270.9	121.4	1.00	1.00	1.00	67	1.12	0.91	50	8	0.15	225	0.58	0.16	1.49	9.29	0.000	0.20	46.13
95	17	1.00	Fine Sand	17.00	41	18.50	19.0	289.9	130.6	1.00	1.00	1.00	67	1.12	0.88	40	8	0.15	225	0.58	0.16	0.70	4.41	0.000	0.15	43.49
Energy Ratio[c]	18	1.00	Fine Sand	18.00	30	19.50	18.0	308.4	139.2	1.00	1.00	1.00	67	1.12	0.85	28	8	0.15	200	0.57	0.16	0.28	1.77	0.000	0.10	40.27
67	19	1.00	Fine Sand	19.00	21	20.50	18.0	326.4	147.4	1.00	1.00	1.00	67	1.12	0.82	19	8	0.15	175	0.57	0.15	0.13	0.87	0.366	0.05	16.51
N (mean)	20	1.00	Fine Sand	20.00	23	21.50	18.0	344.4	155.6	1.00	1.00	1.00	67	1.12	0.80	21	8	0.15	200	0.56	0.15	0.15	0.95	0.217	0.00	38.11
16.0	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
164	25																									
Observed (cm)	26																									
224	27																									
Distance (m)	28																									
86.3	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	19.74																							7.17	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	1.09	Clay	1.50	7	3.00	18.0	25.2	19.4	1.00	0.75	1.00	67	1.12	2.00	12	35	0.01	175	0.99	0.16	0.16	1.01	0.137	0.00	Non-Liq.
Mw	2	1.00	Clay	2.50	6	4.00	16.5	42.4	26.8	1.00	0.75	1.00	67	1.12	1.93	10	35	0.01	150	0.97	0.19	0.12	0.65	0.866	0.00	Non-Liq.
7.5	3	1.00	Clayey Silt	3.50	1	5.00	15.5	58.4	33.0	1.00	0.85	1.00	67	1.12	1.74	2	35	0.03	125	0.95	0.21	0.06	0.28	1.000	0.00	Non-Liq.
Site	4	1.50	Midium Sand	4.50	7	6.00	18.0	75.2	40.0	1.00	0.85	1.00	67	1.12	1.58	11	7	0.35	175	0.93	0.22	0.10	0.45	0.998	0.78	7.73
G-10, B-B'	5	2.00	Midium Sand	6.50	7	8.00	16.5	109.7	54.8	1.00	0.95	1.00	67	1.12	1.35	10	7	0.35	150	0.87	0.22	0.09	0.40	1.000	0.68	7.24
Data Class	6	1.50	Midium Sand	8.50	10	10.00	18.0	144.2	69.7	1.00	0.95	1.00	67	1.12	1.20	13	5	0.35	175	0.80	0.20	0.10	0.48	0.996	0.58	9.75
	7	1.00	Midium Sand	9.50	10	11.00	18.0	162.2	77.9	1.00	1.00	1.00	67	1.12	1.13	13	5	0.35	175	0.76	0.20	0.09	0.48	0.995	0.53	9.69
B. H.	8	1.00	Midium Sand	10.50	9	12.00	18.0	180.2	86.1	1.00	1.00	1.00	67	1.12	1.08	11	5	0.35	175	0.73	0.19	0.08	0.42	0.999	0.48	7.87
137	9	1.00	Midium Sand	11.50	9	13.00	16.5	197.4	93.5	1.00	1.00	1.00	67	1.12	1.03	10	5	0.35	150	0.70	0.18	0.07	0.41	1.000	0.43	7.43
GWT (m)	10	1.00	Midium Sand	12.50	8	14.00	16.5	213.9	100.2	1.00	1.00	1.00	67	1.12	1.00	9	15	0.35	150	0.67	0.18	0.07	0.40	1.000	0.38	6.80
0.91	11	1.00	Midium Sand	13.50	26	15.00	18.0	231.2	107.7	1.00	1.00	1.00	67	1.12	0.96	28	15	0.35	200	0.65	0.17	0.31	1.81	0.000	0.33	40.46
a_{max} (g)	12	1.00	Midium Sand	14.50	19	16.00	18.0	249.2	115.9	1.00	1.00	1.00	67	1.12	0.93	20	9	0.35	175	0.63	0.17	0.15	0.89	0.322	0.28	17.01
0.19	13	1.00	Midium Sand	15.50	31	17.00	19.0	267.7	124.6	1.00	1.00	1.00	67	1.12	0.90	31	9	0.35	225	0.62	0.16	0.35	2.15	0.000	0.23	41.04
Sampler[b]	14	1.00	Midium Sand	16.50	11	18.00	18.0	286.2	133.2	1.00	1.00	1.00	67	1.12	0.87	11	6	0.35	175	0.61	0.16	0.07	0.43	0.999	0.18	7.87
NA	15	1.00	Fine Sand	17.50	33	19.00	19.0	304.7	141.9	1.00	1.00	1.00	67	1.12	0.84	31	3	0.15	225	0.60	0.16	0.31	1.94	0.000	0.13	40.80
B.H. Diam. (mm)	16	1.00	Fine Sand	18.50	39	20.00	19.0	323.7	151.1	1.00	1.00	1.00	67	1.12	0.81	35	3	0.15	225	0.60	0.16	0.43	2.73	0.000	0.08	42.05
95	17	1.00	Fine Sand	19.50	52	21.00	19.0	342.7	160.3	1.00	1.00	1.00	67	1.12	0.79	46	9	0.15	225	0.60	0.16	1.05	6.66	0.000	0.03	45.15
Energy Ratio[c]	18	1.00	Fine Sand	20.50	38	22.00	19.0	361.7	169.5	1.00	1.00	1.00	67	1.12	0.77	33	9	0.15	225	0.59	0.16	0.37	2.35	0.000	0.00	41.47
67	19																									
N (mean)	20																									
17.9	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
174	25																									
Observed (cm)	26																									
52	27																									
Distance (m)	28																									
29.2	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	20.09																							5.43	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	1.09	Clay	1.50	3	3.00	16.5	23.4	17.6	1.00	0.75	1.00	67	1.12	2.00	5	35	0.01	150	0.98	0.16	0.09	0.57	0.000	0.00	Non-Liq.
Mw	2	1.00	Clay	2.50	3	4.00	16.5	39.9	24.3	1.00	0.75	1.00	67	1.12	2.00	5	35	0.01	150	0.97	0.20	0.08	0.43	0.000	0.00	Non-Liq.
7.5	3	1.00	Sandy Silt	3.50	2	5.00	15.5	55.9	30.5	1.00	0.85	1.00	67	1.12	1.81	3	35	0.04	125	0.95	0.21	0.07	0.32	0.000	0.00	Non-Liq.
Site	4	1.00	Midium Sand	4.50	8	6.00	18.0	72.6	37.4	1.00	0.85	1.00	67	1.12	1.63	12	3	0.35	175	0.92	0.22	0.11	0.50	0.990	0.78	9.46
G-10, B-B'	5	1.00	Midium Sand	5.50	10	7.00	18.0	90.6	45.6	1.00	0.95	1.00	67	1.12	1.48	16	3	0.35	175	0.89	0.22	0.14	0.62	0.907	0.73	12.70
Data Class	6	1.00	Midium Sand	6.50	11	8.00	18.0	108.6	53.8	1.00	0.95	1.00	67	1.12	1.36	16	3	0.35	175	0.85	0.21	0.13	0.62	0.912	0.68	12.90
	7	1.00	Midium Sand	7.50	9	9.00	18.0	126.6	62.0	1.00	0.95	1.00	67	1.12	1.27	12	3	0.35	175	0.82	0.21	0.09	0.46	0.997	0.63	9.17
B. H.	8	1.00	Midium Sand	8.50	10	10.00	18.0	144.6	70.2	1.00	0.95	1.00	67	1.12	1.19	13	3	0.35	175	0.78	0.20	0.10	0.48	0.995	0.58	9.70
138	9	1.00	Midium Sand	9.50	13	11.00	18.0	162.6	78.4	1.00	1.00	1.00	67	1.12	1.13	16	3	0.35	175	0.74	0.19	0.12	0.65	0.866	0.53	13.37
GWT (m)	10	1.00	Midium Sand	10.50	11	12.00	18.0	180.6	86.6	1.00	1.00	1.00	67	1.12	1.07	13	3	0.35	175	0.70	0.18	0.09	0.52	0.987	0.48	10.24
0.91	11	1.00	Midium Sand	11.50	13	13.00	18.0	198.6	94.7	1.00	1.00	1.00	67	1.12	1.03	15	3	0.35	175	0.67	0.17	0.10	0.60	0.936	0.43	11.92
a_{max} (g)	12	1.00	Midium Sand	12.50	8	14.00	16.5	215.9	102.2	1.00	1.00	1.00	67	1.12	0.99	9	2	0.35	150	0.65	0.17	0.06	0.38	1.000	0.38	6.00
0.19	13	1.00	Midium Sand	13.50	12	15.00	18.0	233.1	109.6	1.00	1.00	1.00	67	1.12	0.96	13	2	0.35	175	0.63	0.17	0.08	0.51	0.989	0.33	9.84
Sampler[b]	14	1.00	Clay	14.50	2	16.00	15.5	249.9	116.6	1.00	1.00	1.00	67	1.12	0.93	2	35	0.01	125	0.61	0.16	0.04	0.26	0.000	0.00	Non-Liq.
NA	15	1.00	Coarse Sand	15.50	16	17.00	18.0	266.6	123.5	1.00	1.00	1.00	67	1.12	0.90	16	10	0.60	175	0.60	0.16	0.11	0.70	0.771	0.23	13.60
B.H. Diam. (mm)	16	1.00	Coarse Sand	16.50	32	18.00	19.0	285.1	132.2	1.00	1.00	1.00	67	1.12	0.87	31	10	0.60	225	0.59	0.16	0.35	2.24	0.000	0.18	41.10
95	17	1.00	Coarse Sand	17.50	30	19.00	18.0	303.6	140.9	1.00	1.00	1.00	67	1.12	0.84	28	11	0.60	200	0.59	0.16	0.28	1.81	0.000	0.13	40.35
Energy Ratio[c]	18	1.00	Coarse Sand	18.50	32	20.00	18.0	321.6	149.1	1.00	1.00	1.00	67	1.12	0.82	29	7	0.60	200	0.58	0.16	0.29	1.85	0.000	0.08	40.46
67	19	1.00	Coarse Sand	19.50	36	21.00	19.0	340.1	157.8	1.00	1.00	1.00	67	1.12	0.80	32	7	0.60	225	0.58	0.15	0.35	2.26	0.000	0.03	41.21
N (mean)	20	1.00	Coarse Sand	20.50	34	22.00	18.0	358.6	166.5	1.00	1.00	1.00	67	1.12	0.78	29	4	0.60	200	0.57	0.15	0.27	1.77	0.000	0.00	40.42
14.7	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
168	25																									
Observed (cm)	26																									
208	27																									
Distance (m)	28																									
39.3	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	20.09																							5.43	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	1.09	Clay	1.50	4	3.00	16.5	23.4	17.6	1.00	0.75	1.00	67	1.12	2.00	7	35	0.01	150	0.98	0.16	0.11	0.66	0.000	0.00	Non-Liq.
Mw	2	1.00	Clay	2.50	3	4.00	16.5	39.9	24.3	1.00	0.75	1.00	67	1.12	2.00	5	35	0.01	150	0.97	0.20	0.08	0.43	0.000	0.00	Non-Liq.
7.5	3	1.00	Silt	3.50	1	5.00	15.5	55.9	30.5	1.00	0.85	1.00	67	1.12	1.81	2	35	0.03	125	0.95	0.21	0.06	0.28	0.000	0.00	Non-Liq.
Site	4	1.00	Midium Sand	4.50	5	6.00	16.5	71.9	36.7	1.00	0.85	1.00	67	1.12	1.65	8	2	0.35	150	0.92	0.22	0.08	0.35	1.000	0.78	5.26
G-10, B-B'	5	1.00	Midium Sand	5.50	6	7.00	16.5	88.4	43.4	1.00	0.95	1.00	67	1.12	1.52	10	2	0.35	150	0.89	0.22	0.09	0.38	1.000	0.73	6.70
Data Class	6	1.00	Midium Sand	6.50	6	8.00	16.5	104.9	50.0	1.00	0.95	1.00	67	1.12	1.41	9	1	0.35	150	0.86	0.22	0.08	0.35	1.000	0.68	6.13
	7	1.00	Midium Sand	7.50	6	9.00	16.5	121.4	56.7	1.00	0.95	1.00	67	1.12	1.33	8	1	0.35	150	0.82	0.22	0.07	0.33	1.000	0.63	5.70
B. H.	8	1.00	Midium Sand	8.50	6	10.00	16.5	137.9	63.4	1.00	0.95	1.00	67	1.12	1.26	8	1	0.35	150	0.78	0.21	0.07	0.32	1.000	0.58	5.37
139	9	1.00	Midium Sand	9.50	8	11.00	18.0	155.1	70.9	1.00	1.00	1.00	67	1.12	1.19	11	0	0.35	175	0.74	0.20	0.08	0.40	1.000	0.53	7.65
GWT (m)	10	1.00	Midium Sand	10.50	13	12.00	18.0	173.1	79.1	1.00	1.00	1.00	67	1.12	1.12	16	0	0.35	175	0.71	0.19	0.12	0.62	0.909	0.48	13.30
0.91	11	1.00	M to C Sand	11.50	8	13.00	16.5	190.4	86.5	1.00	1.00	1.00	67	1.12	1.08	10	10	0.50	150	0.68	0.18	0.07	0.40	1.000	0.43	7.08
a_{max} (g)	12	1.00	Coarse Sand	12.50	16	14.00	18.0	207.6	93.9	1.00	1.00	1.00	67	1.12	1.03	18	7	0.60	175	0.65	0.18	0.14	0.79	0.546	0.38	15.55
0.19	13	1.00	Coarse Sand	13.50	22	15.00	18.0	225.6	102.1	1.00	1.00	1.00	67	1.12	0.99	24	7	0.60	200	0.63	0.17	0.22	1.26	0.015	0.33	39.10
Sampler[b]	14	1.00	Coarse Sand	14.50	23	16.00	18.0	243.6	110.3	1.00	1.00	1.00	67	1.12	0.95	24	8	0.60	200	0.62	0.17	0.22	1.29	0.011	0.28	39.18
NA	15	1.00	Coarse Sand	15.50	31	17.00	19.0	262.1	119.0	1.00	1.00	1.00	67	1.12	0.92	32	6	0.60	225	0.61	0.16	0.36	2.21	0.000	0.23	41.09
B.H. Diam. (mm)	16	1.00	Coarse Sand	16.50	31	18.00	19.0	281.1	128.2	1.00	1.00	1.00	67	1.12	0.88	31	6	0.60	225	0.60	0.16	0.33	2.02	0.000	0.18	40.78
95	17	1.00	Coarse Sand	17.50	33	19.00	19.0	300.1	137.4	1.00	1.00	1.00	67	1.12	0.85	31	6	0.60	225	0.59	0.16	0.34	2.15	0.000	0.13	41.01
Energy Ratio[c]	18	1.00	Coarse Sand	18.50	37	20.00	19.0	319.1	146.6	1.00	1.00	1.00	67	1.12	0.83	34	6	0.60	225	0.59	0.16	0.41	2.62	0.000	0.08	41.75
67	19	1.00	Coarse Sand	19.50	32	21.00	18.0	337.6	155.3	1.00	1.00	1.00	67	1.12	0.80	29	6	0.60	200	0.58	0.16	0.27	1.71	0.000	0.03	40.26
N (mean)	20	1.00	Coarse Sand	20.50	25	22.00	18.0	355.6	163.5	1.00	1.00	1.00	67	1.12	0.78	22	7	0.60	200	0.58	0.16	0.16	1.01	0.135	0.00	38.42
15.8	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
169	25																									
Observed (cm)	26																									
208	27																									
Distance (m)	28																									
39.3	29																									LSI	
Liquefied ?	30																									Lin.	
	SUM	20.09																							4.97	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	1.09	Midium Sand	1.50	3	3.00	16.5	23.4	17.6	1.00	0.75	1.00	67	1.12	2.00	5	9	0.35	150	0.98	0.16	0.08	0.50	0.991	0.93	3.76
Mw	2	1.00	Midium Sand	2.50	2	4.00	15.5	39.4	23.8	1.00	0.75	1.00	67	1.12	2.00	3	4	0.35	125	0.96	0.20	0.06	0.32	1.000	0.88	2.91
7.5	3	1.00	Silt	3.50	2	5.00	15.5	54.9	29.5	1.00	0.85	1.00	67	1.12	1.84	3	35	0.03	125	0.94	0.22	0.07	0.32	0.000	0.00	Non-Liq.
Site	4	1.00	Midium Sand	4.50	3	6.00	16.5	70.9	35.7	1.00	0.85	1.00	67	1.12	1.67	5	17	0.35	150	0.92	0.22	0.07	0.30	1.000	0.78	3.90
G-10, B-B'	5	1.00	Midium Sand	5.50	5	7.00	16.5	87.4	42.4	1.00	0.95	1.00	67	1.12	1.54	8	5	0.35	150	0.88	0.23	0.08	0.35	1.000	0.73	5.48
Data Class	6	1.00	Midium Sand	6.50	7	8.00	18.0	104.6	49.8	1.00	0.95	1.00	67	1.12	1.42	11	5	0.35	175	0.85	0.22	0.09	0.41	1.000	0.68	7.57
	7	1.00	Midium Sand	7.50	8	9.00	18.0	122.6	58.0	1.00	0.95	1.00	67	1.12	1.31	11	3	0.35	175	0.81	0.21	0.09	0.42	0.999	0.63	8.19
B. H.	8	1.00	Midium Sand	8.50	10	10.00	18.0	140.6	66.2	1.00	0.95	1.00	67	1.12	1.23	13	1	0.35	175	0.77	0.20	0.10	0.49	0.994	0.58	10.08
140	9	1.00	Midium Sand	9.50	13	11.00	18.0	158.6	74.4	1.00	1.00	1.00	67	1.12	1.16	17	1	0.35	175	0.73	0.19	0.13	0.66	0.851	0.53	13.79
GWT (m)	10	1.00	Midium Sand	10.50	13	12.00	18.0	176.6	82.6	1.00	1.00	1.00	67	1.12	1.10	16	1	0.35	175	0.70	0.18	0.11	0.63	0.900	0.48	12.96
0.91	11	1.00	Midium Sand	11.50	14	13.00	18.0	194.6	90.7	1.00	1.00	1.00	67	1.12	1.05	16	0	0.35	175	0.67	0.18	0.11	0.65	0.862	0.43	13.38
a_{max} (g)	12	1.00	Midium Sand	12.50	14	14.00	18.0	212.6	98.9	1.00	1.00	1.00	67	1.12	1.01	16	0	0.35	175	0.64	0.17	0.11	0.62	0.901	0.38	12.71
0.19	13	1.00	Coarse Sand	13.50	16	15.00	18.0	230.6	107.1	1.00	1.00	1.00	67	1.12	0.97	17	0	0.60	175	0.62	0.17	0.12	0.71	0.752	0.33	14.20
Sampler[b]	14	1.00	Coarse Sand	14.50	19	16.00	18.0	248.6	115.3	1.00	1.00	1.00	67	1.12	0.93	20	0	0.60	175	0.61	0.16	0.14	0.85	0.399	0.28	16.58
NA	15	1.00	Coarse Sand	15.50	18	17.00	18.0	266.6	123.5	1.00	1.00	1.00	67	1.12	0.90	18	2	0.60	175	0.60	0.16	0.12	0.77	0.610	0.23	14.99
B.H. Diam. (mm)	16	1.00	Coarse Sand	16.50	21	18.00	18.0	284.6	131.7	1.00	1.00	1.00	67	1.12	0.87	20	5	0.60	175	0.59	0.16	0.15	0.94	0.235	0.18	37.97
95	17	1.00	Coarse Sand	17.50	20	19.00	18.0	302.6	139.9	1.00	1.00	1.00	67	1.12	0.85	19	5	0.60	175	0.58	0.16	0.13	0.83	0.460	0.13	15.75
Energy Ratio[c]	18	1.00	Coarse Sand	18.50	40	20.00	19.0	321.1	148.6	1.00	1.00	1.00	67	1.12	0.82	37	4	0.60	225	0.58	0.15	0.48	3.15	0.000	0.08	42.38
67	19	1.00	Coarse Sand	19.50	34	21.00	18.0	339.6	157.3	1.00	1.00	1.00	67	1.12	0.80	30	7	0.60	200	0.57	0.15	0.31	2.00	0.000	0.03	40.74
N (mean)	20	1.00	Coarse Sand	20.50	37	22.00	19.0	358.1	166.0	1.00	1.00	1.00	67	1.12	0.78	32	4	0.60	225	0.57	0.15	0.33	2.19	0.000	0.00	41.14
15.0	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
166	25																									
Observed (cm)	26																									
208	27																									
Distance (m)	28																									
39.3	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	20.09																							7.41	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	1.09	Clay	1.50	1	3.00	15.5	22.8	17.0	1.00	0.75	1.00	67	1.12	2.00	2	35	0.01	125	0.98	0.16	0.07	0.43	0.000	0.00	Non-Liq.
Mw	2	1.00	Midium Sand	2.50	1	4.00	15.5	38.3	22.7	1.00	0.75	1.00	67	1.12	2.00	2	2	0.35	125	0.96	0.20	0.06	0.28	1.000	0.88	2.33
7.5	3	1.00	Midium Sand	3.50	1	5.00	15.5	53.8	28.4	1.00	0.85	1.00	67	1.12	1.88	2	8	0.35	125	0.93	0.22	0.05	0.25	1.000	0.83	2.41
Site	4	1.00	Midium Sand	4.50	1	6.00	15.5	69.3	34.1	1.00	0.85	1.00	67	1.12	1.71	2	8	0.35	125	0.90	0.23	0.05	0.23	1.000	0.78	2.36
G-10, B-B'	5	1.00	Midium Sand	5.50	3	7.00	16.5	85.3	40.3	1.00	0.95	1.00	67	1.12	1.58	5	3	0.35	150	0.87	0.23	0.06	0.27	1.000	0.73	3.62
Data Class	6	1.00	Midium Sand	6.50	6	8.00	16.5	101.8	47.0	1.00	0.95	1.00	67	1.12	1.46	9	1	0.35	150	0.83	0.22	0.08	0.37	1.000	0.68	6.37
	7	1.00	Midium Sand	7.50	5	9.00	16.5	118.3	53.6	1.00	0.95	1.00	67	1.12	1.37	7	1	0.35	150	0.78	0.21	0.07	0.31	1.000	0.63	4.86
B. H.	8	1.00	Midium Sand	8.50	5	10.00	16.5	134.8	60.3	1.00	0.95	1.00	67	1.12	1.29	7	1	0.35	150	0.74	0.20	0.06	0.31	1.000	0.58	4.60
141	9	1.00	Midium Sand	9.50	6	11.00	16.5	151.3	67.0	1.00	1.00	1.00	67	1.12	1.22	8	6	0.35	150	0.70	0.20	0.07	0.36	1.000	0.53	5.56
GWT (m)	10	1.00	Midium Sand	10.50	8	12.00	16.5	167.8	73.7	1.00	1.00	1.00	67	1.12	1.16	10	3	0.35	150	0.67	0.19	0.08	0.42	0.999	0.48	7.45
0.91	11	1.00	Midium Sand	11.50	9	13.00	18.0	185.0	81.2	1.00	1.00	1.00	67	1.12	1.11	11	3	0.35	175	0.64	0.18	0.08	0.45	0.998	0.43	8.20
a_{max} (g)	12	1.00	Midium Sand	12.50	8	14.00	16.5	202.3	88.6	1.00	1.00	1.00	67	1.12	1.06	9	5	0.35	150	0.62	0.17	0.07	0.41	1.000	0.38	6.54
0.19	13	1.00	Midium Sand	13.50	32	15.00	19.0	220.0	96.5	1.00	1.00	1.00	67	1.12	1.02	36	3	0.35	225	0.60	0.17	0.53	3.12	0.000	0.33	42.31
Sampler[b]	14	1.00	Midium Sand	14.50	34	16.00	19.0	239.0	105.7	1.00	1.00	1.00	67	1.12	0.97	37	3	0.35	225	0.59	0.16	0.54	3.27	0.000	0.28	42.46
NA	15	1.00	Midium Sand	15.50	35	17.00	19.0	258.0	114.9	1.00	1.00	1.00	67	1.12	0.93	36	5	0.35	225	0.58	0.16	0.52	3.26	0.000	0.23	42.33
B.H. Diam. (mm)	16	1.00	Coarse Sand	16.50	39	18.00	19.0	277.0	124.1	1.00	1.00	1.00	67	1.12	0.90	39	9	0.60	225	0.57	0.16	0.66	4.23	0.000	0.18	43.27
95	17	1.00	Coarse Sand	17.50	41	19.00	19.0	296.0	133.3	1.00	1.00	1.00	67	1.12	0.87	40	9	0.60	225	0.56	0.15	0.68	4.40	0.000	0.13	43.43
Energy Ratio[c]	18	1.00	Coarse Sand	18.50	30	20.00	18.0	314.5	142.0	1.00	1.00	1.00	67	1.12	0.84	28	6	0.60	200	0.56	0.15	0.26	1.72	0.000	0.08	40.10
67	19	1.00	Coarse Sand	19.50	21	21.00	18.0	332.5	150.2	1.00	1.00	1.00	67	1.12	0.82	19	8	0.60	175	0.56	0.15	0.13	0.87	0.366	0.03	16.34
N (mean)	20	1.00	Coarse Sand	20.50	23	22.00	18.0	350.5	158.4	1.00	1.00	1.00	67	1.12	0.79	20	8	0.60	175	0.55	0.15	0.14	0.95	0.215	0.00	38.06
15.5	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
160	25																									
Observed (cm)	26																									
208	27																									
Distance (m)	28																									
39.3	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	20.09																							6.88	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (fps)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	0.95	Midium Sand	1.00	4	2.50	16.5	15.7	11.3	1.00	0.75	1.00	67	1.12	2.00	7	5	0.35	150	0.99	0.17	0.10	0.60	0.933	0.95	4.53
Mw	2	1.00	Midium Sand	2.00	4	3.50	16.5	32.2	18.0	1.00	0.75	1.00	67	1.12	2.00	7	5	0.35	150	0.97	0.22	0.09	0.41	1.000	0.90	4.53
7.5	3	1.00	Silt	3.00	2	4.50	15.5	48.2	24.1	1.00	0.85	1.00	67	1.12	2.00	4	35	0.03	125	0.95	0.24	0.08	0.32	1.000	0.00	Non-Liq.
Site	4	1.00	Fine Sand	4.00	2	5.50	15.5	63.7	29.8	1.00	0.85	1.00	67	1.12	1.83	3	8	0.15	125	0.93	0.25	0.06	0.25	1.000	0.80	3.03
G-10, B-B'	5	1.00	Midium Sand	5.00	7	6.50	18.0	80.4	36.8	1.00	0.95	1.00	67	1.12	1.65	12	5	0.35	175	0.90	0.24	0.11	0.46	0.997	0.75	9.29
Data Class	6	1.00	Midium Sand	6.00	6	7.50	16.5	97.7	44.2	1.00	0.95	1.00	67	1.12	1.50	10	5	0.35	150	0.87	0.24	0.09	0.37	1.000	0.70	6.61
	7	1.00	Midium Sand	7.00	8	8.50	18.0	114.9	51.7	1.00	0.95	1.00	67	1.12	1.39	12	5	0.35	175	0.83	0.23	0.10	0.43	0.999	0.65	8.85
B. H.	8	1.00	Midium Sand	8.00	4	9.50	16.5	132.2	59.1	1.00	0.95	1.00	67	1.12	1.30	6	5	0.35	150	0.79	0.22	0.06	0.27	1.000	0.60	3.87
143	9	1.00	Midium Sand	9.00	6	10.50	16.5	148.7	65.8	1.00	1.00	1.00	67	1.12	1.23	8	5	0.35	150	0.75	0.21	0.07	0.34	1.000	0.55	5.56
GWT (m)	10	1.00	Midium Sand	10.00	6	11.50	16.5	165.2	72.5	1.00	1.00	1.00	67	1.12	1.17	8	5	0.35	150	0.71	0.20	0.07	0.33	1.000	0.50	5.28
0.55	11	1.00	Midium Sand	11.00	11	12.50	18.0	182.4	79.9	1.00	1.00	1.00	67	1.12	1.12	14	5	0.35	175	0.68	0.19	0.10	0.53	0.983	0.45	10.77
a_{max} (g)	12	1.00	Midium Sand	12.00	14	13.50	18.0	200.4	88.1	1.00	1.00	1.00	67	1.12	1.07	17	5	0.35	175	0.65	0.18	0.12	0.67	0.828	0.40	13.62
0.19	13	1.00	Midium Sand	13.00	12	14.50	18.0	218.4	96.3	1.00	1.00	1.00	67	1.12	1.02	14	5	0.35	175	0.63	0.18	0.10	0.54	0.978	0.35	10.69
Sampler[b]	14	1.00	Midium Sand	14.00	24	15.50	18.0	236.4	104.5	1.00	1.00	1.00	67	1.12	0.98	26	5	0.35	200	0.62	0.17	0.24	1.42	0.003	0.30	39.54
NA	15	1.00	Midium Sand	15.00	31	16.50	19.0	254.9	113.2	1.00	1.00	1.00	67	1.12	0.94	33	5	0.35	225	0.60	0.17	0.39	2.31	0.000	0.25	41.27
B.H. Diam. (mm)	16	1.00	Midium Sand	16.00	34	17.50	19.0	273.9	122.4	1.00	1.00	1.00	67	1.12	0.90	34	5	0.35	225	0.59	0.16	0.43	2.66	0.000	0.20	41.75
95	17	1.00	Midium Sand	17.00	31	18.50	18.0	292.4	131.1	1.00	1.00	1.00	67	1.12	0.87	30	5	0.35	200	0.58	0.16	0.31	1.94	0.000	0.15	40.64
Energy Ratio[c]	18	1.00	Midium Sand	18.00	36	19.50	19.0	310.9	139.7	1.00	1.00	1.00	67	1.12	0.85	34	5	0.35	225	0.58	0.16	0.41	2.57	0.000	0.10	41.67
67	19	1.00	Silt	19.00	6	20.50	16.5	328.7	147.7	1.00	1.00	1.00	67	1.12	0.82	6	35	0.03	150	0.58	0.16	0.05	0.34	1.000	0.00	Non-Liq.
N (mean)	20	1.00	Fine Sand	20.00	35	21.50	19.0	346.4	155.6	1.00	1.00	1.00	67	1.12	0.80	31	8	0.15	225	0.57	0.16	0.34	2.14	0.000	0.00	41.08
14.2	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
167	25																									
Observed (cm)	26																									
41	27																									
Distance (m)	28																									
38.1	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	19.95																							7.41	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (fps)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	0.86	Clay	1.00	8	2.50	18.0	16.7	13.2	1.00	0.75	1.00	67	1.12	2.00	13	35	0.01	175	0.99	0.16	0.21	1.32	0.000	0.00	Non-Liq.
Mw	2	1.00	Clay	2.00	6	3.50	16.5	34.0	20.6	1.00	0.75	1.00	67	1.12	2.00	10	35	0.01	150	0.98	0.20	0.14	0.68	0.000	0.00	Non-Liq.
7.5	3	1.00	Fine Sand	3.00	7	4.50	18.0	51.2	28.1	1.00	0.85	1.00	67	1.12	1.89	13	8	0.15	175	0.97	0.22	0.13	0.58	0.954	0.85	9.88
Site	4	1.00	Fine Sand	4.00	8	5.50	18.0	69.2	36.3	1.00	0.85	1.00	67	1.12	1.66	13	8	0.15	175	0.96	0.23	0.12	0.52	0.984	0.80	9.95
G-10, B-B'	5	1.00	Fine Sand	5.00	6	6.50	16.5	86.5	43.7	1.00	0.95	1.00	67	1.12	1.51	10	8	0.15	150	0.94	0.23	0.09	0.39	1.000	0.75	6.93
Data Class	6	1.00	Fine Sand	6.00	4	7.50	16.5	103.0	50.4	1.00	0.95	1.00	67	1.12	1.41	6	8	0.15	150	0.91	0.23	0.06	0.28	1.000	0.70	4.23
	7	1.00	Fine Sand	7.00	7	8.50	16.5	119.5	57.1	1.00	0.95	1.00	67	1.12	1.32	10	8	0.15	150	0.88	0.23	0.08	0.37	1.000	0.65	7.13
B. H.	8	1.00	Fine Sand	8.00	8	9.50	18.0	136.7	64.5	1.00	0.95	1.00	67	1.12	1.24	11	8	0.15	175	0.85	0.22	0.09	0.39	1.000	0.60	7.88
146	9	1.00	Fine Sand	9.00	13	10.50	18.0	154.7	72.7	1.00	1.00	1.00	67	1.12	1.17	17	8	0.15	175	0.82	0.21	0.14	0.64	0.881	0.55	14.31
GWT (m)	10	1.00	Fine Sand	10.00	11	11.50	18.0	172.7	80.9	1.00	1.00	1.00	67	1.12	1.11	14	8	0.15	175	0.78	0.21	0.10	0.50	0.992	0.50	10.99
0.64	11	1.00	Midium Sand	11.00	12	12.50	18.0	190.7	89.1	1.00	1.00	1.00	67	1.12	1.06	14	5	0.35	175	0.75	0.20	0.10	0.51	0.988	0.45	11.22
a_{max} (g)	12	1.00	Midium Sand	12.00	18	13.50	18.0	208.7	97.3	1.00	1.00	1.00	67	1.12	1.01	20	5	0.35	175	0.72	0.19	0.16	0.83	0.447	0.40	17.16
0.19	13	1.00	Fine Sand	13.00	22	14.50	18.0	226.7	105.5	1.00	1.00	1.00	67	1.12	0.97	24	8	0.15	200	0.70	0.19	0.21	1.14	0.046	0.35	39.03
Sampler[b]	14	1.00	Fine Sand	14.00	40	15.50	19.0	245.2	114.2	1.00	1.00	1.00	67	1.12	0.94	42	8	0.15	225	0.68	0.18	0.83	4.60	0.000	0.30	43.96
NA	15	1.00	Fine Sand	15.00	41	16.50	19.0	264.2	123.3	1.00	1.00	1.00	67	1.12	0.90	41	8	0.15	225	0.66	0.17	0.77	4.42	0.000	0.25	43.80
B.H. Diam. (mm)	16	1.00	Fine Sand	16.00	37	17.50	19.0	283.2	132.5	1.00	1.00	1.00	67	1.12	0.87	36	8	0.15	225	0.65	0.17	0.50	2.93	0.000	0.20	42.33
95	17	1.00	Fine Sand	17.00	43	18.50	19.0	302.2	141.7	1.00	1.00	1.00	67	1.12	0.84	40	8	0.15	225	0.64	0.17	0.69	4.13	0.000	0.15	43.56
Energy Ratio[c]	18	1.00	Fine Sand	18.00	40	19.50	19.0	321.2	150.9	1.00	1.00	1.00	67	1.12	0.81	36	8	0.15	225	0.63	0.17	0.50	3.02	0.000	0.10	42.46
67	19	1.00	Midium Sand	19.00	46	20.50	19.0	340.2	160.1	1.00	1.00	1.00	67	1.12	0.79	41	5	0.35	225	0.63	0.16	0.65	3.97	0.000	0.05	43.46
N (mean)	20	1.00	Midium Sand	20.00	43	21.50	19.0	359.2	169.3	1.00	1.00	1.00	67	1.12	0.77	37	5	0.35	225	0.62	0.16	0.48	2.97	0.000	0.00	42.45
21.0	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
183	25																									
Observed (cm)	26																									
130	27																									
Distance (m)	28																									
91.4	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	19.86																							5.92	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	1.09	Coarse Sand	1.00	2	2.50	15.5	15.0	14.2	1.00	0.75	1.00	67	1.12	2.00	3	6	0.60	125	0.99	0.13	0.07	0.57	0.959	0.95	2.93
Mw	2	2.00	Coarse Sand	3.00	3	4.50	16.5	47.0	26.5	1.00	0.85	1.00	67	1.12	1.94	6	6	0.60	150	0.97	0.21	0.07	0.35	1.000	0.85	3.91
7.5	3	2.00	Coarse Sand	5.00	8	6.50	18.0	81.5	41.4	1.00	0.95	1.00	67	1.12	1.55	13	6	0.60	175	0.93	0.23	0.12	0.52	0.987	0.75	10.32
Site	4	1.50	Coarse Sand	7.00	15	8.50	18.0	117.5	57.8	1.00	0.95	1.00	67	1.12	1.32	21	6	0.60	200	0.88	0.22	0.19	0.88	0.343	0.65	17.79
G-10, D-D'	5	1.50	Coarse Sand	8.00	17	9.50	18.0	135.5	66.0	1.00	0.95	1.00	67	1.12	1.23	22	6	0.60	200	0.84	0.21	0.21	0.96	0.199	0.60	38.48
Data Class	6	1.50	Coarse Sand	10.00	11	11.50	18.0	171.5	82.4	1.00	1.00	1.00	67	1.12	1.10	14	6	0.60	175	0.77	0.20	0.10	0.50	0.992	0.50	10.67
	7	1.00	Coarse Sand	11.00	22	12.50	18.0	189.5	90.6	1.00	1.00	1.00	67	1.12	1.05	26	6	0.60	200	0.74	0.19	0.25	1.30	0.010	0.45	39.47
B. H.	8	1.00	Coarse Sand	12.00	14	13.50	18.0	207.5	98.8	1.00	1.00	1.00	67	1.12	1.01	16	6	0.60	175	0.71	0.19	0.11	0.61	0.925	0.40	12.83
155	9	1.00	Coarse Sand	13.00	16	14.50	18.0	225.5	106.9	1.00	1.00	1.00	67	1.12	0.97	17	6	0.60	175	0.69	0.18	0.12	0.69	0.790	0.35	14.33
GWT (m)	10	1.50	Midium Sand	14.00	30	15.50	19.0	244.0	115.6	1.00	1.00	1.00	67	1.12	0.93	31	5	0.35	225	0.67	0.17	0.35	1.99	0.000	0.30	40.89
0.91	11	1.50	Midium Sand	16.00	29	17.50	18.0	281.0	133.0	1.00	1.00	1.00	67	1.12	0.87	28	5	0.35	200	0.64	0.17	0.26	1.58	0.001	0.20	40.05
a_{max} (g)	12	1.00	Fine Sand	17.00	29	18.50	18.0	299.0	141.2	1.00	1.00	1.00	67	1.12	0.84	27	8	0.15	200	0.63	0.17	0.25	1.53	0.001	0.15	39.95
0.19	13	1.00	Fine Sand	18.00	34	19.50	19.0	317.5	149.9	1.00	1.00	1.00	67	1.12	0.82	31	8	0.15	225	0.62	0.16	0.33	2.03	0.000	0.10	40.99
Sampler[b]	14	1.00	Fine Sand	19.00	42	20.50	19.0	336.5	159.1	1.00	1.00	1.00	67	1.12	0.79	37	8	0.15	225	0.62	0.16	0.53	3.25	0.000	0.05	42.69
NA	15	1.00	Fine Sand	20.00	46	21.50	19.0	355.5	168.3	1.00	1.00	1.00	67	1.12	0.77	40	8	0.15	225	0.62	0.16	0.62	3.89	0.000	0.00	43.36
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
67	19																									
N (mean)	20																									
21.2	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
181	25																									
Observed (cm)	26																									
89	27																									
Distance (m)	28																									
120.6	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	19.59																							6.08	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	0.59	Sandy Loam	1.00	2	2.50	15.5	15.0	14.2	1.00	0.75	1.00	67	1.12	2.00	3	35	0.02	125	0.99	0.13	0.09	0.66	0.000	0.00	Non-Liq.
Mw	2	1.00	Sandy Loam	2.00	1	3.50	15.5	30.5	19.9	1.00	0.75	1.00	67	1.12	2.00	2	35	0.02	125	0.98	0.19	0.07	0.36	0.000	0.00	Non-Liq.
7.5	3	1.00	Sandy Silt	3.00	2	4.50	15.5	46.0	25.5	1.00	0.85	1.00	67	1.12	1.98	4	35	0.04	125	0.96	0.21	0.07	0.35	0.000	0.00	Non-Liq.
Site	4	1.00	Fine Sand	4.00	5	5.50	16.5	62.0	31.7	1.00	0.85	1.00	67	1.12	1.78	8	8	0.15	150	0.94	0.23	0.09	0.39	1.000	0.80	5.87
G-10, D-D'	5	0.75	Fine Sand	5.00	3	6.50	16.5	78.5	38.4	1.00	0.95	1.00	67	1.12	1.61	5	8	0.15	150	0.91	0.23	0.07	0.28	1.000	0.75	3.78
Data Class	6	0.50	Sandy Silt	5.50	3	7.00	16.5	86.8	41.8	1.00	0.95	1.00	67	1.12	1.55	5	35	0.04	150	0.89	0.23	0.07	0.31	0.000	0.00	Non-Liq.
	7	0.75	F to M Sand	6.00	11	7.50	18.0	95.4	45.5	1.00	0.95	1.00	67	1.12	1.48	17	5	0.25	175	0.88	0.23	0.16	0.68	0.801	0.70	14.24
B. H.	8	1.00	F to M Sand	7.00	9	8.50	18.0	113.4	53.7	1.00	0.95	1.00	67	1.12	1.36	13	5	0.25	175	0.84	0.22	0.11	0.49	0.994	0.65	10.07
160	9	1.00	Fine Sand	8.00	9	9.50	18.0	131.4	61.9	1.00	0.95	1.00	67	1.12	1.27	12	8	0.15	175	0.80	0.21	0.10	0.47	0.997	0.60	9.47
GWT (m)	10	1.00	Fine Sand	9.00	8	10.50	18.0	149.4	70.1	1.00	1.00	1.00	67	1.12	1.19	11	8	0.15	175	0.77	0.20	0.08	0.42	0.999	0.55	7.99
0.91	11	1.00	F to M Sand	10.00	16	11.50	18.0	167.4	78.2	1.00	1.00	1.00	67	1.12	1.13	20	5	0.25	175	0.73	0.19	0.17	0.86	0.375	0.50	16.99
a_{max} (g)	12	1.00	F to M Sand	11.00	14	12.50	18.0	185.4	86.4	1.00	1.00	1.00	67	1.12	1.08	17	5	0.25	175	0.70	0.18	0.13	0.68	0.812	0.45	13.77
0.19	13	1.00	F to M Sand	12.00	19	13.50	18.0	203.4	94.6	1.00	1.00	1.00	67	1.12	1.03	22	5	0.25	200	0.67	0.18	0.18	1.01	0.142	0.40	38.34
Sampler[b]	14	1.00	F to M Sand	13.00	22	14.50	18.0	221.4	102.8	1.00	1.00	1.00	67	1.12	0.99	24	5	0.25	200	0.65	0.17	0.21	1.22	0.021	0.35	39.00
NA	15	1.00	Fine Sand	14.00	24	15.50	18.0	239.4	111.0	1.00	1.00	1.00	67	1.12	0.95	25	10	0.15	200	0.63	0.17	0.24	1.43	0.003	0.30	39.53
B.H. Diam. (mm)	16	1.00	Fine Sand	15.00	25	16.50	18.0	257.4	119.2	1.00	1.00	1.00	67	1.12	0.92	26	10	0.15	200	0.62	0.16	0.24	1.45	0.002	0.25	39.57
95	17	1.00	Fine Sand	16.00	28	17.50	18.0	275.4	127.4	1.00	1.00	1.00	67	1.12	0.89	28	10	0.15	200	0.60	0.16	0.28	1.70	0.000	0.20	40.16
Energy Ratio[c]	18	1.00	Fine Sand	17.00	29	18.50	18.0	293.4	135.6	1.00	1.00	1.00	67	1.12	0.86	28	10	0.15	200	0.60	0.16	0.27	1.71	0.000	0.15	40.19
67	19	1.00	Fine Sand	18.00	33	19.50	19.0	311.9	144.3	1.00	1.00	1.00	67	1.12	0.83	31	10	0.15	225	0.59	0.16	0.34	2.12	0.000	0.10	40.99
N (mean)	20	1.00	F to M Sand	19.00	30	20.50	18.0	330.4	153.0	1.00	1.00	1.00	67	1.12	0.81	27	5	0.25	200	0.59	0.16	0.23	1.50	0.001	0.05	39.78
15.5	21	1.00	F to M Sand	20.00	32	21.50	18.0	348.4	161.1	1.00	1.00	1.00	67	1.12	0.79	28	5	0.25	200	0.58	0.16	0.25	1.61	0.000	0.00	40.07
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
170	25																									
Observed (cm)	26																									
89	27																									
Distance (m)	28																									
17.8	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	19.59																							4.20	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N^d	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	1.09	Midium Sand	1.50	9	3.00	18.0	25.2	19.4	1.00	0.75	1.00	67	1.12	2.00	15	5	0.35	175	0.99	0.16	0.17	1.05	0.101	0.93	36.51
Mw	2	1.00	Fine Sand	2.50	5	4.00	16.5	42.4	26.8	1.00	0.75	1.00	67	1.12	1.93	8	8	0.15	150	0.97	0.19	0.09	0.48	0.996	0.88	5.61
7.5	3	1.00	Midium Sand	3.50	6	5.00	16.5	58.9	33.5	1.00	0.85	1.00	67	1.12	1.73	10	1	0.35	150	0.96	0.21	0.09	0.45	0.998	0.83	6.87
Site	4	1.00	Midium Sand	4.50	8	6.00	18.0	76.2	41.0	1.00	0.85	1.00	67	1.12	1.56	12	1	0.35	175	0.94	0.22	0.10	0.48	0.996	0.78	8.91
G-10, E-E'	5	1.00	Midium Sand	5.50	7	7.00	18.0	94.2	49.2	1.00	0.95	1.00	67	1.12	1.43	11	1	0.35	175	0.91	0.22	0.09	0.41	1.000	0.73	7.63
Data Class	6	1.00	Midium Sand	6.50	11	8.00	18.0	112.2	57.3	1.00	0.95	1.00	67	1.12	1.32	15	1	0.35	175	0.88	0.21	0.12	0.57	0.957	0.68	12.41
	7	1.00	Midium Sand	7.50	13	9.00	18.0	130.2	65.5	1.00	0.95	1.00	67	1.12	1.24	17	1	0.35	175	0.85	0.21	0.13	0.64	0.881	0.63	13.99
B. H.	8	1.00	Midium Sand	8.50	10	10.00	18.0	148.2	73.7	1.00	0.95	1.00	67	1.12	1.16	12	1	0.35	175	0.81	0.20	0.09	0.45	0.998	0.58	9.40
161	9	1.00	Midium Sand	9.50	9	11.00	18.0	166.2	81.9	1.00	1.00	1.00	67	1.12	1.10	11	1	0.35	175	0.78	0.19	0.08	0.41	1.000	0.53	8.15
GWT (m)	10	1.00	Midium Sand	10.50	10	12.00	18.0	184.2	90.1	1.00	1.00	1.00	67	1.12	1.05	12	1	0.35	175	0.74	0.19	0.08	0.44	0.999	0.48	8.81
0.91	11	1.00	Midium Sand	11.50	14	13.00	18.0	202.2	98.3	1.00	1.00	1.00	67	1.12	1.01	16	1	0.35	175	0.71	0.18	0.11	0.60	0.935	0.43	12.76
a_{max} (g)	12	1.00	Midium Sand	12.50	16	14.00	18.0	220.2	106.5	1.00	1.00	1.00	67	1.12	0.97	17	1	0.35	175	0.69	0.17	0.12	0.68	0.812	0.38	14.25
0.19	13	1.00	Midium Sand	13.50	20	15.00	18.0	238.2	114.7	1.00	1.00	1.00	67	1.12	0.93	21	1	0.35	175	0.66	0.17	0.15	0.89	0.321	0.33	17.60
Sampler[b]	14	1.00	Midium Sand	14.50	23	16.00	18.0	256.2	122.9	1.00	1.00	1.00	67	1.12	0.90	23	1	0.35	200	0.65	0.17	0.18	1.06	0.090	0.28	38.71
NA	15	1.00	Fine Sand	15.50	25	17.00	18.0	274.2	131.1	1.00	1.00	1.00	67	1.12	0.87	24	4	0.15	200	0.63	0.16	0.20	1.21	0.025	0.23	39.04
B.H. Diam. (mm)	16	1.00	Fine Sand	16.50	28	18.00	18.0	292.2	139.2	1.00	1.00	1.00	67	1.12	0.85	26	4	0.15	200	0.62	0.16	0.23	1.41	0.003	0.18	39.62
95	17	1.00	Fine Sand	17.50	26	19.00	18.0	310.2	147.4	1.00	1.00	1.00	67	1.12	0.82	24	4	0.15	200	0.62	0.16	0.18	1.15	0.042	0.13	38.91
Energy Ratio[c]	18	1.00	Fine Sand	18.50	23	20.00	18.0	328.2	155.6	1.00	1.00	1.00	67	1.12	0.80	21	4	0.15	175	0.61	0.16	0.14	0.89	0.332	0.08	17.35
67	19	1.00	Fine Sand	19.50	26	21.00	18.0	346.2	163.8	1.00	1.00	1.00	67	1.12	0.78	23	4	0.15	200	0.61	0.16	0.16	1.03	0.120	0.03	38.58
N (mean)	20	1.00	Fine Sand	20.50	25	22.00	18.0	364.2	172.0	1.00	1.00	1.00	67	1.12	0.76	21	4	0.15	200	0.60	0.16	0.14	0.92	0.272	0.00	18.00
15.7	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
177	25																									
Observed (cm)	26																									
534	27																									
Distance (m)	28																									
17.8	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	20.09																							6.93	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (fps)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	0.59	Midium Sand	1.00	6	2.50	16.5	16.0	15.2	1.00	0.75	1.00	67	1.12	2.00	10	5	0.35	150	0.99	0.13	0.12	0.94	0.239	0.95	35.14
Mw	2	1.00	Midium Sand	2.00	12	3.50	18.0	33.3	22.6	1.00	0.75	1.00	67	1.12	2.00	20	5	0.35	175	0.98	0.18	0.23	1.32	0.008	0.90	37.87
7.5	3	1.00	Midium Sand	3.00	6	4.50	16.5	50.5	30.0	1.00	0.85	1.00	67	1.12	1.82	10	5	0.35	150	0.96	0.20	0.10	0.52	0.987	0.85	7.43
Site	4	1.00	Midium Sand	4.00	11	5.50	18.0	67.8	37.5	1.00	0.85	1.00	67	1.12	1.63	17	5	0.35	175	0.93	0.21	0.16	0.77	0.597	0.80	14.00
G-10, E-E'	5	1.00	Midium Sand	5.00	9	6.50	18.0	85.8	45.7	1.00	0.95	1.00	67	1.12	1.48	14	5	0.35	175	0.91	0.21	0.12	0.58	0.951	0.75	11.15
Data Class	6	1.00	Midium Sand	6.00	9	7.50	18.0	103.8	53.9	1.00	0.95	1.00	67	1.12	1.36	13	5	0.35	175	0.87	0.21	0.11	0.51	0.988	0.70	10.05
	7	1.00	Midium Sand	7.00	11	8.50	18.0	121.8	62.1	1.00	0.95	1.00	67	1.12	1.27	15	5	0.35	175	0.84	0.20	0.12	0.58	0.950	0.65	11.83
B. H.	8	1.00	Midium Sand	8.00	6	9.50	16.5	139.0	69.5	1.00	0.95	1.00	67	1.12	1.20	8	5	0.35	150	0.80	0.20	0.07	0.33	1.000	0.60	5.12
162	9	1.00	Midium Sand	9.00	8	10.50	16.5	155.5	76.2	1.00	1.00	1.00	67	1.12	1.15	10	5	0.35	150	0.76	0.19	0.08	0.41	1.000	0.55	7.28
GWT (m)	10	1.00	Midium Sand	10.00	10	11.50	18.0	172.8	83.6	1.00	1.00	1.00	67	1.12	1.09	12	5	0.35	175	0.72	0.18	0.09	0.48	0.995	0.50	9.25
0.91	11	1.00	Midium Sand	11.00	8	12.50	16.5	190.0	91.1	1.00	1.00	1.00	67	1.12	1.05	9	5	0.35	150	0.69	0.18	0.07	0.39	1.000	0.45	6.43
a_{max} (g)	12	1.00	Midium Sand	12.00	13	13.50	18.0	207.3	98.5	1.00	1.00	1.00	67	1.12	1.01	15	5	0.35	175	0.66	0.17	0.10	0.59	0.938	0.40	11.64
0.19	13	1.00	Midium Sand	13.00	18	14.50	18.0	225.3	106.7	1.00	1.00	1.00	67	1.12	0.97	19	5	0.35	175	0.64	0.17	0.14	0.87	0.372	0.35	16.29
Sampler[b]	14	1.00	Midium Sand	14.00	16	15.50	18.0	243.3	114.9	1.00	1.00	1.00	67	1.12	0.93	17	5	0.35	175	0.62	0.16	0.11	0.70	0.759	0.30	13.63
NA	15	1.00	Midium Sand	15.00	15	16.50	18.0	261.3	123.1	1.00	1.00	1.00	67	1.12	0.90	15	5	0.35	175	0.61	0.16	0.10	0.62	0.902	0.25	12.11
B.H. Diam. (mm)	16	1.00	Coarse Sand	16.00	12	17.50	18.0	279.3	131.3	1.00	1.00	1.00	67	1.12	0.87	12	3	0.45	175	0.60	0.16	0.07	0.47	0.996	0.20	8.74
95	17	1.00	Coarse Sand	17.00	9	18.50	16.5	296.5	138.7	1.00	1.00	1.00	67	1.12	0.85	9	3	0.45	150	0.59	0.16	0.06	0.37	1.000	0.15	5.76
Energy Ratio[c]	18	1.00	Fine Sand	18.00	28	19.50	18.0	313.8	146.1	1.00	1.00	1.00	67	1.12	0.83	26	8	0.15	200	0.59	0.16	0.22	1.44	0.002	0.10	39.57
67	19	1.00	Fine Sand	19.00	36	20.50	19.0	332.3	154.8	1.00	1.00	1.00	67	1.12	0.80	32	8	0.15	225	0.58	0.15	0.36	2.36	0.000	0.05	41.35
N (mean)	20																									
12.8	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
169	25																									
Observed (cm)	26																									
476	27																									
Distance (m)	28																									
22.9	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	18.59																							6.89	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N^d	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	0.59	Midium Sand	1.00	4	2.50	16.5	15.1	14.3	1.00	0.75	1.00	67	1.12	2.00	7	5	0.35	150	0.99	0.13	0.10	0.73	0.686	0.95	4.53
Mw	2	1.00	Midium Sand	2.00	6	3.50	16.5	31.6	20.9	1.00	0.75	1.00	67	1.12	2.00	10	5	0.35	150	0.97	0.18	0.11	0.61	0.920	0.90	7.09
7.5	3	1.00	Midium Sand	3.00	6	4.50	18.0	48.9	28.4	1.00	0.85	1.00	67	1.12	1.88	11	5	0.35	175	0.95	0.20	0.11	0.53	0.983	0.85	7.73
Site	4	1.00	Midium Sand	4.00	5	5.50	16.5	66.1	35.8	1.00	0.85	1.00	67	1.12	1.67	8	5	0.35	150	0.93	0.21	0.08	0.38	1.000	0.80	5.32
G-10, E-E'	5	1.00	Midium Sand	5.00	5	6.50	16.5	82.6	42.5	1.00	0.95	1.00	67	1.12	1.53	8	5	0.35	150	0.90	0.22	0.08	0.36	1.000	0.75	5.47
Data Class	6	1.00	Midium Sand	6.00	5	7.50	16.5	99.1	49.2	1.00	0.95	1.00	67	1.12	1.43	8	5	0.35	150	0.86	0.22	0.07	0.34	1.000	0.70	5.07
	7	1.00	Midium Sand	7.00	6	8.50	16.5	115.6	55.9	1.00	0.95	1.00	67	1.12	1.34	9	5	0.35	150	0.83	0.21	0.07	0.35	1.000	0.65	5.75
B. H.	8	1.00	Midium Sand	8.00	7	9.50	16.5	132.1	62.6	1.00	0.95	1.00	67	1.12	1.26	9	5	0.35	150	0.79	0.21	0.08	0.38	1.000	0.60	6.45
163	9	1.00	Midium Sand	9.00	8	10.50	18.0	149.4	70.0	1.00	1.00	1.00	67	1.12	1.20	11	5	0.35	175	0.75	0.20	0.08	0.42	0.999	0.55	7.58
GWT (m)	10	1.00	Midium Sand	10.00	9	11.50	18.0	167.4	78.2	1.00	1.00	1.00	67	1.12	1.13	11	5	0.35	175	0.71	0.19	0.08	0.45	0.998	0.50	8.41
0.91	11	1.00	Midium Sand	11.00	16	12.50	18.0	185.4	86.4	1.00	1.00	1.00	67	1.12	1.08	19	5	0.35	175	0.68	0.18	0.15	0.84	0.438	0.45	16.07
a_{max} (g)	12	1.00	Midium Sand	12.00	12	13.50	18.0	203.4	94.6	1.00	1.00	1.00	67	1.12	1.03	14	5	0.35	175	0.65	0.17	0.10	0.56	0.967	0.40	10.81
0.19	13	1.00	Midium Sand	13.00	10	14.50	18.0	221.4	102.8	1.00	1.00	1.00	67	1.12	0.99	11	5	0.35	175	0.63	0.17	0.08	0.46	0.998	0.35	8.06
Sampler[b]	14	1.00	Midium Sand	14.00	12	15.50	18.0	239.4	111.0	1.00	1.00	1.00	67	1.12	0.95	13	5	0.35	175	0.61	0.16	0.09	0.52	0.985	0.30	9.76
NA	15	1.00	Midium Sand	15.00	16	16.50	18.0	257.4	119.2	1.00	1.00	1.00	67	1.12	0.92	16	5	0.35	175	0.60	0.16	0.11	0.69	0.783	0.25	13.34
B.H. Diam. (mm)	16	1.00	Midium Sand	16.00	15	17.50	18.0	275.4	127.4	1.00	1.00	1.00	67	1.12	0.89	15	5	0.35	175	0.59	0.16	0.10	0.61	0.915	0.20	11.86
95	17	1.00	Midium Sand	17.00	14	18.50	18.0	293.4	135.5	1.00	1.00	1.00	67	1.12	0.86	13	5	0.35	175	0.58	0.16	0.09	0.55	0.974	0.15	10.46
Energy Ratio[c]	18	1.00	Midium Sand	18.00	18	19.50	18.0	311.4	143.7	1.00	1.00	1.00	67	1.12	0.83	17	5	0.35	175	0.58	0.15	0.11	0.70	0.763	0.10	13.73
67	19	1.00	Midium Sand	19.00	24	20.50	18.0	329.4	151.9	1.00	1.00	1.00	67	1.12	0.81	22	5	0.35	200	0.57	0.15	0.16	1.02	0.132	0.05	38.32
N (mean)	20	1.00	Fine Sand	20.00	50	21.50	19.0	347.9	160.6	1.00	1.00	1.00	67	1.12	0.79	44	8	0.15	225	0.57	0.15	0.89	5.85	0.000	0.00	44.59
12.4	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
166	25																									
Observed (cm)	26																									
290	27																									
Distance (m)	28																									
6.3	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	19.59																							8.43	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N^d	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (fps)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	1.09	Midium Sand	1.50	6	3.00	16.5	24.3	18.5	1.00	0.75	1.00	67	1.12	2.00	10	5	0.35	150	0.98	0.16	0.11	0.72	0.725	0.93	7.09
Mw	2	1.00	Midium Sand	2.50	4	4.00	16.5	40.8	25.2	1.00	0.75	1.00	67	1.12	1.99	7	5	0.35	150	0.97	0.19	0.08	0.42	0.999	0.88	4.51
7.5	3	1.00	Midium Sand	3.50	4	5.00	16.5	57.3	31.9	1.00	0.85	1.00	67	1.12	1.77	7	5	0.35	150	0.95	0.21	0.08	0.36	1.000	0.83	4.54
Site	4	1.00	Midium Sand	4.50	5	6.00	16.5	73.8	38.6	1.00	0.85	1.00	67	1.12	1.61	8	5	0.35	150	0.92	0.22	0.08	0.36	1.000	0.78	5.12
G-10, E-E'	5	1.00	Midium Sand	5.50	9	7.00	18.0	91.0	46.0	1.00	0.95	1.00	67	1.12	1.47	14	5	0.35	175	0.89	0.22	0.12	0.55	0.970	0.73	11.10
Data Class	6	1.00	Midium Sand	6.50	10	8.00	18.0	109.0	54.2	1.00	0.95	1.00	67	1.12	1.36	14	5	0.35	175	0.86	0.21	0.12	0.56	0.969	0.68	11.43
	7	1.00	Midium Sand	7.50	11	9.00	18.0	127.0	62.4	1.00	0.95	1.00	67	1.12	1.27	15	5	0.35	175	0.82	0.21	0.12	0.57	0.961	0.63	11.79
B. H.	8	1.00	Midium Sand	8.50	14	10.00	18.0	145.0	70.6	1.00	0.95	1.00	67	1.12	1.19	18	5	0.35	175	0.78	0.20	0.14	0.71	0.739	0.58	14.60
164	9	1.00	Midium Sand	9.50	12	11.00	18.0	163.0	78.8	1.00	1.00	1.00	67	1.12	1.13	15	5	0.35	175	0.75	0.19	0.11	0.59	0.941	0.53	12.10
GWT (m)	10	1.00	Midium Sand	10.50	13	12.00	18.0	181.0	87.0	1.00	1.00	1.00	67	1.12	1.07	16	5	0.35	175	0.71	0.18	0.11	0.62	0.905	0.48	12.56
0.91	11	1.00	Midium Sand	11.50	15	13.00	18.0	199.0	95.2	1.00	1.00	1.00	67	1.12	1.03	17	5	0.35	175	0.68	0.18	0.13	0.71	0.739	0.43	14.12
a_{max} (g)	12	1.00	Midium Sand	12.50	14	14.00	18.0	217.0	103.3	1.00	1.00	1.00	67	1.12	0.98	15	5	0.35	175	0.66	0.17	0.11	0.63	0.897	0.38	12.38
0.19	13	1.00	Midium Sand	13.50	14	15.00	18.0	235.0	111.5	1.00	1.00	1.00	67	1.12	0.95	15	5	0.35	175	0.64	0.17	0.10	0.60	0.926	0.33	11.82
Sampler[b]	14	1.00	Midium Sand	14.50	19	16.00	18.0	253.0	119.7	1.00	1.00	1.00	67	1.12	0.91	19	5	0.35	175	0.62	0.16	0.14	0.86	0.383	0.28	16.23
NA	15	1.00	Midium Sand	15.50	21	17.00	18.0	271.0	127.9	1.00	1.00	1.00	67	1.12	0.88	21	5	0.35	200	0.61	0.16	0.15	0.95	0.212	0.23	38.05
B.H. Diam. (mm)	16	1.00	Midium Sand	16.50	24	18.00	18.0	289.0	136.1	1.00	1.00	1.00	67	1.12	0.86	23	5	0.35	200	0.60	0.16	0.18	1.13	0.052	0.18	38.66
95	17	1.00	Fine Sand	17.50	26	19.00	18.0	307.0	144.3	1.00	1.00	1.00	67	1.12	0.83	24	8	0.15	200	0.59	0.16	0.20	1.27	0.014	0.13	39.10
Energy Ratio[c]	18	1.00	Fine Sand	18.50	15	20.00	18.0	325.0	152.5	1.00	1.00	1.00	67	1.12	0.81	14	8	0.15	175	0.59	0.15	0.09	0.55	0.971	0.08	10.90
67	19	1.00	Fine Sand	19.50	11	21.00	16.5	342.3	159.9	1.00	1.00	1.00	67	1.12	0.79	10	8	0.15	150	0.58	0.15	0.06	0.41	1.000	0.03	7.01
N (mean)	20	1.00	Fine Sand	20.50	23	22.00	18.0	359.5	167.4	1.00	1.00	1.00	67	1.12	0.77	20	8	0.15	175	0.58	0.15	0.14	0.88	0.343	0.00	17.02
13.5	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
170	25																									
Observed (cm)	26																									
872	27																									
Distance (m)	28																									
36.8	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	20.09																							7.72	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	1.09	Midium Sand	1.50	4	3.00	16.5	23.4	17.6	1.00	0.75	1.00	67	1.12	2.00	7	3	0.35	150	0.98	0.16	0.09	0.55	0.972	0.93	4.53
Mw	2	1.00	Midium Sand	2.50	1	4.00	15.5	39.4	23.8	1.00	0.75	1.00	67	1.12	2.00	2	3	0.35	125	0.97	0.20	0.06	0.28	1.000	0.88	2.33
7.5	3	1.00	Midium Sand	3.50	2	5.00	15.5	54.9	29.5	1.00	0.85	1.00	67	1.12	1.84	3	3	0.35	125	0.94	0.22	0.06	0.28	1.000	0.83	2.96
Site	4	1.00	Midium Sand	4.50	6	6.00	16.5	70.9	35.7	1.00	0.85	1.00	67	1.12	1.67	10	3	0.35	150	0.92	0.23	0.09	0.40	1.000	0.78	6.58
G-10, E-E'	5	1.00	Midium Sand	5.50	5	7.00	16.5	87.4	42.4	1.00	0.95	1.00	67	1.12	1.54	8	3	0.35	150	0.89	0.23	0.08	0.34	1.000	0.73	5.48
Data Class	6	1.00	Midium Sand	6.50	8	8.00	18.0	104.6	49.8	1.00	0.95	1.00	67	1.12	1.42	12	3	0.35	175	0.85	0.22	0.10	0.45	0.998	0.68	9.07
	7	1.00	Midium Sand	7.50	12	9.00	18.0	122.6	58.0	1.00	0.95	1.00	67	1.12	1.31	17	3	0.35	175	0.81	0.21	0.14	0.64	0.874	0.63	13.68
B. H.	8	1.00	Midium Sand	8.50	10	10.00	18.0	140.6	66.2	1.00	0.95	1.00	67	1.12	1.23	13	3	0.35	175	0.77	0.20	0.10	0.49	0.993	0.58	10.08
165	9	1.00	Midium Sand	9.50	11	11.00	18.0	158.6	74.4	1.00	1.00	1.00	67	1.12	1.16	14	3	0.35	175	0.74	0.19	0.11	0.54	0.975	0.53	11.27
GWT (m)	10	1.00	Midium Sand	10.50	13	12.00	18.0	176.6	82.6	1.00	1.00	1.00	67	1.12	1.10	16	3	0.35	175	0.70	0.19	0.12	0.63	0.892	0.48	12.96
0.91	11	1.00	Midium Sand	11.50	10	13.00	18.0	194.6	90.7	1.00	1.00	1.00	67	1.12	1.05	12	3	0.35	175	0.67	0.18	0.08	0.46	0.997	0.43	8.77
a_{max} (g)	12	1.00	Midium Sand	12.50	12	14.00	18.0	212.6	98.9	1.00	1.00	1.00	67	1.12	1.01	13	3	0.35	175	0.65	0.17	0.09	0.54	0.980	0.38	10.51
0.19	13	1.00	Midium Sand	13.50	13	15.00	18.0	230.6	107.1	1.00	1.00	1.00	67	1.12	0.97	14	3	0.35	175	0.63	0.17	0.09	0.56	0.964	0.33	11.05
Sampler[b]	14	1.00	Midium Sand	14.50	18	16.00	18.0	248.6	115.3	1.00	1.00	1.00	67	1.12	0.93	19	3	0.35	175	0.61	0.16	0.13	0.81	0.511	0.28	15.59
NA	15	1.00	Midium Sand	15.50	21	17.00	18.0	266.6	123.5	1.00	1.00	1.00	67	1.12	0.90	21	3	0.35	200	0.60	0.16	0.15	0.96	0.195	0.23	38.15
B.H. Diam. (mm)	16	1.00	Fine Sand	16.50	23	18.00	18.0	284.6	131.7	1.00	1.00	1.00	67	1.12	0.87	22	2	0.15	200	0.59	0.16	0.17	1.05	0.103	0.18	38.50
95	17	1.00	Fine Sand	17.50	25	19.00	18.0	302.6	139.9	1.00	1.00	1.00	67	1.12	0.85	24	2	0.15	200	0.59	0.16	0.18	1.14	0.046	0.13	38.83
Energy Ratio[c]	18	1.00	Fine Sand	18.50	29	20.00	18.0	320.6	148.1	1.00	1.00	1.00	67	1.12	0.82	27	2	0.15	200	0.58	0.16	0.22	1.42	0.003	0.08	39.65
67	19	1.00	Fine Sand	19.50	30	21.00	18.0	338.6	156.3	1.00	1.00	1.00	67	1.12	0.80	27	2	0.15	200	0.58	0.15	0.22	1.43	0.003	0.03	39.70
N (mean)	20	1.00	Fine Sand	20.50	34	22.00	18.0	356.6	164.5	1.00	1.00	1.00	67	1.12	0.78	30	2	0.15	200	0.57	0.15	0.27	1.75	0.000	0.00	40.47
14.4	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
168	25																									
Observed (cm)	26																									
345	27																									
Distance (m)	28																									
57	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	20.09																							8.22	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	1.09	Midium Sand	1.50	1	3.00	15.5	22.8	17.0	1.00	0.75	1.00	67	1.12	2.00	2	5	0.35	125	0.98	0.16	0.06	0.38	1.000	0.93	2.33
Mw	2	1.00	Midium Sand	2.50	1	4.00	15.5	38.3	22.7	1.00	0.75	1.00	67	1.12	2.00	2	5	0.35	125	0.96	0.20	0.06	0.28	1.000	0.88	2.33
7.5	3	1.00	Midium Sand	3.50	2	5.00	15.5	53.8	28.4	1.00	0.85	1.00	67	1.12	1.88	4	5	0.35	125	0.94	0.22	0.06	0.28	1.000	0.83	2.99
Site	4	1.00	Midium Sand	4.50	3	6.00	16.5	69.8	34.6	1.00	0.85	1.00	67	1.12	1.70	5	5	0.35	150	0.91	0.23	0.06	0.29	1.000	0.78	3.54
G-10, E-E'	5	1.00	Midium Sand	5.50	5	7.00	16.5	86.3	41.3	1.00	0.95	1.00	67	1.12	1.56	8	5	0.35	150	0.87	0.23	0.08	0.35	1.000	0.73	5.56
Data Class	6	1.00	Midium Sand	6.50	10	8.00	18.0	103.5	48.7	1.00	0.95	1.00	67	1.12	1.43	15	5	0.35	175	0.83	0.22	0.13	0.59	0.939	0.68	12.21
	7	1.00	Fine Sand	7.50	7	9.00	16.5	120.8	56.1	1.00	0.95	1.00	67	1.12	1.33	10	8	0.15	150	0.79	0.21	0.08	0.40	1.000	0.63	7.21
B. H.	8	1.00	Fine Sand	8.50	7	10.00	16.5	137.3	62.8	1.00	0.95	1.00	67	1.12	1.26	9	8	0.15	150	0.75	0.20	0.08	0.39	1.000	0.58	6.66
166	9	1.00	Midium Sand	9.50	13	11.00	18.0	154.5	70.3	1.00	1.00	1.00	67	1.12	1.19	17	5	0.35	175	0.72	0.19	0.14	0.71	0.744	0.53	14.26
GWT (m)	10	1.00	Midium Sand	10.50	10	12.00	18.0	172.5	78.5	1.00	1.00	1.00	67	1.12	1.13	13	5	0.35	175	0.68	0.18	0.09	0.50	0.990	0.48	9.65
0.91	11	1.00	Fine Sand	11.50	7	13.00	16.5	189.8	85.9	1.00	1.00	1.00	67	1.12	1.08	8	8	0.15	150	0.65	0.18	0.07	0.38	1.000	0.43	5.88
a_{max} (g)	12	1.00	Fine Sand	12.50	4	14.00	16.5	206.3	92.6	1.00	1.00	1.00	67	1.12	1.04	5	8	0.15	150	0.63	0.17	0.05	0.28	1.000	0.38	3.54
0.19	13	1.00	Midium Sand	13.50	11	15.00	18.0	223.5	100.0	1.00	1.00	1.00	67	1.12	1.00	12	5	0.35	175	0.61	0.17	0.08	0.51	0.990	0.33	9.32
Sampler[b]	14	1.00	Midium Sand	14.50	19	16.00	18.0	241.5	108.2	1.00	1.00	1.00	67	1.12	0.96	20	5	0.35	175	0.60	0.16	0.15	0.94	0.226	0.28	37.96
NA	15	1.00	Midium Sand	15.50	17	17.00	18.0	259.5	116.4	1.00	1.00	1.00	67	1.12	0.93	18	5	0.35	175	0.58	0.16	0.12	0.76	0.622	0.23	14.52
B.H. Diam. (mm)	16	1.00	Fine Sand	16.50	21	18.00	18.0	277.5	124.6	1.00	1.00	1.00	67	1.12	0.90	21	8	0.15	200	0.58	0.16	0.16	1.01	0.134	0.18	38.23
95	17	1.00	Fine Sand	17.50	54	19.00	19.0	296.0	133.3	1.00	1.00	1.00	67	1.12	0.87	52	8	0.15	225	0.57	0.16	1.77	11.33	0.000	0.13	46.84
Energy Ratio[c]	18	1.00	Fine Sand	18.50	55	20.00	19.0	315.0	142.5	1.00	1.00	1.00	67	1.12	0.84	51	8	0.15	225	0.57	0.15	1.64	10.60	0.000	0.08	46.62
67	19	1.00	Fine Sand	19.50	59	21.00	19.0	334.0	151.7	1.00	1.00	1.00	67	1.12	0.81	53	8	0.15	225	0.56	0.15	1.89	12.32	0.000	0.03	47.19
N (mean)	20	1.00	Fine Sand	20.50	49	22.00	19.0	353.0	160.9	1.00	1.00	1.00	67	1.12	0.79	43	8	0.15	225	0.56	0.15	0.83	5.49	0.000	0.00	44.33
17.8	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
163	25																									
Observed (cm)	26																									
629	27																									
Distance (m)	28																									
50.8	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	20.09																							8.25	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N^d	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	0.59	Midium Sand	1.00	4	2.50	16.5	15.1	14.3	1.00	0.75	1.00	67	1.12	2.00	7	5	0.35	150	0.99	0.13	0.10	0.73	0.693	0.95	4.53
Mw	2	1.00	Midium Sand	2.00	6	3.50	16.5	31.6	20.9	1.00	0.75	1.00	67	1.12	2.00	10	5	0.35	150	0.98	0.18	0.11	0.60	0.927	0.90	7.09
7.5	3	1.00	Midium Sand	3.00	4	4.50	16.5	48.1	27.6	1.00	0.85	1.00	67	1.12	1.90	7	5	0.35	150	0.97	0.21	0.08	0.40	1.000	0.85	4.85
Site	4	1.00	Coarse Sand	4.00	4	5.50	16.5	64.6	34.3	1.00	0.85	1.00	67	1.12	1.71	6	6	0.60	150	0.95	0.22	0.07	0.33	1.000	0.80	4.44
G-10, E-E'	5	1.00	Coarse Sand	5.00	7	6.50	18.0	81.9	41.8	1.00	0.95	1.00	67	1.12	1.55	11	6	0.60	175	0.93	0.22	0.10	0.46	0.998	0.75	8.63
Data Class	6	1.00	Coarse Sand	6.00	8	7.50	18.0	99.9	50.0	1.00	0.95	1.00	67	1.12	1.41	12	6	0.60	175	0.90	0.22	0.10	0.46	0.998	0.70	9.15
	7	1.00	Midium Sand	7.00	6	8.50	16.5	117.1	57.4	1.00	0.95	1.00	67	1.12	1.32	8	5	0.35	150	0.87	0.22	0.07	0.34	1.000	0.65	5.66
B. H.	8	1.00	Midium Sand	8.00	11	9.50	18.0	134.4	64.8	1.00	0.95	1.00	67	1.12	1.24	14	5	0.35	175	0.84	0.21	0.11	0.53	0.982	0.60	11.51
167	9	1.00	Fine Sand	9.00	8	10.50	16.5	151.6	72.3	1.00	1.00	1.00	67	1.12	1.18	10	8	0.15	150	0.80	0.21	0.08	0.40	1.000	0.55	7.69
GWT (m)	10	1.00	Fine Sand	10.00	9	11.50	18.0	168.9	79.7	1.00	1.00	1.00	67	1.12	1.12	11	8	0.15	175	0.77	0.20	0.09	0.43	0.999	0.50	8.58
0.91	11	1.00	Midium Sand	11.00	23	12.50	18.0	186.9	87.9	1.00	1.00	1.00	67	1.12	1.07	27	5	0.35	200	0.73	0.19	0.28	1.46	0.002	0.45	39.86
a_{max} (g)	12	1.00	Fine Sand	12.00	36	13.50	19.0	205.4	96.6	1.00	1.00	1.00	67	1.12	1.02	41	8	0.15	225	0.70	0.18	0.81	4.36	0.000	0.40	43.72
0.19	13	1.00	Fine Sand	13.00	25	14.50	18.0	223.9	105.3	1.00	1.00	1.00	67	1.12	0.97	27	8	0.15	200	0.68	0.18	0.27	1.53	0.001	0.35	39.94
Sampler[b]	14	1.00	Fine Sand	14.00	20	15.50	18.0	241.9	113.5	1.00	1.00	1.00	67	1.12	0.94	21	8	0.15	200	0.66	0.17	0.16	0.95	0.222	0.30	38.22
NA	15	1.00	Fine Sand	15.00	33	16.50	19.0	260.4	122.2	1.00	1.00	1.00	67	1.12	0.90	33	8	0.15	225	0.64	0.17	0.42	2.48	0.000	0.25	41.63
B.H. Diam. (mm)	16	1.00	Fine Sand	16.00	30	17.50	18.0	278.9	130.9	1.00	1.00	1.00	67	1.12	0.87	29	8	0.15	200	0.63	0.17	0.30	1.81	0.000	0.20	40.51
95	17	1.00	Fine Sand	17.00	28	18.50	18.0	296.9	139.0	1.00	1.00	1.00	67	1.12	0.85	27	8	0.15	200	0.62	0.16	0.24	1.45	0.002	0.15	39.75
Energy Ratio[c]	18	1.00	Fine Sand	18.00	51	19.50	19.0	315.4	147.7	1.00	1.00	1.00	67	1.12	0.82	47	8	0.15	225	0.62	0.16	1.14	6.98	0.000	0.10	45.36
67	19	1.00	Fine Sand	19.00	48	20.50	19.0	334.4	156.9	1.00	1.00	1.00	67	1.12	0.80	43	8	0.15	225	0.61	0.16	0.82	5.06	0.000	0.05	44.24
N (mean)	20	1.00	Fine Sand	20.00	47	21.50	19.0	353.4	166.1	1.00	1.00	1.00	67	1.12	0.78	41	8	0.15	225	0.61	0.16	0.68	4.27	0.000	0.00	43.67
20.4	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
179	25																									
Observed (cm)	26																									
185	27																									
Distance (m)	28																									
2.5	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	19.59																							6.68	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	0.59	Midium Sand	1.00	3	2.50	16.5	15.1	14.3	1.00	0.75	1.00	67	1.12	2.00	5	5	0.35	150	0.99	0.13	0.08	0.64	0.873	0.95	3.63
Mw	2	1.00	Midium Sand	2.00	3	3.50	16.5	31.6	20.9	1.00	0.75	1.00	67	1.12	2.00	5	5	0.35	150	0.98	0.18	0.08	0.41	1.000	0.90	3.63
7.5	3	1.00	Midium Sand	3.00	2	4.50	15.5	47.6	27.1	1.00	0.85	1.00	67	1.12	1.92	4	5	0.35	125	0.97	0.21	0.06	0.30	1.000	0.85	3.02
Site	4	1.00	Midium Sand	4.00	9	5.50	18.0	64.4	34.1	1.00	0.85	1.00	67	1.12	1.71	15	5	0.35	175	0.96	0.22	0.14	0.62	0.913	0.80	11.65
G-10, E-E'	5	1.00	Midium Sand	5.00	8	6.50	18.0	82.4	42.3	1.00	0.95	1.00	67	1.12	1.54	13	5	0.35	175	0.94	0.23	0.11	0.51	0.989	0.75	10.09
Data Class	6	1.00	Midium Sand	6.00	7	7.50	16.5	99.6	49.7	1.00	0.95	1.00	67	1.12	1.42	10	5	0.35	150	0.91	0.23	0.09	0.40	1.000	0.70	7.42
	7	1.00	Midium Sand	7.00	8	8.50	18.0	116.9	57.1	1.00	0.95	1.00	67	1.12	1.32	11	5	0.35	175	0.88	0.22	0.09	0.41	1.000	0.65	8.27
B. H.	8	1.00	Midium Sand	8.00	11	9.50	18.0	134.9	65.3	1.00	0.95	1.00	67	1.12	1.24	14	5	0.35	175	0.85	0.22	0.11	0.52	0.985	0.60	11.46
168	9	1.00	Coarse Sand	9.00	16	10.50	18.0	152.9	73.5	1.00	1.00	1.00	67	1.12	1.17	21	6	0.60	200	0.82	0.21	0.18	0.86	0.384	0.55	17.71
GWT (m)	10	1.00	Coarse Sand	10.00	13	11.50	18.0	170.9	81.7	1.00	1.00	1.00	67	1.12	1.11	16	6	0.60	175	0.78	0.20	0.12	0.60	0.930	0.50	13.15
0.91	11	1.00	Fine Sand	11.00	9	12.50	18.0	188.9	89.9	1.00	1.00	1.00	67	1.12	1.05	11	8	0.15	175	0.75	0.19	0.08	0.40	1.000	0.45	7.91
a_{max} (g)	12	1.00	Fine Sand	12.00	39	13.50	19.0	207.4	98.6	1.00	1.00	1.00	67	1.12	1.01	44	8	0.15	225	0.72	0.19	1.01	5.40	0.000	0.40	44.53
0.19	13	1.00	Fine Sand	13.00	29	14.50	19.0	226.4	107.8	1.00	1.00	1.00	67	1.12	0.96	31	8	0.15	225	0.69	0.18	0.37	2.05	0.000	0.35	41.04
Sampler[b]	14	1.00	Fine Sand	14.00	27	15.50	18.0	244.9	116.5	1.00	1.00	1.00	67	1.12	0.93	28	8	0.15	200	0.67	0.17	0.28	1.60	0.000	0.30	40.14
NA	15	1.00	Fine Sand	15.00	49	16.50	19.0	263.4	125.2	1.00	1.00	1.00	67	1.12	0.89	49	8	0.15	225	0.66	0.17	1.39	8.16	0.000	0.25	45.92
B.H. Diam. (mm)	16	1.00	Fine Sand	16.00	45	17.50	19.0	282.4	134.4	1.00	1.00	1.00	67	1.12	0.86	43	8	0.15	225	0.65	0.17	0.89	5.31	0.000	0.20	44.39
95	17	1.00	Fine Sand	17.00	50	18.50	19.0	301.4	143.5	1.00	1.00	1.00	67	1.12	0.83	47	8	0.15	225	0.64	0.16	1.12	6.81	0.000	0.15	45.29
Energy Ratio[c]	18	1.00	Fine Sand	18.00	55	19.50	19.0	320.4	152.7	1.00	1.00	1.00	67	1.12	0.81	50	8	0.15	225	0.63	0.16	1.40	8.61	0.000	0.10	46.14
67	19	1.00	Fine Sand	19.00	51	20.50	19.0	339.4	161.9	1.00	1.00	1.00	67	1.12	0.79	45	8	0.15	225	0.62	0.16	0.94	5.83	0.000	0.05	44.78
N (mean)	20	1.00	Fine Sand	20.00	49	21.50	19.0	358.4	171.1	1.00	1.00	1.00	67	1.12	0.76	42	8	0.15	225	0.62	0.16	0.74	4.61	0.000	0.00	43.97
24.1	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
182	25																									
Observed (cm)	26																									
325	27																									
Distance (m)	28																									
6.3	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	19.59																							6.78	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	1.16	Midium Sand	2.00	6	3.50	16.5	32.3	25.9	1.00	0.75	1.00	67	1.12	1.97	10	5	0.35	150	0.98	0.15	0.10	0.68	0.806	0.90	6.92
Mw	2	1.00	Midium Sand	3.00	5	4.50	16.5	48.8	32.5	1.00	0.85	1.00	67	1.12	1.75	8	5	0.35	150	0.97	0.18	0.09	0.48	0.995	0.85	5.60
7.5	3	1.00	Midium Sand	4.00	6	5.50	16.5	65.3	39.2	1.00	0.85	1.00	67	1.12	1.60	9	5	0.35	150	0.95	0.19	0.09	0.44	0.999	0.80	6.20
Site	4	1.00	Midium Sand	5.00	9	6.50	18.0	82.6	46.7	1.00	0.95	1.00	67	1.12	1.46	14	5	0.35	175	0.92	0.20	0.12	0.59	0.939	0.75	11.00
G-10, E-E'	5	1.00	Fine Sand	6.00	9	7.50	18.0	100.6	54.9	1.00	0.95	1.00	67	1.12	1.35	13	8	0.15	175	0.90	0.20	0.11	0.53	0.982	0.70	10.23
Data Class	6	1.00	Midium Sand	7.00	13	8.50	18.0	118.6	63.1	1.00	0.95	1.00	67	1.12	1.26	17	5	0.35	175	0.86	0.20	0.14	0.71	0.740	0.65	14.30
	7	1.00	Coarse Sand	8.00	15	9.50	18.0	136.6	71.2	1.00	0.95	1.00	67	1.12	1.18	19	6	0.60	175	0.83	0.20	0.16	0.80	0.536	0.60	15.84
B. H.	8	1.00	Coarse Sand	9.00	17	10.50	18.0	154.6	79.4	1.00	1.00	1.00	67	1.12	1.12	21	6	0.60	200	0.79	0.19	0.18	0.96	0.202	0.55	38.24
169	9	1.00	Coarse Sand	10.00	19	11.50	18.0	172.6	87.6	1.00	1.00	1.00	67	1.12	1.07	23	6	0.60	200	0.76	0.18	0.20	1.07	0.083	0.50	38.61
GWT (m)	10	1.00	Coarse Sand	11.00	13	12.50	18.0	190.6	95.8	1.00	1.00	1.00	67	1.12	1.02	15	6	0.60	175	0.72	0.18	0.11	0.59	0.938	0.45	11.95
1.34	11	1.00	Coarse Sand	12.00	16	13.50	18.0	208.6	104.0	1.00	1.00	1.00	67	1.12	0.98	18	6	0.60	175	0.69	0.17	0.13	0.74	0.681	0.40	14.56
a_{max} (g)	12	1.00	Coarse Sand	13.00	18	14.50	18.0	226.6	112.2	1.00	1.00	1.00	67	1.12	0.94	19	6	0.60	175	0.67	0.17	0.14	0.83	0.454	0.35	15.96
0.19	13	1.00	Coarse Sand	14.00	14	15.50	18.0	244.6	120.4	1.00	1.00	1.00	67	1.12	0.91	14	6	0.60	175	0.65	0.16	0.09	0.58	0.951	0.30	11.37
Sampler[b]	14	1.00	Coarse Sand	15.00	15	16.50	18.0	262.6	128.6	1.00	1.00	1.00	67	1.12	0.88	15	6	0.60	175	0.64	0.16	0.10	0.60	0.928	0.25	11.89
NA	15	1.00	Coarse Sand	16.00	13	17.50	18.0	280.6	136.8	1.00	1.00	1.00	67	1.12	0.86	12	6	0.60	175	0.62	0.16	0.08	0.50	0.991	0.20	9.55
B.H. Diam. (mm)	16	1.00	Fine Sand	17.00	40	18.50	19.0	299.1	145.5	1.00	1.00	1.00	67	1.12	0.83	37	8	0.15	225	0.62	0.16	0.53	3.41	0.000	0.15	42.65
95	17	1.00	Fine Sand	18.00	43	19.50	19.0	318.1	154.6	1.00	1.00	1.00	67	1.12	0.80	39	8	0.15	225	0.61	0.15	0.59	3.82	0.000	0.10	43.08
Energy Ratio[c]	18	1.00	Fine Sand	19.00	40	20.50	19.0	337.1	163.8	1.00	1.00	1.00	67	1.12	0.78	35	8	0.15	225	0.61	0.15	0.44	2.84	0.000	0.05	42.06
67	19	1.00	Silt	20.00	17	21.50	18.0	355.6	172.5	1.00	1.00	1.00	67	1.12	0.76	14	35	0.04	175	0.60	0.15	0.11	0.72	0.000	0.00	Non-Liq.
N (mean)	20																									
17.3	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
176	25																									
Observed (cm)	26																									
155	27																									
Distance (m)	28																									
176.5	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	19.16																							6.40	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	0.59	Clayey Silt	1.00	2	2.50	15.5	15.0	14.2	1.00	0.75	1.00	67	1.12	2.00	3	35	0.02	125	0.99	0.13	0.09	0.66	0.000	0.00	Non-Liq.
Mw	2	1.00	Silty F.Sand	2.00	5	3.50	16.5	31.0	20.4	1.00	0.75	1.00	67	1.12	2.00	8	35	0.07	150	0.97	0.18	0.12	0.65	0.868	0.90	7.87
7.5	3	1.00	Silty F.Sand	3.00	2	4.50	15.5	47.0	26.5	1.00	0.85	1.00	67	1.12	1.94	4	35	0.07	125	0.95	0.21	0.07	0.35	1.000	0.85	3.91
Site	4	1.00	Fine Sand	4.00	7	5.50	18.0	63.8	33.5	1.00	0.85	1.00	67	1.12	1.73	11	13	0.12	175	0.93	0.22	0.11	0.53	0.983	0.80	9.28
G-10, E-E'	5	1.00	Fine Sand	5.00	4	6.50	16.5	81.0	40.9	1.00	0.95	1.00	67	1.12	1.56	7	13	0.12	150	0.89	0.22	0.07	0.34	1.000	0.75	4.86
Data Class	6	1.00	Fine Sand	6.00	6	7.50	16.5	97.5	47.6	1.00	0.95	1.00	67	1.12	1.45	9	13	0.12	150	0.86	0.22	0.09	0.40	1.000	0.70	6.94
	7	1.00	Fine Sand	7.00	3	8.50	15.5	113.5	53.8	1.00	0.95	1.00	67	1.12	1.36	4	13	0.12	150	0.82	0.21	0.06	0.27	1.000	0.65	3.55
B. H.	8	1.00	Fine Sand	8.00	15	9.50	18.0	130.3	60.7	1.00	0.95	1.00	67	1.12	1.28	20	8	0.15	175	0.78	0.21	0.19	0.91	0.289	0.60	17.55
170	9	1.00	Silty F.Sand	9.00	7	10.50	16.5	147.5	68.2	1.00	1.00	1.00	67	1.12	1.21	9	35	0.07	150	0.74	0.20	0.09	0.47	0.996	0.55	9.09
GWT (m)	10	1.00	Midium Sand	10.00	11	11.50	18.0	164.8	75.6	1.00	1.00	1.00	67	1.12	1.15	14	5	0.35	175	0.70	0.19	0.11	0.56	0.967	0.50	11.15
0.91	11	1.00	Fine Sand	11.00	12	12.50	18.0	182.8	83.8	1.00	1.00	1.00	67	1.12	1.09	15	8	0.15	175	0.67	0.18	0.11	0.60	0.926	0.45	11.97
a_{max} (g)	12	1.00	Fine Sand	12.00	7	13.50	16.5	200.0	91.3	1.00	1.00	1.00	67	1.12	1.05	8	8	0.15	150	0.65	0.17	0.06	0.37	1.000	0.40	5.68
0.19	13	1.00	Fine Sand	13.00	11	14.50	18.0	217.3	98.7	1.00	1.00	1.00	67	1.12	1.01	12	8	0.15	175	0.62	0.17	0.09	0.52	0.987	0.35	9.70
Sampler[b]	14	1.00	Fine Sand	14.00	12	15.50	18.0	235.3	106.9	1.00	1.00	1.00	67	1.12	0.97	13	8	0.15	175	0.61	0.17	0.09	0.54	0.975	0.30	10.30
NA	15	1.00	Fine Sand	15.00	13	16.50	18.0	253.3	115.1	1.00	1.00	1.00	67	1.12	0.93	14	8	0.15	175	0.59	0.16	0.09	0.57	0.959	0.25	10.87
B.H. Diam. (mm)	16	1.00	Fine Sand	16.00	15	17.50	18.0	271.3	123.3	1.00	1.00	1.00	67	1.12	0.90	15	8	0.15	175	0.58	0.16	0.10	0.64	0.876	0.20	12.41
95	17	1.00	Fine Sand	17.00	46	18.50	19.0	289.8	132.0	1.00	1.00	1.00	67	1.12	0.87	45	12	0.12	225	0.58	0.16	1.06	6.79	0.000	0.15	45.01
Energy Ratio[c]	18	1.00	Fine Sand	18.00	43	19.50	19.0	308.8	141.1	1.00	1.00	1.00	67	1.12	0.84	40	12	0.12	225	0.57	0.15	0.74	4.81	0.000	0.10	43.81
67	19	1.00	Fine Sand	19.00	41	20.50	19.0	327.8	150.3	1.00	1.00	1.00	67	1.12	0.82	37	12	0.12	225	0.57	0.15	0.57	3.75	0.000	0.05	42.95
N (mean)	20	1.00	Clayey Silt	20.00	17	21.50	18.0	346.3	159.0	1.00	1.00	1.00	67	1.12	0.79	15	35	0.02	175	0.57	0.15	0.12	0.78	0.000	0.00	Non-Liq.
14.0	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
164	25																									
Observed (cm)	26																									
155	27																									
Distance (m)	28																									
177.8	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	19.59																							7.59	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	0.89	Medium Sand	1.30	3	2.80	16.5	20.1	16.3	1.00	0.75	1.00	67	1.12	2.00	5	5	0.35	150	0.99	0.15	0.08	0.54	0.979	0.94	3.63
Mw	2	1.00	Medium Sand	2.30	4	3.80	16.5	36.6	22.9	1.00	0.75	1.00	67	1.12	2.00	7	5	0.35	150	0.97	0.19	0.08	0.43	0.999	0.89	4.53
7.5	3	1.00	Medium Sand	3.30	4	4.80	16.5	53.1	29.6	1.00	0.85	1.00	67	1.12	1.84	7	5	0.35	150	0.96	0.21	0.08	0.37	1.000	0.84	4.69
Site	4	1.00	Medium Sand	4.30	4	5.80	16.5	69.6	36.3	1.00	0.85	1.00	67	1.12	1.66	6	5	0.35	150	0.94	0.22	0.07	0.32	1.000	0.79	4.29
G-10, F-F'	5	1.00	Fine Sand	5.30	5	6.80	16.5	86.1	43.0	1.00	0.95	1.00	67	1.12	1.52	8	8	0.15	150	0.91	0.23	0.08	0.35	1.000	0.74	5.61
Data Class	6	1.00	Fine Sand	6.30	10	7.80	18.0	103.3	50.5	1.00	0.95	1.00	67	1.12	1.41	15	8	0.15	175	0.88	0.22	0.13	0.58	0.950	0.69	12.26
	7	1.00	Fine Sand	7.30	4	8.80	16.5	120.6	57.9	1.00	0.95	1.00	67	1.12	1.31	6	8	0.15	150	0.85	0.22	0.06	0.28	1.000	0.64	4.01
B. H.	8	1.00	Fine Sand	8.30	9	9.80	18.0	137.8	65.3	1.00	0.95	1.00	67	1.12	1.24	12	8	0.15	175	0.81	0.21	0.09	0.45	0.998	0.59	9.14
171	9	1.00	Fine Sand	9.30	7	10.80	16.5	155.1	72.8	1.00	1.00	1.00	67	1.12	1.17	9	8	0.15	150	0.77	0.20	0.07	0.37	1.000	0.54	6.47
GWT (m)	10	1.00	Medium Sand	10.30	10	11.80	18.0	172.3	80.2	1.00	1.00	1.00	67	1.12	1.12	12	5	0.35	175	0.74	0.20	0.09	0.47	0.996	0.49	9.51
0.91	11	1.00	Medium Sand	11.30	23	12.80	18.0	190.3	88.4	1.00	1.00	1.00	67	1.12	1.06	27	5	0.35	200	0.70	0.19	0.28	1.48	0.001	0.44	39.84
a_{max} (g)	12	1.00	Medium Sand	12.30	19	13.80	18.0	208.3	96.6	1.00	1.00	1.00	67	1.12	1.02	22	5	0.35	200	0.68	0.18	0.18	0.97	0.189	0.39	38.28
0.19	13	1.00	Medium Sand	13.30	16	14.80	18.0	226.3	104.8	1.00	1.00	1.00	67	1.12	0.98	17	5	0.35	175	0.66	0.17	0.12	0.71	0.737	0.34	14.39
Sampler[b]	14	1.00	Medium Sand	14.30	31	15.80	19.0	244.8	113.5	1.00	1.00	1.00	67	1.12	0.94	32	5	0.35	225	0.64	0.17	0.39	2.27	0.000	0.29	41.25
NA	15	1.00	Fine Sand	15.30	45	16.80	19.0	263.8	122.7	1.00	1.00	1.00	67	1.12	0.90	45	8	0.15	225	0.62	0.17	1.07	6.43	0.000	0.24	44.95
B.H. Diam. (mm)	16	1.00	Fine Sand	16.30	50	17.80	19.0	282.8	131.9	1.00	1.00	1.00	67	1.12	0.87	49	8	0.15	225	0.61	0.16	1.34	8.26	0.000	0.19	45.84
95	17	1.00	Fine Sand	17.30	50	18.80	19.0	301.8	141.0	1.00	1.00	1.00	67	1.12	0.84	47	8	0.15	225	0.61	0.16	1.16	7.26	0.000	0.14	45.40
Energy Ratio[c]	18	1.00	Fine Sand	18.30	50	19.80	19.0	320.8	150.2	1.00	1.00	1.00	67	1.12	0.82	46	8	0.15	225	0.60	0.16	1.02	6.44	0.000	0.09	45.00
67	19	0.75	Fine Sand	19.30	23	20.80	18.0	339.3	158.9	1.00	1.00	1.00	67	1.12	0.79	20	8	0.15	175	0.60	0.16	0.14	0.91	0.287	0.04	17.51
N (mean)	20	0.50	Fine Sand	19.80	29	21.30	18.0	348.3	163.0	1.00	1.00	1.00	67	1.12	0.78	25	8	0.15	200	0.60	0.16	0.21	1.33	0.007	0.01	39.43
19.8	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
174	25																									
Observed (cm)	26																									
617	27																									
Distance (m)	28																									
63.5	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	19.14																							7.27	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	0.59	Clay	1.00	3	2.50	16.5	15.1	14.3	1.00	0.75	1.00	67	1.12	2.00	5	35	0.01	150	0.99	0.13	0.10	0.75	0.000	0.00	Non-Liq.
Mw	2	1.00	Medium Sand	2.00	4	3.50	16.5	31.6	20.9	1.00	0.75	1.00	67	1.12	2.00	7	5	0.35	150	0.98	0.18	0.09	0.47	0.997	0.90	4.53
7.5	3	1.00	Medium Sand	3.00	3	4.50	16.5	48.1	27.6	1.00	0.85	1.00	67	1.12	1.90	5	5	0.35	150	0.97	0.21	0.07	0.34	1.000	0.85	3.82
Site	4	1.00	Medium Sand	4.00	1	5.50	15.5	64.1	33.8	1.00	0.85	1.00	67	1.12	1.72	2	5	0.35	125	0.95	0.22	0.05	0.23	1.000	0.80	2.31
G-10, F-F'	5	1.00	Medium Sand	5.00	2	6.50	15.5	79.6	39.5	1.00	0.95	1.00	67	1.12	1.59	3	5	0.35	125	0.93	0.23	0.06	0.24	1.000	0.75	2.91
Data Class	6	1.00	Fine Sand	6.00	5	7.50	16.5	95.6	45.7	1.00	0.95	1.00	67	1.12	1.48	8	8	0.15	150	0.90	0.23	0.08	0.33	1.000	0.70	5.43
	7	1.00	Medium Sand	7.00	9	8.50	18.0	112.9	53.1	1.00	0.95	1.00	67	1.12	1.37	13	5	0.35	175	0.87	0.23	0.11	0.47	0.996	0.65	10.13
B. H.	8	1.00	Medium Sand	8.00	17	9.50	18.0	130.9	61.3	1.00	0.95	1.00	67	1.12	1.28	23	5	0.35	200	0.84	0.22	0.22	1.01	0.144	0.60	38.67
172	9	1.00	Medium Sand	9.00	19	10.50	18.0	148.9	69.5	1.00	1.00	1.00	67	1.12	1.20	25	5	0.35	200	0.80	0.21	0.26	1.22	0.023	0.55	39.33
GWT (m)	10	1.00	Fine Sand	10.00	19	11.50	18.0	166.9	77.7	1.00	1.00	1.00	67	1.12	1.13	24	8	0.15	200	0.77	0.20	0.23	1.14	0.045	0.50	39.07
0.91	11	1.00	Fine Sand	11.00	30	12.50	19.0	185.4	86.4	1.00	1.00	1.00	67	1.12	1.08	36	8	0.15	225	0.73	0.19	0.57	2.94	0.000	0.45	42.37
a_{max} (g)	12	1.00	Fine Sand	12.00	24	13.50	18.0	203.9	95.1	1.00	1.00	1.00	67	1.12	1.03	27	8	0.15	200	0.70	0.19	0.29	1.53	0.001	0.40	40.02
0.19	13	1.00	Fine Sand	13.00	29	14.50	19.0	222.4	103.8	1.00	1.00	1.00	67	1.12	0.98	32	8	0.15	225	0.68	0.18	0.39	2.17	0.000	0.35	41.20
Sampler[b]	14	1.00	Fine Sand	14.00	34	15.50	19.0	241.4	113.0	1.00	1.00	1.00	67	1.12	0.94	36	8	0.15	225	0.66	0.17	0.52	2.96	0.000	0.30	42.29
NA	15	1.00	Fine Sand	15.00	45	16.50	19.0	260.4	122.2	1.00	1.00	1.00	67	1.12	0.90	45	8	0.15	225	0.64	0.17	1.08	6.33	0.000	0.25	44.97
B.H. Diam. (mm)	16	1.00	Fine Sand	16.00	35	17.50	19.0	279.4	131.4	1.00	1.00	1.00	67	1.12	0.87	34	8	0.15	225	0.63	0.17	0.44	2.63	0.000	0.20	41.84
95	17	1.00	Fine Sand	17.00	28	18.50	18.0	297.9	140.0	1.00	1.00	1.00	67	1.12	0.85	26	8	0.15	200	0.62	0.16	0.24	1.44	0.002	0.15	39.72
Energy Ratio[c]	18	1.00	Fine Sand	18.00	34	19.50	19.0	316.4	148.7	1.00	1.00	1.00	67	1.12	0.82	31	8	0.15	225	0.62	0.16	0.34	2.07	0.000	0.10	41.02
67	19	1.00	Fine Sand	19.00	26	20.50	18.0	334.9	157.4	1.00	1.00	1.00	67	1.12	0.80	23	8	0.15	200	0.61	0.16	0.18	1.10	0.064	0.05	38.82
N (mean)	20	1.00	Fine Sand	20.00	29	21.50	18.0	352.9	165.6	1.00	1.00	1.00	67	1.12	0.78	25	8	0.15	200	0.61	0.16	0.21	1.28	0.012	0.00	39.38
19.8	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
179	25																									
Observed (cm)	26																									
617	27																									
Distance (m)	28																									
66.0	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	19.59																							4.77	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	1.09	Medium Sand	1.50	5	3.00	16.5	24.3	18.5	1.00	0.75	1.00	67	1.12	2.00	8	5	0.35	150	0.98	0.16	0.10	0.63	0.891	0.93	5.64
Mw	2	1.00	Medium Sand	2.50	6	4.00	16.5	40.8	25.2	1.00	0.75	1.00	67	1.12	1.99	10	5	0.35	150	0.97	0.19	0.10	0.54	0.977	0.88	7.05
7.5	3	1.00	Silty Sand	3.50	2	5.00	15.5	56.8	31.4	1.00	0.85	1.00	67	1.12	1.78	3	35	0.07	125	0.95	0.21	0.07	0.32	1.000	0.83	3.74
Site	4	1.00	Silty Sand	4.50	3	6.00	16.5	72.8	37.6	1.00	0.85	1.00	67	1.12	1.63	5	35	0.07	150	0.92	0.22	0.07	0.33	1.000	0.78	4.50
G-10, F-F'	5	1.00	Medium Sand	5.50	4	7.00	16.5	89.3	44.3	1.00	0.95	1.00	67	1.12	1.50	6	5	0.35	150	0.90	0.22	0.07	0.30	1.000	0.73	4.34
Data Class	6	1.00	Medium Sand	6.50	8	8.00	18.0	106.5	51.7	1.00	0.95	1.00	67	1.12	1.39	12	5	0.35	175	0.86	0.22	0.10	0.45	0.998	0.68	8.85
	7	1.00	Medium Sand	7.50	10	9.00	18.0	124.5	59.9	1.00	0.95	1.00	67	1.12	1.29	14	5	0.35	175	0.82	0.21	0.11	0.52	0.987	0.63	10.74
B. H.	8	1.00	Medium Sand	8.50	21	10.00	18.0	142.5	68.1	1.00	0.95	1.00	67	1.12	1.21	27	5	0.35	200	0.79	0.20	0.29	1.44	0.002	0.58	39.75
173	9	1.00	Silt	9.50	5	11.00	16.5	159.8	75.5	1.00	1.00	1.00	67	1.12	1.15	6	35	0.03	150	0.75	0.20	0.07	0.36	0.000	0.00	Non-Liq.
GWT (m)	10	1.00	Fine Sand	10.50	7	12.00	16.5	176.3	82.2	1.00	1.00	1.00	67	1.12	1.10	9	8	0.15	150	0.71	0.19	0.07	0.37	1.000	0.48	6.02
0.91	11	1.00	Fine Sand	11.50	11	13.00	18.0	193.5	89.7	1.00	1.00	1.00	67	1.12	1.06	13	8	0.15	175	0.68	0.18	0.09	0.52	0.986	0.43	10.31
a_{max} (g)	12	1.00	Medium Sand	12.50	20	14.00	18.0	211.5	97.8	1.00	1.00	1.00	67	1.12	1.01	23	5	0.35	200	0.66	0.18	0.19	1.07	0.086	0.38	38.55
0.19	13	1.00	Medium Sand	13.50	39	15.00	19.0	230.0	106.5	1.00	1.00	1.00	67	1.12	0.97	42	5	0.35	225	0.64	0.17	0.83	4.85	0.000	0.33	43.90
Sampler[b]	14	1.00	Fine Sand	14.50	5	16.00	16.5	247.8	114.5	1.00	1.00	1.00	67	1.12	0.93	5	8	0.15	150	0.62	0.17	0.05	0.29	1.000	0.28	3.82
NA	15	1.00	Fine Sand	15.50	30	17.00	18.0	265.0	121.9	1.00	1.00	1.00	67	1.12	0.91	30	8	0.15	200	0.61	0.16	0.33	2.03	0.000	0.23	40.80
B.H. Diam. (mm)	16	1.00	Fine Sand	16.50	28	18.00	18.0	283.0	130.1	1.00	1.00	1.00	67	1.12	0.88	27	8	0.15	200	0.60	0.16	0.26	1.62	0.000	0.18	40.00
95	17	1.00	Fine Sand	17.50	38	19.00	19.0	301.5	138.8	1.00	1.00	1.00	67	1.12	0.85	36	8	0.15	225	0.59	0.16	0.50	3.13	0.000	0.13	42.37
Energy Ratio[c]	18	1.00	Fine Sand	18.50	22	20.00	18.0	320.0	147.5	1.00	1.00	1.00	67	1.12	0.82	20	8	0.15	175	0.59	0.16	0.14	0.91	0.276	0.08	17.38
67	19	1.00	Fine Sand	19.50	33	21.00	18.0	338.0	155.7	1.00	1.00	1.00	67	1.12	0.80	30	8	0.15	200	0.59	0.16	0.29	1.86	0.000	0.03	40.58
N (mean)	20	1.00	Fine Sand	20.50	30	22.00	18.0	356.0	163.9	1.00	1.00	1.00	67	1.12	0.78	26	8	0.15	200	0.58	0.16	0.22	1.42	0.003	0.00	39.65
16.4	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
171	25																									
Observed (cm)	26																									
188	27																									
Distance (m)	28																									
72.0	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	20.09																							6.59	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	1.09	F to M Sand	1.50	10	3.00	18.0	25.2	19.4	1.00	0.75	1.00	67	1.12	2.00	17	7	0.25	175	0.98	0.16	0.19	1.22	0.022	0.93	37.02
Mw	2	1.00	F to M Sand	2.50	4	4.00	16.5	42.4	26.8	1.00	0.75	1.00	67	1.12	1.93	6	7	0.25	150	0.97	0.19	0.08	0.42	0.999	0.88	4.48
7.5	3	1.00	F to M Sand	3.50	3	5.00	16.5	58.9	33.5	1.00	0.85	1.00	67	1.12	1.73	5	7	0.25	150	0.95	0.21	0.07	0.32	1.000	0.83	3.64
Site	4	1.00	Clay	4.50	3	6.00	15.5	74.9	39.7	1.00	0.85	1.00	67	1.12	1.59	4	35	0.01	125	0.92	0.21	0.07	0.33	0.000	0.00	Non-Liq.
G-10, F-F'	5	1.00	Fine Sand	5.50	2	7.00	15.5	90.4	45.4	1.00	0.95	1.00	67	1.12	1.48	3	8	0.15	125	0.89	0.22	0.05	0.24	1.000	0.73	2.90
Data Class	6	1.00	Fine Sand	6.50	11	8.00	18.0	107.2	52.3	1.00	0.95	1.00	67	1.12	1.38	16	8	0.15	175	0.85	0.22	0.14	0.65	0.862	0.68	13.44
	7	1.00	Fine Sand	7.50	13	9.00	18.0	125.2	60.5	1.00	0.95	1.00	67	1.12	1.29	18	8	0.15	175	0.81	0.21	0.15	0.73	0.691	0.63	14.99
B. H.	8	1.00	Fine Sand	8.50	11	10.00	18.0	143.2	68.7	1.00	0.95	1.00	67	1.12	1.21	14	8	0.15	175	0.78	0.20	0.11	0.56	0.969	0.58	11.41
174	9	1.00	Silt	9.50	4	11.00	16.5	160.4	76.2	1.00	1.00	1.00	67	1.12	1.15	5	35	0.03	150	0.74	0.19	0.06	0.32	0.000	0.00	Non-Liq.
GWT (m)	10	1.00	Silt	10.50	3	12.00	15.5	176.4	82.4	1.00	1.00	1.00	67	1.12	1.10	4	35	0.03	125	0.70	0.19	0.05	0.29	0.000	0.00	Non-Liq.
0.91	11	1.00	Midium Sand	11.50	19	13.00	18.0	193.2	89.3	1.00	1.00	1.00	67	1.12	1.06	22	5	0.35	200	0.67	0.18	0.19	1.06	0.091	0.43	38.52
a_{max} (g)	12	1.00	Midium Sand	12.50	17	14.00	18.0	211.2	97.5	1.00	1.00	1.00	67	1.12	1.01	19	5	0.35	175	0.65	0.17	0.15	0.84	0.430	0.38	16.08
0.19	13	1.00	Midium Sand	13.50	28	15.00	18.0	229.2	105.7	1.00	1.00	1.00	67	1.12	0.97	30	5	0.35	200	0.63	0.17	0.34	1.99	0.000	0.33	40.69
Sampler[b]	14	1.00	Midium Sand	14.50	10	16.00	16.5	246.4	113.1	1.00	1.00	1.00	67	1.12	0.94	10	5	0.35	150	0.61	0.16	0.07	0.43	0.999	0.28	7.54
NA	15	1.00	Fine Sand	15.50	32	17.00	19.0	264.2	121.1	1.00	1.00	1.00	67	1.12	0.91	32	8	0.15	225	0.60	0.16	0.39	2.43	0.000	0.23	41.39
B.H. Diam. (mm)	16	1.00	Fine Sand	16.50	17	18.00	18.0	282.7	129.7	1.00	1.00	1.00	67	1.12	0.88	17	8	0.15	175	0.59	0.16	0.11	0.71	0.738	0.18	13.96
95	17	1.00	Fine Sand	17.50	36	19.00	19.0	301.2	138.4	1.00	1.00	1.00	67	1.12	0.85	34	8	0.15	225	0.59	0.16	0.43	2.75	0.000	0.13	41.86
Energy Ratio[c]	18	1.00	Fine Sand	18.50	38	20.00	19.0	320.2	147.6	1.00	1.00	1.00	67	1.12	0.82	35	8	0.15	225	0.58	0.16	0.45	2.89	0.000	0.08	42.07
67	19	1.00	Fine Sand	19.50	17	21.00	18.0	338.7	156.3	1.00	1.00	1.00	67	1.12	0.80	15	8	0.15	175	0.58	0.15	0.10	0.62	0.905	0.03	12.51
N (mean)	20	1.00	Fine Sand	20.50	43	22.00	19.0	357.2	165.0	1.00	1.00	1.00	67	1.12	0.78	37	8	0.15	225	0.57	0.15	0.53	3.44	0.000	0.00	42.74
16.0	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
168	25																									
Observed (cm)	26																									
247	27																									
Distance (m)	28																									
40.6	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	20.09																							4.64	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	0.59	Coarse Sand	1.00	10	2.50	18.0	16.2	15.3	1.00	0.75	1.00	67	1.12	2.00	17	6	0.60	175	0.99	0.13	0.20	1.57	0.001	0.95	36.99
Mw	2	1.00	Coarse Sand	2.00	8	3.50	18.0	34.2	23.5	1.00	0.75	1.00	67	1.12	2.00	13	6	0.60	175	0.98	0.18	0.14	0.79	0.549	0.90	10.54
7.5	3	1.00	Coarse Sand	3.00	3	4.50	16.5	51.4	30.9	1.00	0.85	1.00	67	1.12	1.80	5	6	0.60	150	0.97	0.20	0.07	0.34	1.000	0.85	3.71
Site	4	1.00	Coarse Sand	4.00	5	5.50	16.5	67.9	37.6	1.00	0.85	1.00	67	1.12	1.63	8	6	0.60	150	0.95	0.21	0.08	0.37	1.000	0.80	5.24
G-10, F-F'	5	1.00	Coarse Sand	5.00	13	6.50	18.0	85.2	45.1	1.00	0.95	1.00	67	1.12	1.49	21	6	0.60	200	0.93	0.22	0.20	0.93	0.249	0.75	38.03
Data Class	6	1.00	Coarse Sand	6.00	7	7.50	16.5	102.4	52.5	1.00	0.95	1.00	67	1.12	1.38	10	6	0.60	150	0.90	0.22	0.09	0.40	1.000	0.70	7.38
	7	1.00	Midium Sand	7.00	11	8.50	18.0	119.7	59.9	1.00	0.95	1.00	67	1.12	1.29	15	5	0.35	175	0.87	0.21	0.12	0.56	0.963	0.65	12.08
B. H.	8	1.00	Fine Sand	8.00	10	9.50	18.0	137.7	68.1	1.00	0.95	1.00	67	1.12	1.21	13	8	0.15	175	0.84	0.21	0.10	0.48	0.995	0.60	10.19
175	9	1.00	Fine Sand	9.00	8	10.50	16.5	154.9	75.6	1.00	1.00	1.00	67	1.12	1.15	10	8	0.15	150	0.80	0.20	0.08	0.39	1.000	0.55	7.46
GWT (m)	10	1.00	Fine Sand	10.00	10	11.50	18.0	172.2	83.0	1.00	1.00	1.00	67	1.12	1.10	12	8	0.15	175	0.77	0.20	0.09	0.46	0.997	0.50	9.59
0.91	11	1.00	Fine Sand	11.00	13	12.50	18.0	190.2	91.2	1.00	1.00	1.00	67	1.12	1.05	15	8	0.15	175	0.73	0.19	0.11	0.59	0.940	0.45	12.52
a_{max} (g)	12	1.00	Fine Sand	12.00	12	13.50	18.0	208.2	99.4	1.00	1.00	1.00	67	1.12	1.00	13	8	0.15	175	0.71	0.18	0.10	0.52	0.985	0.40	10.78
0.19	13	1.00	Fine Sand	13.00	30	14.50	19.0	226.7	108.1	1.00	1.00	1.00	67	1.12	0.96	32	8	0.15	225	0.68	0.18	0.40	2.26	0.000	0.35	41.32
Sampler[b]	14	1.00	Fine Sand	14.00	33	15.50	19.0	245.7	117.3	1.00	1.00	1.00	67	1.12	0.92	34	8	0.15	225	0.66	0.17	0.45	2.62	0.000	0.30	41.82
NA	15	1.00	Fine Sand	15.00	32	16.50	19.0	264.7	126.5	1.00	1.00	1.00	67	1.12	0.89	32	8	0.15	225	0.65	0.17	0.37	2.21	0.000	0.25	41.20
B.H. Diam. (mm)	16	1.00	Fine Sand	16.00	23	17.50	18.0	283.2	135.1	1.00	1.00	1.00	67	1.12	0.86	22	8	0.15	200	0.63	0.16	0.17	1.04	0.107	0.20	38.53
95	17	1.00	Fine Sand	17.00	19	18.50	18.0	301.2	143.3	1.00	1.00	1.00	67	1.12	0.84	18	8	0.15	175	0.63	0.16	0.12	0.74	0.675	0.15	14.98
Energy Ratio[c]	18	1.00	Silt	18.00	26	19.50	18.0	319.2	151.5	1.00	1.00	1.00	67	1.12	0.81	24	35	0.03	200	0.62	0.16	0.25	1.55	0.000	0.00	Non-Liq.
67	19	1.00	Fine Sand	19.00	31	20.50	18.0	337.2	159.7	1.00	1.00	1.00	67	1.12	0.79	27	8	0.15	200	0.61	0.16	0.25	1.54	0.001	0.05	39.99
N (mean)	20	1.00	Fine Sand	20.00	31	21.50	18.0	355.2	167.9	1.00	1.00	1.00	67	1.12	0.77	27	8	0.15	200	0.61	0.16	0.23	1.44	0.002	0.00	39.80
16.7	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
179	25																									
Observed (cm)	26																									
181	27																									
Distance (m)	28																									
31.7	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	19.59																							6.24	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	1.09	Coarse Sand	1.50	4	3.00	16.5	23.4	17.6	1.00	0.75	1.00	67	1.12	2.00	7	4	0.60	150	0.99	0.16	0.09	0.55	0.971	0.93	4.53
Mw	2	1.00	Coarse Sand	2.50	3	4.00	16.5	39.9	24.3	1.00	0.75	1.00	67	1.12	2.00	5	4	0.60	150	0.97	0.20	0.07	0.36	1.000	0.88	3.63
7.5	3	1.00	Coarse Sand	3.50	2	5.00	15.5	55.9	30.5	1.00	0.85	1.00	67	1.12	1.81	3	4	0.60	125	0.95	0.22	0.06	0.28	1.000	0.83	2.94
Site	4	1.00	Coarse Sand	4.50	6	6.00	16.5	71.9	36.7	1.00	0.85	1.00	67	1.12	1.65	9	4	0.60	150	0.93	0.23	0.09	0.39	1.000	0.78	6.33
G-10, F-F'	5	1.00	Coarse Sand	5.50	5	7.00	16.5	88.4	43.4	1.00	0.95	1.00	67	1.12	1.52	8	4	0.60	150	0.90	0.23	0.08	0.34	1.000	0.73	5.41
Data Class	6	1.00	Coarse Sand	6.50	13	8.00	18.0	105.6	50.8	1.00	0.95	1.00	67	1.12	1.40	19	4	0.60	175	0.87	0.22	0.17	0.78	0.576	0.68	16.19
	7	1.00	Coarse Sand	7.50	7	9.00	16.5	122.9	58.2	1.00	0.95	1.00	67	1.12	1.31	10	4	0.60	150	0.84	0.22	0.08	0.37	1.000	0.63	6.77
B. H.	8	1.00	Coarse Sand	8.50	5	10.00	16.5	139.4	64.9	1.00	0.95	1.00	67	1.12	1.24	7	4	0.60	150	0.80	0.21	0.06	0.29	1.000	0.58	4.46
176	9	1.00	Midium Sand	9.50	19	11.00	18.0	156.6	72.4	1.00	1.00	1.00	67	1.12	1.18	25	8	0.35	200	0.76	0.20	0.25	1.24	0.017	0.53	39.31
GWT (m)	10	1.00	Midium Sand	10.50	22	12.00	18.0	174.6	80.6	1.00	1.00	1.00	67	1.12	1.11	27	8	0.35	200	0.73	0.19	0.30	1.52	0.001	0.48	39.98
0.91	11	1.00	Midium Sand	11.50	22	13.00	18.0	192.6	88.7	1.00	1.00	1.00	67	1.12	1.06	26	8	0.35	200	0.70	0.19	0.26	1.40	0.004	0.43	39.63
a_{max} (g)	12	1.00	Midium Sand	12.50	29	14.00	19.0	211.1	97.4	1.00	1.00	1.00	67	1.12	1.01	33	8	0.35	225	0.67	0.18	0.43	2.39	0.000	0.38	41.48
0.19	13	1.00	Midium Sand	13.50	35	15.00	19.0	230.1	106.6	1.00	1.00	1.00	67	1.12	0.97	38	8	0.35	225	0.65	0.17	0.62	3.57	0.000	0.33	42.87
Sampler[b]	14	1.00	Midium Sand	14.50	24	16.00	18.0	248.6	115.3	1.00	1.00	1.00	67	1.12	0.93	25	8	0.35	200	0.63	0.17	0.22	1.32	0.008	0.28	39.32
NA	15	1.00	Midium Sand	15.50	20	17.00	18.0	266.6	123.5	1.00	1.00	1.00	67	1.12	0.90	20	10	0.35	175	0.62	0.17	0.15	0.92	0.258	0.23	17.49
B.H. Diam. (mm)	16	1.00	Midium Sand	16.50	25	18.00	18.0	284.6	131.7	1.00	1.00	1.00	67	1.12	0.87	24	10	0.35	200	0.61	0.16	0.21	1.28	0.012	0.18	39.22
95	17	1.00	Fine Sand	17.50	22	19.00	18.0	302.6	139.9	1.00	1.00	1.00	67	1.12	0.85	21	8	0.15	200	0.60	0.16	0.15	0.95	0.222	0.13	38.16
Energy Ratio[c]	18	1.00	Midium Sand	18.50	15	20.00	18.0	320.6	148.1	1.00	1.00	1.00	67	1.12	0.82	14	5	0.35	175	0.60	0.16	0.09	0.53	0.981	0.08	10.80
67	19	1.00	Fine Sand	19.50	47	21.00	19.0	339.1	156.8	1.00	1.00	1.00	67	1.12	0.80	42	8	0.15	225	0.60	0.16	0.76	4.79	0.000	0.03	44.00
N (mean)	20	1.00	Fine Sand	20.50	49	22.00	19.0	358.1	166.0	1.00	1.00	1.00	67	1.12	0.78	42	8	0.15	225	0.59	0.16	0.78	4.97	0.000	0.00	44.15
18.7	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
174	25																									
Observed (cm)	26																									
181	27																									
Distance (m)	28																									
25.4	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	20.09																							5.94	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	1.09	F to M Sand	1.50	5	3.00	16.5	24.3	18.5	1.00	0.75	1.00	67	1.12	2.00	8	11	0.25	150	0.99	0.16	0.10	0.65	0.855	0.93	6.02
Mw	2	1.00	F to M Sand	2.50	4	4.00	16.5	40.8	25.2	1.00	0.75	1.00	67	1.12	1.99	7	11	0.25	150	0.97	0.19	0.08	0.43	0.999	0.88	4.79
7.5	3	1.00	F to M Sand	3.50	2	5.00	15.5	56.8	31.4	1.00	0.85	1.00	67	1.12	1.78	3	11	0.25	125	0.96	0.21	0.06	0.29	1.000	0.83	3.07
Site	4	1.00	F to M Sand	4.50	14	6.00	18.0	73.5	38.3	1.00	0.85	1.00	67	1.12	1.62	21	13	0.25	200	0.93	0.22	0.24	1.10	0.066	0.78	38.54
G-10, F-F'	5	1.00	Coarse Sand	5.50	11	7.00	18.0	91.5	46.5	1.00	0.95	1.00	67	1.12	1.47	17	6	0.60	175	0.91	0.22	0.15	0.70	0.772	0.73	14.17
Data Class	6	1.00	Silty Sand	6.50	4	8.00	16.5	108.8	54.0	1.00	0.95	1.00	67	1.12	1.36	6	35	0.08	150	0.88	0.22	0.07	0.33	1.000	0.68	5.32
	7	1.00	Fine Sand	7.50	8	9.00	18.0	126.0	61.4	1.00	0.95	1.00	67	1.12	1.28	11	18	0.15	175	0.84	0.21	0.10	0.45	0.998	0.63	9.06
B. H.	8	1.00	Fine Sand	8.50	6	10.00	16.5	143.3	68.8	1.00	0.95	1.00	67	1.12	1.21	8	18	0.15	150	0.80	0.21	0.07	0.35	1.000	0.58	5.89
177	9	1.00	Silty Clay	9.50	9	11.00	18.0	160.5	76.3	1.00	1.00	1.00	67	1.12	1.14	12	28	0.01	175	0.77	0.20	0.10	0.51	0.000	0.00	Non-Liq.
GWT (m)	10	1.00	Fine Sand	10.50	10	12.00	18.0	178.5	84.5	1.00	1.00	1.00	67	1.12	1.09	12	19	0.15	175	0.73	0.19	0.10	0.51	0.988	0.48	10.54
0.91	11	1.00	Coarse Sand	11.50	15	13.00	18.0	196.5	92.7	1.00	1.00	1.00	67	1.12	1.04	17	10	0.60	175	0.70	0.18	0.13	0.73	0.696	0.43	14.90
a_{max} (g)	12	1.00	Coarse Sand	12.50	18	14.00	18.0	214.5	100.8	1.00	1.00	1.00	67	1.12	1.00	20	10	0.60	175	0.68	0.18	0.16	0.91	0.291	0.38	17.41
0.19	13	1.00	Coarse Sand	13.50	34	15.00	19.0	233.0	109.5	1.00	1.00	1.00	67	1.12	0.96	36	10	0.60	225	0.65	0.17	0.56	3.26	0.000	0.33	42.54
Sampler[b]	14	0.75	Fine Sand	14.50	27	16.00	18.0	251.5	118.2	1.00	1.00	1.00	67	1.12	0.92	28	11	0.15	200	0.64	0.17	0.28	1.70	0.000	0.28	40.21
NA	15	0.75	Fine Sand	15.00	38	16.50	19.0	260.8	122.6	1.00	1.00	1.00	67	1.12	0.90	38	11	0.15	225	0.63	0.17	0.65	3.90	0.000	0.25	43.17
B.H. Diam. (mm)	16	1.00	Fine Sand	16.00	30	17.50	18.0	279.3	131.3	1.00	1.00	1.00	67	1.12	0.87	29	13	0.15	200	0.62	0.16	0.32	1.96	0.000	0.20	40.72
95	17	1.00	Fine Sand	17.00	37	18.50	19.0	297.8	140.0	1.00	1.00	1.00	67	1.12	0.85	35	13	0.15	225	0.61	0.16	0.49	3.06	0.000	0.15	42.32
Energy Ratio[c]	18	1.00	Fine Sand	18.00	38	19.50	19.0	316.8	149.1	1.00	1.00	1.00	67	1.12	0.82	35	9	0.15	225	0.61	0.16	0.45	2.83	0.000	0.10	42.07
67	19	1.00	Fine Sand	19.00	44	20.50	19.0	335.8	158.3	1.00	1.00	1.00	67	1.12	0.79	39	9	0.15	225	0.60	0.16	0.62	3.93	0.000	0.05	43.26
N (mean)	20	1.00	Fine Sand	20.00	10	21.50	16.5	353.5	166.3	1.00	1.00	1.00	67	1.12	0.78	9	9	0.15	150	0.60	0.16	0.06	0.37	1.000	0.00	6.12
18.2	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
175	25																									
Observed (cm)	26																									
188	27																									
Distance (m)	28																									
34.3	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	19.59																							5.92	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	1.09	Medium Sand	1.50	7	3.00	18.0	25.2	19.4	1.00	0.75	1.00	67	1.12	2.00	12	5	0.35	175	1.00	0.16	0.13	0.81	0.513	0.93	8.77
Mw	2	0.75	Fine Sand	2.50	7	4.00	18.0	43.2	27.6	1.00	0.75	1.00	67	1.12	1.90	11	8	0.15	175	0.99	0.19	0.11	0.60	0.936	0.88	8.49
7.5	3	0.50	Sandy Silt	3.00	7	4.50	18.0	52.2	31.7	1.00	0.85	1.00	67	1.12	1.78	12	35	0.04	175	0.99	0.20	0.14	0.70	0.000	0.00	Non-Liq.
Site	4	1.25	Peat	3.50	3	5.00	16.5	60.8	35.4	1.00	0.85	1.00	67	1.12	1.68	5	35	0.01	150	0.98	0.21	0.07	0.36	0.000	0.00	Non-Liq.
G10, G-G'	5	2.00	Medium Sand	5.50	27	7.00	19.0	96.3	51.3	1.00	0.95	1.00	67	1.12	1.40	40	5	0.35	225	0.96	0.22	0.85	3.82	0.000	0.73	43.30
Data Class	6	2.00	Medium Sand	7.50	33	9.00	19.0	134.3	69.7	1.00	0.95	1.00	67	1.12	1.20	42	5	0.35	225	0.93	0.22	0.91	4.11	0.000	0.63	43.83
	7	1.50	Medium Sand	9.50	40	11.00	19.0	172.3	88.0	1.00	1.00	1.00	67	1.12	1.07	48	5	0.35	225	0.88	0.21	1.32	6.16	0.000	0.53	45.37
B. H.	8	1.00	Medium Sand	10.50	43	12.00	19.0	191.3	97.2	1.00	1.00	1.00	67	1.12	1.01	49	5	0.35	225	0.86	0.21	1.39	6.69	0.000	0.48	45.67
178	9	1.00	Medium Sand	11.50	26	13.00	18.0	209.8	105.9	1.00	1.00	1.00	67	1.12	0.97	28	5	0.35	200	0.83	0.20	0.28	1.40	0.004	0.43	40.09
GWT (m)	10	1.00	Medium Sand	12.50	34	14.00	19.0	228.3	114.6	1.00	1.00	1.00	67	1.12	0.93	35	5	0.35	225	0.80	0.20	0.48	2.45	0.000	0.38	42.06
0.91	11	1.00	Medium Sand	13.50	37	15.00	19.0	247.3	123.8	1.00	1.00	1.00	67	1.12	0.90	37	5	0.35	225	0.78	0.19	0.54	2.80	0.000	0.33	42.52
a_{max} (g)	12	1.00	Medium Sand	14.50	42	16.00	19.0	266.3	133.0	1.00	1.00	1.00	67	1.12	0.87	41	5	0.35	225	0.76	0.19	0.69	3.69	0.000	0.28	43.48
0.19	13	1.00	Medium Sand	15.50	49	17.00	19.0	285.3	142.2	1.00	1.00	1.00	67	1.12	0.84	46	5	0.35	225	0.74	0.18	1.01	5.52	0.000	0.23	44.90
Sampler[b]	14	1.50	Fine Sand	16.50	41	18.00	19.0	304.3	151.4	1.00	1.00	1.00	67	1.12	0.81	37	8	0.15	225	0.73	0.18	0.53	2.97	0.000	0.18	42.70
NA	15	1.50	Fine Sand	18.50	50	20.00	19.0	342.3	169.7	1.00	1.00	1.00	67	1.12	0.77	43	8	0.15	225	0.71	0.18	0.80	4.56	0.000	0.08	44.25
B.H. Diam. (mm)	16	1.00	Fine Sand	19.50	61	21.00	19.0	361.3	178.9	1.00	1.00	1.00	67	1.12	0.75	51	8	0.15	225	0.70	0.17	1.48	8.46	0.000	0.03	46.48
95	17	1.00	Fine Sand	20.50	58	22.00	19.0	380.3	188.1	1.00	1.00	1.00	67	1.12	0.73	47	8	0.15	225	0.69	0.17	1.09	6.30	0.000	0.00	45.46
Energy Ratio[c]	18																									
67	19																									
N (mean)	20																									
33.2	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
207	25																									
Observed (cm)	26																									
105	27																									
Distance (m)	28																									
88.9	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	20.09																							1.13	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N^d	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	0.89	Midium Sand	1.30	3	2.80	16.5	20.1	16.3	1.00	0.75	1.00	67	1.12	2.00	5	7	0.35	150	0.99	0.15	0.08	0.54	0.978	0.94	3.69
Mw	2	1.00	Silt	2.30	2	3.80	15.5	36.1	22.4	1.00	0.75	1.00	67	1.12	2.00	3	35	0.03	125	0.99	0.20	0.07	0.38	0.000	0.00	Non-Liq.
7.5	3	0.73	Silt	3.30	2	4.80	15.5	51.6	28.1	1.00	0.85	1.00	67	1.12	1.89	4	35	0.03	125	0.98	0.22	0.07	0.33	0.000	0.00	Non-Liq.
Site	4	0.50	Peat	3.75	2	5.25	15.5	58.6	30.7	1.00	0.85	1.00	67	1.12	1.80	3	35	0.01	125	0.97	0.23	0.07	0.30	0.000	0.00	Non-Liq.
G-10, G-G'	5	0.78	Fine Sand	4.30	15	5.80	18.0	67.8	34.5	1.00	0.85	1.00	67	1.12	1.70	24	4	0.15	200	0.96	0.23	0.28	1.21	0.024	0.79	39.00
Data Class	6	1.00	Fine Sand	5.30	28	6.80	19.0	86.3	43.2	1.00	0.95	1.00	67	1.12	1.52	45	4	0.15	225	0.94	0.23	1.31	5.63	0.000	0.74	44.71
	7	1.00	Fine Sand	6.30	35	7.80	19.0	105.3	52.4	1.00	0.95	1.00	67	1.12	1.38	51	2	0.15	225	0.92	0.23	1.91	8.31	0.000	0.69	46.38
B. H.	8	1.00	Fine Sand	7.30	36	8.80	19.0	124.3	61.6	1.00	0.95	1.00	67	1.12	1.27	49	2	0.15	225	0.90	0.22	1.49	6.67	0.000	0.64	45.66
179	9	1.00	Fine Sand	8.30	31	9.80	19.0	143.3	70.8	1.00	0.95	1.00	67	1.12	1.19	39	4	0.15	225	0.87	0.22	0.72	3.30	0.000	0.59	43.05
GWT (m)	10	1.00	Fine Sand	9.30	36	10.80	19.0	162.3	80.0	1.00	1.00	1.00	67	1.12	1.12	45	4	0.15	225	0.84	0.21	1.09	5.17	0.000	0.54	44.65
0.91	11	1.00	Fine Sand	10.30	37	11.80	19.0	181.3	89.2	1.00	1.00	1.00	67	1.12	1.06	44	7	0.15	225	0.81	0.20	1.01	4.99	0.000	0.49	44.44
a_{max} (g)	12	1.00	Fine Sand	11.30	36	12.80	19.0	200.3	98.3	1.00	1.00	1.00	67	1.12	1.01	41	7	0.15	225	0.78	0.19	0.77	3.94	0.000	0.44	43.56
0.19	13	1.00	Fine Sand	12.30	35	13.80	19.0	219.3	107.5	1.00	1.00	1.00	67	1.12	0.96	38	7	0.15	225	0.75	0.19	0.60	3.19	0.000	0.39	42.78
Sampler[b]	14	1.00	Fine Sand	13.30	47	14.80	19.0	238.3	116.7	1.00	1.00	1.00	67	1.12	0.93	49	2	0.15	225	0.72	0.18	1.24	6.82	0.000	0.34	45.64
NA	15	1.00	Fine Sand	14.30	37	15.80	19.0	257.3	125.9	1.00	1.00	1.00	67	1.12	0.89	37	2	0.15	225	0.70	0.18	0.50	2.82	0.000	0.29	42.43
B.H. Diam. (mm)	16	1.00	Midium Sand	15.30	40	16.80	19.0	276.3	135.1	1.00	1.00	1.00	67	1.12	0.86	38	8	0.35	225	0.69	0.17	0.61	3.50	0.000	0.24	43.03
95	17	1.00	Midium Sand	16.30	39	17.80	19.0	295.3	144.3	1.00	1.00	1.00	67	1.12	0.83	36	8	0.35	225	0.67	0.17	0.50	2.96	0.000	0.19	42.43
Energy Ratio[c]	18	1.00	Midium Sand	17.30	40	18.80	19.0	314.3	153.5	1.00	1.00	1.00	67	1.12	0.81	36	8	0.35	225	0.66	0.17	0.49	2.90	0.000	0.14	42.38
67	19	1.00	Midium Sand	18.30	34	19.80	18.0	332.8	162.2	1.00	1.00	1.00	67	1.12	0.79	30	8	0.35	200	0.66	0.17	0.30	1.78	0.000	0.09	40.66
N (mean)	20	1.00	Clay	19.30	11	20.80	16.5	350.0	169.6	1.00	1.00	1.00	67	1.12	0.77	9	35	0.01	150	0.65	0.17	0.07	0.43	0.000	0.00	Non-Liq.
27.9	21	1.00	Midium Sand	20.30	39	21.80	19.0	367.8	177.6	1.00	1.00	1.00	67	1.12	0.75	33	4	0.35	225	0.65	0.17	0.34	2.06	0.000	0.00	41.30
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
191	25																									
Observed (cm)	26																									
85	27																									
Distance (m)	28																									
129	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	19.89																							0.83	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	1.09	Fine Sand	1.00	3	2.50	16.5	15.1	14.3	1.00	0.75	1.00	67	1.12	2.00	5	8	0.15	150	1.00	0.13	0.09	0.65	0.858	0.95	3.73
Mw	2	1.50	Silt	3.00	1	4.50	15.5	47.1	26.6	1.00	0.85	1.00	67	1.12	1.94	2	35	0.03	125	0.98	0.21	0.06	0.29	0.000	0.00	Non-Liq.
7.5	3	1.00	Fine Sand	4.00	29	5.50	19.0	64.4	34.1	1.00	0.85	1.00	67	1.12	1.71	47	8	0.15	225	0.97	0.23	1.75	7.73	0.000	0.80	45.44
Site	4	1.00	Fine Sand	5.00	33	6.50	19.0	83.4	43.3	1.00	0.95	1.00	67	1.12	1.52	53	8	0.15	225	0.95	0.23	2.62	11.52	0.000	0.75	47.11
G-10, G-G'	5	1.00	Fine Sand	6.00	49	7.50	19.0	102.4	52.5	1.00	0.95	1.00	67	1.12	1.38	72	8	0.15	225	0.94	0.23	10.44	46.28	0.000	0.70	52.23
Data Class	6	1.00	Fine Sand	7.00	53	8.50	19.0	121.4	61.6	1.00	0.95	1.00	67	1.12	1.27	72	8	0.15	225	0.91	0.22	9.86	44.39	0.000	0.65	52.18
	7	1.00	Fine Sand	8.00	60	9.50	19.0	140.4	70.8	1.00	0.95	1.00	67	1.12	1.19	76	8	0.15	225	0.89	0.22	12.95	59.65	0.000	0.60	53.29
B. H.	8	1.00	Fine Sand	9.00	50	10.50	19.0	159.4	80.0	1.00	1.00	1.00	67	1.12	1.12	62	8	0.15	225	0.86	0.21	4.50	21.32	0.000	0.55	49.65
180	9	1.00	Fine Sand	10.00	75	11.50	19.0	178.4	89.2	1.00	1.00	1.00	67	1.12	1.06	89	8	0.15	225	0.83	0.20	33.36	163.4	0.000	0.50	56.89
GWT (m)	10	1.00	Fine Sand	11.00	115	12.50	19.0	197.4	98.4	1.00	1.00	1.00	67	1.12	1.01	129	8	0.15	225	0.80	0.20	765.2	3882	0.000	0.45	68.13
0.91	11	1.00	Fine Sand	12.00	57	13.50	19.0	216.4	107.6	1.00	1.00	1.00	67	1.12	0.96	61	8	0.15	225	0.77	0.19	3.82	20.05	0.000	0.40	49.36
a_{max} (g)	12	1.00	Fine Sand	13.00	75	14.50	19.0	235.4	116.8	1.00	1.00	1.00	67	1.12	0.93	77	8	0.15	225	0.74	0.18	13.03	70.67	0.000	0.35	53.81
0.19	13	1.00	Fine Sand	14.00	68	15.50	19.0	254.4	126.0	1.00	1.00	1.00	67	1.12	0.89	68	8	0.15	225	0.72	0.18	5.95	33.20	0.000	0.30	51.09
Sampler[b]	14	1.00	Fine Sand	15.00	57	16.50	19.0	273.4	135.2	1.00	1.00	1.00	67	1.12	0.86	55	8	0.15	225	0.70	0.17	2.15	12.27	0.000	0.25	47.53
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
67	19																									
N (mean)	20																									
51.8	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
194	25																									
Observed (cm)	26																									
105	27																									
Distance (m)	28																									
142.2	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	14.59																							0.89	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	0.84	Clay	1.20	6	2.70	16.5	19.3	16.5	1.00	0.75	1.00	67	1.12	2.00	10	35	0.01	150	0.99	0.14	0.14	1.01	0.000	0.00	Non-Liq.
Mw	2	1.15	Silty Clay	2.30	2	3.80	15.5	36.9	23.3	1.00	0.75	1.00	67	1.12	2.00	3	35	0.02	125	0.98	0.19	0.07	0.39	0.000	0.00	Non-Liq.
7.5	3	1.10	Midium Sand	3.50	10	5.00	18.0	57.0	31.6	1.00	0.85	1.00	67	1.12	1.78	17	5	0.35	175	0.97	0.22	0.17	0.77	0.599	0.83	13.83
Site	4	1.00	Midium Sand	4.50	17	6.00	18.0	75.0	39.8	1.00	0.85	1.00	67	1.12	1.58	26	5	0.35	200	0.95	0.22	0.30	1.37	0.005	0.78	39.37
G-10, G-G'	5	1.00	Midium Sand	5.50	19	7.00	18.0	93.0	48.0	1.00	0.95	1.00	67	1.12	1.44	29	5	0.35	200	0.94	0.22	0.38	1.69	0.000	0.73	40.32
Data Class	6	1.00	Midium Sand	6.50	21	8.00	18.0	111.0	56.2	1.00	0.95	1.00	67	1.12	1.33	30	5	0.35	200	0.91	0.22	0.38	1.70	0.000	0.68	40.50
	7	1.00	Midium Sand	7.50	24	9.00	19.0	129.5	64.9	1.00	0.95	1.00	67	1.12	1.24	32	5	0.35	225	0.88	0.22	0.42	1.93	0.000	0.63	41.01
B. H.	8	1.00	Midium Sand	8.50	21	10.00	18.0	148.0	73.6	1.00	0.95	1.00	67	1.12	1.17	26	5	0.35	200	0.85	0.21	0.26	1.25	0.017	0.58	39.47
182	9	1.00	Midium Sand	9.50	22	11.00	18.0	166.0	81.8	1.00	1.00	1.00	67	1.12	1.11	27	5	0.35	200	0.82	0.21	0.28	1.37	0.005	0.53	39.80
GWT (m)	10	1.00	Midium Sand	10.50	22	12.00	18.0	184.0	90.0	1.00	1.00	1.00	67	1.12	1.05	26	5	0.35	200	0.79	0.20	0.25	1.25	0.017	0.48	39.46
0.91	11	1.00	Midium Sand	11.50	21	13.00	18.0	202.0	98.2	1.00	1.00	1.00	67	1.12	1.01	24	5	0.35	200	0.76	0.19	0.20	1.06	0.091	0.43	38.85
a_{max} (g)	12	1.00	Midium Sand	12.50	21	14.00	18.0	220.0	106.3	1.00	1.00	1.00	67	1.12	0.97	23	5	0.35	200	0.73	0.19	0.19	1.00	0.151	0.38	38.59
0.19	13	1.00	Midium Sand	13.50	23	15.00	18.0	238.0	114.5	1.00	1.00	1.00	67	1.12	0.93	24	5	0.35	200	0.71	0.18	0.20	1.11	0.061	0.33	38.94
Sampler[b]	14	1.00	Midium Sand	14.50	24	16.00	18.0	256.0	122.7	1.00	1.00	1.00	67	1.12	0.90	24	5	0.35	200	0.69	0.18	0.20	1.13	0.051	0.28	38.99
NA	15	1.00	Midium Sand	15.50	27	17.00	18.0	274.0	130.9	1.00	1.00	1.00	67	1.12	0.87	26	5	0.35	200	0.67	0.17	0.23	1.33	0.007	0.23	39.58
B.H. Diam. (mm)	16	1.00	Midium Sand	16.50	26	18.00	18.0	292.0	139.1	1.00	1.00	1.00	67	1.12	0.85	25	5	0.35	200	0.66	0.17	0.20	1.17	0.037	0.18	39.11
95	17	1.00	Midium Sand	17.50	26	19.00	18.0	310.0	147.3	1.00	1.00	1.00	67	1.12	0.82	24	5	0.35	200	0.65	0.17	0.19	1.10	0.066	0.13	38.92
Energy Ratio[c]	18	1.00	Midium Sand	18.50	31	20.00	18.0	328.0	155.5	1.00	1.00	1.00	67	1.12	0.80	28	5	0.35	200	0.64	0.17	0.25	1.46	0.002	0.08	39.96
67	19	1.00	Midium Sand	19.50	33	21.00	18.0	346.0	163.7	1.00	1.00	1.00	67	1.12	0.78	29	5	0.35	200	0.64	0.17	0.26	1.57	0.001	0.03	40.25
N (mean)	20	1.00	Midium Sand	20.50	31	22.00	18.0	364.0	171.9	1.00	1.00	1.00	67	1.12	0.76	26	5	0.35	200	0.64	0.17	0.22	1.30	0.010	0.00	39.59
21.4	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
188	25																									
Observed (cm)	26																									
85	27																									
Distance (m)	28																									
177.8	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	20.09																							0.71	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	1.59	Medium Sand	2.00	7	3.50	18.0	34.2	23.5	1.00	0.75	1.00	67	1.12	2.00	12	5	0.35	175	0.98	0.18	0.12	0.69	0.782	0.90	8.77
Mw	2	1.00	Medium Sand	3.00	7	4.50	18.0	52.2	31.7	1.00	0.85	1.00	67	1.12	1.78	12	5	0.35	175	0.96	0.20	0.11	0.58	0.954	0.85	8.85
7.5	3	1.00	Silt + F Sand	4.00	8	5.50	18.0	70.2	39.9	1.00	0.85	1.00	67	1.12	1.58	12	35	0.07	175	0.94	0.21	0.13	0.65	0.854	0.80	11.92
Site	4	1.00	Silt + F Sand	5.00	7	6.50	18.0	88.2	48.1	1.00	0.95	1.00	67	1.12	1.44	11	35	0.07	175	0.92	0.21	0.11	0.55	0.974	0.75	10.48
G-10, H-H'	5	1.00	Silt + F Sand	6.00	7	7.50	16.5	105.4	55.5	1.00	0.95	1.00	67	1.12	1.34	10	35	0.07	150	0.89	0.21	0.10	0.49	0.993	0.70	9.65
Data Class	6	1.00	Silt + F Sand	7.00	6	8.50	16.5	121.9	62.2	1.00	0.95	1.00	67	1.12	1.27	8	35	0.07	150	0.86	0.21	0.08	0.41	1.000	0.65	7.53
	7	1.00	Silt + F Sand	8.00	7	9.50	16.5	138.4	68.9	1.00	0.95	1.00	67	1.12	1.20	9	35	0.07	150	0.82	0.20	0.09	0.44	0.999	0.60	8.52
B. H.	8	1.00	Silt + F Sand	9.00	9	10.50	18.0	155.7	76.3	1.00	1.00	1.00	67	1.12	1.14	12	35	0.07	175	0.78	0.20	0.11	0.54	0.975	0.55	11.35
183	9	1.00	Medium Sand	10.00	9	11.50	18.0	173.7	84.5	1.00	1.00	1.00	67	1.12	1.09	11	5	0.35	175	0.75	0.19	0.08	0.42	0.999	0.50	7.98
GWT (m)	10	1.00	Medium Sand	11.00	9	12.50	16.5	190.9	91.9	1.00	1.00	1.00	67	1.12	1.04	10	5	0.35	150	0.71	0.18	0.08	0.41	1.000	0.45	7.52
0.91	11	1.00	Medium Sand	12.00	13	13.50	18.0	208.2	99.4	1.00	1.00	1.00	67	1.12	1.00	15	5	0.35	175	0.69	0.18	0.10	0.57	0.957	0.40	11.58
a_{max} (g)	12	1.00	Medium Sand	13.00	13	14.50	18.0	226.2	107.6	1.00	1.00	1.00	67	1.12	0.96	14	5	0.35	175	0.66	0.17	0.09	0.55	0.970	0.35	11.02
0.19	13	1.00	Medium Sand	14.00	13	15.50	18.0	244.2	115.8	1.00	1.00	1.00	67	1.12	0.93	13	5	0.35	175	0.64	0.17	0.09	0.53	0.980	0.30	10.53
Sampler[b]	14	1.00	Medium Sand	15.00	14	16.50	18.0	262.2	124.0	1.00	1.00	1.00	67	1.12	0.90	14	5	0.35	175	0.63	0.16	0.09	0.56	0.967	0.25	11.07
NA	15	1.00	Medium Sand	16.00	32	17.50	19.0	280.7	132.6	1.00	1.00	1.00	67	1.12	0.87	31	5	0.35	225	0.62	0.16	0.33	2.05	0.000	0.20	40.85
B.H. Diam. (mm)	16	1.00	Medium Sand	17.00	30	18.50	18.0	299.2	141.3	1.00	1.00	1.00	67	1.12	0.84	28	5	0.35	200	0.61	0.16	0.26	1.64	0.000	0.15	40.08
95	17	1.00	Medium Sand	18.00	30	19.50	18.0	317.2	149.5	1.00	1.00	1.00	67	1.12	0.82	27	5	0.35	200	0.60	0.16	0.24	1.53	0.001	0.10	39.86
Energy Ratio[c]	18	1.00	Medium Sand	19.00	31	20.50	18.0	335.2	157.7	1.00	1.00	1.00	67	1.12	0.80	28	5	0.35	200	0.60	0.16	0.24	1.54	0.001	0.05	39.91
67	19	1.00	Medium Sand	20.00	30	21.50	18.0	353.2	165.9	1.00	1.00	1.00	67	1.12	0.78	26	5	0.35	200	0.60	0.16	0.21	1.35	0.006	0.00	39.49
N (mean)	20																									
14.8	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
174	25																									
Observed (cm)	26																									
712	27																									
Distance (m)	28																									
68.5	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	19.59																							8.03	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	0.59	Medium Sand	1.00	4	2.50	16.5	15.1	14.3	1.00	0.75	1.00	67	1.12	2.00	7	5	0.35	150	0.99	0.13	0.10	0.73	0.691	0.95	4.53
Mw	2	1.00	Medium Sand	2.00	3	3.50	16.5	31.6	20.9	1.00	0.75	1.00	67	1.12	2.00	5	5	0.35	150	0.98	0.18	0.08	0.41	1.000	0.90	3.63
7.5	3	1.00	Silt	3.00	3	4.50	16.5	48.1	27.6	1.00	0.85	1.00	67	1.12	1.90	5	35	0.03	150	0.97	0.21	0.08	0.41	0.000	0.00	Non-Liq.
Site	4	1.00	Medium Sand	4.00	5	5.50	16.5	64.6	34.3	1.00	0.85	1.00	67	1.12	1.71	8	5	0.35	150	0.95	0.22	0.08	0.38	1.000	0.80	5.44
G-10, H-H'	5	1.00	Medium Sand	5.00	7	6.50	18.0	81.9	41.8	1.00	0.95	1.00	67	1.12	1.55	11	5	0.35	175	0.92	0.22	0.10	0.46	0.998	0.75	8.54
Data Class	6	1.00	Medium Sand	6.00	8	7.50	18.0	99.9	50.0	1.00	0.95	1.00	67	1.12	1.41	12	5	0.35	175	0.90	0.22	0.10	0.46	0.998	0.70	9.05
	7	1.00	Medium Sand	7.00	8	8.50	18.0	117.9	58.1	1.00	0.95	1.00	67	1.12	1.31	11	5	0.35	175	0.86	0.22	0.09	0.42	0.999	0.65	8.17
B. H.	8	1.00	Medium Sand	8.00	13	9.50	18.0	135.9	66.3	1.00	0.95	1.00	67	1.12	1.23	17	5	0.35	175	0.83	0.21	0.14	0.65	0.862	0.60	13.89
184	9	1.00	Medium Sand	9.00	11	10.50	18.0	153.9	74.5	1.00	1.00	1.00	67	1.12	1.16	14	5	0.35	175	0.79	0.20	0.11	0.53	0.982	0.55	11.25
GWT (m)	10	1.00	Medium Sand	10.00	10	11.50	18.0	171.9	82.7	1.00	1.00	1.00	67	1.12	1.10	12	5	0.35	175	0.76	0.19	0.09	0.46	0.997	0.50	9.32
0.91	11	1.00	Medium Sand	11.00	4	12.50	16.5	189.1	90.2	1.00	1.00	1.00	67	1.12	1.05	5	5	0.35	150	0.72	0.19	0.05	0.26	1.000	0.45	3.48
a_{max} (g)	12	1.00	Fine Sand	12.00	9	13.50	16.5	205.6	96.8	1.00	1.00	1.00	67	1.12	1.02	10	8	0.15	150	0.69	0.18	0.07	0.41	1.000	0.40	7.52
0.19	13	1.00	Fine Sand	13.00	11	14.50	18.0	222.9	104.3	1.00	1.00	1.00	67	1.12	0.98	12	8	0.15	175	0.67	0.18	0.08	0.48	0.996	0.35	9.36
Sampler[b]	14	1.00	Fine Sand	14.00	25	15.50	18.0	240.9	112.5	1.00	1.00	1.00	67	1.12	0.94	26	8	0.15	200	0.65	0.17	0.25	1.45	0.002	0.30	39.70
NA	15	1.00	Fine Sand	15.00	35	16.50	19.0	259.4	121.2	1.00	1.00	1.00	67	1.12	0.91	36	8	0.15	225	0.64	0.17	0.50	2.96	0.000	0.25	42.23
B.H. Diam. (mm)	16	1.00	Fine Sand	16.00	40	17.50	19.0	278.4	130.4	1.00	1.00	1.00	67	1.12	0.88	39	8	0.15	225	0.62	0.16	0.65	3.92	0.000	0.20	43.22
95	17	1.00	Fine Sand	17.00	44	18.50	19.0	297.4	139.5	1.00	1.00	1.00	67	1.12	0.85	42	8	0.15	225	0.62	0.16	0.77	4.74	0.000	0.15	43.91
Energy Ratio[c]	18	1.00	Fine Sand	18.00	37	19.50	19.0	316.4	148.7	1.00	1.00	1.00	67	1.12	0.82	34	8	0.15	225	0.61	0.16	0.41	2.59	0.000	0.10	41.78
67	19	1.00	Fine Sand	19.00	41	20.50	19.0	335.4	157.9	1.00	1.00	1.00	67	1.12	0.80	36	8	0.15	225	0.61	0.16	0.50	3.13	0.000	0.05	42.48
N (mean)	20	1.00	Fine Sand	20.00	50	21.50	19.0	354.4	167.1	1.00	1.00	1.00	67	1.12	0.77	43	8	0.15	225	0.60	0.16	0.83	5.24	0.000	0.00	44.35
18.4	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
176	25																									
Observed (cm)	26																									
487	27																									
Distance (m)	28																									
118.1	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	19.59																							6.94	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N^d	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	1.09	Fine Sand	1.50	5	3.00	16.5	24.3	18.5	1.00	0.75	1.00	67	1.12	2.00	8	8	0.15	150	0.99	0.16	0.10	0.64	0.875	0.93	5.83
Mw	2	0.75	Fine Sand	2.50	4	4.00	16.5	40.8	25.2	1.00	0.75	1.00	67	1.12	1.99	7	8	0.15	150	0.97	0.19	0.08	0.42	0.999	0.88	4.65
7.5	3	1.00	Clayey Silt	3.00	2	4.50	15.5	48.8	28.3	1.00	0.85	1.00	67	1.12	1.88	4	35	0.02	125	0.97	0.21	0.07	0.35	0.000	0.00	Non-Liq.
Site	4	1.25	Coarse Sand	4.50	14	6.00	18.0	73.9	38.7	1.00	0.85	1.00	67	1.12	1.61	21	6	0.60	200	0.94	0.22	0.22	1.01	0.134	0.78	38.25
G-10, I-I'	5	1.00	Fine Sand	5.50	11	7.00	18.0	91.9	46.9	1.00	0.95	1.00	67	1.12	1.46	17	3	0.15	175	0.91	0.22	0.15	0.67	0.819	0.73	13.99
Data Class	6	1.00	Sandy Silt	6.50	4	8.00	16.5	109.2	54.3	1.00	0.95	1.00	67	1.12	1.36	6	35	0.07	150	0.88	0.22	0.07	0.33	0.000	0.00	Non-Liq.
	7	1.00	Silty Sand	7.50	8	9.00	18.0	126.4	61.8	1.00	0.95	1.00	67	1.12	1.27	11	35	0.07	175	0.85	0.21	0.11	0.50	0.991	0.63	10.57
B. H.	8	1.00	Midium Sand	8.50	6	10.00	16.5	143.7	69.2	1.00	0.95	1.00	67	1.12	1.20	8	6	0.35	150	0.81	0.21	0.07	0.32	1.000	0.58	5.18
185	9	1.00	Midium Sand	9.50	9	11.00	18.0	160.9	76.7	1.00	1.00	1.00	67	1.12	1.14	11	6	0.35	175	0.77	0.20	0.09	0.43	0.999	0.53	8.62
GWT (m)	10	1.00	Midium Sand	10.50	10	12.00	18.0	178.9	84.8	1.00	1.00	1.00	67	1.12	1.09	12	6	0.35	175	0.74	0.19	0.09	0.46	0.997	0.48	9.26
0.91	11	1.00	Midium Sand	11.50	15	13.00	18.0	196.9	93.0	1.00	1.00	1.00	67	1.12	1.04	17	6	0.35	175	0.71	0.19	0.13	0.70	0.769	0.43	14.42
a_{max} (g)	12	1.00	Fine Sand	12.50	18	14.00	18.0	214.9	101.2	1.00	1.00	1.00	67	1.12	0.99	20	12	0.15	175	0.68	0.18	0.16	0.92	0.275	0.38	17.61
0.19	13	1.00	Fine Sand	13.50	34	15.00	19.0	233.4	109.9	1.00	1.00	1.00	67	1.12	0.95	36	12	0.15	225	0.66	0.17	0.57	3.31	0.000	0.33	42.63
Sampler[b]	14	1.00	Midium Sand	14.50	27	16.00	18.0	251.9	118.6	1.00	1.00	1.00	67	1.12	0.92	28	5	0.35	200	0.64	0.17	0.26	1.56	0.001	0.28	39.94
NA	15	1.00	Midium Sand	15.50	38	17.00	19.0	270.4	127.3	1.00	1.00	1.00	67	1.12	0.89	38	5	0.35	225	0.63	0.17	0.55	3.35	0.000	0.23	42.65
B.H. Diam. (mm)	16	1.00	Fine Sand	16.50	30	18.00	18.0	288.9	136.0	1.00	1.00	1.00	67	1.12	0.86	29	13	0.15	200	0.62	0.16	0.30	1.87	0.000	0.18	40.58
95	17	1.00	Fine Sand	17.50	37	19.00	19.0	307.4	144.7	1.00	1.00	1.00	67	1.12	0.83	34	13	0.15	225	0.61	0.16	0.47	2.90	0.000	0.13	42.16
Energy Ratio[c]	18	1.00	Fine Sand	18.50	38	20.00	19.0	326.4	153.9	1.00	1.00	1.00	67	1.12	0.81	34	13	0.15	225	0.61	0.16	0.45	2.84	0.000	0.08	42.12
67	19	1.00	Fine Sand	19.50	44	21.00	19.0	345.4	163.1	1.00	1.00	1.00	67	1.12	0.78	38	13	0.15	225	0.60	0.16	0.62	3.95	0.000	0.03	43.32
N (mean)	20	1.00	Sandy Silt	20.50	10	22.00	16.5	363.2	171.0	1.00	1.00	1.00	67	1.12	0.76	9	35	0.04	150	0.60	0.16	0.07	0.42	0.000	0.00	Non-Liq.
18.2	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
176	25																									
Observed (cm)	26																									
273	27																									
Distance (m)	28																									
95.2	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	20.09																							4.88	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N^d	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	1.09	Coarse Sand	1.50	7	3.00	18.0	25.2	19.4	1.00	0.75	1.00	67	1.12	2.00	12	4	0.60	175	0.99	0.16	0.13	0.81	0.511	0.93	8.77
Mw	2	1.00	Coarse Sand	2.50	4	4.00	16.5	42.4	26.8	1.00	0.75	1.00	67	1.12	1.93	6	4	0.60	150	0.97	0.19	0.08	0.41	1.000	0.88	4.39
7.5	3	1.00	Coarse Sand	3.50	3	5.00	16.5	58.9	33.5	1.00	0.85	1.00	67	1.12	1.73	5	4	0.60	150	0.96	0.21	0.07	0.31	1.000	0.83	3.58
Site	4	1.00	Coarse Sand	4.50	7	6.00	16.5	75.4	40.2	1.00	0.85	1.00	67	1.12	1.58	10	4	0.60	150	0.94	0.22	0.09	0.44	0.999	0.78	7.52
G-10, I-I'	5	1.00	Coarse Sand	5.50	5	7.00	16.5	91.9	46.9	1.00	0.95	1.00	67	1.12	1.46	8	4	0.60	150	0.91	0.22	0.07	0.33	1.000	0.73	5.19
Data Class	6	1.00	Coarse Sand	6.50	10	8.00	18.0	109.2	54.3	1.00	0.95	1.00	67	1.12	1.36	14	4	0.60	175	0.88	0.22	0.12	0.54	0.979	0.68	11.41
	7	1.00	Midium Sand	7.50	10	9.00	18.0	127.2	62.5	1.00	0.95	1.00	67	1.12	1.26	13	4	0.35	175	0.85	0.21	0.10	0.49	0.993	0.63	10.45
B. H.	8	1.00	Coarse Sand	8.50	7	10.00	16.5	144.4	70.0	1.00	0.95	1.00	67	1.12	1.20	9	6	0.60	150	0.81	0.21	0.07	0.35	1.000	0.58	6.10
186	9	1.00	Fine Sand	9.50	10	11.00	18.0	161.7	77.4	1.00	1.00	1.00	67	1.12	1.14	13	5	0.15	175	0.78	0.20	0.09	0.47	0.996	0.53	9.73
GWT (m)	10	1.00	Fine Sand	10.50	14	12.00	18.0	179.7	85.6	1.00	1.00	1.00	67	1.12	1.08	17	5	0.15	175	0.74	0.19	0.13	0.66	0.851	0.48	13.85
0.91	11	1.00	Fine Sand	11.50	13	13.00	18.0	197.7	93.8	1.00	1.00	1.00	67	1.12	1.03	15	5	0.15	175	0.71	0.19	0.11	0.57	0.955	0.43	12.00
a_{max} (g)	12	1.00	Fine Sand	12.50	14	14.00	18.0	215.7	102.0	1.00	1.00	1.00	67	1.12	0.99	15	5	0.15	175	0.69	0.18	0.11	0.60	0.928	0.38	12.48
0.19	13	1.00	Fine Sand	13.50	30	15.00	19.0	234.2	110.7	1.00	1.00	1.00	67	1.12	0.95	32	5	0.15	225	0.66	0.17	0.37	2.13	0.000	0.33	41.08
Sampler[b]	14	1.00	Fine Sand	14.50	30	16.00	19.0	253.2	119.9	1.00	1.00	1.00	67	1.12	0.91	31	5	0.15	225	0.65	0.17	0.33	1.95	0.000	0.28	40.74
NA	15	1.00	Fine Sand	15.50	33	17.00	19.0	272.2	129.1	1.00	1.00	1.00	67	1.12	0.88	32	5	0.15	225	0.63	0.16	0.37	2.25	0.000	0.23	41.24
B.H. Diam. (mm)	16	1.00	Fine Sand	16.50	28	18.00	18.0	290.7	137.7	1.00	1.00	1.00	67	1.12	0.85	27	5	0.15	200	0.62	0.16	0.23	1.44	0.002	0.18	39.66
95	17	1.00	Fine Sand	17.50	32	19.00	18.0	308.7	145.9	1.00	1.00	1.00	67	1.12	0.83	30	35	0.15	200	0.62	0.16	0.42	2.61	0.000	0.13	41.81
Energy Ratio[c]	18	1.00	Sandy Silt	18.50	15	20.00	18.0	326.7	154.1	1.00	1.00	1.00	67	1.12	0.81	13	35	0.04	175	0.61	0.16	0.10	0.65	0.000	0.00	Non-Liq.
67	19	1.00	Fine Sand	19.50	31	21.00	18.0	344.7	162.3	1.00	1.00	1.00	67	1.12	0.78	27	8	0.15	200	0.61	0.16	0.24	1.51	0.001	0.03	39.93
N (mean)	20	1.00	Fine Sand	20.50	41	22.00	19.0	363.2	171.0	1.00	1.00	1.00	67	1.12	0.76	35	8	0.15	225	0.60	0.16	0.44	2.76	0.000	0.00	42.09
17.2	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
177	25																									
Observed (cm)	26																									
110	27																									
Distance (m)	28																									
77.4	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	20.09																							7.25	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	2.59	Clay	2.50	13	4.00	18.0	44.5	28.9	1.00	0.75	1.00	67	1.12	1.86	20	35	0.01	175	0.99	0.19	0.30	1.58	0.000	0.00	Non-Liq.
Mw	2	2.00	Fine Sand	4.50	26	6.00	19.0	81.5	46.3	1.00	0.85	1.00	67	1.12	1.47	36	8	0.15	225	0.96	0.21	0.69	3.29	0.000	0.78	42.43
7.5	3	2.00	Fine Sand	6.50	11	8.00	18.0	118.5	63.7	1.00	0.95	1.00	67	1.12	1.25	15	8	0.15	175	0.93	0.21	0.12	0.55	0.971	0.68	11.95
Site	4	2.00	Fine Sand	8.50	8	10.00	16.5	153.0	78.6	1.00	0.95	1.00	67	1.12	1.13	10	8	0.15	150	0.88	0.21	0.08	0.36	1.000	0.58	6.87
G-10, I-I'	5	2.00	Fine Sand	10.50	14	12.00	18.0	187.5	93.5	1.00	1.00	1.00	67	1.12	1.03	16	8	0.15	175	0.82	0.20	0.12	0.59	0.942	0.48	13.48
Data Class	6	2.00	Fine Sand	12.50	61	14.00	19.0	224.5	110.8	1.00	1.00	1.00	67	1.12	0.95	65	8	0.15	225	0.76	0.19	4.90	25.71	0.000	0.38	50.28
	7	2.00	Fine Sand	14.50	67	16.00	19.0	262.5	129.2	1.00	1.00	1.00	67	1.12	0.88	66	8	0.15	225	0.72	0.18	5.12	28.45	0.000	0.28	50.59
B. H.	8	2.00	Fine Sand	16.50	100	18.00	19.0	300.5	147.6	1.00	1.00	1.00	67	1.12	0.82	92	8	0.15	225	0.69	0.17	37.29	215.4	0.000	0.18	57.78
188	9	2.00	Fine Sand	18.50	46	20.00	19.0	338.5	166.0	1.00	1.00	1.00	67	1.12	0.78	40	8	0.15	225	0.67	0.17	0.64	3.79	0.000	0.08	43.43
GWT (m)	10	2.00	Fine Sand	20.50	43	22.00	19.0	376.5	184.4	1.00	1.00	1.00	67	1.12	0.74	35	8	0.15	225	0.66	0.17	0.44	2.63	0.000	0.00	42.19
0.91	11																									
a_{max} (g)	12																									
0.19	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
67	19																									
N (mean)	20																									
38.9	21																									
γ_{dry} (kN/m^3)	22																									
17.5	23																									
Vs* (m/s)	24																									
196	25																									
Observed (cm)	26																									
61	27																									
Distance (m)	28																									
14	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	20.59																							3.36	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	1.21	Silt	3.00	4	4.50	16.5	46.1	39.1	1.00	0.85	1.00	67	1.12	1.60	6	35	0.03	150	0.96	0.14	0.08	0.58	0.000	0.00	Non-Liq.
Mw	2	1.00	Fine Sand	4.00	5	5.50	16.5	62.6	45.8	1.00	0.85	1.00	67	1.12	1.48	7	8	0.15	150	0.93	0.16	0.07	0.46	0.998	0.80	4.86
7.5	3	1.00	Medium Sand	5.00	6	6.50	16.5	79.1	52.5	1.00	0.95	1.00	67	1.12	1.38	9	5	0.35	150	0.91	0.17	0.08	0.46	0.997	0.75	5.96
Site	4	1.00	Medium Sand	6.00	6	7.50	16.5	95.6	59.2	1.00	0.95	1.00	67	1.12	1.30	8	5	0.35	150	0.87	0.17	0.07	0.42	1.000	0.70	5.57
H-10, M-M'	5	1.00	Medium Sand	7.00	6	8.50	16.5	112.1	65.9	1.00	0.95	1.00	67	1.12	1.23	8	5	0.35	150	0.84	0.18	0.07	0.39	1.000	0.65	5.26
Data Class	6	1.00	Clay	8.00	4	9.50	16.5	128.6	72.5	1.00	0.95	1.00	67	1.12	1.17	5	35	0.01	150	0.80	0.17	0.06	0.36	0.000	0.00	Non-Liq.
	7	1.00	Fine Sand	9.00	5	10.50	16.5	145.1	79.2	1.00	1.00	1.00	67	1.12	1.12	6	8	0.15	150	0.76	0.17	0.06	0.34	1.000	0.55	4.40
B. H.	8	1.00	Medium Sand	10.00	9	11.50	18.0	162.3	86.7	1.00	1.00	1.00	67	1.12	1.07	11	5	0.35	175	0.72	0.17	0.08	0.47	0.996	0.50	7.84
194	9	1.00	Medium Sand	11.00	15	12.50	18.0	180.3	94.9	1.00	1.00	1.00	67	1.12	1.03	17	5	0.35	175	0.69	0.16	0.13	0.77	0.590	0.45	14.14
GWT (m)	10	1.00	Medium Sand	12.00	17	13.50	18.0	198.3	103.1	1.00	1.00	1.00	67	1.12	0.99	19	5	0.35	175	0.66	0.16	0.14	0.87	0.357	0.40	15.58
2.29	11	1.00	Medium Sand	13.00	22	14.50	18.0	216.3	111.2	1.00	1.00	1.00	67	1.12	0.95	23	5	0.35	200	0.64	0.15	0.19	1.24	0.017	0.35	38.74
a_{max} (g)	12	1.00	Medium Sand	14.00	28	15.50	18.0	234.3	119.4	1.00	1.00	1.00	67	1.12	0.92	29	5	0.35	200	0.62	0.15	0.28	1.87	0.000	0.30	40.19
0.19	13	1.00	Medium Sand	15.00	27	16.50	18.0	252.3	127.6	1.00	1.00	1.00	67	1.12	0.89	27	5	0.35	200	0.61	0.15	0.24	1.61	0.000	0.25	39.67
Sampler[b]	14	1.00	Medium Sand	16.00	23	17.50	18.0	270.3	135.8	1.00	1.00	1.00	67	1.12	0.86	22	5	0.35	200	0.60	0.15	0.16	1.12	0.057	0.20	38.40
NA	15	1.00	Medium Sand	17.00	33	18.50	19.0	288.8	144.5	1.00	1.00	1.00	67	1.12	0.83	31	5	0.35	225	0.59	0.15	0.31	2.14	0.000	0.15	40.75
B.H. Diam. (mm)	16	1.00	Medium Sand	18.00	34	19.50	19.0	307.8	153.7	1.00	1.00	1.00	67	1.12	0.81	31	5	0.35	225	0.59	0.15	0.31	2.12	0.000	0.10	40.74
95	17	1.00	Medium Sand	19.00	36	20.50	19.0	326.8	162.9	1.00	1.00	1.00	67	1.12	0.78	31	5	0.35	225	0.58	0.14	0.32	2.24	0.000	0.05	40.98
Energy Ratio[c]	18	1.00	Medium Sand	20.00	37	21.50	19.0	345.8	172.1	1.00	1.00	1.00	67	1.12	0.76	31	5	0.35	225	0.58	0.14	0.32	2.21	0.000	0.00	40.98
67	19																									
N (mean)	20																									
17.6	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
169	25																									
Observed (cm)	26																									
426	27																									
Distance (m)	28																									
57.2	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	18.21																							4.37	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	1.59	Medium Sand	2.00	6	3.50	16.5	32.5	21.9	1.00	0.75	1.00	67	1.12	2.00	10	5	0.35	150	0.98	0.18	0.11	0.61	0.925	0.90	7.09
Mw	2	1.00	Fine Sand	3.00	9	4.50	18.0	49.8	29.3	1.00	0.85	1.00	67	1.12	1.85	16	8	0.15	175	0.97	0.20	0.16	0.79	0.554	0.85	13.10
7.5	3	1.00	Fine Sand	4.00	7	5.50	18.0	67.8	37.5	1.00	0.85	1.00	67	1.12	1.63	11	8	0.15	175	0.95	0.21	0.10	0.48	0.995	0.80	8.17
Site	4	1.00	Fine Sand	5.00	6	6.50	16.5	85.0	44.9	1.00	0.95	1.00	67	1.12	1.49	9	8	0.15	150	0.93	0.22	0.09	0.40	1.000	0.75	6.79
H-10, M-M'	5	1.50	Fine Sand	6.00	6	7.50	16.5	101.5	51.6	1.00	0.95	1.00	67	1.12	1.39	9	8	0.15	150	0.90	0.22	0.08	0.37	1.000	0.70	6.22
Data Class	6	1.50	Fine Sand	8.00	11	9.50	18.0	136.0	66.5	1.00	0.95	1.00	67	1.12	1.23	14	8	0.15	175	0.84	0.21	0.11	0.54	0.978	0.60	11.64
	7	1.00	Fine Sand	9.00	11	10.50	18.0	154.0	74.7	1.00	1.00	1.00	67	1.12	1.16	14	8	0.15	175	0.80	0.20	0.11	0.54	0.980	0.55	11.55
B. H.	8	1.00	Medium Sand	10.00	32	11.50	19.0	172.5	83.4	1.00	1.00	1.00	67	1.12	1.10	39	5	0.35	225	0.77	0.20	0.70	3.56	0.000	0.50	43.06
195	9	1.00	Medium Sand	11.00	20	12.50	18.0	191.0	92.1	1.00	1.00	1.00	67	1.12	1.04	23	5	0.35	200	0.73	0.19	0.20	1.07	0.084	0.45	38.74
GWT (m)	10	1.00	Medium Sand	12.00	19	13.50	18.0	209.0	100.3	1.00	1.00	1.00	67	1.12	1.00	21	5	0.35	200	0.71	0.18	0.17	0.92	0.259	0.40	17.91
0.91	11	1.00	Medium Sand	13.00	23	14.50	18.0	227.0	108.4	1.00	1.00	1.00	67	1.12	0.96	25	5	0.35	200	0.68	0.18	0.21	1.22	0.022	0.35	39.12
a_{max} (g)	12	1.00	Medium Sand	14.00	36	15.50	19.0	245.5	117.1	1.00	1.00	1.00	67	1.12	0.92	37	5	0.35	225	0.66	0.17	0.55	3.19	0.000	0.30	42.52
0.19	13	1.00	Medium Sand	15.00	25	16.50	18.0	264.0	125.8	1.00	1.00	1.00	67	1.12	0.89	25	5	0.35	200	0.65	0.17	0.21	1.25	0.016	0.25	39.18
Sampler[b]	14	1.00	Medium Sand	16.00	25	17.50	18.0	282.0	134.0	1.00	1.00	1.00	67	1.12	0.86	24	5	0.35	200	0.63	0.16	0.19	1.18	0.033	0.20	38.97
NA	15	1.00	Medium Sand	17.00	23	18.50	18.0	300.0	142.2	1.00	1.00	1.00	67	1.12	0.84	22	5	0.35	200	0.63	0.16	0.16	0.96	0.200	0.15	38.27
B.H. Diam. (mm)	16	1.00	Medium Sand	18.00	20	19.50	18.0	318.0	150.4	1.00	1.00	1.00	67	1.12	0.82	18	5	0.35	175	0.62	0.16	0.12	0.74	0.674	0.10	15.11
95	17	1.00	Medium Sand	19.00	21	20.50	18.0	336.0	158.6	1.00	1.00	1.00	67	1.12	0.79	19	5	0.35	175	0.61	0.16	0.12	0.76	0.633	0.05	15.50
Energy Ratio[c]	18	1.00	Medium Sand	20.00	26	21.50	18.0	354.0	166.8	1.00	1.00	1.00	67	1.12	0.77	22	5	0.35	200	0.61	0.16	0.16	1.01	0.143	0.00	38.52
67	19																									
N (mean)	20																									
18.1	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
179	25																									
Observed (cm)	26																									
426	27																									
Distance (m)	28																									
38.1	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	19.59																							6.10	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	1.07	Coarse Sand	1.00	8	2.50	18.0	17.1	11.5	1.00	0.75	1.00	67	1.12	2.00	13	6	0.60	175	0.99	0.18	0.17	0.94	0.240	0.95	36.08
Mw	2	1.00	Fine Sand	2.00	4	3.50	16.5	34.4	19.0	1.00	0.75	1.00	67	1.12	2.00	7	8	0.15	150	0.98	0.22	0.09	0.41	1.000	0.90	4.66
7.5	3	1.00	Clay	3.00	5	4.50	16.5	50.9	25.7	1.00	0.85	1.00	67	1.12	1.97	9	35	0.01	150	0.97	0.24	0.12	0.51	0.000	0.00	Non-Liq.
Site	4	1.00	Coarse Sand	4.00	10	5.50	18.0	68.1	33.1	1.00	0.85	1.00	67	1.12	1.74	16	6	0.60	175	0.95	0.24	0.16	0.67	0.829	0.80	13.57
H-10, M-M'	5	1.00	Coarse Sand	5.00	8	6.50	18.0	86.1	41.3	1.00	0.95	1.00	67	1.12	1.56	13	6	0.60	175	0.92	0.24	0.12	0.49	0.993	0.75	10.34
Data Class	6	1.00	Coarse Sand	6.00	13	7.50	18.0	104.1	49.5	1.00	0.95	1.00	67	1.12	1.42	20	6	0.60	175	0.90	0.23	0.18	0.79	0.561	0.70	16.55
	7	1.00	Midium Sand	7.00	5	8.50	16.5	121.4	56.9	1.00	0.95	1.00	67	1.12	1.33	7	5	0.35	150	0.86	0.23	0.07	0.29	1.000	0.65	4.73
B. H.	8	1.00	Midium Sand	8.00	6	9.50	16.5	137.9	63.6	1.00	0.95	1.00	67	1.12	1.25	8	5	0.35	150	0.83	0.22	0.07	0.31	1.000	0.60	5.36
197	9	1.00	Midium Sand	9.00	6	10.50	16.5	154.4	70.3	1.00	1.00	1.00	67	1.12	1.19	8	5	0.35	150	0.79	0.21	0.07	0.31	1.000	0.55	5.37
GWT (m)	10	1.00	Midium Sand	10.00	9	11.50	18.0	171.6	77.8	1.00	1.00	1.00	67	1.12	1.13	11	5	0.35	175	0.76	0.21	0.09	0.41	1.000	0.50	8.44
0.43	11	1.00	Midium Sand	11.00	6	12.50	16.5	188.9	85.2	1.00	1.00	1.00	67	1.12	1.08	7	5	0.35	150	0.72	0.20	0.06	0.31	1.000	0.45	4.87
a_{max} (g)	12	1.00	Midium Sand	12.00	10	13.50	18.0	206.1	92.6	1.00	1.00	1.00	67	1.12	1.04	12	5	0.35	175	0.69	0.19	0.08	0.43	0.999	0.40	8.65
0.19	13	1.00	Midium Sand	13.00	13	14.50	18.0	224.1	100.8	1.00	1.00	1.00	67	1.12	1.00	14	5	0.35	175	0.67	0.18	0.10	0.54	0.975	0.35	11.48
Sampler[b]	14	1.00	Midium Sand	14.00	32	15.50	19.0	242.6	109.5	1.00	1.00	1.00	67	1.12	0.96	34	5	0.35	225	0.65	0.18	0.44	2.48	0.000	0.30	41.70
NA	15	1.00	Midium Sand	15.00	32	16.50	19.0	261.6	118.7	1.00	1.00	1.00	67	1.12	0.92	33	5	0.35	225	0.64	0.17	0.39	2.25	0.000	0.25	41.34
B.H. Diam. (mm)	16	1.00	Midium Sand	16.00	19	17.50	18.0	280.1	127.4	1.00	1.00	1.00	67	1.12	0.89	19	5	0.35	175	0.62	0.17	0.13	0.77	0.596	0.20	15.67
95	17	1.00	Midium Sand	17.00	31	18.50	18.0	298.1	135.6	1.00	1.00	1.00	67	1.12	0.86	30	5	0.35	200	0.62	0.17	0.30	1.78	0.000	0.15	40.50
Energy Ratio[c]	18	1.00	Coarse Sand	18.00	37	19.50	19.0	316.6	144.3	1.00	1.00	1.00	67	1.12	0.83	34	6	0.60	225	0.61	0.17	0.42	2.56	0.000	0.10	41.82
67	19	1.00	Midium Sand	19.00	36	20.50	19.0	335.6	153.5	1.00	1.00	1.00	67	1.12	0.81	32	5	0.35	225	0.61	0.16	0.35	2.16	0.000	0.05	41.24
N (mean)	20	1.00	Midium Sand	20.00	39	21.50	19.0	354.6	162.7	1.00	1.00	1.00	67	1.12	0.78	34	5	0.35	225	0.60	0.16	0.40	2.45	0.000	0.00	41.70
16.5	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
176	25																									
Observed (cm)	26																									
112	27																									
Distance (m)	28																									
120.6	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	20.07																							6.55	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	1.30	Fine Sand	1.00	7	2.50	18.0	17.6	9.8	1.00	0.75	1.00	67	1.12	2.00	12	8	0.15	175	0.99	0.22	0.16	0.72	0.727	0.95	9.05
Mw	2	1.00	Silt + Sand	2.00	7	3.50	18.0	35.6	17.9	1.00	0.75	1.00	67	1.12	2.00	12	35	0.09	175	0.99	0.24	0.16	0.68	0.817	0.90	11.59
7.5	3	1.00	Medium Sand	3.00	7	4.50	18.0	53.6	26.1	1.00	0.85	1.00	67	1.12	1.96	13	5	0.35	175	0.98	0.25	0.13	0.53	0.983	0.85	10.04
Site	4	1.00	Medium Sand	4.00	5	5.50	16.5	70.9	33.6	1.00	0.85	1.00	67	1.12	1.73	8	5	0.35	150	0.96	0.25	0.08	0.33	1.000	0.80	5.51
H-10, N-N'	5	1.00	Medium Sand	5.00	4	6.50	16.5	87.4	40.3	1.00	0.95	1.00	67	1.12	1.58	7	5	0.35	150	0.95	0.25	0.07	0.28	1.000	0.75	4.52
Data Class	6	1.00	Medium Sand	6.00	4	7.50	16.5	103.9	47.0	1.00	0.95	1.00	67	1.12	1.46	6	5	0.35	150	0.93	0.25	0.07	0.26	1.000	0.70	4.23
	7	1.00	Medium Sand	7.00	8	8.50	18.0	121.1	54.4	1.00	0.95	1.00	67	1.12	1.36	12	5	0.35	175	0.90	0.25	0.09	0.38	1.000	0.65	8.55
B. H.	8	1.00	Medium Sand	8.00	7	9.50	16.5	138.4	61.8	1.00	0.95	1.00	67	1.12	1.27	9	5	0.35	150	0.87	0.24	0.08	0.32	1.000	0.60	6.50
198	9	1.00	Medium Sand	9.00	7	10.50	16.5	154.9	68.5	1.00	1.00	1.00	67	1.12	1.21	9	5	0.35	150	0.84	0.23	0.08	0.32	1.000	0.55	6.50
GWT (m)	10	1.00	Medium Sand	10.00	55	11.50	19.0	172.6	76.5	1.00	1.00	1.00	67	1.12	1.14	70	5	0.35	225	0.81	0.23	7.75	34.34	0.000	0.50	51.54
0.2	11	1.00	Fine Sand	11.00	36	12.50	19.0	191.6	85.7	1.00	1.00	1.00	67	1.12	1.08	43	8	0.15	225	0.78	0.21	1.01	4.72	0.000	0.45	44.41
a_{max} (g)	12	1.00	Fine Sand	12.00	39	13.50	19.0	210.6	94.8	1.00	1.00	1.00	67	1.12	1.03	45	8	0.15	225	0.75	0.21	1.09	5.31	0.000	0.40	44.77
0.19	13	1.00	Fine Sand	13.00	41	14.50	19.0	229.6	104.0	1.00	1.00	1.00	67	1.12	0.98	45	8	0.15	225	0.72	0.20	1.08	5.46	0.000	0.35	44.81
Sampler[b]	14	1.00	Fine Sand	14.00	45	15.50	19.0	248.6	113.2	1.00	1.00	1.00	67	1.12	0.94	47	8	0.15	225	0.70	0.19	1.26	6.62	0.000	0.30	45.46
NA	15	1.00	Fine Sand	15.00	48	16.50	19.0	267.6	122.4	1.00	1.00	1.00	67	1.12	0.90	48	8	0.15	225	0.68	0.18	1.35	7.33	0.000	0.25	45.80
B.H. Diam. (mm)	16	1.00	Fine Sand	16.00	66	17.50	19.0	286.6	131.6	1.00	1.00	1.00	67	1.12	0.87	64	8	0.15	225	0.67	0.18	4.51	25.03	0.000	0.20	50.15
95	17	1.00	Fine Sand	17.00	68	18.50	19.0	305.6	140.8	1.00	1.00	1.00	67	1.12	0.84	64	8	0.15	225	0.66	0.18	4.34	24.55	0.000	0.15	50.08
Energy Ratio[c]	18	1.00	Silty Sand	18.00	43	19.50	19.0	324.6	150.0	1.00	1.00	1.00	67	1.12	0.82	39	35	0.07	225	0.65	0.17	0.95	5.46	0.000	0.10	44.74
67	19	1.00	Silty Sand	19.00	45	20.50	19.0	343.6	159.2	1.00	1.00	1.00	67	1.12	0.79	40	35	0.07	225	0.65	0.17	0.99	5.72	0.000	0.05	44.93
N (mean)	20	1.00	Silty Sand	20.00	53	21.50	19.0	362.6	168.4	1.00	1.00	1.00	67	1.12	0.77	46	35	0.07	225	0.64	0.17	1.59	9.33	0.000	0.00	46.69
29.8	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
190	25																									
Observed (cm)	26																									
173	27																									
Distance (m)	28																									
139.7	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	20.30																							6.52	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	1.59	Midium Sand	2.20	6	3.70	16.5	35.8	23.2	1.00	0.75	1.00	67	1.12	2.00	10	5	0.35	150	0.98	0.19	0.11	0.57	0.955	0.89	7.09
Mw	2	0.75	Midium Sand	2.80	6	4.30	18.0	46.2	27.7	1.00	0.85	1.00	67	1.12	1.90	11	5	0.35	175	0.97	0.20	0.11	0.54	0.977	0.86	7.87
7.5	3	1.45	Midium Sand	3.70	6	5.20	16.5	61.7	34.4	1.00	0.85	1.00	67	1.12	1.71	10	5	0.35	150	0.96	0.21	0.09	0.44	0.999	0.82	6.75
Site	4	1.50	Midium Sand	5.70	8	7.20	18.0	96.2	49.2	1.00	0.95	1.00	67	1.12	1.43	12	3	0.35	175	0.91	0.22	0.10	0.46	0.998	0.72	9.14
H-10, A-A'	5	1.25	Coarse Sand	6.70	7	8.20	16.5	113.5	56.7	1.00	0.95	1.00	67	1.12	1.33	10	3	0.35	150	0.89	0.22	0.08	0.37	1.000	0.67	6.90
Data Class	6	1.50	Coarse Sand	8.20	11	9.70	18.0	139.3	67.8	1.00	0.95	1.00	67	1.12	1.21	14	1	0.60	175	0.84	0.21	0.11	0.50	0.992	0.59	11.19
	7	1.50	Coarse Sand	9.70	12	11.20	18.0	166.3	80.1	1.00	1.00	1.00	67	1.12	1.12	15	1	0.60	175	0.78	0.20	0.11	0.53	0.980	0.52	11.98
B. H.	8	1.50	Coarse Sand	11.20	13	12.70	18.0	193.3	92.4	1.00	1.00	1.00	67	1.12	1.04	15	0	0.60	175	0.73	0.19	0.10	0.55	0.975	0.44	12.11
199	9	1.50	Coarse Sand	12.70	17	14.20	18.0	220.3	104.7	1.00	1.00	1.00	67	1.12	0.98	19	0	0.60	175	0.69	0.18	0.13	0.72	0.725	0.37	15.44
GWT (m)	10	1.50	Fine Sand	14.20	42	15.70	19.0	248.1	117.7	1.00	1.00	1.00	67	1.12	0.92	43	5	0.60	225	0.66	0.17	0.87	5.03	0.000	0.29	44.18
0.91	11	2.25	Fine Sand	15.70	32	17.20	19.0	276.6	131.5	1.00	1.00	1.00	67	1.12	0.87	31	12	0.15	225	0.64	0.17	0.37	2.20	0.000	0.22	41.22
a_{max} (g)	12	3.00	Fine Sand	18.70	31	20.20	18.0	332.1	157.6	1.00	1.00	1.00	67	1.12	0.80	28	12	0.15	200	0.62	0.16	0.26	1.63	0.000	0.07	40.21
0.19	13	3.00	9.84	21.70	32	23.20	18.0	386.1	182.1	1.00	1.00	1.00	67	1.12	0.74	26	15	0.15	200	0.61	0.16	0.24	1.51	0.001	0.00	40.03
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
67	19																									
N (mean)	20																									
17.2	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
181	25																									
Observed (cm)	26																									
189	27																									
Distance (m)	28																									
96.5	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	22.29																							7.74	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	1.09	Fine Sand	1.50	3	3.00	16.5	23.4	17.6	1.00	0.75	1.00	67	1.12	2.00	5	8	0.15	150	0.99	0.16	0.08	0.49	0.993	0.93	3.73
Mw	2	1.00	Medium Sand	2.50	12	4.00	18.0	40.6	25.0	1.00	0.75	1.00	67	1.12	2.00	20	3	0.35	175	0.98	0.20	0.22	1.13	0.049	0.88	37.87
7.5	3	1.00	Medium Sand	3.50	10	5.00	18.0	58.6	33.2	1.00	0.85	1.00	67	1.12	1.73	16	9	0.35	175	0.97	0.21	0.16	0.78	0.568	0.83	13.87
Site	4	1.00	Medium Sand	4.50	8	6.00	18.0	76.6	41.4	1.00	0.85	1.00	67	1.12	1.55	12	9	0.35	175	0.95	0.22	0.11	0.50	0.992	0.78	9.22
F-10, J-J'	5	1.00	Medium Sand	5.50	9	7.00	18.0	94.6	49.6	1.00	0.95	1.00	67	1.12	1.42	14	9	0.35	175	0.93	0.22	0.12	0.54	0.978	0.73	10.99
Data Class	6	1.00	Medium Sand	6.50	10	8.00	18.0	112.6	57.8	1.00	0.95	1.00	67	1.12	1.32	14	9	0.35	175	0.90	0.22	0.12	0.54	0.979	0.68	11.39
	7	1.00	Medium Sand	7.50	12	9.00	18.0	130.6	66.0	1.00	0.95	1.00	67	1.12	1.23	16	5	0.35	175	0.87	0.21	0.12	0.58	0.949	0.63	12.66
B. H.	8	1.00	Medium Sand	8.50	10	10.00	18.0	148.6	74.2	1.00	0.95	1.00	67	1.12	1.16	12	5	0.35	175	0.84	0.21	0.09	0.45	0.998	0.58	9.36
205	9	1.00	Medium Sand	9.50	11	11.00	18.0	166.6	82.4	1.00	1.00	1.00	67	1.12	1.10	14	5	0.35	175	0.80	0.20	0.10	0.49	0.993	0.53	10.57
GWT (m)	10	1.00	Medium Sand	10.50	11	12.00	18.0	184.6	90.6	1.00	1.00	1.00	67	1.12	1.05	13	5	0.35	175	0.77	0.19	0.09	0.47	0.996	0.48	9.95
0.91	11	1.00	Medium Sand	11.50	8	13.00	16.5	201.9	98.0	1.00	1.00	1.00	67	1.12	1.01	9	5	0.35	150	0.74	0.19	0.07	0.36	1.000	0.43	6.15
a_{max} (g)	12	1.00	Medium Sand	12.50	33	14.00	19.0	219.6	105.9	1.00	1.00	1.00	67	1.12	0.97	36	5	0.35	225	0.71	0.18	0.51	2.79	0.000	0.38	42.15
0.19	13	1.00	Medium Sand	13.50	38	15.00	19.0	238.6	115.1	1.00	1.00	1.00	67	1.12	0.93	40	5	0.35	225	0.69	0.18	0.66	3.75	0.000	0.33	43.18
Sampler[b]	14	1.00	Medium Sand	14.50	31	16.00	19.0	257.6	124.3	1.00	1.00	1.00	67	1.12	0.90	31	5	0.35	225	0.67	0.17	0.34	1.97	0.000	0.28	40.86
NA	15	1.00	Medium Sand	15.50	37	17.00	19.0	276.6	133.5	1.00	1.00	1.00	67	1.12	0.87	36	5	0.35	225	0.65	0.17	0.47	2.83	0.000	0.23	42.14
B.H. Diam. (mm)	16	1.00	Medium Sand	16.50	36	18.00	19.0	295.6	142.7	1.00	1.00	1.00	67	1.12	0.84	34	5	0.35	225	0.64	0.16	0.40	2.40	0.000	0.18	41.57
95	17	1.00	Medium Sand	17.50	39	19.00	19.0	314.6	151.9	1.00	1.00	1.00	67	1.12	0.81	35	5	0.35	225	0.64	0.16	0.44	2.72	0.000	0.13	42.03
Energy Ratio[c]	18	1.00	Medium Sand	18.50	37	20.00	19.0	333.6	161.1	1.00	1.00	1.00	67	1.12	0.79	33	5	0.35	225	0.63	0.16	0.35	2.18	0.000	0.08	41.27
67	19	1.00	Silty Sand	19.50	13	21.00	18.0	352.1	169.8	1.00	1.00	1.00	67	1.12	0.77	11	30	0.16	175	0.63	0.16	0.08	0.50	0.991	0.03	10.49
N (mean)	20	1.00	Fine Sand	20.50	28	22.00	18.0	370.1	178.0	1.00	1.00	1.00	67	1.12	0.75	23	8	0.15	200	0.62	0.16	0.18	1.10	0.065	0.00	38.90
19.8	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
183	25																									
Observed (cm)	26																									
207	27																									
Distance (m)	28																									
190.5	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	20.09																							6.26	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	1.09	Fine Sand	1.50	2	3.00	15.5	22.8	17.0	1.00	0.75	1.00	67	1.12	2.00	3	8	0.15	125	0.98	0.16	0.07	0.44	0.999	0.93	2.98
Mw	2	1.00	Midium Sand	2.50	8	4.00	18.0	39.5	23.9	1.00	0.75	1.00	67	1.12	2.00	13	5	0.35	175	0.97	0.20	0.14	0.70	0.772	0.88	10.43
7.5	3	1.00	Midium Sand	3.50	3	5.00	16.5	56.8	31.4	1.00	0.85	1.00	67	1.12	1.78	5	5	0.35	150	0.95	0.21	0.07	0.32	1.000	0.83	3.65
Site	4	1.00	Midium Sand	4.50	6	6.00	16.5	73.3	38.1	1.00	0.85	1.00	67	1.12	1.62	9	5	0.35	150	0.93	0.22	0.09	0.40	1.000	0.78	6.32
F-10, J-J'	5	1.00	Midium Sand	5.50	6	7.00	16.5	89.8	44.8	1.00	0.95	1.00	67	1.12	1.49	10	5	0.35	150	0.90	0.22	0.09	0.39	1.000	0.73	6.56
Data Class	6	1.00	Midium Sand	6.50	8	8.00	18.0	107.0	52.2	1.00	0.95	1.00	67	1.12	1.38	12	5	0.35	175	0.86	0.22	0.10	0.45	0.998	0.68	8.79
	7	1.00	Midium Sand	7.50	13	9.00	18.0	125.0	60.4	1.00	0.95	1.00	67	1.12	1.29	18	5	0.35	175	0.83	0.21	0.15	0.70	0.760	0.63	14.67
B. H.	8	1.00	Midium Sand	8.50	15	10.00	18.0	143.0	68.6	1.00	0.95	1.00	67	1.12	1.21	19	5	0.35	175	0.79	0.20	0.16	0.79	0.551	0.58	16.06
206	9	1.00	Midium Sand	9.50	14	11.00	18.0	161.0	76.8	1.00	1.00	1.00	67	1.12	1.14	18	5	0.35	175	0.75	0.19	0.14	0.72	0.723	0.53	14.76
GWT (m)	10	1.00	Midium Sand	10.50	14	12.00	18.0	179.0	85.0	1.00	1.00	1.00	67	1.12	1.08	17	5	0.35	175	0.72	0.19	0.13	0.68	0.803	0.48	13.91
0.91	11	1.00	Midium Sand	11.50	15	13.00	18.0	197.0	93.2	1.00	1.00	1.00	67	1.12	1.04	17	5	0.35	175	0.69	0.18	0.13	0.71	0.738	0.43	14.29
a_{max} (g)	12	1.00	Midium Sand	12.50	14	14.00	18.0	215.0	101.3	1.00	1.00	1.00	67	1.12	0.99	16	5	0.35	175	0.66	0.17	0.11	0.63	0.898	0.38	12.53
0.19	13	1.00	Midium Sand	13.50	22	15.00	18.0	233.0	109.5	1.00	1.00	1.00	67	1.12	0.96	23	5	0.35	200	0.64	0.17	0.20	1.16	0.039	0.33	38.79
Sampler[b]	14	1.00	Midium Sand	14.50	21	16.00	18.0	251.0	117.7	1.00	1.00	1.00	67	1.12	0.92	22	5	0.35	200	0.62	0.16	0.17	1.01	0.140	0.28	38.29
NA	15	1.00	Midium Sand	15.50	29	17.00	18.0	269.0	125.9	1.00	1.00	1.00	67	1.12	0.89	29	5	0.35	200	0.61	0.16	0.28	1.76	0.000	0.23	40.26
B.H. Diam. (mm)	16	1.00	Midium Sand	16.50	34	18.00	19.0	287.5	134.6	1.00	1.00	1.00	67	1.12	0.86	33	5	0.35	225	0.60	0.16	0.37	2.35	0.000	0.18	41.32
95	17	1.00	Midium Sand	17.50	29	19.00	18.0	306.0	143.3	1.00	1.00	1.00	67	1.12	0.84	27	5	0.35	200	0.60	0.16	0.24	1.52	0.001	0.13	39.77
Energy Ratio[c]	18	1.00	Midium Sand	18.50	25	20.00	18.0	324.0	151.5	1.00	1.00	1.00	67	1.12	0.81	23	5	0.35	200	0.59	0.16	0.17	1.07	0.082	0.08	38.58
67	19	1.00	Fine Sand	19.50	14	21.00	18.0	342.0	159.7	1.00	1.00	1.00	67	1.12	0.79	12	8	0.15	175	0.59	0.16	0.08	0.49	0.993	0.03	9.71
N (mean)	20	1.00	Silt	20.50	17	22.00	18.0	360.0	167.9	1.00	1.00	1.00	67	1.12	0.77	15	35	0.03	175	0.58	0.15	0.11	0.73	0.000	0.00	Non-Liq.
15.5	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
171	25																									
Observed (cm)	26																									
169	27																									
Distance (m)	28																									
34.3	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	20.09																							6.97	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	1.09	Fine Sand	1.50	3	3.00	16.5	23.4	17.6	1.00	0.75	1.00	67	1.12	2.00	5	8	0.15	150	0.99	0.16	0.08	0.50	0.992	0.93	3.73
Mw	2	1.00	Silt	2.50	3	4.00	16.5	39.9	24.3	1.00	0.75	1.00	67	1.12	2.00	5	35	0.03	150	0.98	0.20	0.08	0.42	0.000	0.00	Non-Liq.
7.5	3	1.00	Fine Sand	3.50	3	5.00	16.5	56.4	31.0	1.00	0.85	1.00	67	1.12	1.80	5	8	0.15	150	0.96	0.22	0.07	0.32	1.000	0.83	3.77
Site	4	1.00	Fine Sand	4.50	6	6.00	16.5	72.9	37.7	1.00	0.85	1.00	67	1.12	1.63	9	8	0.15	150	0.94	0.22	0.09	0.40	1.000	0.78	6.58
F-10, J-J'	5	1.00	Fine Sand	5.50	12	7.00	18.0	90.1	45.1	1.00	0.95	1.00	67	1.12	1.49	19	8	0.15	175	0.92	0.23	0.18	0.80	0.516	0.73	16.17
Data Class	6	1.00	Fine Sand	6.50	13	8.00	18.0	108.1	53.3	1.00	0.95	1.00	67	1.12	1.37	19	8	0.15	175	0.89	0.22	0.17	0.78	0.584	0.68	16.11
	7	1.00	Midium Sand	7.50	10	9.00	18.0	126.1	61.5	1.00	0.95	1.00	67	1.12	1.28	14	5	0.35	175	0.86	0.22	0.11	0.49	0.993	0.63	10.56
B. H.	8	1.00	Midium Sand	8.50	9	10.00	18.0	144.1	69.7	1.00	0.95	1.00	67	1.12	1.20	11	5	0.35	175	0.82	0.21	0.09	0.42	0.999	0.58	8.48
207	9	1.00	Midium Sand	9.50	10	11.00	18.0	162.1	77.9	1.00	1.00	1.00	67	1.12	1.13	13	5	0.35	175	0.78	0.20	0.09	0.46	0.997	0.53	9.70
GWT (m)	10	1.00	Midium Sand	10.50	17	12.00	18.0	180.1	86.1	1.00	1.00	1.00	67	1.12	1.08	20	5	0.35	175	0.75	0.19	0.17	0.85	0.397	0.48	17.24
0.91	11	1.00	Midium Sand	11.50	21	13.00	18.0	198.1	94.2	1.00	1.00	1.00	67	1.12	1.03	24	5	0.35	200	0.72	0.19	0.21	1.15	0.043	0.43	38.98
a_{max} (g)	12	1.00	Midium Sand	12.50	20	14.00	18.0	216.1	102.4	1.00	1.00	1.00	67	1.12	0.99	22	5	0.35	200	0.69	0.18	0.18	0.99	0.163	0.38	38.41
0.19	13	1.00	Midium Sand	13.50	22	15.00	18.0	234.1	110.6	1.00	1.00	1.00	67	1.12	0.95	23	5	0.35	200	0.67	0.18	0.19	1.10	0.066	0.33	38.76
Sampler[b]	14	1.00	Midium Sand	14.50	27	16.00	18.0	252.1	118.8	1.00	1.00	1.00	67	1.12	0.92	28	5	0.35	200	0.65	0.17	0.26	1.54	0.001	0.28	39.94
NA	15	1.00	Midium Sand	15.50	30	17.00	18.0	270.1	127.0	1.00	1.00	1.00	67	1.12	0.89	30	5	0.35	200	0.64	0.17	0.30	1.80	0.000	0.23	40.50
B.H. Diam. (mm)	16	1.00	Midium Sand	16.50	40	18.00	19.0	288.6	135.7	1.00	1.00	1.00	67	1.12	0.86	38	5	0.35	225	0.63	0.17	0.57	3.48	0.000	0.18	42.85
95	17	1.00	Fine Sand	17.50	42	19.00	19.0	307.6	144.9	1.00	1.00	1.00	67	1.12	0.83	39	8	0.15	225	0.62	0.16	0.62	3.80	0.000	0.13	43.18
Energy Ratio[c]	18	1.00	Fine Sand	18.50	49	20.00	19.0	326.6	154.1	1.00	1.00	1.00	67	1.12	0.81	44	8	0.15	225	0.62	0.16	0.91	5.61	0.000	0.08	44.59
67	19	1.00	Fine Sand	19.50	29	21.00	18.0	345.1	162.8	1.00	1.00	1.00	67	1.12	0.78	25	8	0.15	200	0.61	0.16	0.21	1.31	0.009	0.03	39.44
N (mean)	20	1.00	Fine Sand	20.50	27	22.00	18.0	363.1	171.0	1.00	1.00	1.00	67	1.12	0.76	23	8	0.15	200	0.61	0.16	0.17	1.08	0.077	0.00	38.80
19.6	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
179	25																									
Observed (cm)	26																									
169	27																									
Distance (m)	28																									
34.3	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	20.09																							5.38	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	1.09	Fine Sand	1.50	3	3.00	16.5	23.4	17.6	1.00	0.75	1.00	67	1.12	2.00	5	8	0.15	150	0.99	0.16	0.08	0.50	0.992	0.93	3.73
Mw	2	1.00	Midium Sand	2.50	3	4.00	16.5	39.9	24.3	1.00	0.75	1.00	67	1.12	2.00	5	5	0.35	150	0.98	0.20	0.07	0.36	1.000	0.88	3.55
7.5	3	1.00	Midium Sand	3.50	4	5.00	16.5	56.4	31.0	1.00	0.85	1.00	67	1.12	1.80	7	5	0.35	150	0.96	0.22	0.08	0.36	1.000	0.83	4.60
Site	4	1.00	Midium Sand	4.50	8	6.00	18.0	73.6	38.4	1.00	0.85	1.00	67	1.12	1.61	12	5	0.35	175	0.94	0.22	0.11	0.50	0.992	0.78	9.29
F-10, J-J'	5	1.00	Midium Sand	5.50	11	7.00	18.0	91.6	46.6	1.00	0.95	1.00	67	1.12	1.46	17	5	0.35	175	0.92	0.22	0.15	0.68	0.802	0.73	14.04
Data Class	6	1.00	Midium Sand	6.50	13	8.00	18.0	109.6	54.8	1.00	0.95	1.00	67	1.12	1.35	19	5	0.35	175	0.89	0.22	0.16	0.74	0.663	0.68	15.51
	7	1.00	Midium Sand	7.50	14	9.00	18.0	127.6	63.0	1.00	0.95	1.00	67	1.12	1.26	19	5	0.35	175	0.86	0.21	0.16	0.74	0.677	0.63	15.59
B. H.	8	1.00	Midium Sand	8.50	17	10.00	18.0	145.6	71.2	1.00	0.95	1.00	67	1.12	1.19	21	5	0.35	200	0.82	0.21	0.19	0.90	0.296	0.58	18.08
208	9	1.00	Midium Sand	9.50	19	11.00	18.0	163.6	79.4	1.00	1.00	1.00	67	1.12	1.12	24	5	0.35	200	0.79	0.20	0.22	1.10	0.068	0.53	38.89
GWT (m)	10	1.00	Coarse Sand	10.50	22	12.00	18.0	181.6	87.6	1.00	1.00	1.00	67	1.12	1.07	26	6	0.60	200	0.75	0.19	0.26	1.35	0.006	0.48	39.59
0.91	11	1.00	Coarse Sand	11.50	14	13.00	18.0	199.6	95.7	1.00	1.00	1.00	67	1.12	1.02	16	6	0.60	175	0.72	0.19	0.12	0.62	0.906	0.43	13.07
a_{max} (g)	12	1.00	Coarse Sand	12.50	17	14.00	18.0	217.6	103.9	1.00	1.00	1.00	67	1.12	0.98	19	6	0.60	175	0.69	0.18	0.14	0.77	0.602	0.38	15.62
0.19	13	1.00	Coarse Sand	13.50	26	15.00	18.0	235.6	112.1	1.00	1.00	1.00	67	1.12	0.94	27	6	0.60	200	0.67	0.17	0.27	1.52	0.001	0.33	39.91
Sampler[b]	14	1.00	Midium Sand	14.50	33	16.00	19.0	254.1	120.8	1.00	1.00	1.00	67	1.12	0.91	34	5	0.35	225	0.65	0.17	0.41	2.42	0.000	0.28	41.53
NA	15	1.00	Midium Sand	15.50	34	17.00	19.0	273.1	130.0	1.00	1.00	1.00	67	1.12	0.88	33	5	0.35	225	0.64	0.17	0.40	2.38	0.000	0.23	41.47
B.H. Diam. (mm)	16	1.00	Midium Sand	16.50	50	18.00	19.0	292.1	139.2	1.00	1.00	1.00	67	1.12	0.85	47	5	0.35	225	0.63	0.16	1.13	6.95	0.000	0.18	45.29
95	17	1.00	Midium Sand	17.50	39	19.00	19.0	311.1	148.4	1.00	1.00	1.00	67	1.12	0.82	36	5	0.35	225	0.62	0.16	0.46	2.85	0.000	0.13	42.14
Energy Ratio[c]	18	1.00	Fine Sand	18.50	20	20.00	18.0	329.6	157.1	1.00	1.00	1.00	67	1.12	0.80	18	8	0.15	175	0.62	0.16	0.12	0.74	0.680	0.08	15.08
67	19	1.00	Silt	19.50	14	21.00	18.0	347.6	165.3	1.00	1.00	1.00	67	1.12	0.78	12	35	0.03	175	0.61	0.16	0.09	0.58	0.000	0.00	Non-Liq.
N (mean)	20	1.00	Silt	20.50	17	22.00	18.0	365.6	173.5	1.00	1.00	1.00	67	1.12	0.76	14	35	0.03	175	0.61	0.16	0.11	0.69	0.000	0.00	Non-Liq.
18.9	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
179	25																									
Observed (cm)	26																									
169	27																									
Distance (m)	28																									
34.3	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	20.09																							5.79	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	0.59	Medium Sand	1.00	2	2.50	15.5	15.0	14.2	1.00	0.75	1.00	67	1.12	2.00	3	5	0.35	125	0.99	0.13	0.07	0.57	0.960	0.95	2.91
Mw	2	1.00	Silt	2.00	1	3.50	15.5	30.5	19.9	1.00	0.75	1.00	67	1.12	2.00	2	35	0.03	125	0.98	0.19	0.07	0.36	0.000	0.00	Non-Liq.
7.5	3	1.00	Silty Sand	3.00	8	4.50	18.0	47.3	26.8	1.00	0.85	1.00	67	1.12	1.93	15	30	0.16	175	0.96	0.21	0.18	0.86	0.387	0.85	14.27
Site	4	1.00	Medium Sand	4.00	11	5.50	18.0	65.3	35.0	1.00	0.85	1.00	67	1.12	1.69	18	5	0.35	175	0.94	0.22	0.17	0.79	0.551	0.80	14.58
F-10, J-J'	5	1.00	Medium Sand	5.00	10	6.50	18.0	83.3	43.2	1.00	0.95	1.00	67	1.12	1.52	16	5	0.35	175	0.92	0.22	0.14	0.66	0.845	0.75	13.13
Data Class	6	1.00	Medium Sand	6.00	11	7.50	18.0	101.3	51.4	1.00	0.95	1.00	67	1.12	1.40	16	5	0.35	175	0.89	0.22	0.14	0.64	0.875	0.70	13.26
	7	1.00	Medium Sand	7.00	14	8.50	18.0	119.3	59.6	1.00	0.95	1.00	67	1.12	1.30	19	5	0.35	175	0.85	0.21	0.17	0.79	0.547	0.65	16.09
B. H.	8	1.00	Medium Sand	8.00	11	9.50	18.0	137.3	67.7	1.00	0.95	1.00	67	1.12	1.21	14	5	0.35	175	0.82	0.20	0.11	0.53	0.980	0.60	11.20
210	9	1.00	Medium Sand	9.00	13	10.50	18.0	155.3	75.9	1.00	1.00	1.00	67	1.12	1.15	17	5	0.35	175	0.78	0.20	0.13	0.65	0.861	0.55	13.62
GWT (m)	10	1.00	Medium Sand	10.00	12	11.50	18.0	173.3	84.1	1.00	1.00	1.00	67	1.12	1.09	15	5	0.35	175	0.75	0.19	0.11	0.56	0.964	0.50	11.63
0.91	11	1.00	Medium Sand	11.00	11	12.50	18.0	191.3	92.3	1.00	1.00	1.00	67	1.12	1.04	13	5	0.35	175	0.71	0.18	0.09	0.50	0.992	0.45	9.83
a_{max} (g)	12	1.00	Medium Sand	12.00	10	13.50	18.0	209.3	100.5	1.00	1.00	1.00	67	1.12	1.00	11	5	0.35	175	0.68	0.18	0.08	0.44	0.999	0.40	8.18
0.19	13	1.00	Medium Sand	13.00	14	14.50	18.0	227.3	108.7	1.00	1.00	1.00	67	1.12	0.96	15	5	0.35	175	0.66	0.17	0.10	0.60	0.932	0.35	12.00
Sampler[b]	14	1.00	Medium Sand	14.00	20	15.50	18.0	245.3	116.9	1.00	1.00	1.00	67	1.12	0.92	21	5	0.35	200	0.64	0.17	0.15	0.93	0.250	0.30	17.42
NA	15	1.00	Medium Sand	15.00	25	16.50	18.0	263.3	125.1	1.00	1.00	1.00	67	1.12	0.89	25	5	0.35	200	0.63	0.16	0.21	1.29	0.011	0.25	39.20
B.H. Diam. (mm)	16	1.00	Medium Sand	16.00	27	17.50	18.0	281.3	133.3	1.00	1.00	1.00	67	1.12	0.87	26	5	0.35	200	0.62	0.16	0.23	1.41	0.003	0.20	39.52
95	17	1.00	Medium Sand	17.00	30	18.50	18.0	299.3	141.5	1.00	1.00	1.00	67	1.12	0.84	28	5	0.35	200	0.61	0.16	0.26	1.64	0.000	0.15	40.07
Energy Ratio[c]	18	1.00	Medium Sand	18.00	31	19.50	18.0	317.3	149.6	1.00	1.00	1.00	67	1.12	0.82	28	5	0.35	200	0.60	0.16	0.26	1.64	0.000	0.10	40.11
67	19	1.00	Medium Sand	19.00	33	20.50	18.0	335.3	157.8	1.00	1.00	1.00	67	1.12	0.80	29	5	0.35	200	0.60	0.16	0.28	1.76	0.000	0.05	40.39
N (mean)	20	1.00	Medium Sand	20.00	25	21.50	18.0	353.3	166.0	1.00	1.00	1.00	67	1.12	0.78	22	5	0.35	200	0.59	0.16	0.15	0.97	0.188	0.00	38.30
16.0	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
174	25																									
Observed (cm)	26																									
207	27																									
Distance (m)	28																									
241.3	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	19.59																							5.70	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	0.59	Medium Sand	1.00	5	2.50	16.5	16.0	15.2	1.00	0.75	1.00	67	1.12	2.00	8	5	0.35	150	0.99	0.13	0.11	0.83	0.462	0.95	5.64
Mw	2	1.00	Medium Sand	2.00	9	3.50	18.0	33.3	22.6	1.00	0.75	1.00	67	1.12	2.00	15	5	0.35	175	0.97	0.18	0.16	0.90	0.293	0.90	12.08
7.5	3	1.00	Medium Sand	3.00	10	4.50	18.0	51.3	30.8	1.00	0.85	1.00	67	1.12	1.80	17	5	0.35	175	0.94	0.19	0.17	0.88	0.343	0.85	14.05
Site	4	1.00	Medium Sand	4.00	9	5.50	18.0	69.3	39.0	1.00	0.85	1.00	67	1.12	1.60	14	5	0.35	175	0.91	0.20	0.12	0.61	0.916	0.80	10.71
F-10, K-K'	5	1.00	Coarse Sand	5.00	4	6.50	16.5	86.5	46.4	1.00	0.95	1.00	67	1.12	1.47	6	6	0.60	150	0.88	0.20	0.07	0.33	1.000	0.75	4.29
Data Class	6	1.00	Silty Sand	6.00	3	7.50	15.5	102.5	52.6	1.00	0.95	1.00	67	1.12	1.38	4	35	0.05	125	0.84	0.20	0.06	0.32	1.000	0.70	4.33
	7	1.00	Silt & Sand	7.00	2	8.50	15.5	118.0	58.3	1.00	0.95	1.00	67	1.12	1.31	3	35	0.20	125	0.80	0.20	0.05	0.27	1.000	0.65	3.42
B. H.	8	1.00	Silt & Sand	8.00	3	9.50	15.5	133.5	64.0	1.00	0.95	1.00	67	1.12	1.25	4	35	0.20	125	0.76	0.19	0.06	0.30	1.000	0.60	4.08
211	9	1.00	Coarse Sand	9.00	9	10.50	18.0	150.3	70.9	1.00	1.00	1.00	67	1.12	1.19	12	6	0.60	175	0.72	0.19	0.09	0.49	0.994	0.55	9.07
GWT (m)	10	1.00	Silt & Sand	10.00	9	11.50	18.0	168.3	79.1	1.00	1.00	1.00	67	1.12	1.12	11	35	0.20	175	0.68	0.18	0.10	0.58	0.947	0.50	11.12
0.91	11	1.00	Medium Sand	11.00	12	12.50	18.0	186.3	87.3	1.00	1.00	1.00	67	1.12	1.07	14	5	0.35	175	0.65	0.17	0.10	0.60	0.926	0.45	11.36
a_{max} (g)	12	1.00	Medium Sand	12.00	14	13.50	18.0	204.3	95.5	1.00	1.00	1.00	67	1.12	1.02	16	5	0.35	175	0.62	0.16	0.11	0.70	0.775	0.40	12.98
0.19	13	1.00	Medium Sand	13.00	15	14.50	18.0	222.3	103.7	1.00	1.00	1.00	67	1.12	0.98	16	5	0.35	175	0.60	0.16	0.12	0.73	0.708	0.35	13.42
Sampler[b]	14	1.00	Fine Sand	14.00	14	15.50	18.0	240.3	111.9	1.00	1.00	1.00	67	1.12	0.95	15	8	0.15	175	0.59	0.16	0.10	0.66	0.851	0.30	12.11
NA	15	1.00	Fine Sand	15.00	15	16.50	18.0	258.3	120.1	1.00	1.00	1.00	67	1.12	0.91	15	8	0.15	175	0.58	0.15	0.10	0.68	0.802	0.25	12.61
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
67	19																									
N (mean)	20																									
8.9	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
158	25																									
Observed (cm)	26																									
205	27																									
Distance (m)	28																									
108	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	14.59																							6.70	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	2.59	Fine Sand	2.50	5	4.00	16.5	40.8	25.2	1.00	0.75	1.00	67	1.12	1.99	8	8	0.15	150	0.98	0.20	0.09	0.48	0.995	0.88	5.80
Mw	2	2.00	Fine Sand	4.50	8	6.00	18.0	75.3	40.1	1.00	0.85	1.00	67	1.12	1.58	12	8	0.15	175	0.95	0.22	0.11	0.50	0.992	0.78	9.33
7.5	3	2.00	Fine Sand	6.50	7	8.00	16.5	109.8	55.0	1.00	0.95	1.00	67	1.12	1.35	10	8	0.15	150	0.90	0.22	0.09	0.39	1.000	0.68	7.32
Site	4	2.00	Fine Sand	8.50	16	10.00	18.0	144.3	69.8	1.00	0.95	1.00	67	1.12	1.20	20	8	0.15	175	0.83	0.21	0.18	0.84	0.424	0.58	17.45
F-10, K-K'	5	2.00	Fine Sand	10.50	17	12.00	18.0	180.3	86.2	1.00	1.00	1.00	67	1.12	1.08	20	8	0.15	175	0.76	0.20	0.17	0.86	0.375	0.48	17.58
Data Class	6	2.00	Fine Sand	12.50	17	14.00	18.0	216.3	102.6	1.00	1.00	1.00	67	1.12	0.99	19	8	0.15	175	0.71	0.18	0.14	0.78	0.587	0.38	15.96
	7	2.00	Medium Sand	14.50	38	16.00	19.0	253.3	120.0	1.00	1.00	1.00	67	1.12	0.91	39	5	0.35	225	0.66	0.17	0.61	3.54	0.000	0.28	42.96
B. H.	8	2.00	Medium Sand	16.50	43	18.00	19.0	291.3	138.4	1.00	1.00	1.00	67	1.12	0.85	41	5	0.35	225	0.64	0.17	0.69	4.15	0.000	0.18	43.52
212	9	2.00	Fine Sand	18.50	47	20.00	19.0	329.3	156.7	1.00	1.00	1.00	67	1.12	0.80	42	8	0.15	225	0.63	0.16	0.76	4.70	0.000	0.08	44.00
GWT (m)	10	2.00	Fine Sand	20.50	37	22.00	19.0	367.3	175.1	1.00	1.00	1.00	67	1.12	0.76	31	8	0.15	225	0.62	0.16	0.32	2.02	0.000	0.00	41.05
0.91	11																									
a_{max} (g)	12																									
0.19	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
67	19																									
N (mean)	20																									
23.5	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
182	25																									
Observed (cm)	26																									
205	27																									
Distance (m)	28																									
336.6	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	20.59																							6.43	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	2.59	Medium Sand	2.50	4	4.00	16.5	39.9	24.3	1.00	0.75	1.00	67	1.12	2.00	7	5	0.35	150	0.98	0.20	0.08	0.41	1.000	0.88	4.53
Mw	2	2.00	Medium Sand	4.50	9	6.00	18.0	74.4	39.2	1.00	0.85	1.00	67	1.12	1.60	14	5	0.35	175	0.95	0.22	0.12	0.55	0.973	0.78	10.68
7.5	3	2.00	Silty Sand	6.50	11	8.00	18.0	110.4	55.5	1.00	0.95	1.00	67	1.12	1.34	16	30	0.16	175	0.91	0.22	0.16	0.72	0.719	0.68	15.31
Site	4	2.00	Medium Sand	8.50	17	10.00	18.0	146.4	71.9	1.00	0.95	1.00	67	1.12	1.18	21	5	0.35	200	0.84	0.21	0.19	0.87	0.356	0.58	17.98
F-10, K-K'	5	2.00	Coarse Sand	10.50	12	12.00	18.0	182.4	88.3	1.00	1.00	1.00	67	1.12	1.06	14	3	0.60	175	0.78	0.20	0.10	0.51	0.989	0.48	11.28
Data Class	6	2.00	Coarse Sand	12.50	11	14.00	18.0	218.4	104.7	1.00	1.00	1.00	67	1.12	0.98	12	3	0.60	175	0.72	0.19	0.08	0.44	0.999	0.38	9.05
	7	2.00	Medium Sand	14.50	36	16.00	19.0	255.4	122.1	1.00	1.00	1.00	67	1.12	0.91	36	5	0.35	225	0.68	0.17	0.51	2.91	0.000	0.28	42.31
B. H.	8	2.00	Medium Sand	16.50	43	18.00	19.0	293.4	140.4	1.00	1.00	1.00	67	1.12	0.84	41	5	0.35	225	0.65	0.17	0.67	4.00	0.000	0.18	43.44
213	9	2.00	Fine Sand	18.50	50	20.00	19.0	331.4	158.8	1.00	1.00	1.00	67	1.12	0.79	44	8	0.15	225	0.64	0.16	0.91	5.57	0.000	0.08	44.65
GWT (m)	10	2.00	Fine Sand	20.50	40	22.00	19.0	369.4	177.2	1.00	1.00	1.00	67	1.12	0.75	34	8	0.15	225	0.63	0.16	0.39	2.38	0.000	0.00	41.69
0.91	11																									
a_{max} (g)	12																									
0.19	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
67	19																									
N (mean)	20																									
23.3	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
186	25																									
Observed (cm)	26																									
205	27																									
Distance (m)	28																									
266.7	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	20.59																							6.84	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	1.09	Fine Sand	1.50	3	3.00	16.5	23.4	17.6	1.00	0.75	1.00	67	1.12	2.00	5	8	0.15	150	0.99	0.16	0.08	0.50	0.992	0.93	3.73
Mw	2	1.50	Medium Sand	2.50	3	4.00	16.5	39.9	24.3	1.00	0.75	1.00	67	1.12	2.00	5	5	0.35	150	0.97	0.20	0.07	0.37	1.000	0.88	3.63
7.5	3	2.00	Medium Sand	4.50	3	6.00	16.5	72.9	37.7	1.00	0.85	1.00	67	1.12	1.63	5	5	0.35	150	0.94	0.22	0.06	0.28	1.000	0.78	3.45
Site	4	2.00	Medium Sand	6.50	9	8.00	18.0	107.4	52.5	1.00	0.95	1.00	67	1.12	1.38	13	5	0.35	175	0.88	0.22	0.11	0.49	0.993	0.68	10.21
F-10, K-K'	5	2.00	Medium Sand	8.50	11	10.00	18.0	143.4	68.9	1.00	0.95	1.00	67	1.12	1.20	14	5	0.35	175	0.81	0.21	0.11	0.52	0.986	0.58	11.08
Data Class	6	2.00	Medium Sand	10.50	11	12.00	18.0	179.4	85.3	1.00	1.00	1.00	67	1.12	1.08	13	5	0.35	175	0.74	0.19	0.10	0.50	0.991	0.48	10.34
	7	2.00	Medium Sand	12.50	9	14.00	16.5	213.9	100.2	1.00	1.00	1.00	67	1.12	1.00	10	5	0.35	150	0.68	0.18	0.07	0.40	1.000	0.38	7.08
B. H.	8	2.00	Medium Sand	14.50	20	16.00	18.0	248.4	115.1	1.00	1.00	1.00	67	1.12	0.93	21	5	0.35	200	0.64	0.17	0.16	0.92	0.268	0.28	17.57
214	9	2.00	Fine Sand	16.50	47	18.00	19.0	285.4	132.4	1.00	1.00	1.00	67	1.12	0.87	46	8	0.15	225	0.62	0.16	1.06	6.46	0.000	0.18	45.01
GWT (m)	10	2.00	Fine Sand	18.50	45	20.00	19.0	323.4	150.8	1.00	1.00	1.00	67	1.12	0.81	41	8	0.15	225	0.61	0.16	0.71	4.44	0.000	0.08	43.72
0.91	11	2.00	Fine Sand	20.50	42	22.00	19.0	361.4	169.2	1.00	1.00	1.00	67	1.12	0.77	36	8	0.15	225	0.60	0.16	0.47	3.00	0.000	0.00	42.38
a_{max} (g)	12																									
0.19	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
67	19																									
N (mean)	20																									
18.5	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
176	25																									
Observed (cm)	26																									
205	27																									
Distance (m)	28																									
279.4	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	20.59																							8.18	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N^d	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	0.34	Fine Sand	1.00	3	2.50	16.5	15.1	14.3	1.00	0.75	1.00	67	1.12	2.00	5	8	0.15	150	0.99	0.13	0.09	0.66	0.851	0.95	3.73
Mw	2	0.50	Silty Clay	1.50	3	3.00	16.5	23.4	17.6	1.00	0.75	1.00	67	1.12	2.00	5	35	0.02	150	0.98	0.16	0.09	0.57	0.000	0.00	Non-Liq.
7.5	3	0.75	Fine Sand	2.00	2	3.50	15.5	31.4	20.7	1.00	0.75	1.00	67	1.12	2.00	3	8	0.15	125	0.97	0.18	0.07	0.37	1.000	0.90	2.98
Site	4	1.00	Silty Sand	3.00	1	4.50	15.5	46.9	26.4	1.00	0.85	1.00	67	1.12	1.95	2	35	0.07	125	0.95	0.21	0.06	0.30	1.000	0.85	2.98
F-10, K-K'	5	1.00	Silt	4.00	2	5.50	15.5	62.4	32.1	1.00	0.85	1.00	67	1.12	1.77	3	35	0.03	125	0.93	0.22	0.07	0.30	0.000	0.00	Non-Liq.
Data Class	6	1.00	Fine Sand	5.00	6	6.50	16.5	78.4	38.3	1.00	0.95	1.00	67	1.12	1.62	10	8	0.15	150	0.90	0.23	0.10	0.43	0.999	0.75	7.60
	7	1.00	Fine Sand	6.00	6	7.50	16.5	94.9	45.0	1.00	0.95	1.00	67	1.12	1.49	9	8	0.15	150	0.87	0.23	0.09	0.39	1.000	0.70	6.79
B. H.	8	1.00	Fine Sand	7.00	9	8.50	18.0	112.1	52.4	1.00	0.95	1.00	67	1.12	1.38	13	8	0.15	175	0.83	0.22	0.11	0.51	0.989	0.65	10.53
215	9	1.00	Fine Sand	8.00	12	9.50	18.0	130.1	60.6	1.00	0.95	1.00	67	1.12	1.28	16	8	0.15	175	0.79	0.21	0.14	0.65	0.855	0.60	13.66
GWT (m)	10	1.00	Fine Sand	9.00	14	10.50	18.0	148.1	68.8	1.00	1.00	1.00	67	1.12	1.21	19	8	0.15	175	0.75	0.20	0.16	0.80	0.516	0.55	16.07
0.91	11	1.00	Fine Sand	10.00	12	11.50	18.0	166.1	77.0	1.00	1.00	1.00	67	1.12	1.14	15	8	0.15	175	0.71	0.19	0.12	0.62	0.908	0.50	12.60
a_{max} (g)	12	1.00	Fine Sand	11.00	8	12.50	16.5	183.4	84.4	1.00	1.00	1.00	67	1.12	1.09	10	8	0.15	150	0.68	0.18	0.07	0.41	1.000	0.45	7.02
0.19	13	1.00	Fine Sand	12.00	21	13.50	18.0	200.6	91.8	1.00	1.00	1.00	67	1.12	1.04	24	8	0.15	200	0.65	0.18	0.23	1.30	0.010	0.40	39.18
Sampler[b]	14	1.00	Fine Sand	13.00	29	14.50	19.0	219.1	100.5	1.00	1.00	1.00	67	1.12	1.00	32	8	0.15	225	0.63	0.17	0.41	2.40	0.000	0.35	41.34
NA	15	1.00	Fine Sand	14.00	15	15.50	18.0	237.6	109.2	1.00	1.00	1.00	67	1.12	0.96	16	8	0.15	175	0.62	0.17	0.11	0.69	0.795	0.30	13.34
B.H. Diam. (mm)	16	1.00	Fine Sand	15.00	22	16.50	18.0	255.6	117.4	1.00	1.00	1.00	67	1.12	0.92	23	8	0.15	200	0.60	0.16	0.19	1.15	0.043	0.25	38.69
95	17	1.00	Fine Sand	16.00	31	17.50	19.0	274.1	126.1	1.00	1.00	1.00	67	1.12	0.89	31	8	0.15	225	0.59	0.16	0.34	2.16	0.000	0.20	40.94
Energy Ratio[c]	18	1.00	Fine Sand	17.00	31	18.50	18.0	292.6	134.8	1.00	1.00	1.00	67	1.12	0.86	30	8	0.15	200	0.58	0.16	0.31	1.99	0.000	0.15	40.66
67	19	1.00	Fine Sand	18.00	27	19.50	18.0	310.6	143.0	1.00	1.00	1.00	67	1.12	0.84	25	8	0.15	200	0.58	0.16	0.21	1.38	0.004	0.10	39.39
N (mean)	20	1.00	Fine Sand	19.00	23	20.50	18.0	328.6	151.2	1.00	1.00	1.00	67	1.12	0.81	21	8	0.15	200	0.58	0.15	0.15	0.98	0.178	0.05	38.20
13.8	21	1.00	Silty Clay	20.00	13	21.50	18.0	346.6	159.4	1.00	1.00	1.00	67	1.12	0.79	11	35	0.02	175	0.57	0.15	0.09	0.57	0.000	0.00	Non-Liq.
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
167	25																									
Observed (cm)	26																									
112	27																									
Distance (m)	28																									
209.5	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	19.59																							5.86	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	0.76	C to M Sand	3.00	10	4.50	18.0	48.5	46.0	1.00	0.85	1.00	67	1.12	1.47	14	0	0.50	175	0.97	0.13	0.12	0.91	0.280	0.85	11.03
Mw	2	1.00	C to M Sand	4.00	6	5.50	16.5	65.8	53.4	1.00	0.85	1.00	67	1.12	1.37	8	0	0.50	150	0.96	0.15	0.07	0.48	0.995	0.80	5.23
7.5	3	1.00	C to M Sand	5.00	15	6.50	18.0	83.0	60.8	1.00	0.95	1.00	67	1.12	1.28	20	0	0.50	175	0.94	0.16	0.17	1.10	0.069	0.75	37.96
Site	4	1.00	C to M Sand	6.00	17	7.50	18.0	101.0	69.0	1.00	0.95	1.00	67	1.12	1.20	22	0	0.50	200	0.91	0.16	0.18	1.12	0.057	0.70	38.31
F-10, K-K'	5	1.00	C to M Sand	7.00	16	8.50	18.0	119.0	77.2	1.00	0.95	1.00	67	1.12	1.14	19	0	0.50	175	0.88	0.17	0.15	0.89	0.329	0.65	16.16
Data Class	6	1.00	C to M Sand	8.00	13	9.50	18.0	137.0	85.4	1.00	0.95	1.00	67	1.12	1.08	15	0	0.50	175	0.85	0.17	0.10	0.62	0.910	0.60	11.93
	7	1.00	C to M Sand	9.00	8	10.50	16.5	154.3	92.9	1.00	1.00	1.00	67	1.12	1.04	9	0	0.50	150	0.82	0.17	0.07	0.40	1.000	0.55	6.35
B. H.	8	1.00	C to M Sand	10.00	14	11.50	18.0	171.5	100.3	1.00	1.00	1.00	67	1.12	1.00	16	0	0.50	175	0.78	0.17	0.11	0.63	0.886	0.50	12.60
216	9	1.00	M to F Sand	11.00	17	12.50	18.0	189.5	108.5	1.00	1.00	1.00	67	1.12	0.96	18	7	0.25	175	0.75	0.16	0.13	0.82	0.470	0.45	15.36
GWT (m)	10	1.00	M to F Sand	12.00	18	13.50	18.0	207.5	116.7	1.00	1.00	1.00	67	1.12	0.93	19	7	0.25	175	0.72	0.16	0.13	0.85	0.409	0.40	15.72
2.74	11	1.00	M to F Sand	13.00	37	14.50	19.0	226.0	125.4	1.00	1.00	1.00	67	1.12	0.89	37	7	0.25	225	0.70	0.16	0.54	3.49	0.000	0.35	42.56
a_{max} (g)	12	1.00	M to F Sand	14.00	48	15.50	19.0	245.0	134.6	1.00	1.00	1.00	67	1.12	0.86	46	7	0.25	225	0.68	0.15	1.09	7.16	0.000	0.30	45.12
0.19	13	1.00	M to F Sand	15.00	50	16.50	19.0	264.0	143.7	1.00	1.00	1.00	67	1.12	0.83	47	7	0.25	225	0.66	0.15	1.10	7.34	0.000	0.25	45.21
Sampler[b]	14	1.00	M to F Sand	16.00	42	17.50	19.0	283.0	152.9	1.00	1.00	1.00	67	1.12	0.81	38	7	0.25	225	0.65	0.15	0.55	3.75	0.000	0.20	42.84
NA	15	1.00	M to F Sand	17.00	33	18.50	18.0	301.5	161.6	1.00	1.00	1.00	67	1.12	0.79	29	7	0.25	200	0.64	0.15	0.27	1.86	0.000	0.15	40.39
B.H. Diam. (mm)	16	1.00	Fine Sand	18.00	37	19.50	19.0	320.0	170.3	1.00	1.00	1.00	67	1.12	0.77	32	8	0.15	225	0.63	0.15	0.34	2.30	0.000	0.10	41.17
95	17	1.00	Fine Sand	19.00	28	20.50	18.0	338.5	179.0	1.00	1.00	1.00	67	1.12	0.75	23	8	0.15	200	0.63	0.15	0.17	1.19	0.028	0.05	38.88
Energy Ratio[c]	18	1.00	Fine Sand	20.00	40	21.50	19.0	357.0	187.7	1.00	1.00	1.00	67	1.12	0.73	33	8	0.15	225	0.62	0.15	0.35	2.41	0.000	0.00	41.43
67	19																									
N (mean)	20																									
24.9	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
183	25																									
Observed (cm)	26																									
112	27																									
Distance (m)	28																									
177.8	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	17.76																							3.20	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N^d	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	2.99	Sand	4.00	4	5.50	16.5	63.0	43.5	1.00	0.85	1.00	67	1.12	1.52	6	5	0.35	150	0.92	0.16	0.07	0.40	1.000	0.80	4.00
Mw	2	2.00	Sand	6.00	4	7.50	16.5	96.0	56.8	1.00	0.95	1.00	67	1.12	1.33	6	5	0.35	150	0.85	0.18	0.06	0.34	1.000	0.70	3.93
7.5	3	2.00	Sandy Clay	8.00	3	9.50	15.5	128.0	69.2	1.00	0.95	1.00	67	1.12	1.20	4	35	0.01	125	0.77	0.18	0.06	0.33	0.000	0.00	Non-Liq.
Site	4	2.00	Clayey Sand	10.00	5	11.50	16.5	160.0	81.6	1.00	1.00	1.00	67	1.12	1.11	6	35	0.16	150	0.69	0.17	0.07	0.40	1.000	0.50	5.65
G-10, L-L'	5	2.00	Sand	12.00	24	13.50	18.0	194.5	96.5	1.00	1.00	1.00	67	1.12	1.02	27	5	0.35	200	0.63	0.16	0.27	1.72	0.000	0.40	39.83
Data Class	6	2.00	Sand	14.00	11	15.50	18.0	230.5	112.9	1.00	1.00	1.00	67	1.12	0.94	12	5	0.35	175	0.60	0.15	0.08	0.52	0.987	0.30	8.61
	7	1.50	Sand	16.00	24	17.50	18.0	266.5	129.2	1.00	1.00	1.00	67	1.12	0.88	24	5	0.35	200	0.58	0.15	0.19	1.28	0.012	0.20	38.82
B. H.	8	1.00	Sand	17.00	30	18.50	18.0	284.5	137.4	1.00	1.00	1.00	67	1.12	0.85	29	5	0.35	200	0.57	0.15	0.27	1.86	0.000	0.15	40.18
219	9	1.50	Sand	18.00	32	19.50	18.0	302.5	145.6	1.00	1.00	1.00	67	1.12	0.83	30	5	0.35	200	0.56	0.14	0.29	2.00	0.000	0.10	40.47
GWT (m)	10	2.00	Clayey Sand	20.00	28	21.50	18.0	338.5	162.0	1.00	1.00	1.00	67	1.12	0.79	25	35	0.14	200	0.56	0.14	0.27	1.85	0.000	0.00	40.28
2.01	11																									
a_{max} (g)	12																									
0.19	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
67	19																									
N (mean)	20																									
16.5	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
161	25																									
Observed (cm)	26																									
151	27																									
Distance (m)	28																									
260.3	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	18.99																							5.39	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	1.49	Medium Sand	3.00	6	4.50	16.5	48.5	38.8	1.00	0.85	1.00	67	1.12	1.61	9	5	0.35	150	0.97	0.15	0.09	0.58	0.949	0.85	6.25
Mw	2	1.00	Medium Sand	4.00	14	5.50	18.0	65.7	46.2	1.00	0.85	1.00	67	1.12	1.47	20	5	0.35	175	0.95	0.17	0.18	1.10	0.065	0.80	37.72
7.5	3	1.00	Loamy Clay	5.00	3	6.50	15.5	82.5	53.2	1.00	0.95	1.00	67	1.12	1.37	4	35	0.01	125	0.93	0.18	0.06	0.36	0.000	0.00	Non-Liq.
Site	4	1.00	Medium Sand	6.00	7	7.50	16.5	98.5	59.4	1.00	0.95	1.00	67	1.12	1.30	10	5	0.35	150	0.90	0.18	0.08	0.44	0.999	0.70	6.67
G-10, L-L'	5	1.00	Coarse Sand	7.00	12	8.50	18.0	115.7	66.8	1.00	0.95	1.00	67	1.12	1.22	16	6	0.60	175	0.87	0.19	0.12	0.66	0.837	0.65	12.68
Data Class	6	1.00	M-C Sand	8.00	18	9.50	18.0	133.7	75.0	1.00	0.95	1.00	67	1.12	1.15	22	0	0.45	200	0.83	0.18	0.18	1.01	0.143	0.60	38.41
	7	1.00	M-C Sand	9.00	20	10.50	18.0	151.7	83.2	1.00	1.00	1.00	67	1.12	1.10	24	0	0.45	200	0.80	0.18	0.22	1.20	0.027	0.55	39.07
B. H.	8	1.00	M-C Sand	10.00	20	11.50	18.0	169.7	91.4	1.00	1.00	1.00	67	1.12	1.05	23	0	0.45	200	0.76	0.17	0.19	1.10	0.064	0.50	38.76
221	9	1.00	M-C Sand	11.00	24	12.50	18.0	187.7	99.6	1.00	1.00	1.00	67	1.12	1.00	27	0	0.45	200	0.73	0.17	0.25	1.44	0.002	0.45	39.72
GWT (m)	10	1.00	M-C Sand	12.00	19	13.50	18.0	205.7	107.7	1.00	1.00	1.00	67	1.12	0.96	20	0	0.45	175	0.70	0.17	0.15	0.90	0.312	0.40	17.21
2.01	11	1.00	M-C Sand	13.00	20	14.50	18.0	223.7	115.9	1.00	1.00	1.00	67	1.12	0.93	21	0	0.45	200	0.68	0.16	0.15	0.92	0.267	0.35	17.50
a_{max} (g)	12	1.00	M-C Sand	14.00	23	15.50	18.0	241.7	124.1	1.00	1.00	1.00	67	1.12	0.90	23	0	0.45	200	0.66	0.16	0.17	1.10	0.069	0.30	38.68
0.19	13	1.00	M-C Sand	15.00	25	16.50	18.0	259.7	132.3	1.00	1.00	1.00	67	1.12	0.87	24	0	0.45	200	0.64	0.16	0.19	1.20	0.027	0.25	39.01
Sampler[b]	14	1.00	M-C Sand	16.00	23	17.50	18.0	277.7	140.5	1.00	1.00	1.00	67	1.12	0.84	22	0	0.45	200	0.63	0.15	0.15	0.98	0.175	0.20	38.30
NA	15	1.00	M-C Sand	17.00	27	18.50	18.0	295.7	148.7	1.00	1.00	1.00	67	1.12	0.82	25	0	0.45	200	0.62	0.15	0.19	1.22	0.021	0.15	39.14
B.H. Diam. (mm)	16	1.00	M-C Sand	18.00	30	19.50	18.0	313.7	156.9	1.00	1.00	1.00	67	1.12	0.80	27	0	0.45	200	0.61	0.15	0.21	1.41	0.003	0.10	39.69
95	17	1.00	M-C Sand	19.00	31	20.50	18.0	331.7	165.1	1.00	1.00	1.00	67	1.12	0.78	27	0	0.45	200	0.61	0.15	0.21	1.41	0.003	0.05	39.74
Energy Ratio[c]	18	1.00	M-C Sand	20.00	32	21.50	18.0	349.7	173.3	1.00	1.00	1.00	67	1.12	0.76	27	0	0.45	200	0.61	0.15	0.21	1.42	0.003	0.00	39.80
67	19																									
N (mean)	20																									
19.7	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
178	25																									
Observed (cm)	26																									
151	27																									
Distance (m)	28																									
69.8	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	18.49																							2.91	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	0.95	Fine Sand	1.00	2	2.50	15.5	15.4	8.5	1.00	0.75	1.00	67	1.12	2.00	3	8	0.15	125	0.99	0.22	0.09	0.39	1.000	0.95	2.98
Mw	2	0.50	Clayey Silt	1.50	2	3.00	15.5	23.1	11.3	1.00	0.75	1.00	67	1.12	2.00	3	35	0.02	125	0.98	0.25	0.09	0.37	0.000	0.00	Non-Liq.
7.5	3	0.75	Sandy Silt	2.00	2	3.50	15.5	30.9	14.2	1.00	0.75	1.00	67	1.12	2.00	3	35	0.04	125	0.97	0.26	0.09	0.33	0.000	0.00	Non-Liq.
Site	4	1.00	Fine Sand	3.00	3	4.50	16.5	46.9	20.4	1.00	0.85	1.00	67	1.12	2.00	6	8	0.15	150	0.95	0.27	0.08	0.30	1.000	0.85	4.08
H-10, N-N'	5	1.00	Fine Sand	4.00	3	5.50	16.5	63.4	27.1	1.00	0.85	1.00	67	1.12	1.92	5	8	0.15	150	0.93	0.27	0.07	0.27	1.000	0.80	3.96
Data Class	6	1.00	Fine Sand	5.00	2	6.50	15.5	79.4	33.2	1.00	0.95	1.00	67	1.12	1.73	4	8	0.15	125	0.90	0.27	0.06	0.23	1.000	0.75	3.11
	7	1.00	Fine Sand	6.00	3	7.50	16.5	95.4	39.4	1.00	0.95	1.00	67	1.12	1.59	5	8	0.15	150	0.86	0.26	0.06	0.25	1.000	0.70	3.75
B. H.	8	1.00	Fine Sand	7.00	6	8.50	16.5	111.9	46.1	1.00	0.95	1.00	67	1.12	1.47	9	8	0.15	150	0.83	0.25	0.09	0.35	1.000	0.65	6.67
225	9	1.00	Fine Sand	8.00	7	9.50	16.5	128.4	52.8	1.00	0.95	1.00	67	1.12	1.38	10	8	0.15	150	0.79	0.24	0.09	0.37	1.000	0.60	7.53
GWT (m)	10	1.00	Fine Sand	9.00	6	10.50	16.5	144.9	59.5	1.00	1.00	1.00	67	1.12	1.30	9	8	0.15	150	0.75	0.22	0.08	0.34	1.000	0.55	6.08
0.3	11	1.00	M to C Sand	10.00	4	11.50	16.5	161.4	66.2	1.00	1.00	1.00	67	1.12	1.23	5	5	0.45	150	0.71	0.21	0.06	0.26	1.000	0.50	3.86
a_{max} (g)	12	1.00	Fine Sand	11.00	20	12.50	18.0	178.6	73.6	1.00	1.00	1.00	67	1.12	1.17	26	8	0.15	200	0.68	0.20	0.27	1.35	0.006	0.45	39.61
0.19	13	1.00	Fine Sand	12.00	19	13.50	18.0	196.6	81.8	1.00	1.00	1.00	67	1.12	1.11	23	8	0.15	200	0.65	0.19	0.22	1.13	0.051	0.40	38.90
Sampler[b]	14	1.00	Fine Sand	13.00	21	14.50	18.0	214.6	90.0	1.00	1.00	1.00	67	1.12	1.05	25	8	0.15	200	0.63	0.19	0.23	1.26	0.014	0.35	39.25
NA	15	1.00	Fine Sand	14.00	27	15.50	18.0	232.6	98.2	1.00	1.00	1.00	67	1.12	1.01	30	8	0.15	200	0.61	0.18	0.36	1.99	0.000	0.30	40.83
B.H. Diam. (mm)	16	1.00	Fine Sand	15.00	27	16.50	18.0	250.6	106.4	1.00	1.00	1.00	67	1.12	0.97	29	8	0.15	200	0.60	0.17	0.32	1.82	0.000	0.25	40.50
95	17	1.00	Fine Sand	16.00	22	17.50	18.0	268.6	114.6	1.00	1.00	1.00	67	1.12	0.93	23	8	0.15	200	0.59	0.17	0.19	1.12	0.055	0.20	38.77
Energy Ratio[c]	18	1.00	Fine Sand	17.00	21	18.50	18.0	286.6	122.8	1.00	1.00	1.00	67	1.12	0.90	21	8	0.15	200	0.58	0.17	0.16	0.97	0.184	0.15	38.27
67	19	1.00	Fine Sand	18.00	24	19.50	18.0	304.6	131.0	1.00	1.00	1.00	67	1.12	0.87	23	8	0.15	200	0.58	0.17	0.19	1.15	0.041	0.10	38.89
N (mean)	20	1.00	Fine Sand	19.00	35	20.50	19.0	323.1	139.7	1.00	1.00	1.00	67	1.12	0.85	33	8	0.15	225	0.57	0.16	0.40	2.42	0.000	0.05	41.56
14.0	21	1.00	Fine Sand	20.00	38	21.50	19.0	342.1	148.8	1.00	1.00	1.00	67	1.12	0.82	35	8	0.15	225	0.57	0.16	0.44	2.75	0.000	0.00	42.03
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
166	25																									
Observed (cm)	26																									
100	27																									
Distance (m)	28																									
50.8	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	20.20																							6.37	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	1.10	Medium Sand	2.00	6	3.50	16.5	30.9	25.0	1.00	0.75	1.00	67	1.12	2.00	10	5	0.35	150	0.97	0.15	0.11	0.71	0.745	0.90	7.09
Mw	2	1.00	M to C Sand	3.00	9	4.50	18.0	48.2	32.5	1.00	0.85	1.00	67	1.12	1.76	15	3	0.45	175	0.95	0.17	0.14	0.81	0.511	0.85	12.00
7.5	3	1.00	M to C Sand	4.00	6	5.50	16.5	65.4	39.9	1.00	0.85	1.00	67	1.12	1.58	9	3	0.45	150	0.93	0.19	0.08	0.45	0.998	0.80	6.14
Site	4	1.00	Coarse Sand	5.00	5	6.50	16.5	81.9	46.6	1.00	0.95	1.00	67	1.12	1.47	8	6	0.60	150	0.90	0.19	0.07	0.38	1.000	0.75	5.27
H-10, N-N'	5	1.00	Coarse Sand	6.00	5	7.50	16.5	98.4	53.3	1.00	0.95	1.00	67	1.12	1.37	7	6	0.60	150	0.86	0.20	0.07	0.35	1.000	0.70	4.93
Data Class	6	1.00	Coarse Sand	7.00	7	8.50	16.5	114.9	60.0	1.00	0.95	1.00	67	1.12	1.29	10	6	0.60	150	0.82	0.20	0.08	0.41	1.000	0.65	6.71
	7	1.00	Coarse Sand	8.00	7	9.50	16.5	131.4	66.7	1.00	0.95	1.00	67	1.12	1.22	9	6	0.60	150	0.78	0.19	0.08	0.39	1.000	0.60	6.28
B. H.	8	1.00	Coarse Sand	9.00	8	10.50	16.5	147.9	73.3	1.00	1.00	1.00	67	1.12	1.17	10	6	0.60	150	0.75	0.19	0.08	0.44	0.999	0.55	7.56
226	9	1.00	Coarse Sand	10.00	7	11.50	16.5	164.4	80.0	1.00	1.00	1.00	67	1.12	1.12	9	6	0.60	150	0.71	0.18	0.07	0.39	1.000	0.50	5.99
GWT (m)	10	1.00	Coarse Sand	11.00	9	12.50	18.0	181.7	87.5	1.00	1.00	1.00	67	1.12	1.07	11	6	0.60	175	0.68	0.17	0.08	0.45	0.998	0.45	7.88
1.4	11	1.00	Coarse Sand	12.00	9	13.50	16.5	198.9	94.9	1.00	1.00	1.00	67	1.12	1.03	10	6	0.60	150	0.65	0.17	0.07	0.44	0.999	0.40	7.45
a_{max} (g)	12	1.00	Coarse Sand	13.00	11	14.50	18.0	216.2	102.4	1.00	1.00	1.00	67	1.12	0.99	12	6	0.60	175	0.63	0.16	0.08	0.51	0.988	0.35	9.28
0.19	13	1.00	Coarse Sand	14.00	16	15.50	18.0	234.2	110.5	1.00	1.00	1.00	67	1.12	0.95	17	6	0.60	175	0.61	0.16	0.12	0.75	0.653	0.30	14.06
Sampler[b]	14	1.00	Coarse Sand	15.00	16	16.50	18.0	252.2	118.7	1.00	1.00	1.00	67	1.12	0.92	16	6	0.60	175	0.60	0.16	0.11	0.71	0.734	0.25	13.48
NA	15	1.00	Coarse Sand	16.00	16	17.50	18.0	270.2	126.9	1.00	1.00	1.00	67	1.12	0.89	16	6	0.60	175	0.59	0.15	0.11	0.68	0.802	0.20	12.95
B.H. Diam. (mm)	16	1.00	Medium Sand	17.00	41	18.50	19.0	288.7	135.6	1.00	1.00	1.00	67	1.12	0.86	39	5	0.35	225	0.58	0.15	0.62	4.05	0.000	0.15	43.11
95	17	1.00	Medium Sand	18.00	43	19.50	19.0	307.7	144.8	1.00	1.00	1.00	67	1.12	0.83	40	5	0.35	225	0.58	0.15	0.64	4.21	0.000	0.10	43.27
Energy Ratio[c]	18	1.00	Medium Sand	19.00	39	20.50	19.0	326.7	154.0	1.00	1.00	1.00	67	1.12	0.81	35	5	0.35	225	0.57	0.15	0.43	2.89	0.000	0.05	41.96
67	19	1.00	Medium Sand	20.00	38	21.50	19.0	345.7	163.2	1.00	1.00	1.00	67	1.12	0.78	33	5	0.35	225	0.57	0.15	0.37	2.48	0.000	0.00	41.45
N (mean)	20																									
15.7	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
165	25																									
Observed (cm)	26																									
75	27																									
Distance (m)	28																									
44.5	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	19.10																							7.45	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	0.76	Fine Sand	3.50	3	5.00	15.5	52.8	47.8	1.00	0.85	1.00	67	1.12	1.45	4	8	0.15	125	0.94	0.13	0.06	0.44	0.999	0.83	3.30
Mw	2	0.75	Midium Sand	4.00	11	5.50	18.0	61.1	51.2	1.00	0.85	1.00	67	1.12	1.40	15	5	0.35	175	0.93	0.14	0.12	0.89	0.317	0.80	11.61
7.5	3	1.00	Midium Sand	5.00	7	6.50	16.5	78.4	58.7	1.00	0.95	1.00	67	1.12	1.31	10	5	0.35	150	0.90	0.15	0.08	0.55	0.975	0.75	6.73
Site	4	1.00	Midium Sand	6.00	4	7.50	16.5	94.9	65.4	1.00	0.95	1.00	67	1.12	1.24	5	5	0.35	150	0.86	0.15	0.06	0.36	1.000	0.70	3.74
H-10, N-N'	5	1.00	Fine Sand	7.00	2	8.50	15.5	110.9	71.5	1.00	0.95	1.00	67	1.12	1.18	3	8	0.15	125	0.83	0.16	0.04	0.28	1.000	0.65	2.66
Data Class	6	1.00	Midium Sand	8.00	9	9.50	18.0	127.6	78.5	1.00	0.95	1.00	67	1.12	1.13	11	5	0.35	175	0.79	0.16	0.08	0.51	0.989	0.60	7.70
	7	1.00	Midium Sand	9.00	12	10.50	18.0	145.6	86.7	1.00	1.00	1.00	67	1.12	1.07	14	5	0.35	175	0.75	0.15	0.10	0.67	0.823	0.55	11.41
B. H.	8	1.00	Midium Sand	10.00	11	11.50	18.0	163.6	94.9	1.00	1.00	1.00	67	1.12	1.03	13	5	0.35	175	0.71	0.15	0.09	0.59	0.946	0.50	9.65
227	9	1.00	Midium Sand	11.00	11	12.50	18.0	181.6	103.1	1.00	1.00	1.00	67	1.12	0.99	12	5	0.35	175	0.68	0.15	0.08	0.56	0.964	0.45	9.14
GWT (m)	10	1.00	Midium Sand	12.00	13	13.50	18.0	199.6	111.2	1.00	1.00	1.00	67	1.12	0.95	14	5	0.35	175	0.65	0.14	0.09	0.64	0.877	0.40	10.79
2.99	11	1.00	Fine Sand	13.00	12	14.50	18.0	217.6	119.4	1.00	1.00	1.00	67	1.12	0.92	12	8	0.15	175	0.63	0.14	0.08	0.58	0.947	0.35	9.59
a_{max} (g)	12	1.00	Fine Sand	14.00	22	15.50	18.0	235.6	127.6	1.00	1.00	1.00	67	1.12	0.89	22	8	0.15	200	0.61	0.14	0.17	1.21	0.024	0.30	38.43
0.19	13	1.00	Fine Sand	15.00	25	16.50	18.0	253.6	135.8	1.00	1.00	1.00	67	1.12	0.86	24	8	0.15	200	0.60	0.14	0.20	1.43	0.003	0.25	39.04
Sampler[b]	14	1.00	Fine Sand	16.00	23	17.50	18.0	271.6	144.0	1.00	1.00	1.00	67	1.12	0.83	21	8	0.15	200	0.59	0.14	0.16	1.16	0.038	0.20	38.34
NA	15	1.00	Fine Sand	17.00	38	18.50	19.0	290.1	152.7	1.00	1.00	1.00	67	1.12	0.81	34	8	0.15	225	0.58	0.14	0.43	3.13	0.000	0.15	41.91
B.H. Diam. (mm)	16	1.00	Fine Sand	18.00	36	19.50	19.0	309.1	161.9	1.00	1.00	1.00	67	1.12	0.79	32	8	0.15	225	0.58	0.14	0.34	2.50	0.000	0.10	41.15
95	17	1.00	Fine Sand	19.00	33	20.50	18.0	327.6	170.6	1.00	1.00	1.00	67	1.12	0.77	28	8	0.15	200	0.57	0.14	0.26	1.90	0.000	0.05	40.22
Energy Ratio[c]	18	1.00	Fine Sand	20.00	34	21.50	18.0	345.6	178.8	1.00	1.00	1.00	67	1.12	0.75	28	8	0.15	200	0.57	0.14	0.26	1.89	0.000	0.00	40.27
67	19																									
N (mean)	20																									
17.0	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
166	25																									
Observed (cm)	26																									
100	27																									
Distance (m)	28																									
38.1	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	17.51																							5.55	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	1.51	Fine Sand	4.00	10	5.50	18.0	63.0	53.1	1.00	0.85	1.00	67	1.12	1.37	13	8	0.15	175	0.92	0.14	0.11	0.81	0.501	0.80	10.36
Mw	2	1.00	Fine Sand	5.00	3	6.50	15.5	79.8	60.1	1.00	0.95	1.00	67	1.12	1.29	4	8	0.15	125	0.89	0.15	0.05	0.36	1.000	0.75	3.30
7.5	3	1.00	Fine Sand	6.00	3	7.50	15.5	95.3	65.8	1.00	0.95	1.00	67	1.12	1.23	4	8	0.15	125	0.86	0.15	0.05	0.33	1.000	0.70	3.22
Site	4	1.00	Fine Sand	7.00	9	8.50	18.0	112.0	72.7	1.00	0.95	1.00	67	1.12	1.17	11	8	0.15	175	0.82	0.16	0.09	0.56	0.965	0.65	8.52
H-10, N-N'	5	1.00	Fine Sand	8.00	4	9.50	16.5	129.3	80.1	1.00	0.95	1.00	67	1.12	1.12	5	8	0.15	150	0.78	0.15	0.05	0.33	1.000	0.60	3.59
Data Class	6	1.00	Fine Sand	9.00	7	10.50	16.5	145.8	86.8	1.00	1.00	1.00	67	1.12	1.07	8	8	0.15	150	0.74	0.15	0.07	0.44	0.999	0.55	5.84
	7	1.00	Fine Sand	10.00	13	11.50	18.0	163.0	94.3	1.00	1.00	1.00	67	1.12	1.03	15	8	0.15	175	0.70	0.15	0.11	0.72	0.709	0.50	12.28
B. H.	8	1.00	Fine Sand	11.00	15	12.50	18.0	181.0	102.5	1.00	1.00	1.00	67	1.12	0.99	17	8	0.15	175	0.67	0.15	0.12	0.82	0.473	0.45	13.85
228	9	1.00	Fine Sand	12.00	16	13.50	18.0	199.0	110.6	1.00	1.00	1.00	67	1.12	0.95	17	8	0.15	175	0.64	0.14	0.12	0.85	0.404	0.40	14.27
GWT (m)	10	1.00	Fine Sand	13.00	26	14.50	18.0	217.0	118.8	1.00	1.00	1.00	67	1.12	0.92	27	8	0.15	200	0.62	0.14	0.25	1.80	0.000	0.35	39.78
2.99	11	1.00	Fine Sand	14.00	19	15.50	18.0	235.0	127.0	1.00	1.00	1.00	67	1.12	0.89	19	8	0.15	175	0.61	0.14	0.14	0.98	0.179	0.30	37.63
a_{max} (g)	12	1.00	Fine Sand	15.00	20	16.50	18.0	253.0	135.2	1.00	1.00	1.00	67	1.12	0.86	19	8	0.15	175	0.59	0.14	0.14	1.00	0.152	0.25	37.73
0.19	13	1.00	Fine Sand	16.00	22	17.50	18.0	271.0	143.4	1.00	1.00	1.00	67	1.12	0.84	21	8	0.15	200	0.58	0.14	0.15	1.09	0.070	0.20	38.09
Sampler[b]	14	1.00	Fine Sand	17.00	37	18.50	19.0	289.5	152.1	1.00	1.00	1.00	67	1.12	0.81	34	8	0.15	225	0.58	0.14	0.40	2.96	0.000	0.15	41.68
NA	15	1.00	Fine Sand	18.00	23	19.50	18.0	308.0	160.8	1.00	1.00	1.00	67	1.12	0.79	20	8	0.15	175	0.57	0.14	0.14	1.05	0.104	0.10	38.02
B.H. Diam. (mm)	16	1.00	Fine Sand	19.00	37	20.50	19.0	326.5	169.5	1.00	1.00	1.00	67	1.12	0.77	32	8	0.15	225	0.57	0.13	0.34	2.51	0.000	0.05	41.19
95	17	1.00	Fine Sand	20.00	40	21.50	19.0	345.5	178.7	1.00	1.00	1.00	67	1.12	0.75	33	8	0.15	225	0.56	0.13	0.38	2.82	0.000	0.00	41.65
Energy Ratio[c]	18																									
67	19																									
N (mean)	20																									
17.9	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
164	25																									
Observed (cm)	26																									
173	27																									
Distance (m)	28																									
139.7	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	17.51																							4.68	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Niigata-1964	1	2.30	Fine Sand	4.00	12	5.50	18.0	65.4	47.7	1.00	0.85	1.00	67	1.12	1.45	16	8	0.15	175	0.95	0.16	0.15	0.92	0.272	0.80	13.78
Mw	2	1.25	Fine Sand	5.00	12	6.50	18.0	83.4	55.9	1.00	0.95	1.00	67	1.12	1.34	17	8	0.15	175	0.93	0.17	0.15	0.86	0.386	0.75	14.31
7.5	3	1.50	V. Fine Sand	6.50	10	8.00	18.0	110.4	68.2	1.00	0.95	1.00	67	1.12	1.21	13	15	0.10	175	0.89	0.18	0.11	0.60	0.934	0.68	10.87
Site	4	1.50	Midium Sand	8.00	17	9.50	18.0	137.4	80.5	1.00	0.95	1.00	67	1.12	1.11	20	5	0.35	175	0.84	0.18	0.16	0.92	0.257	0.60	16.90
H-10, N-N'	5	1.50	Midium Sand	9.50	18	11.00	18.0	164.4	92.8	1.00	1.00	1.00	67	1.12	1.04	21	5	0.35	200	0.79	0.17	0.17	0.97	0.189	0.53	38.08
Data Class	6	1.50	Midium Sand	11.00	25	12.50	18.0	191.4	105.1	1.00	1.00	1.00	67	1.12	0.98	27	5	0.35	200	0.74	0.17	0.26	1.58	0.000	0.45	39.82
	7	1.50	Midium Sand	12.50	34	14.00	19.0	219.2	118.1	1.00	1.00	1.00	67	1.12	0.92	35	5	0.35	225	0.70	0.16	0.46	2.87	0.000	0.38	41.92
B. H.	8	1.50	Midium Sand	14.00	35	15.50	19.0	247.7	131.9	1.00	1.00	1.00	67	1.12	0.87	34	5	0.35	225	0.67	0.15	0.42	2.69	0.000	0.30	41.67
232	9	1.50	Midium Sand	15.50	35	17.00	19.0	276.2	145.7	1.00	1.00	1.00	67	1.12	0.83	32	5	0.35	225	0.64	0.15	0.36	2.37	0.000	0.23	41.22
GWT (m)	10																									
2.20	11																									
a_{max} (g)	12																									
0.19	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
67	19																									
N (mean)	20																									
22.0	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
180	25																									
Observed (cm)	26																									
150	27																									
Distance (m)	28																									
67.3	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	14.05																							2.19	

SEISMIC EVENT # 3

EARTHQUAKE:	Prince William Sound
MOMENT MAGNITUDE:	9.2
LOCATION:	Alaska
DATE:	March 27, 1964
REFERENCE(S):	Database of Youd et al. (2002)

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Alaska-1964	1	1.07	Silty Sand	3.05	5	4.55	16.5	46.2	43.2	1.00	0.85	1.00	65	1.08	1.52	7	35	0.08	150	0.97	0.21	0.05	0.26	1.000	0.85	6.38
Mw	2	1.53	Silty Sand	4.57	5	6.07	16.5	71.3	53.3	1.00	0.95	1.00	65	1.08	1.37	7	35	0.07	150	0.95	0.26	0.05	0.20	1.000	0.77	6.41
9.2	3	1.53	Coarse Sand	6.10	19	7.60	18.0	97.7	64.7	1.00	0.95	1.00	65	1.08	1.24	24	7	0.69	200	0.92	0.28	0.16	0.56	0.965	0.70	21.01
Site	4	1.53	Coarse Sand	7.62	22	9.12	18.0	125.0	77.2	1.00	0.95	1.00	65	1.08	1.14	26	5	1.13	200	0.88	0.29	0.16	0.57	0.959	0.62	22.05
MP 63.5	5	1.53	Coarse Sand	9.15	23	10.65	18.0	152.6	89.7	1.00	1.00	1.00	65	1.08	1.06	26	5	0.75	200	0.83	0.29	0.16	0.57	0.958	0.54	22.52
Data Class	6	1.53	Coarse Sand	10.67	29	12.17	19.0	180.7	102.9	1.00	1.00	1.00	65	1.08	0.99	31	6	0.84	225	0.79	0.28	0.23	0.81	0.497	0.47	26.60
	7	1.53	Midium Sand	12.20	20	13.70	18.0	209.0	116.2	1.00	1.00	1.00	65	1.08	0.93	20	16	0.26	175	0.76	0.27	0.11	0.38	1.000	0.39	18.20
B. H.	8	1.52	Coarse Sand	13.72	27	15.22	18.0	236.4	128.7	1.00	1.00	1.00	65	1.08	0.88	26	4	1.16	200	0.73	0.27	0.14	0.52	0.986	0.31	22.06
5	9	1.53	Silty Sand	15.24	53	16.74	19.0	264.5	141.9	1.00	1.00	1.00	65	1.08	0.84	48	35	0.05	225	0.71	0.27	1.33	4.97	0.000	0.24	47.48
GWT (m)	10	1.53	Fine Sand	16.77	55	18.27	19.0	293.6	155.9	1.00	1.00	1.00	65	1.08	0.80	48	27	0.09	225	0.70	0.26	1.07	4.05	0.000	0.16	46.82
2.74	11																									
a_{max} (g)	12																									
0.31	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
65	19																									
N (mean)	20																									
25.8	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
178	25																									
Observed (cm)	26																									
185	27																									
Distance (m)	28																									
85.4	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	14.80																							6.22	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Alaska-1964	1	1.91	Sand	1.22	15	2.72	18.0	22.0	10.0	1.00	0.75	1.00	45	0.75	2.00	17	8	0.69	175	0.99	0.30	0.15	0.50	0.991	0.94	14.16
Mw	2	1.68	Coarse Sand	2.59	13	4.09	18.0	46.6	21.2	1.00	0.85	1.00	45	0.75	2.00	17	3	2.28	175	0.99	0.30	0.11	0.38	1.000	0.87	13.54
9.2	3	1.53	Sand	4.57	9	6.07	16.5	80.8	35.9	1.00	0.95	1.00	45	0.75	1.67	10	6	0.84	150	0.97	0.30	0.06	0.21	1.000	0.77	7.59
Site	4	1.38	Coarse Sand	5.64	11	7.14	18.0	99.2	43.9	1.00	0.95	1.00	45	0.75	1.51	12	2	1.96	175	0.95	0.29	0.06	0.22	1.000	0.72	8.87
MP 148.3	5	1.60	Silt	7.32	12	8.82	18.0	129.5	57.7	1.00	0.95	1.00	45	0.75	1.32	11	34	0.04	175	0.92	0.28	0.07	0.25	1.000	0.00	Non-Liq.
Data Class	6	1.53	Silt	8.84	23	10.34	18.0	156.8	70.1	1.00	1.00	1.00	45	0.75	1.19	21	34	0.04	200	0.89	0.27	0.15	0.56	0.969	0.00	Non-Liq.
	7	1.60	Silt	10.37	27	11.87	18.0	184.4	82.6	1.00	1.00	1.00	45	0.75	1.10	22	30	0.04	200	0.85	0.26	0.16	0.61	0.915	0.00	Non-Liq.
B. H.	8	1.60	Silty Sand	12.04	45	13.54	19.0	215.3	97.2	1.00	1.00	1.00	45	0.75	1.01	34	35	0.10	225	0.81	0.25	0.45	1.81	0.000	0.40	43.23
15	9	1.53	Sand	13.57	54	15.07	19.0	244.3	111.2	1.00	1.00	1.00	45	0.75	0.95	38	12	0.23	225	0.79	0.24	0.43	1.83	0.000	0.32	43.24
GWT (m)	10	1.45	Coarse Sand	15.09	32	16.59	18.0	272.5	124.4	1.00	1.00	1.00	45	0.75	0.90	22	5	1.19	200	0.77	0.23	0.10	0.45	0.998	0.25	18.21
0.00	11	1.45	Sand	16.46	27	17.96	18.0	297.1	135.6	1.00	1.00	1.00	45	0.75	0.86	17	0	0.26	175	0.75	0.23	0.07	0.31	1.000	0.18	14.32
a_{max} (g)	12	1.15	Silty Sand	17.99	22	19.49	18.0	324.7	148.2	1.00	1.00	1.00	45	0.75	0.82	14	26	0.20	175	0.74	0.22	0.06	0.28	1.000	0.10	12.69
0.21	13	0.76	Silty Sand	18.75	24	20.25	18.0	338.3	154.4	1.00	1.00	1.00	45	0.75	0.80	14	20	0.30	175	0.74	0.22	0.06	0.29	1.000	0.06	13.06
Sampler[b]	14	0.61	Coarse Sand	19.51	29	21.01	18.0	352.0	160.6	1.00	1.00	1.00	45	0.75	0.79	17	6	0.54	175	0.74	0.22	0.07	0.31	1.000	0.02	14.22
NA	15	0.84	Sandy Silt	19.97	59	21.47	19.0	360.5	164.6	1.00	1.00	1.00	45	0.75	0.78	34	35	0.05	225	0.74	0.22	0.39	1.78	0.000	0.00	Non-Liq.
B.H. Diam. (mm)	16	1.30	Silty Sand	21.19	58	22.69	19.0	383.7	175.8	1.00	1.00	1.00	45	0.75	0.75	33	18	0.22	225	0.73	0.22	0.27	1.22	0.022	0.00	41.97
95	17	1.45	Silt	22.56	53	24.06	18.0	409.1	187.7	1.00	1.00	1.00	45	0.75	0.73	29	35	0.05	200	0.73	0.22	0.24	1.10	0.066	0.00	Non-Liq.
Energy Ratio[c]	18	1.53	Sandy Silt	24.09	46	25.59	18.0	436.6	200.3	1.00	1.00	1.00	45	0.75	0.71	24	35	0.07	200	0.72	0.21	0.16	0.73	0.689	0.00	Non-Liq.
45	19																									
N (mean)	20																									
31.0	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
189	25																									
Observed (cm)	26																									
137	27																									
Distance (m)	28																									
670.7	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	24.86																							6.18	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Alaska-1964	1	1.37	Coarse Sand	0.91	6	2.41	16.5	15.0	6.1	1.00	0.75	1.00	45	0.75	2.00	7	5	2.61	150	0.99	0.33	0.08	0.23	1.000	0.95	4.56
Mw	2	0.84	Coarse Sand	1.83	4	3.33	16.5	30.2	12.2	1.00	0.75	1.00	45	0.75	2.00	5	3	1.55	150	0.98	0.33	0.05	0.16	1.000	0.91	3.38
9.2	3	0.76	Coarse Sand	2.59	11	4.09	18.0	43.3	17.9	1.00	0.85	1.00	45	0.75	2.00	14	4	1.77	175	0.97	0.32	0.10	0.31	1.000	0.87	11.05
Site	4	0.77	Coarse Sand	3.35	11	4.85	18.0	57.0	24.1	1.00	0.85	1.00	45	0.75	2.00	14	5	1.40	175	0.96	0.31	0.09	0.30	1.000	0.83	11.05
MP 147.4	5	0.77	Coarse Sand	4.12	11	5.62	18.0	70.8	30.4	1.00	0.85	1.00	45	0.75	1.81	13	4	1.49	175	0.94	0.30	0.08	0.26	1.000	0.79	9.75
Data Class	6	0.99	Coarse Sand	4.88	14	6.38	18.0	84.5	36.7	1.00	0.95	1.00	45	0.75	1.65	16	3	1.78	175	0.93	0.29	0.10	0.33	1.000	0.76	13.45
	7	0.99	Gravel	6.10	28	7.60	18.0	106.5	46.6	1.00	0.95	1.00	45	0.75	1.46	29	6	5.61	200	0.89	0.28	0.25	0.89	0.326	0.70	25.14
B. H.	8	0.76	Gravel	6.86	21	8.36	18.0	120.2	52.9	1.00	0.95	1.00	45	0.75	1.38	21	6	8.38	200	0.87	0.27	0.12	0.45	0.998	0.66	17.46
17	9	0.76	Coarse Sand	7.62	11	9.12	16.5	133.3	58.5	1.00	0.95	1.00	45	0.75	1.31	10	4	3.60	150	0.85	0.26	0.05	0.20	1.000	0.62	7.29
GWT (m)	10	0.77	Coarse Sand	8.38	5	9.88	15.5	145.4	63.2	1.00	0.95	1.00	45	0.75	1.26	4	14	2.52	125	0.83	0.26	0.04	0.14	1.000	0.58	3.65
0.00	11	1.53	Sand	9.15	30	10.65	18.0	158.3	68.6	1.00	1.00	1.00	45	0.75	1.21	27	10	0.37	200	0.80	0.25	0.20	0.79	0.556	0.54	23.93
a_{max} (g)	12	1.68	Sand	11.43	25	12.93	18.0	199.4	87.2	1.00	1.00	1.00	45	0.75	1.07	20	9	0.29	175	0.74	0.23	0.11	0.46	0.998	0.43	17.35
0.21	13	1.15	Sand	12.50	9	14.00	16.5	217.8	95.2	1.00	1.00	1.00	45	0.75	1.02	7	5	0.37	150	0.72	0.23	0.04	0.16	1.000	0.38	4.66
Sampler[b]	14	1.37	Sand	13.72	8	15.22	16.5	238.0	103.4	1.00	1.00	1.00	45	0.75	0.98	6	15	0.30	150	0.71	0.22	0.03	0.16	1.000	0.31	4.48
NA	15	1.53	Sand	15.24	14	16.74	16.5	263.0	113.5	1.00	1.00	1.00	45	0.75	0.94	10	8	0.32	150	0.69	0.22	0.04	0.20	1.000	0.24	7.16
B.H. Diam. (mm)	16	1.53	Silty Sand	16.77	43	18.27	18.0	289.4	124.9	1.00	1.00	1.00	45	0.75	0.89	29	35	2.75	200	0.68	0.22	0.26	1.22	0.022	0.16	41.59
95	17	1.53	Clayey Silt	18.29	18	19.79	18.0	316.8	137.4	1.00	1.00	1.00	45	0.75	0.85	12	35	0.03	175	0.67	0.21	0.06	0.27	1.000	0.00	Non-Liq.
Energy Ratio[c]	18	1.53	Silty Sand	19.82	14	21.32	16.5	343.2	148.8	1.00	1.00	1.00	45	0.75	0.82	9	17	0.22	150	0.67	0.21	0.04	0.19	1.000	0.01	6.64
45	19	1.53	Sand	21.34	32	22.84	18.0	369.4	160.1	1.00	1.00	1.00	45	0.75	0.79	19	10	0.24	175	0.66	0.21	0.08	0.40	1.000	0.00	16.42
N (mean)	20	1.53	Silty Sand	22.87	14	24.37	16.5	395.8	171.4	1.00	1.00	1.00	45	0.75	0.76	8	35	0.11	150	0.66	0.21	0.04	0.20	1.000	0.00	7.47
17.5	21	1.52	Silty Sand	24.39	32	25.89	18.0	422.0	182.8	1.00	1.00	1.00	45	0.75	0.74	18	16	0.22	175	0.65	0.20	0.08	0.38	1.000	0.00	15.92
γ_{dry} (kN/m^3)	22	1.52	Silty Sand	25.91	25	27.41	18.0	449.4	195.2	1.00	1.00	1.00	45	0.75	0.72	13	35	0.10	175	0.64	0.20	0.06	0.31	1.000	0.00	13.44
16.0	23																									
Vs* (m/s)	24																									
166	25																									
Observed (cm)	26																									
30	27																									
Distance (m)	28																									
289.6	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	26.67																							8.78	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Alaska-1964	1	1.07	Sand	0.61	3	2.11	15.5	9.5	3.5	1.00	0.75	1.00	45	0.75	2.00	3	2	1.73	125	1.00	0.37	0.07	0.18	1.000	0.97	2.91
Mw	2	1.22	Sand	1.52	2	3.02	15.5	23.6	8.6	1.00	0.75	1.00	45	0.75	2.00	2	2	1.55	125	0.99	0.37	0.05	0.13	1.000	0.92	2.51
9.2	3	1.53	Coarse Sand	3.05	9	4.55	18.0	49.2	19.3	1.00	0.85	1.00	45	0.75	2.00	11	5	2.18	175	0.98	0.34	0.08	0.24	1.000	0.85	8.52
Site	4	1.07	Coarse Sand	4.57	18	6.07	18.0	76.5	31.7	1.00	0.95	1.00	45	0.75	1.78	23	5	2.50	200	0.96	0.32	0.17	0.53	0.983	0.77	19.37
MP 147.5	5	1.53	Coarse Sand	5.18	51	6.68	19.0	87.8	37.0	1.00	0.95	1.00	45	0.75	1.64	60	12	3.57	225	0.95	0.31	3.14	10.22	0.000	0.74	49.21
Data Class	6	1.99	Fine Sand	7.62	17	9.12	18.0	133.0	58.2	1.00	0.95	1.00	45	0.75	1.31	16	8	0.26	175	0.90	0.28	0.08	0.30	1.000	0.62	13.19
	7	1.99	Silt	9.15	9	10.65	16.5	159.4	69.6	1.00	1.00	1.00	45	0.75	1.20	8	35	0.06	150	0.86	0.27	0.05	0.20	1.000	0.00	Non-Liq.
B. H.	8	2.03	Fine Sand	11.59	43	13.09	19.0	202.7	89.0	1.00	1.00	1.00	45	0.75	1.06	34	10	0.35	225	0.80	0.25	0.32	1.29	0.010	0.42	41.96
18	9	1.32	Gravel	13.20	29	14.70	18.0	232.5	103.0	1.00	1.00	1.00	45	0.75	0.99	21	10	1.62	200	0.77	0.24	0.11	0.48	0.995	0.34	18.75
GWT (m)	10	1.79	Gravel	14.23	29	15.73	18.0	251.0	111.4	1.00	1.00	1.00	45	0.75	0.95	21	10	1.62	200	0.75	0.23	0.10	0.45	0.998	0.29	17.97
0.00	11	2.34	Sand	16.77	44	18.27	18.0	296.7	132.2	1.00	1.00	1.00	45	0.75	0.87	29	12	0.35	200	0.73	0.22	0.19	0.86	0.385	0.16	25.52
a_{max} (g)	12	1.83	Silty Sand	18.90	44	20.40	18.0	335.1	149.7	1.00	1.00	1.00	45	0.75	0.82	27	35	0.17	200	0.72	0.22	0.21	0.97	0.190	0.06	41.01
0.21	13	1.53	Silty Sand	20.43	76	21.93	19.0	363.4	162.9	1.00	1.00	1.00	45	0.75	0.78	45	25	0.20	225	0.71	0.22	0.79	3.66	0.000	0.00	45.79
Sampler[b]	14	1.68	Silty Sand	21.95	30	23.45	18.0	391.5	176.2	1.00	1.00	1.00	45	0.75	0.75	17	26	0.19	175	0.71	0.21	0.08	0.37	1.000	0.00	16.22
NA	15	1.68	Silty Sand	23.78	32	25.28	18.0	424.4	191.1	1.00	1.00	1.00	45	0.75	0.72	17	30	0.18	175	0.70	0.21	0.08	0.39	1.000	0.00	17.07
B.H. Diam. (mm)	16	1.53	Sandy Silt	25.30	49	26.80	18.0	451.8	203.6	1.00	1.00	1.00	45	0.75	0.70	26	35	0.07	200	0.69	0.21	0.18	0.84	0.429	0.00	Non-Liq.
95	17	1.53	Sandy Silt	26.83	26	28.33	18.0	479.3	216.1	1.00	1.00	1.00	45	0.75	0.68	13	35	0.05	175	0.68	0.21	0.06	0.29	1.000	0.00	Non-Liq.
Energy Ratio[c]	18	1.53	Silty Sand	28.35	29	29.85	18.0	506.7	228.6	1.00	1.00	1.00	45	0.75	0.66	14	35	0.16	175	0.68	0.20	0.06	0.31	1.000	0.00	14.48
45	19	1.53	Sandy Silt	29.88	31	31.38	18.0	534.2	241.1	1.00	1.00	1.00	45	0.75	0.64	15	35	0.10	175	0.67	0.20	0.07	0.33	1.000	0.00	Non-Liq.
N (mean)	20																									
30.1	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
182	25																									
Observed (cm)	26																									
30	27																									
Distance (m)	28																									
304.9	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	30.65																							6.62	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Alaska-1964	1	2.29	Silt	1.52	14	3.02	18.0	27.4	12.4	1.00	0.75	1.00	45	0.75	2.00	16	35	0.05	175	0.99	0.44	0.16	0.37	0.000	0.00	Non-Liq.
Mw	2	1.68	Sandy Gravel	3.05	14	4.55	18.0	54.9	25.0	1.00	0.85	1.00	45	0.75	2.00	18	2	1.84	175	0.99	0.44	0.12	0.27	1.000	0.85	14.77
9.2	3	1.83	Sandy Gravel	4.88	20	6.38	18.0	87.8	40.0	1.00	0.95	1.00	45	0.75	1.58	23	2	1.84	200	0.97	0.43	0.15	0.35	1.000	0.76	19.15
Site	4	1.37	Sandy Gravel	6.71	28	8.21	18.0	120.8	55.0	1.00	0.95	1.00	45	0.75	1.35	27	2	1.84	200	0.94	0.42	0.19	0.45	0.998	0.66	23.04
MP 64.7	5	1.22	Sandy Silt	7.62	39	9.12	19.0	137.6	62.9	1.00	0.95	1.00	45	0.75	1.26	35	35	0.05	225	0.93	0.41	0.54	1.32	0.000	0.00	Non-Liq.
Data Class	6	1.68	Silty Sand	9.15	29	10.65	18.0	165.9	76.2	1.00	1.00	1.00	45	0.75	1.15	25	10	1.01	200	0.89	0.39	0.16	0.41	1.000	0.54	21.95
	7	1.53	Silty Sand	10.98	19	12.48	18.0	198.9	91.1	1.00	1.00	1.00	45	0.75	1.05	15	14	0.69	175	0.85	0.37	0.07	0.20	1.000	0.45	12.88
B. H.	8	1.52	Silty Sand	12.20	33	13.70	18.0	220.8	101.1	1.00	1.00	1.00	45	0.75	0.99	25	2	1.58	200	0.82	0.36	0.13	0.37	1.000	0.39	21.02
20	9	3.20	Sand	14.02	51	15.52	19.0	254.5	117.0	1.00	1.00	1.00	45	0.75	0.92	35	7	0.33	225	0.79	0.35	0.31	0.90	0.305	0.30	30.24
GWT (m)	10																									
0.00	11																									
a_{max} (g)	12																									
0.31	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
45	19																									
N (mean)	20																									
27.4	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
196	25																									
Observed (cm)	26																									
157	27																									
Distance (m)	28																									
97.6	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	16.31																							6.20	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Alaska-1964	1	2.29	Silty Sand	1.52	14	3.02	18.0	27.4	12.4	1.00	0.75	1.00	45	0.75	2.00	16	20	0.10	175	0.99	0.44	0.14	0.32	1.000	0.92	14.35
Mw	2	2.29	Silty Sand	3.05	14	4.55	18.0	54.9	25.0	1.00	0.85	1.00	45	0.75	2.00	18	4	2.97	175	0.98	0.44	0.12	0.28	1.000	0.85	14.77
9.2	3	3.05	Silty Sand	6.10	26	7.60	18.0	109.8	50.0	1.00	0.95	1.00	45	0.75	1.41	26	4	1.75	200	0.95	0.42	0.19	0.45	0.998	0.70	22.43
Site	4	3.05	Silty Sand	9.15	33	10.65	18.0	164.7	74.9	1.00	1.00	1.00	45	0.75	1.16	29	6	0.99	200	0.89	0.39	0.21	0.53	0.983	0.54	24.62
MP 64.7	5	3.05	Silty Sand	12.20	36	13.70	18.0	219.6	99.9	1.00	1.00	1.00	45	0.75	1.00	27	20	0.25	200	0.81	0.36	0.20	0.55	0.970	0.39	25.11
Data Class	6	3.05	Sandy Silt	15.24	92	16.74	19.0	275.8	126.3	1.00	1.00	1.00	45	0.75	0.89	61	35	0.10	225	0.77	0.34	4.23	12.58	0.000	0.00	Non-Liq.
	7	3.05	Sandy Silt	18.29	18	19.79	18.0	332.3	152.8	1.00	1.00	1.00	45	0.75	0.81	11	35	0.04	175	0.74	0.32	0.05	0.16	0.000	0.00	Non-Liq.
B. H.	8	3.05	Sandy Silt	21.34	55	22.84	19.0	388.7	179.3	1.00	1.00	1.00	45	0.75	0.75	31	35	0.05	225	0.73	0.32	0.28	0.88	0.000	0.00	Non-Liq.
23	9	3.05	Sandy Silt	24.39	34	25.89	18.0	445.1	205.8	1.00	1.00	1.00	45	0.75	0.70	18	35	0.03	175	0.71	0.31	0.09	0.28	0.000	0.00	Non-Liq.
GWT (m)	10																									
0.00	11																									
a_{max} (g)	12																									
0.31	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
45	19																									
N (mean)	20																									
35.8	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
194	25																									
Observed (cm)	26																									
157	27																									
Distance (m)	28																									
219.5	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	25.92																							8.95	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Alaska-1964	1	2.05	Gravel + Sand	5.70	10	7.20	16.5	91.8	79.3	1.00	0.95	1.00	45	0.75	1.12	8	20	1.80	150	0.92	0.21	0.05	0.21	1.000	0.72	6.30
Mw	2	1.53	Gravel + Sand	7.23	13	8.73	16.5	117.1	89.5	1.00	0.95	1.00	45	0.75	1.06	10	20	1.80	150	0.87	0.23	0.05	0.22	1.000	0.64	8.15
9.2	3	1.22	Silty Sand	8.75	21	10.25	18.0	143.3	100.8	1.00	1.00	1.00	45	0.75	1.00	16	35	0.09	175	0.83	0.24	0.09	0.38	1.000	0.56	15.86
Site	4	2.75	Silty Sand	9.66	27	11.16	18.0	159.7	108.3	1.00	1.00	1.00	45	0.75	0.96	19	35	0.09	175	0.80	0.24	0.12	0.51	0.988	0.52	19.77
MP 64.7	5	4.43	Silty Sand	14.24	35	15.74	18.0	242.1	145.8	1.00	1.00	1.00	45	0.75	0.83	22	35	0.09	200	0.71	0.24	0.14	0.58	0.952	0.29	22.05
Data Class	6	3.66	Silty Sand	18.51	41	20.01	18.0	319.0	180.8	1.00	1.00	1.00	45	0.75	0.74	23	35	0.09	200	0.68	0.24	0.14	0.59	0.941	0.07	23.15
	7	3.81	Silty Clay	21.55	27	23.05	18.0	373.7	205.7	1.00	1.00	1.00	45	0.75	0.70	14	35	0.00	175	0.66	0.24	0.06	0.27	0.000	0.00	Non-Liq.
B. H.	8	3.20	Silty Clay	26.13	37	27.63	18.0	456.1	243.2	1.00	1.00	1.00	45	0.75	0.64	18	35	0.01	175	0.64	0.24	0.08	0.35	0.000	0.00	Non-Liq.
24	9																									
GWT (m)	10																									
4.42	11																									
a_{max} (g)	12																									
0.31	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
45	19																									
N (mean)	20																									
26.4	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
173	25																									
Observed (cm)	26																									
157	27																									
Distance (m)	28																									
54.9	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	22.62																							5.99	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Alaska-1964	1	3.36	Sandy Silt	4.57	18	6.07	18.0	76.8	58.8	1.00	0.95	1.00	45	0.75	1.30	17	35	0.07	175	0.97	0.25	0.11	0.45	0.998	0.00	Non-Liq.
Mw	2	3.05	Sandy Silt	7.62	18	9.12	18.0	131.7	83.8	1.00	0.95	1.00	45	0.75	1.09	14	35	0.07	175	0.91	0.29	0.08	0.29	1.000	0.00	Non-Liq.
9.2	3	3.05	Silty Sand	10.67	36	12.17	18.0	186.6	108.8	1.00	1.00	1.00	45	0.75	0.96	26	4	1.38	200	0.84	0.29	0.15	0.51	0.988	0.47	22.15
Site	4	3.05	Silty Sand	13.72	64	15.22	19.0	243.0	135.3	1.00	1.00	1.00	45	0.75	0.86	41	4	1.38	225	0.77	0.28	0.45	1.61	0.000	0.31	43.64
MP 63.0	5	3.05	Sandy Gravel	16.77	44	18.27	18.0	299.4	161.8	1.00	1.00	1.00	45	0.75	0.79	26	0	4.75	200	0.74	0.28	0.13	0.46	0.997	0.16	22.20
Data Class	6	3.05	Sandy Gravel	19.82	130	21.32	19.0	355.9	188.3	1.00	1.00	1.00	45	0.75	0.73	71	10	3.00	225	0.72	0.28	4.63	16.81	0.000	0.01	52.21
	7																									
B. H.	8																									
25	9																									
GWT (m)	10																									
2.74	11																									
a_{max} (g)	12																									
0.31	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
45	19																									
N (mean)	20																									
51.7	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
190	25																									
Observed (cm)	26																									
191	27																									
Distance (m)	28																									
21.3	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	18.61																							1.90	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Alaska-1964	1	1.37	Sand	1.83	6	3.33	16.5	29.6	23.6	1.00	0.75	1.00	45	0.75	2.00	7	7	0.69	150	0.99	0.25	0.05	0.21	1.000	0.91	4.65
Mw	2	1.22	Silty Sand	3.35	11	4.85	18.0	55.8	34.9	1.00	0.85	1.00	45	0.75	1.69	12	30	0.15	175	0.98	0.32	0.08	0.27	1.000	0.83	11.28
9.2	3	0.87	Silty Sand	4.27	19	5.77	18.0	72.4	42.4	1.00	0.85	1.00	45	0.75	1.53	19	30	0.10	175	0.97	0.33	0.14	0.42	0.999	0.79	18.33
Site	4	1.53	Silty Sand	5.08	19	6.58	18.0	86.9	49.1	1.00	0.95	1.00	45	0.75	1.43	19	30	0.10	175	0.96	0.34	0.14	0.42	0.999	0.75	19.07
MP 63.5	5	1.88	Silty Sand	7.32	18	8.82	18.0	127.3	67.4	1.00	0.95	1.00	45	0.75	1.22	16	35	0.09	175	0.91	0.35	0.10	0.29	1.000	0.63	15.79
Data Class	6	1.98	Silty Sand	8.84	35	10.34	18.0	154.6	79.9	1.00	1.00	1.00	45	0.75	1.12	29	35	0.09	200	0.88	0.34	0.31	0.91	0.290	0.56	29.13
	7	2.09	Silty Sand	11.28	32	12.78	18.0	198.5	99.9	1.00	1.00	1.00	45	0.75	1.00	24	35	0.05	200	0.82	0.33	0.18	0.56	0.963	0.44	24.25
B. H.	8	1.53	Silty Sand	13.01	32	14.51	18.0	229.7	114.0	1.00	1.00	1.00	45	0.75	0.94	22	35	0.05	200	0.78	0.32	0.16	0.49	0.993	0.35	22.76
27	9	1.88	Silty Sand	14.33	47	15.83	19.0	254.1	125.5	1.00	1.00	1.00	45	0.75	0.89	31	35	0.08	225	0.76	0.31	0.33	1.06	0.095	0.28	42.38
GWT (m)	10	3.20	Silty Sand	16.77	71	18.27	19.0	300.5	147.9	1.00	1.00	1.00	45	0.75	0.82	44	35	0.08	225	0.73	0.30	0.90	2.99	0.000	0.16	46.13
1.22	11	3.51	Silty Clay	20.73	28	22.23	18.0	373.7	182.3	1.00	1.00	1.00	45	0.75	0.74	16	35	0.00	175	0.72	0.30	0.08	0.26	1.000	0.00	Non-Liq.
a_{max} (g)	12	3.96	Silty Sand	23.78	51	25.28	18.0	428.6	207.3	1.00	1.00	1.00	45	0.75	0.69	27	35	0.09	200	0.70	0.29	0.19	0.64	0.876	0.00	26.62
0.31	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
45	19																									
N (mean)	20																									
30.8	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
189	25																									
Observed (cm)	26																									
185	27																									
Distance (m)	28																									
15.2	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	25.00																							7.05	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Alaska-1964	1	2.29	Sandy Gravel	4.57	11	6.07	16.5	73.9	59.0	1.00	0.95	1.00	45	0.75	1.30	10	7	5.58	150	0.94	0.24	0.05	0.23	1.000	0.77	7.43
Mw	2	1.53	Coarse Sand	6.10	14	7.60	18.0	100.3	70.4	1.00	0.95	1.00	45	0.75	1.19	12	15	1.75	175	0.90	0.26	0.06	0.24	1.000	0.70	9.89
9.2	3	1.53	Silt	7.62	26	9.12	18.0	127.6	82.8	1.00	0.95	1.00	45	0.75	1.10	20	35	0.06	175	0.86	0.27	0.14	0.53	0.981	0.00	Non-Liq.
Site	4	1.53	Silt	9.15	24	10.65	18.0	155.2	95.3	1.00	1.00	1.00	45	0.75	1.02	18	35	0.04	175	0.81	0.27	0.12	0.43	0.999	0.00	Non-Liq.
MP 63.5	5	1.53	Silty Sand	10.67	43	12.17	19.0	183.3	108.5	1.00	1.00	1.00	45	0.75	0.96	31	18	0.83	225	0.77	0.26	0.26	1.00	0.154	0.47	41.44
Data Class	6	1.53	Silty Sand	12.20	64	13.70	19.0	212.4	122.6	1.00	1.00	1.00	45	0.75	0.90	43	14	1.72	225	0.74	0.26	0.64	2.50	0.000	0.39	44.75
	7																									
B. H.	8																									
28	9																									
GWT (m)	10																									
3.05	11																									
a_{max} (g)	12																									
0.31	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
45	19																									
N (mean)	20																									
30.3	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
172	25																									
Observed (cm)	26																									
185	27																									
Distance (m)	28																									
30.5	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	9.92																							2.93	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Alaska-1964	1	4.12	Silty Sand	2.59	11	4.09	18.0	46.6	21.2	1.00	0.85	1.00	45	0.75	2.00	14	17	0.18	175	0.95	0.53	0.10	0.20	1.000	0.87	12.28
Mw	2	3.05	Silty Sand	5.64	6	7.14	16.5	99.2	43.9	1.00	0.95	1.00	45	0.75	1.51	6	17	0.18	150	0.86	0.49	0.05	0.09	1.000	0.72	4.93
9.2	3	3.05	Silty Sand	8.69	9	10.19	16.5	149.6	64.3	1.00	1.00	1.00	45	0.75	1.25	8	16	0.18	150	0.75	0.44	0.05	0.11	1.000	0.57	6.39
Site	4	3.05	Silty Sand	11.74	6	13.24	16.5	199.9	84.7	1.00	1.00	1.00	45	0.75	1.09	5	25	0.15	150	0.67	0.40	0.04	0.09	1.000	0.41	4.27
Snow River	5	3.05	Silty Sand	14.79	14	16.29	16.5	250.2	105.1	1.00	1.00	1.00	45	0.75	0.98	10	26	0.16	150	0.62	0.38	0.05	0.14	1.000	0.26	9.16
Data Class	6	6.48	Silty Sand	17.84	13	19.34	16.5	300.5	125.5	1.00	1.00	1.00	45	0.75	0.89	9	21	0.18	150	0.61	0.37	0.04	0.12	1.000	0.11	7.07
	7	5.41	Silty Sand	27.74	19	29.24	16.5	463.9	191.8	1.00	1.00	1.00	45	0.75	0.72	10	20	0.18	150	0.57	0.35	0.04	0.12	1.000	0.00	8.68
B. H.	8																									
120	9																									
GWT (m)	10																									
0.00	11																									
a_{max} (g)	12																									
0.39	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
45	19																									
N (mean)	20																									
11.1	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
153	25																									
Observed (cm)	26																									
244	27																									
Distance (m)	28																									
27.4	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	28.20																							10.25	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Alaska-1964	1	5.64	Sand	3.66	7	5.16	16.5	60.4	24.5	1.00	0.85	1.00	45	0.75	2.00	9	20	0.20	150	0.93	0.58	0.07	0.12	1.000	0.82	7.23
Mw	2	3.51	Silty Sand	7.62	15	9.12	18.0	128.7	53.9	1.00	0.95	1.00	45	0.75	1.36	15	25	0.20	175	0.79	0.47	0.09	0.19	1.000	0.62	13.64
9.2	3	3.05	Silty Sand	10.67	11	12.17	16.5	181.3	76.6	1.00	1.00	1.00	45	0.75	1.14	9	25	0.20	150	0.69	0.41	0.05	0.13	1.000	0.47	8.19
Site	4	2.29	Silty Sand	13.72	3	15.22	15.5	230.1	95.5	1.00	1.00	1.00	45	0.75	1.02	2	25	0.20	125	0.63	0.39	0.03	0.07	1.000	0.31	2.95
Snow River	5	2.59	Silty Sand	15.24	6	16.74	15.5	253.7	104.2	1.00	1.00	1.00	45	0.75	0.98	4	25	0.20	125	0.62	0.38	0.03	0.08	1.000	0.24	3.98
Data Class	6	3.05	Silty Sand	18.90	11	20.40	16.5	312.2	126.8	1.00	1.00	1.00	45	0.75	0.89	7	25	0.20	150	0.60	0.38	0.04	0.10	1.000	0.06	6.03
	7	3.05	Silty Sand	21.34	12	22.84	16.5	352.5	143.1	1.00	1.00	1.00	45	0.75	0.84	8	25	0.20	150	0.60	0.37	0.04	0.10	1.000	0.00	6.20
B. H.	8	3.05	Silty Sand	25.00	25	26.50	18.0	415.6	170.4	1.00	1.00	1.00	45	0.75	0.77	14	25	0.20	175	0.58	0.36	0.06	0.18	1.000	0.00	13.44
122	9	2.75	Sandy Silt	27.44	31	28.94	18.0	459.5	190.4	1.00	1.00	1.00	45	0.75	0.72	17	35	0.10	175	0.57	0.35	0.08	0.24	1.000	0.00	Non-Liq.
GWT (m)	10	3.05	Sandy Silt	30.49	27	31.99	18.0	514.4	215.3	1.00	1.00	1.00	45	0.75	0.68	14	35	0.10	175	0.55	0.34	0.06	0.19	1.000	0.00	Non-Liq.
0.00	11	3.05	Sandy Silt	33.54	21	35.04	16.5	567.1	238.0	1.00	1.00	1.00	45	0.75	0.65	10	35	0.10	150	0.54	0.33	0.04	0.14	1.000	0.00	Non-Liq.
a_{max} (g)	12	3.05	Sandy Silt	36.59	15	38.09	16.5	617.4	258.4	1.00	1.00	1.00	45	0.75	0.62	7	35	0.10	150	0.53	0.32	0.03	0.10	1.000	0.00	Non-Liq.
0.39	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
45	19																									
N (mean)	20																									
15.3	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
153	25																									
Observed (cm)	26																									
244	27																									
Distance (m)	28																									
9.1	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	38.12																							9.70	

SEISMIC EVENT # 4

EARTHQUAKE:	San Fernando
MOMENT MAGNITUDE:	6.4
LOCATION:	USA
DATE:	February 9, 1971
REFERENCE(S):	Database of Youd et al. (2002) Housner, G. et al. (1971)

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
San Fernando-1971	1	1.39	Sandy Silt	5.49	4	6.99	16.5	95.1	85.2	1.00	0.95	1.00	68	1.13	1.08	5	35	0.06	150	0.85	0.34	0.08	0.24	0.000	0.00	Non-Liq.
Mw	2	0.99	Sandy Silt	6.25	7	7.75	16.5	107.6	90.2	1.00	0.95	1.00	68	1.13	1.05	8	35	0.04	150	0.82	0.35	0.1	0.31	0.000	0.00	Non-Liq.
6.4	3	0.99	Sandy Silt	7.47	4	8.97	15.5	127.1	97.8	1.00	0.95	1.00	68	1.13	1.01	4	35	0.03	125	0.76	0.35	0.08	0.22	0.000	0.00	Non-Liq.
Site	4	0.84	Sandy Silt	8.23	10	9.73	18.0	139.9	103.1	1.00	0.95	1.00	68	1.13	0.99	11	35	0.03	175	0.72	0.35	0.13	0.37	0.000	0.00	Non-Liq.
Juvenile Hall	5	0.84	Sandy Silt	9.15	7	10.65	16.5	155.7	109.9	1.00	1.00	1.00	68	1.13	0.95	8	35	0.02	150	0.67	0.34	0.10	0.29	0.000	0.00	Non-Liq.
Data Class	6	0.84	Sandy Silt	9.91	21	11.41	18.0	168.8	115.6	1.00	1.00	1.00	68	1.13	0.93	22	35	0.07	200	0.63	0.33	0.34	1.02	0.000	0.00	Non-Liq.
	7	0.99	Sandy Silt	10.82	20	12.32	18.0	185.2	123.0	1.00	1.00	1.00	68	1.13	0.90	20	35	0.06	175	0.59	0.32	0.29	0.89	0.000	0.00	Non-Liq.
B. H.	8	1.07	Silty Sand	11.89	24	13.39	18.0	204.5	131.8	1.00	1.00	1.00	68	1.13	0.87	24	35	0.13	200	0.56	0.31	0.37	1.21	0.025	0.41	40.01
54	9	1.22	Sandy Silt	12.96	17	14.46	18.0	223.7	140.5	1.00	1.00	1.00	68	1.13	0.84	16	35	0.06	175	0.52	0.30	0.19	0.65	0.000	0.00	Non-Liq.
GWT (m)	10	1.37	Sandy Silt	14.33	20	15.83	18.0	248.4	151.8	1.00	1.00	1.00	68	1.13	0.81	18	35	0.05	175	0.49	0.29	0.23	0.79	0.000	0.00	Non-Liq.
4.48	11																									
a_{max} (g)	12																									
0.55	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
68	19																									
N (mean)	20																									
13.4	21																									
γ_{dry} (kN/m^3)	22																									
17.5	23																									
Vs* (m/s)	24																									
167	25																									
Observed (cm)	26																									
168	27																									
Distance (m)	28																									
0.3	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	10.54																							0.01	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
San Fernando-1971	1	0.93	Sandy Silt	5.95	7	7.45	16.5	95.4	91.5	1.00	0.95	1.00	68	1.13	1.05	8	35	0.05	150	0.81	0.30	0.11	0.35	0.000	0.00	Non-Liq.
Mw	2	0.99	Silty Sand	7.01	11	8.51	18.0	113.7	99.4	1.00	0.95	1.00	68	1.13	1.00	12	35	0.11	175	0.75	0.31	0.1	0.48	0.996	0.65	11.76
6.4	3	1.38	Sandy Silt	7.93	7	9.43	16.5	129.6	106.2	1.00	0.95	1.00	68	1.13	0.97	7	35	0.02	150	0.70	0.31	0.10	0.32	0.000	0.00	Non-Liq.
Site	4	1.83	Silty Sand	9.76	61	11.26	19.0	162.0	120.7	1.00	1.00	1.00	68	1.13	0.91	63	32	0.20	225	0.61	0.29	10.21	34.83	0.000	0.51	51.72
Juvenile Hall	5																									
Data Class	6																									
	7																									
B. H.	8																									
55	9																									
GWT (m)	10																									
5.55	11																									
a_{max} (g)	12																									
0.55	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
68	19																									
N (mean)	20																									
21.5	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
161	25																									
Observed (cm)	26																									
51	27																									
Distance (m)	28																									
0.3	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	5.13																							0.64	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
San Fernando-1971	1	0.84	Sandy Silt	8.54	12	10.04	18.0	149.5	148.0	1.00	1.00	1.00	68	1.13	0.82	11	35	0.06	175	0.76	0.27	0.12	0.45	0.000	0.00	Non-Liq.
Mw	2	1.37	Sandy Silt	9.91	12	11.41	18.0	174.2	159.2	1.00	1.00	1.00	68	1.13	0.79	11	35	0.07	175	0.69	0.27	0.1	0.43	0.000	0.00	Non-Liq.
6.4	3	1.53	Sandy Silt	11.28	15	12.78	18.0	198.9	170.4	1.00	1.00	1.00	68	1.13	0.77	13	35	0.02	175	0.63	0.26	0.14	0.53	0.000	0.00	Non-Liq.
Site	4	1.15	Silty Sand	12.96	46	14.46	19.0	229.9	185.0	1.00	1.00	1.00	68	1.13	0.74	38	18	0.40	225	0.57	0.26	0.91	3.57	0.000	0.35	43.55
Juvenile Hall	5	0.53	Sandy Silt	13.57	18	15.07	18.0	241.2	190.3	1.00	1.00	1.00	68	1.13	0.72	15	35	0.07	175	0.56	0.25	0.16	0.62	0.000	0.00	Non-Liq.
Data Class	6	0.46	Sandy Silt	14.02	18	15.52	18.0	249.3	194.0	1.00	1.00	1.00	68	1.13	0.72	15	35	0.07	175	0.55	0.25	0.15	0.61	0.000	0.00	Non-Liq.
	7	0.46	Sandy Silt	14.48	32	15.98	18.0	257.6	197.8	1.00	1.00	1.00	68	1.13	0.71	26	35	0.04	200	0.54	0.25	0.40	1.59	0.000	0.00	Non-Liq.
B. H.	8																									
56	9																									
GWT (m)	10																									
8.38	11																									
a_{max} (g)	12																									
0.55	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
68	19																									
N (mean)	20																									
21.9	21																									
γ_{dry} (kN/m^3)	22																									
17.5	23																									
Vs* (m/s)	24																									
179	25																									
Observed (cm)	26																									
122	27																									
Distance (m)	28																									
0.3	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	6.33																							0.00	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
San Fernando-1971	1	0.88	Sandy Silt	6.10	8	7.60	16.5	97.8	94.7	1.00	0.95	1.00	68	1.13	1.03	9	35	0.05	150	0.77	0.28	0.11	0.40	0.000	0.00	Non-Liq.
Mw	2	1.10	Sandy Silt	7.23	4	8.73	15.5	115.8	101.7	1.00	0.95	1.00	68	1.13	0.99	4	35	0.03	125	0.70	0.29	0.1	0.26	0.000	0.00	Non-Liq.
6.4	3	1.27	Sandy Silt	8.29	11	9.79	18.0	133.6	109.1	1.00	0.95	1.00	68	1.13	0.96	11	35	0.05	175	0.64	0.28	0.14	0.48	0.000	0.00	Non-Liq.
Site	4	1.04	Silty Sand	9.76	16	11.26	18.0	160.1	121.1	1.00	1.00	1.00	68	1.13	0.91	16	35	0.07	175	0.57	0.27	0.21	0.76	0.630	0.51	16.70
Juvenile Hall	5	0.61	Silty Sand	10.37	23	11.87	18.0	171.0	126.1	1.00	1.00	1.00	68	1.13	0.89	23	35	0.16	200	0.55	0.27	0.36	1.36	0.005	0.48	39.87
Data Class	6																									
	7																									
B. H.	8																									
57	9																									
GWT (m)	10																									
5.79	11																									
a_{max} (g)	12																									
0.55	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
68	19																									
N (mean)	20																									
12.4	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
154	25																									
Observed (cm)	26																									
168	27																									
Distance (m)	28																									
0.3	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	4.89																							0.34	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
San Fernando-1971	1	0.54	Sandy Silt	4.27	3	5.77	15.5	68.3	68.3	1.00	0.85	1.00	68	1.13	1.21	3	35	0.04	125	0.90	0.32	0.08	0.25	0.000	0.00	Non-Liq.
Mw	2	0.87	Sandy Silt	5.34	5	6.84	16.5	85.4	74.9	1.00	0.95	1.00	68	1.13	1.16	6	35	0.04	150	0.85	0.35	0.1	0.28	0.000	0.00	Non-Liq.
6.4	3	0.99	Sandy Silt	6.01	7	7.51	16.5	96.5	79.4	1.00	0.95	1.00	68	1.13	1.12	8	35	0.03	150	0.82	0.36	0.12	0.33	0.000	0.00	Non-Liq.
Site	4	1.42	Sandy Silt	7.32	4	8.82	16.5	118.1	88.2	1.00	0.95	1.00	68	1.13	1.06	5	35	0.04	150	0.75	0.36	0.08	0.22	0.000	0.00	Non-Liq.
Juvenile Hall	5	1.53	Sandy Silt	8.84	17	10.34	18.0	144.3	99.5	1.00	1.00	1.00	68	1.13	1.00	19	35	0.05	175	0.68	0.35	0.28	0.79	0.000	0.00	Non-Liq.
Data Class	6	1.22	Silty Sand	10.37	20	11.87	18.0	171.9	112.0	1.00	1.00	1.00	68	1.13	0.94	21	35	0.10	200	0.60	0.33	0.32	0.97	0.194	0.48	39.32
	7	1.60	Sandy Silt	11.28	20	12.78	18.0	188.3	119.5	1.00	1.00	1.00	68	1.13	0.91	21	35	0.07	200	0.57	0.32	0.30	0.93	0.000	0.00	Non-Liq.
B. H.	8	1.76	Sandy Silt	13.57	28	15.07	18.0	229.5	138.2	1.00	1.00	1.00	68	1.13	0.85	27	35	0.06	200	0.50	0.30	0.49	1.63	0.000	0.00	Non-Liq.
58	9	1.22	Silty Sand	14.79	19	16.29	18.0	251.4	148.2	1.00	1.00	1.00	68	1.13	0.82	18	35	0.08	175	0.48	0.29	0.22	0.74	0.672	0.26	17.96
GWT (m)	10																									
4.27	11																									
a_{max} (g)	12																									
0.55	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
68	19																									
N (mean)	20																									
13.7	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
165	25																									
Observed (cm)	26																									
168	27																									
Distance (m)	28																									
0.3	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	11.13																							0.33	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
San Fernando-1971	1	4.49	Alluvium	10.50	11	12.00	16.5	180.3	146.0	1.00	1.00	1.00	60	1.00	0.83	9	35	0.08	150	0.65	0.29	0.10	0.36	1.000	0.48	8.69
Mw	2	1.50	Alluvium	12.50	15	14.00	18.0	214.8	160.9	1.00	1.00	1.00	60	1.00	0.79	12	35	0.08	175	0.58	0.28	0.13	0.46	0.997	0.38	11.70
6.4	3	1.50	Alluvium	13.50	15	15.00	18.0	232.8	169.1	1.00	1.00	1.00	60	1.00	0.77	12	35	0.08	175	0.55	0.27	0.12	0.45	0.998	0.33	11.38
Site	4	1.50	Alluvium	15.50	15	17.00	18.0	268.8	185.5	1.00	1.00	1.00	60	1.00	0.73	11	35	0.08	175	0.51	0.26	0.11	0.43	0.999	0.23	10.81
Jensen Plant	5	1.50	Alluvium	16.50	22	18.00	18.0	286.8	193.7	1.00	1.00	1.00	60	1.00	0.72	16	35	0.08	175	0.50	0.26	0.17	0.65	0.865	0.18	15.99
Data Class	6																									
	7																									
B. H.	8																									
244	9																									
GWT (m)	10																									
7.01	11																									
a_{max} (g)	12																									
0.55	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
15.6	21																									
γ_{dry} (kN/m^3)	22																									
17.5	23																									
Vs* (m/s)	24																									
176	25																									
Observed (cm)	26																									
8	27																									
Distance (m)	28																									
79.6	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	10.49																							3.74	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
San Fernando-1971	1	3.00	Fill	1.50	36	3.00	19.0	28.5	13.8	1.00	0.75	1.00	60	1.00	2.00	54	20	1.00	225	0.99	0.73	6.90	9.39	0.000	0.93	48.18
Mw	2	2.00	Fill	4.50	88	6.00	19.0	85.5	41.4	1.00	0.85	1.00	60	1.00	1.56	116	20	1.00	225	0.97	0.72	795.3	1112	0.000	0.78	66.16
6.4	3	1.25	Fill	5.50	33	7.00	19.0	104.5	50.5	1.00	0.95	1.00	60	1.00	1.41	44	20	1.00	225	0.95	0.70	2.15	3.06	0.000	0.73	45.32
Site	4	1.25	Fill	7.00	36	8.50	19.0	133.0	64.3	1.00	0.95	1.00	60	1.00	1.25	43	20	1.00	225	0.92	0.68	1.79	2.62	0.000	0.65	44.90
Jensen Plant	5	2.25	Alluvium	9.00	13	10.50	18.0	170.0	81.7	1.00	1.00	1.00	60	1.00	1.11	14	35	0.08	175	0.87	0.64	0.19	0.30	1.000	0.55	14.47
Data Class	6	1.75	Alluvium	10.50	41	12.00	19.0	197.8	94.7	1.00	1.00	1.00	60	1.00	1.03	42	35	0.08	225	0.81	0.61	1.97	3.26	0.000	0.48	45.63
	7	3.50	Alluvium	12.50	27	14.00	18.0	234.8	112.1	1.00	1.00	1.00	60	1.00	0.94	25	35	0.08	200	0.74	0.55	0.45	0.82	0.469	0.38	25.64
B. H.	8																									
245	9																									
GWT (m)	10																									
0	11																									
a_{max} (g)	12																									
0.55	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
39.1	21																									
γ_{dry} (kN/m^3)	22																									
17.5	23																									
Vs* (m/s)	24																									
210	25																									
Observed (cm)	26																									
8	27																									
Distance (m)	28																									
110.4	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	15.00																							1.85	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
San Fernando-1971	1	4.01	Alluvium	13.00	16	14.50	18.0	239.2	214.6	1.00	1.00	1.00	60	1.00	0.68	11	35	0.08	175	0.71	0.28	0.11	0.38	1.000	0.35	10.71
Mw	2																									
6.4	3																									
Site	4																									
Jensen Plant	5																									
Data Class	6																									
	7																									
B. H.	8																									
246	9																									
GWT (m)	10																									
10.49	11																									
a_{max} (g)	12																									
0.55	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
16.0	21																									
γ_{dry} (kN/m^3)	22																									
18.5	23																									
Vs* (m/s)	24																									
209	25																									
Observed (cm)	26																									
145	27																									
Distance (m)	28																									
29.9	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	4.01																							1.40	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
San Fernando-1971	1	1.99	Alluvium	3.00	5	4.50	16.5	51.5	41.8	1.00	0.85	1.00	60	1.00	1.55	7	35	0.08	150	0.97	0.43	0.12	0.28	1.000	0.85	5.98
Mw	2	2.30	Alluvium	5.00	27	6.50	19.0	87.0	57.7	1.00	0.95	1.00	60	1.00	1.32	34	35	0.08	225	0.93	0.50	1.11	2.22	0.000	0.75	43.09
6.4	3																									
Site	4																									
Jensen Plant	5																									
Data Class	6																									
	7																									
B. H.	8																									
247	9																									
GWT (m)	10																									
2.01	11																									
a_{max} (g)	12																									
0.55	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
16.0	21																									
γ_{dry} (kN/m^3)	22																									
17.5	23																									
Vs* (m/s)	24																									
188	25																									
Observed (cm)	26																									
145	27																									
Distance (m)	28																									
22.0	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	4.29																							1.69	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
San Fernando-1971	1	2.36	Alluvium	10.50	13	12.00	16.5	182.6	171.8	1.00	1.00	1.00	60	1.00	0.76	10	35	0.08	150	0.65	0.25	0.11	0.43	0.999	0.48	9.60
Mw	2	2.00	Alluvium	13.00	8	14.50	16.5	223.9	188.5	1.00	1.00	1.00	60	1.00	0.73	6	35	0.08	150	0.56	0.24	0.07	0.31	1.000	0.35	5.36
6.4	3	1.25	Alluvium	14.50	9	16.00	16.5	248.6	198.5	1.00	1.00	1.00	60	1.00	0.71	6	35	0.08	150	0.52	0.23	0.08	0.32	1.000	0.28	5.82
Site	4	1.25	Alluvium	15.50	12	17.00	16.5	265.1	205.2	1.00	1.00	1.00	60	1.00	0.70	8	35	0.08	150	0.51	0.23	0.09	0.38	1.000	0.23	7.88
Jensen Plant	5	1.25	Alluvium	17.00	17	18.50	18.0	291.0	216.4	1.00	1.00	1.00	60	1.00	0.68	12	35	0.08	175	0.49	0.23	0.11	0.49	0.994	0.15	11.41
Data Class	6																									
	7																									
B. H.	8																									
248	9																									
GWT (m)	10																									
9.39	11																									
a_{max} (g)	12																									
0.55	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
11.8	21																									
γ_{dry} (kN/m^3)	22																									
17.5	23																									
Vs* (m/s)	24																									
175	25																									
Observed (cm)	26																									
8	27																									
Distance (m)	28																									
133.2	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	8.11																							2.63	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
San Fernando-1971	1	1.46	Alluvium	10.00	21	11.50	18.0	184.9	182.8	1.00	1.00	1.00	60	1.00	0.74	16	35	0.08	175	0.76	0.27	0.17	0.62	0.913	0.50	15.70
Mw	2	2.00	Alluvium	12.50	8	14.00	16.5	228.0	201.4	1.00	1.00	1.00	60	1.00	0.70	6	35	0.08	150	0.66	0.27	0.07	0.26	1.000	0.38	5.21
6.4	3	2.25	Alluvium	14.00	12	15.50	16.5	252.8	211.5	1.00	1.00	1.00	60	1.00	0.69	8	35	0.08	150	0.61	0.26	0.09	0.33	1.000	0.30	7.74
Site	4																									
Jensen Plant	5																									
Data Class	6																									
	7																									
B. H.	8																									
249	9																									
GWT (m)	10																									
9.79	11																									
a_{max} (g)	12																									
0.55	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
13.7	21																									
γ_{dry} (kN/m^3)	22																									
18.5	23																									
Vs* (m/s)	24																									
193	25																									
Observed (cm)	26																									
8	27																									
Distance (m)	28																									
147.9	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	5.71																							2.09	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
San Fernando-1971	1	2.29	Alluvium	15.50	19	17.00	18.0	271.9	259.2	1.00	1.00	1.00	60	1.00	0.62	12	35	0.08	175	0.56	0.21	0.11	0.53	0.982	0.23	11.68
Mw	2	1.50	Alluvium	17.50	17	19.00	16.5	306.4	274.1	1.00	1.00	1.00	60	1.00	0.60	10	35	0.08	150	0.53	0.21	0.10	0.45	0.998	0.13	9.99
6.4	3	1.00	Alluvium	18.50	24	20.00	18.0	323.6	281.6	1.00	1.00	1.00	60	1.00	0.60	14	35	0.08	175	0.52	0.21	0.13	0.63	0.897	0.08	14.39
Site	4	1.00	Alluvium	19.50	19	21.00	18.0	341.6	289.8	1.00	1.00	1.00	60	1.00	0.59	11	35	0.08	175	0.52	0.22	0.10	0.47	0.996	0.03	10.97
Jensen Plant	5																									
Data Class	6																									
	7																									
B. H.	8																									
250	9																									
GWT (m)	10																									
14.21	11																									
a_{max} (g)	12																									
0.55	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
19.8	21																									
γ_{dry} (kN/m^3)	22																									
17.5	23																									
Vs* (m/s)	24																									
189	25																									
Observed (cm)	26																									
262	27																									
Distance (m)	28																									
182.3	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	5.79																							0.79	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
San Fernando-1971	1	1.74	Alluvium	4.50	8	6.00	16.5	81.3	71.6	1.00	0.85	1.00	60	1.00	1.18	8	35	0.08	150	0.94	0.38	0.12	0.30	1.000	0.78	7.50
Mw	2	1.75	Alluvium	6.00	42	7.50	19.0	107.9	83.5	1.00	0.95	1.00	60	1.00	1.09	44	35	0.08	225	0.90	0.42	2.33	5.59	0.000	0.70	46.10
6.4	3	2.00	Alluvium	8.00	12	9.50	18.0	144.9	100.8	1.00	0.95	1.00	60	1.00	1.00	11	35	0.08	175	0.83	0.43	0.14	0.33	1.000	0.60	11.18
Site	4	2.00	Alluvium	10.00	21	11.50	18.0	180.9	117.2	1.00	1.00	1.00	60	1.00	0.92	19	35	0.08	175	0.74	0.41	0.27	0.65	0.866	0.50	19.71
Jensen Plant	5																									
Data Class	6																									
	7																									
B. H.	8																									
251	9																									
GWT (m)	10																									
3.51	11																									
a_{max} (g)	12																									
0.55	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
20.8	21																									
γ_{dry} (kN/m^3)	22																									
18.5	23																									
Vs* (m/s)	24																									
190	25																									
Observed (cm)	26																									
262	27																									
Distance (m)	28																									
180.5	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	7.49																							3.41	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
San Fernando-1971	1	1.45	Alluvium	11.00	17	12.50	18.0	203.2	196.3	1.00	1.00	1.00	60	1.00	0.71	12	35	0.08	175	0.76	0.28	0.12	0.44	0.999	0.45	12.04
Mw	2	1.75	Alluvium	12.50	14	14.00	16.5	229.0	207.4	1.00	1.00	1.00	60	1.00	0.69	10	35	0.08	150	0.70	0.28	0.10	0.36	1.000	0.38	9.38
6.4	3	1.50	Alluvium	14.50	24	16.00	18.0	263.5	222.3	1.00	1.00	1.00	60	1.00	0.67	16	35	0.08	175	0.63	0.27	0.17	0.62	0.902	0.28	16.30
Site	4																									
Jensen Plant	5																									
Data Class	6																									
	7																									
B. H.	8																									
252	9																									
GWT (m)	10																									
10.30	11																									
a_{max} (g)	12																									
0.55	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
18.3	21																									
γ_{dry} (kN/m^3)	22																									
18.5	23																									
Vs* (m/s)	24																									
202	25																									
Observed (cm)	26																									
51	27																									
Distance (m)	28																									
200.3	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	4.70																							1.68	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
San Fernando-1971	1	1.50	Alluvium	11.00	7	12.50	16.5	201.5	191.7	1.00	1.00	1.00	60	1.00	0.72	5	35	0.08	150	0.65	0.24	0.07	0.28	1.000	0.45	4.78
Mw	2	2.00	Alluvium	12.00	8	13.50	16.5	218.0	198.4	1.00	1.00	1.00	60	1.00	0.71	6	35	0.08	150	0.61	0.24	0.07	0.30	1.000	0.40	5.25
6.4	3	3.00	Alluvium	15.00	5	16.50	15.5	266.0	217.0	1.00	1.00	1.00	60	1.00	0.68	3	35	0.08	125	0.53	0.23	0.06	0.24	1.000	0.25	3.74
Site	4																									
Jensen Plant	5																									
Data Class	6																									
	7																									
B. H.	8																									
253	9																									
GWT (m)	10																									
10.00	11																									
a_{max} (g)	12																									
0.55	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
6.7	21																									
γ_{dry} (kN/m^3)	22																									
18.5	23																									
Vs* (m/s)	24																									
180	25																									
Observed (cm)	26																									
51	27																									
Distance (m)	28																									
177.1	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	6.50																							2.22	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
San Fernando-1971	1	3.96	Alluvium	15.50	13	17.00	16.5	268.0	236.5	1.00	1.00	1.00	60	1.00	0.65	8	35	0.08	150	0.54	0.22	0.09	0.39	1.000	0.23	7.96
Mw	2	1.50	Alluvium	17.00	34	18.50	18.0	293.9	247.7	1.00	1.00	1.00	60	1.00	0.64	22	35	0.08	200	0.52	0.22	0.26	1.18	0.033	0.15	39.38
6.4	3	1.25	Alluvium	18.50	23	20.00	18.0	320.9	260.0	1.00	1.00	1.00	60	1.00	0.62	14	35	0.08	175	0.51	0.22	0.14	0.61	0.918	0.08	14.35
Site	4																									
Jensen Plant	5																									
Data Class	6																									
	7																									
B. H.	8																									
254	9																									
GWT (m)	10																									
12.29	11																									
a_{max} (g)	12																									
0.55	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
23.3	21																									
γ_{dry} (kN/m^3)	22																									
17.5	23																									
Vs* (m/s)	24																									
185	25																									
Observed (cm)	26																									
315	27																									
Distance (m)	28																									
61.0	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	6.71																							0.98	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
San Fernando-1971	1	2.70	Alluvium	3.50	3	5.00	15.5	59.7	43.0	1.00	0.85	1.00	60	1.00	1.53	4	35	0.08	125	0.91	0.45	0.09	0.21	1.000	0.83	4.03
Mw	2	1.75	Alluvium	5.50	12	7.00	18.0	93.2	56.9	1.00	0.95	1.00	60	1.00	1.33	15	35	0.08	175	0.83	0.49	0.23	0.46	0.997	0.73	15.26
6.4	3	1.75	Alluvium	7.00	10	8.50	18.0	120.2	69.1	1.00	0.95	1.00	60	1.00	1.20	11	35	0.08	175	0.75	0.47	0.16	0.33	1.000	0.65	11.26
Site	4																									
Jensen Plant	5																									
Data Class	6																									
	7																									
B. H.	8																									
255	9																									
GWT (m)	10																									
1.80	11																									
a_{max} (g)	12																									
0.55	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
8.3	21																									
γ_{dry} (kN/m^3)	22																									
18.5	23																									
Vs* (m/s)	24																									
161	25																									
Observed (cm)	26																									
315	27																									
Distance (m)	28																									
46.3	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	6.20																							4.63	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
San Fernando-1971	1	1.76	Alluvium	15.00	7	16.50	15.5	260.5	250.6	1.00	1.00	1.00	60	1.00	0.63	4	35	0.08	125	0.55	0.20	0.06	0.29	1.000	0.25	4.36
Mw	2	1.25	Alluvium	16.50	11	18.00	16.5	284.5	259.9	1.00	1.00	1.00	60	1.00	0.62	7	35	0.08	150	0.52	0.21	0.07	0.35	1.000	0.18	6.21
6.4	3																									
Site	4																									
Jensen Plant	5																									
Data Class	6																									
	7																									
B. H.	8																									
256	9																									
GWT (m)	10																									
13.99	11																									
a_{max} (g)	12																									
0.55	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
9.0	21																									
γ_{dry} (kN/m^3)	22																									
17.5	23																									
Vs* (m/s)	24																									
184	25																									
Observed (cm)	26																									
10	27																									
Distance (m)	28																									
97.9	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	3.01																							0.66	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N^d	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
San Fernando-1971	1	1.50	Alluvium	16.00	8	17.50	16.5	294.0	284.2	1.00	1.00	1.00	60	1.00	0.59	5	35	0.08	150	0.61	0.22	0.06	0.26	1.000	0.20	4.57
Mw	2	1.50	Alluvium	17.00	6	18.50	15.5	310.0	290.4	1.00	1.00	1.00	60	1.00	0.59	4	35	0.08	125	0.59	0.22	0.05	0.24	1.000	0.15	3.81
6.4	3																									
Site	4																									
Jensen Plant	5																									
Data Class	6																									
	7																									
B. H.	8																									
257	9																									
GWT (m)	10																									
15.00	11																									
a_{max} (g)	12																									
0.55	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
7.0	21																									
γ_{dry} (kN/m^3)	22																									
18.5	23																									
Vs* (m/s)	24																									
203	25																									
Observed (cm)	26																									
10	27																									
Distance (m)	28																									
136.9	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	3.00																							0.52	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
San Fernando-1971	1	1.76	Alluvium	14.50	31	16.00	18.0	254.0	249.0	1.00	1.00	1.00	60	1.00	0.63	20	35	0.08	175	0.59	0.21	0.22	1.03	0.120	0.28	38.78
Mw	2	1.75	Alluvium	17.00	12	18.50	16.5	297.1	267.6	1.00	1.00	1.00	60	1.00	0.61	7	35	0.08	150	0.54	0.22	0.08	0.35	1.000	0.15	6.71
6.4	3																									
Site	4																									
Jensen Plant	5																									
Data Class	6																									
	7																									
B. H.	8																									
258	9																									
GWT (m)	10																									
13.99	11																									
a_{max} (g)	12																									
0.55	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
21.5	21																									
γ_{dry} (kN/m^3)	22																									
17.5	23																									
Vs* (m/s)	24																									
191	25																									
Observed (cm)	26																									
315	27																									
Distance (m)	28																									
224.1	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	3.51																							0.32	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
San Fernando-1971	1	1.26	Alluvium	2.00	14	3.50	18.0	35.3	30.3	1.00	0.75	1.00	60	1.00	1.82	19	35	0.08	175	0.98	0.41	0.38	0.93	0.256	0.90	19.40
Mw	2	2.95	Alluvium	3.50	13	5.00	18.0	62.3	42.5	1.00	0.85	1.00	60	1.00	1.53	17	35	0.08	175	0.95	0.50	0.29	0.57	0.955	0.83	17.18
6.4	3																									
Site	4																									
Jensen Plant	5																									
Data Class	6																									
	7																									
B. H.	8																									
259	9																									
GWT (m)	10																									
1.49	11																									
a_{max} (g)	12																									
0.55	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
13.5	21																									
γ_{dry} (kN/m^3)	22																									
17.5	23																									
Vs* (m/s)	24																									
181	25																									
Observed (cm)	26																									
315	27																									
Distance (m)	28																									
170.7	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	4.21																							2.61	

SEISMIC EVENT # 5

EARTHQUAKE:	Guatemala
MOMENT MAGNITUDE:	7.5
LOCATION:	Guatemala
DATE:	February 4, 1976
REFERENCE(S):	Seed, H. B. et al. (1979)

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Guatemala - 1976	1	1.75	Midium Sand	2.59	8	4.09	14.5	31.2	21.4	1.00	0.85	1.00	60	1.00	2.00	14	10	1.00	175	0.92	0.10	0.15	1.43	0.002	0.87	36.24
Mw	2	1.56	Midium Sand	4.11	3	5.61	14.5	53.3	28.6	1.00	0.85	1.00	60	1.00	1.87	4	10	1.00	125	0.86	0.12	0.07	0.52	0.985	0.79	3.29
7.5	3	1.60	Midium Sand	5.72	5	7.22	14.5	76.5	36.1	1.00	0.95	1.00	60	1.00	1.66	8	10	1.00	150	0.78	0.13	0.08	0.64	0.874	0.71	5.59
Site	4	1.56	Midium Sand	7.32	4	8.82	14.5	99.7	43.6	1.00	0.95	1.00	60	1.00	1.51	6	10	1.00	150	0.71	0.13	0.07	0.53	0.983	0.63	4.19
La Playa	5	1.52	Midium Sand	8.84	2	10.34	14.5	121.8	50.8	1.00	1.00	1.00	60	1.00	1.40	3	10	1.00	125	0.65	0.12	0.05	0.42	0.999	0.56	2.81
Data Class	6	1.52	Midium Sand	10.36	3	11.86	14.5	143.9	57.9	1.00	1.00	1.00	60	1.00	1.31	3	10	1.00	125	0.60	0.12	0.05	0.44	0.999	0.48	3.00
	7	1.45	Midium Sand	11.89	5	13.39	14.5	166.0	65.0	1.00	1.00	1.00	60	1.00	1.24	6	10	1.00	150	0.57	0.11	0.06	0.55	0.972	0.41	4.45
B. H.	8	1.30	Midium Sand	13.26	4	14.76	14.5	185.9	71.5	1.00	1.00	1.00	60	1.00	1.18	5	10	1.00	150	0.54	0.11	0.05	0.49	0.994	0.34	3.65
1	9	1.22	Midium Sand	14.48	3	15.98	14.5	203.5	77.2	1.00	1.00	1.00	60	1.00	1.14	3	10	1.00	125	0.53	0.11	0.05	0.43	0.999	0.28	3.05
GWT (m)	10																									
1.6	11																									
a_{max} (g)	12																									
0.12	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
4.0	21																									
γ_{dry} (kN/m^3)	22																									
10.5	23																									
Vs* (m/s)	24																									
139	25																									
Observed (cm)	26																									
	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	13.49																							6.12	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Guatemala - 1976	1	1.19	Midium Sand	2.90	9	9.50	14.5	32.0	28.2	1.00	0.95	1.00	60	1.00	1.88	16	10	1.00	175	0.96	0.08	0.17	1.99	0.000	0.86	36.94
Mw	2	1.33	Midium Sand	4.50	10	6.00	14.5	55.2	35.7	1.00	0.85	1.00	60	1.00	1.67	14	10	1.00	175	0.92	0.11	0.13	1.16	0.037	0.78	36.22
7.5	3	2.13	Midium Sand	5.56	7	7.06	14.5	70.6	40.7	1.00	0.95	1.00	60	1.00	1.57	10	10	1.00	175	0.89	0.12	0.10	0.82	0.488	0.72	7.92
Site	4	2.37	Midium Sand	8.76	16	10.26	14.5	117.0	55.7	1.00	1.00	1.00	60	1.00	1.34	21	10	1.00	200	0.77	0.13	0.21	1.68	0.000	0.56	38.42
La Playa	5	1.53	Midium Sand	10.29	12	11.79	14.5	139.2	62.8	1.00	1.00	1.00	60	1.00	1.26	15	10	1.00	175	0.72	0.12	0.13	1.01	0.135	0.49	36.67
Data Class	6	1.53	Midium Sand	11.81	14	13.31	14.5	161.2	70.0	1.00	1.00	1.00	60	1.00	1.20	17	10	1.00	175	0.67	0.12	0.14	1.14	0.046	0.41	37.11
	7	1.53	Midium Sand	13.34	13	14.84	14.5	183.4	77.1	1.00	1.00	1.00	60	1.00	1.14	15	10	1.00	175	0.64	0.12	0.12	0.97	0.184	0.33	36.58
B. H.	8	1.52	Midium Sand	14.86	11	16.36	14.5	205.4	84.3	1.00	1.00	1.00	60	1.00	1.09	12	10	1.00	175	0.62	0.12	0.09	0.77	0.602	0.26	9.50
2	9																									
GWT (m)	10																									
2.51	11																									
a_{max} (g)	12																									
0.12	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
11.4	21																									
γ_{dry} (kN/m^3)	22																									
10.5	23																									
Vs* (m/s)	24																									
167	25																									
Observed (cm)	26																									
	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	13.11																							1.25	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Guatemala - 1976	1	0.96	Clayey Silt	4.34	1	9.50	14.5	46.5	44.2	1.00	0.95	1.00	60	1.00	1.50	1	35	0.10	125	0.88	0.07	0.05	0.73	0.000	0.00	Non-Liq.
Mw	2	1.64	Clayey Silt	5.79	1	7.29	14.5	67.5	51.0	1.00	0.95	1.00	60	1.00	1.40	1	35	0.10	125	0.82	0.08	0.05	0.59	0.000	0.00	Non-Liq.
7.5	3	1.79	Midium Sand	7.62	14	9.12	14.5	94.1	59.6	1.00	0.95	1.00	60	1.00	1.30	17	10	1.00	175	0.74	0.09	0.15	1.64	0.000	0.62	37.25
Site	4	1.68	Midium Sand	9.37	16	10.87	14.5	119.5	67.8	1.00	1.00	1.00	60	1.00	1.21	19	10	1.00	175	0.67	0.09	0.17	1.85	0.000	0.53	37.86
La Playa	5	2.21	Midium Sand	10.97	16	12.47	14.5	142.7	75.3	1.00	1.00	1.00	60	1.00	1.15	18	10	1.00	175	0.63	0.09	0.15	1.67	0.000	0.45	37.59
Data Class	6	2.17	Midium Sand	13.79	17	15.29	14.5	183.5	88.6	1.00	1.00	1.00	60	1.00	1.06	18	10	1.00	175	0.57	0.09	0.14	1.55	0.001	0.31	37.48
	7	1.52	Midium Sand	15.32	13	16.82	14.5	205.6	95.7	1.00	1.00	1.00	60	1.00	1.02	13	10	1.00	175	0.56	0.09	0.10	1.03	0.116	0.23	36.16
B. H.	8																									
3	9																									
GWT (m)	10																									
4.11	11																									
a_{max} (g)	12																									
0.12	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
11.1	21																									
γ_{dry} (kN/m^3)	22																									
10.5	23																									
Vs* (m/s)	24																									
150	25																									
Observed (cm)	26																									
	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	11.97																							0.04	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Guatemala - 1976	1	4.77	Medium Sand	7.32	16	9.50	14.5	92.7	53.8	1.00	0.95	1.00	60	1.00	1.36	21	10	1.00	200	0.83	0.11	0.20	1.83	0.000	0.63	38.22
Mw	2	2.32	Medium Sand	8.92	15	10.42	14.5	115.9	61.3	1.00	1.00	1.00	60	1.00	1.28	19	10	1.00	175	0.76	0.11	0.17	1.53	0.001	0.55	37.79
7.5	3	3.05	Medium Sand	11.96	14	13.46	14.5	160.1	75.6	1.00	1.00	1.00	60	1.00	1.15	16	10	1.00	175	0.67	0.11	0.12	1.11	0.059	0.40	36.78
Site	4	3.05	Medium Sand	15.01	13	16.51	14.5	204.3	89.9	1.00	1.00	1.00	60	1.00	1.05	13	10	1.00	175	0.62	0.11	0.10	0.89	0.317	0.25	10.72
La Playa	5																									
Data Class	6																									
	7																									
B. H.	8																									
4	9																									
GWT (m)	10																									
3.35	11																									
a_{max} (g)	12																									
0.12	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
14.3	21																									
γ_{dry} (kN/m^3)	22																									
10.5	23																									
Vs* (m/s)	24																									
167	25																									
Observed (cm)	26																									
	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	13.19																							0.32	

SEISMIC EVENT # 6

EARTHQUAKE:	San Juan
MOMENT MAGNITUDE:	7.4
LOCATION:	Argentina
DATE:	November 23, 1977
REFERENCE(S):	Rojahn, C. et al. (1977)

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Argentina - 1977	1	1.19	Silty Clay	5.19	5	6.69	17.6	80.4	74.6	1.00	0.95	1.00	45	0.75	1.16	4	35	0.05	150	0.86	0.12	0.06	0.49	0.000	0.00	Non-Liq.
Mw	2	1.09	Silty Sand	6.40	16	7.90	17.6	101.7	84.1	1.00	0.95	1.00	45	0.75	1.09	12	20	0.14	175	0.80	0.13	0.10	0.82	0.470	0.68	10.93
7.4	3	1.39	Silty Clay	7.36	13	8.86	17.6	118.7	91.6	1.00	0.95	1.00	45	0.75	1.04	10	35	0.05	150	0.76	0.13	0.09	0.72	0.000	0.00	Non-Liq.
Site	4	1.33	Clay	9.17	17	10.67	17.6	150.7	105.8	1.00	1.00	1.00	45	0.75	0.97	12	35	0.05	175	0.69	0.13	0.11	0.85	0.000	0.00	Non-Liq.
San Juan	5	0.91	Silty Sand	10.02	32	11.52	17.6	165.6	112.4	1.00	1.00	1.00	45	0.75	0.94	23	20	0.14	200	0.66	0.13	0.22	1.79	0.000	0.50	39.21
Data Class	6	1.09	Silty Sand	10.98	27	12.48	17.6	182.6	119.9	1.00	1.00	1.00	45	0.75	0.91	19	20	0.14	175	0.63	0.12	0.16	1.26	0.015	0.45	37.97
	7	1.09	Sand	12.19	13	13.69	17.6	203.9	129.4	1.00	1.00	1.00	45	0.75	0.88	8	20	0.14	150	0.60	0.12	0.07	0.55	0.974	0.39	6.71
B. H.	8	1.09	Sand	13.16	48	14.66	17.6	220.9	136.9	1.00	1.00	1.00	45	0.75	0.85	31	20	0.14	225	0.58	0.12	0.41	3.38	0.000	0.34	41.55
1	9	1.03	Clay	14.36	36	15.86	17.6	242.2	146.4	1.00	1.00	1.00	45	0.75	0.83	22	35	0.05	200	0.56	0.12	0.23	1.89	0.000	0.00	Non-Liq.
GWT (m)	10	0.84	Sand	15.21	15	16.71	17.6	257.1	153.0	1.00	1.00	1.00	45	0.75	0.81	9	20	0.14	150	0.55	0.12	0.07	0.56	0.968	0.24	7.41
4.6	11																									
a_{max} (g)	12																									
0.2	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
45	19																									
N (mean)	20																									
22.3	21																									
γ_{dry} (kN/m^3)	22																									
15.22	23																									
Vs* (m/s)	24																									
154	25																									
Observed (cm)	26																									
	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	11.03																							0.96	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Argentina - 1977	1	1.60	Sand	5.79	9	7.29	17.6	90.6	80.8	1.00	0.95	1.00	45	0.75	1.11	7	20	0.14	150	0.81	0.12	0.07	0.57	0.955	0.71	5.46
Mw	2	1.21	Sand	7.00	15	8.50	17.6	111.9	90.3	1.00	0.95	1.00	45	0.75	1.05	11	20	0.14	175	0.75	0.12	0.09	0.76	0.631	0.65	9.53
7.4	3	1.09	Silty Sand	8.21	28	9.71	17.6	133.1	99.7	1.00	0.95	1.00	45	0.75	1.00	20	20	0.14	175	0.70	0.12	0.18	1.51	0.001	0.59	38.36
Site	4	0.91	Silty Sand	9.17	31	10.67	17.6	150.2	107.3	1.00	1.00	1.00	45	0.75	0.97	23	20	0.14	200	0.66	0.12	0.22	1.85	0.000	0.54	39.12
San Juan	5	0.91	Sandy Clay	10.02	9	11.52	17.6	165.1	113.9	1.00	1.00	1.00	45	0.75	0.94	6	35	0.05	150	0.63	0.12	0.06	0.54	0.000	0.00	Non-Liq.
Data Class	6	1.39	Silty Sand	10.98	8	12.48	17.6	182.1	121.4	1.00	1.00	1.00	45	0.75	0.91	5	20	0.14	150	0.60	0.12	0.05	0.46	0.998	0.45	4.41
	7	1.51	Silt	12.80	14	14.30	17.6	214.0	135.6	1.00	1.00	1.00	45	0.75	0.86	9	35	0.05	150	0.56	0.12	0.08	0.66	0.000	0.00	Non-Liq.
B. H.	8	1.21	Silty Clay	14.00	29	15.50	17.6	235.3	145.0	1.00	1.00	1.00	45	0.75	0.83	18	35	0.05	175	0.54	0.11	0.16	1.42	0.000	0.00	Non-Liq.
2	9	1.21	Silty Sand	15.21	10	16.71	17.6	256.6	154.5	1.00	1.00	1.00	45	0.75	0.80	6	20	0.14	150	0.53	0.12	0.05	0.45	0.998	0.24	4.79
GWT (m)	10																									
4.8	11																									
a_{max} (g)	12																									
0.2	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
45	19																									
N (mean)	20																									
17.0	21																									
γ_{dry} (kN/m^3)	22																									
15.22	23																									
Vs* (m/s)	24																									
148	25																									
Observed (cm)	26																									
	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	11.01																							2.49	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Argentina - 1977	1	0.40	Silty Sand	7.00	4	8.50	17.6	106.8	105.8	1.00	0.95	1.00	45	0.75	0.97	3	20	0.14	125	0.72	0.09	0.04	0.47	0.996	0.65	3.03
Mw	2	1.09	Silty Sand	7.60	7	9.10	17.6	117.4	110.5	1.00	0.95	1.00	45	0.75	0.95	5	20	0.14	150	0.69	0.10	0.05	0.55	0.975	0.62	4.07
7.4	3	1.87	Silty Clay	9.17	10	10.67	17.6	145.1	122.8	1.00	1.00	1.00	45	0.75	0.90	7	35	0.05	150	0.63	0.10	0.06	0.67	0.000	0.00	Non-Liq.
Site	4	1.99	Sand	11.35	13	12.85	17.6	183.4	139.8	1.00	1.00	1.00	45	0.75	0.85	8	20	0.14	150	0.57	0.10	0.06	0.67	0.835	0.43	6.52
San Juan	5	1.33	Sand	13.16	23	14.66	17.6	215.3	154.0	1.00	1.00	1.00	45	0.75	0.81	14	20	0.14	175	0.53	0.10	0.10	1.03	0.120	0.34	36.64
Data Class	6	0.97	Sand	14.00	32	15.50	17.6	230.2	160.6	1.00	1.00	1.00	45	0.75	0.79	19	20	0.14	175	0.52	0.10	0.15	1.51	0.001	0.30	38.06
	7	1.09	Sand	15.09	23	16.59	17.6	249.4	169.1	1.00	1.00	1.00	45	0.75	0.77	13	20	0.14	175	0.51	0.10	0.09	0.92	0.265	0.25	11.68
B. H.	8																									
3	9																									
GWT (m)	10																									
6.9	11																									
a_{max} (g)	12																									
0.2	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
45	19																									
N (mean)	20																									
16.0	21																									
γ_{dry} (kN/m^3)	22																									
15.22	23																									
Vs* (m/s)	24																									
141	25																									
Observed (cm)	26																									
	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	8.73																							1.76	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Argentina - 1977	1	1.94	Silty Clay	3.26	2	4.76	17.6	53.1	38.8	1.00	0.85	1.00	45	0.75	1.61	2	35	0.05	125	0.93	0.17	0.06	0.36	0.000	0.00	Non-Liq.
Mw	2	0.94	Silty Clay	4.22	6	5.72	17.6	70.1	46.4	1.00	0.85	1.00	45	0.75	1.47	6	35	0.05	150	0.90	0.18	0.08	0.43	0.000	0.00	Non-Liq.
7.4	3	0.91	Silty Sand	5.13	6	6.63	17.6	86.1	53.4	1.00	0.95	1.00	45	0.75	1.37	6	35	0.10	150	0.87	0.18	0.08	0.41	1.000	0.74	5.38
Site	4	1.06	Silty Clay	6.04	20	7.54	17.6	102.1	60.5	1.00	0.95	1.00	45	0.75	1.29	18	35	0.05	175	0.83	0.18	0.21	1.16	0.000	0.00	Non-Liq.
San Juan	5	1.09	Silty Clay	7.24	9	8.74	17.6	123.4	70.0	1.00	0.95	1.00	45	0.75	1.20	8	35	0.05	150	0.78	0.18	0.08	0.46	0.000	0.00	Non-Liq.
Data Class	6	0.97	Sand	8.21	30	9.71	17.6	140.4	77.5	1.00	0.95	1.00	45	0.75	1.14	24	20	0.10	200	0.73	0.17	0.27	1.57	0.001	0.59	39.51
	7	0.97	Sand	9.17	14	10.67	17.6	157.4	85.1	1.00	1.00	1.00	45	0.75	1.08	11	20	0.10	175	0.70	0.17	0.10	0.57	0.959	0.54	9.83
B. H.	8	1.03	Silty Clay	10.14	14	11.64	17.6	174.4	92.6	1.00	1.00	1.00	45	0.75	1.04	11	35	0.05	175	0.66	0.16	0.10	0.61	0.000	0.00	Non-Liq.
6	9	1.03	Silty Clay	11.23	20	12.73	17.6	193.6	101.1	1.00	1.00	1.00	45	0.75	0.99	15	35	0.05	175	0.63	0.16	0.14	0.88	0.000	0.00	Non-Liq.
GWT (m)	10	0.91	Silty Clay	12.19	20	13.69	17.6	210.6	108.7	1.00	1.00	1.00	45	0.75	0.96	15	35	0.05	175	0.60	0.15	0.13	0.86	0.000	0.00	Non-Liq.
1.8	11	1.03	Silty Sand	13.04	28	14.54	17.6	225.5	115.3	1.00	1.00	1.00	45	0.75	0.93	20	35	0.10	175	0.59	0.15	0.20	1.31	0.009	0.35	38.76
a_{max} (g)	12	1.09	Silty Clay	14.24	25	15.74	17.6	246.8	124.7	1.00	1.00	1.00	45	0.75	0.90	17	35	0.05	175	0.57	0.15	0.15	1.02	0.000	0.00	Non-Liq.
0.2	13	0.97	Sand	15.21	26	16.71	17.6	263.8	132.3	1.00	1.00	1.00	45	0.75	0.87	17	20	0.10	175	0.56	0.15	0.13	0.91	0.279	0.24	15.57
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
45	19																									
N (mean)	20																									
16.9	21																									
γ_{dry} (kN/m^3)	22																									
15.22	23																									
Vs* (m/s)	24																									
156	25																									
Observed (cm)	26																									
	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	13.89																							1.24	

SEISMIC EVENT # 7

EARTHQUAKE:	Imperial Valley
MOMENT MAGNITUDE:	6.5
LOCATION:	USA
DATE:	October 15, 1979
REFERENCE(S):	Database of Youd et al. (2002)

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Imperial V. 1979	1	1.37	Fine Sand	2.44	29	3.94	19.0	43.6	37.6	1.00	0.75	1.00	60	1.00	1.63	35	13	0.11	225	0.98	0.38	1.01	2.70	0.000	0.88	42.47
Mw	2	1.37	Fine Sand	3.66	36	5.16	19.0	66.8	48.8	1.00	0.85	1.00	60	1.00	1.43	44	8	0.12	225	0.96	0.43	1.67	3.85	0.000	0.82	44.51
6.5	3	0.77	Silt	4.88	8	6.38	16.5	88.5	58.5	1.00	0.95	1.00	60	1.00	1.31	10	35	0.02	150	0.93	0.47	0.14	0.30	0.000	0.00	Non-Liq.
Site	4	0.98	Sand	6.71	16	8.21	18.0	120.0	72.1	1.00	0.95	1.00	60	1.00	1.18	18	20	0.13	175	0.88	0.49	0.23	0.46	0.997	0.66	16.51
Heber Road	5																									
Data Class	6																									
	7																									
B. H.	8																									
61	9																									
GWT (m)	10																									
1.83	11																									
a_{max} (g)	12																									
0.51	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
22.3	21																									
γ_{dry} (kN/m^3)	22																									
17.5	23																									
Vs* (m/s)	24																									
189	25																									
Observed (cm)	26																									
66	27																									
Distance (m)	28																									
64	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	4.49																							0.65	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Imperial V. 1979	1	0.31	Fine Sand	1.83	19	3.33	19.0	32.5	29.4	1.00	0.75	1.00	78	1.30	1.84	34	14	0.11	225	0.99	0.36	0.99	2.74	0.000	0.91	42.15
Mw	2	0.61	Fine Sand	2.44	34	3.94	19.0	44.1	35.1	1.00	0.75	1.00	78	1.30	1.69	56	20	0.10	225	0.99	0.41	6.04	14.70	0.000	0.88	48.75
6.5	3	0.61	Fine Sand	3.05	37	4.55	19.0	55.7	40.7	1.00	0.85	1.00	78	1.30	1.57	64	13	0.11	225	0.98	0.45	9.54	21.44	0.000	0.85	50.53
Site	4	0.61	Fine Sand	3.66	37	5.16	19.0	67.3	46.3	1.00	0.85	1.00	78	1.30	1.47	60	11	0.12	225	0.97	0.47	6.42	13.68	0.000	0.82	49.24
Heber Road	5	0.61	Fine Sand	4.27	28	5.77	19.0	78.9	51.9	1.00	0.85	1.00	78	1.30	1.39	43	10	0.12	225	0.97	0.49	1.60	3.28	0.000	0.79	44.40
Data Class	6																									
	7																									
B. H.	8																									
64	9																									
GWT (m)	10																									
1.52	11																									
a_{max} (g)	12																									
0.51	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
78	19																									
N (mean)	20																									
31.0	21																									
γ_{dry} (kN/m^3)	22																									
17.5	23																									
Vs* (m/s)	24																									
204	25																									
Observed (cm)	26																									
66	27																									
Distance (m)	28																									
58.8	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	2.74																							0.00	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Imperial V. 1979	1	2.83	Silty Sand	3.40	8	4.90	18.0	58.0	40.5	1.00	0.85	1.00	60	1.00	1.57	11	26	0.10	175	0.96	0.45	0.15	0.34	1.000	0.83	9.64
Mw	2	1.20	Silty Clay	4.60	16	6.10	18.0	79.6	50.3	1.00	0.95	1.00	60	1.00	1.41	21	35	0.00	200	0.93	0.49	0.39	0.79	0.000	0.00	Non-Liq.
6.5	3	1.30	Fine Sand	5.80	49	7.30	19.0	101.8	60.8	1.00	0.95	1.00	60	1.00	1.28	60	11	0.13	225	0.90	0.50	5.78	11.59	0.000	0.71	49.14
Site	4	0.50	Silty Clay	7.20	21	8.70	18.0	127.7	72.9	1.00	0.95	1.00	60	1.00	1.17	23	35	0.00	200	0.85	0.49	0.41	0.84	0.000	0.00	Non-Liq.
Heber Road	5	2.40	Clayey Silt	8.40	21	9.90	18.0	149.3	82.7	1.00	0.95	1.00	60	1.00	1.10	22	35	0.00	200	0.80	0.48	0.35	0.74	0.000	0.00	Non-Liq.
Data Class	6																									
	7																									
B. H.	8																									
65	9																									
GWT (m)	10																									
1.62	11																									
a_{max} (g)	12																									
0.51	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
23.0	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
185	25																									
Observed (cm)	26																									
66	27																									
Distance (m)	28																									
23.2	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	8.23																							2.35	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Imperial V. 1979	1	1.28	Silty Sand	2.44	1	3.94	15.5	37.0	29.0	1.00	0.75	1.00	60	1.00	1.86	1	26	0.11	125	0.93	0.39	0.08	0.20	1.000	0.88	2.61
Mw	2	1.59	Silty Sand	3.35	7	4.85	16.5	51.6	34.6	1.00	0.85	1.00	60	1.00	1.70	10	24	0.11	150	0.89	0.44	0.15	0.34	1.000	0.83	8.85
6.5	3	1.16	Silty Clay	4.88	7	6.38	16.5	76.8	44.8	1.00	0.95	1.00	60	1.00	1.49	10	35	0.00	150	0.81	0.46	0.15	0.32	0.000	0.00	Non-Liq.
Site	4	1.31	Silty Sand	6.10	32	7.60	19.0	98.5	54.5	1.00	0.95	1.00	60	1.00	1.35	41	11	0.13	225	0.74	0.44	1.39	3.14	0.000	0.70	43.96
Heber Road	5																									
Data Class	6																									
	7																									
B. H.	8																									
66	9																									
GWT (m)	10																									
1.62	11																									
a_{max} (g)	12																									
0.51	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
11.8	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
147	25																									
Observed (cm)	26																									
66	27																									
Distance (m)	28																									
23.2	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	5.33																							2.44	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Imperial V. 1979	1	0.62	V. Fine Sand	1.83	1	3.33	15.5	27.6	24.6	1.00	0.75	1.00	60	1.00	2.00	2	14	0.12	125	0.95	0.35	0.08	0.22	1.000	0.91	2.43
Mw	2	0.61	V. Fine Sand	2.44	1	3.94	15.5	37.1	28.0	1.00	0.75	1.00	60	1.00	1.89	1	14	0.12	125	0.93	0.41	0.08	0.18	1.000	0.88	2.40
6.5	3	0.61	V. Fine Sand	3.05	1	4.55	15.5	46.5	31.5	1.00	0.85	1.00	60	1.00	1.78	2	14	0.12	125	0.90	0.44	0.07	0.17	1.000	0.85	2.43
Site	4	0.61	V. Fine Sand	3.66	3	5.16	15.5	56.0	35.0	1.00	0.85	1.00	60	1.00	1.69	4	14	0.12	125	0.88	0.47	0.09	0.19	1.000	0.82	3.57
Heber Road	5	0.61	V. Fine Sand	4.27	4	5.77	16.5	65.7	38.8	1.00	0.85	1.00	60	1.00	1.61	5	14	0.12	150	0.85	0.48	0.09	0.20	1.000	0.79	4.18
Data Class	6	0.92	V. Fine Sand	4.88	10	6.38	18.0	76.3	43.3	1.00	0.95	1.00	60	1.00	1.52	14	14	0.13	175	0.82	0.48	0.19	0.39	1.000	0.76	12.39
	7	0.52	Silty Clay	5.49	10	6.99	18.0	87.2	48.3	1.00	0.95	1.00	60	1.00	1.44	14	35	0.00	175	0.78	0.47	0.20	0.43	0.000	0.00	Non-Liq.
B. H.	8	0.61	Fine Sand	6.10	24	7.60	19.0	98.5	53.6	1.00	0.95	1.00	60	1.00	1.37	31	0	0.15	225	0.75	0.46	0.55	1.21	0.024	0.70	40.89
68	9	0.70	Silty Clay	6.71	10	8.21	18.0	109.8	58.9	1.00	0.95	1.00	60	1.00	1.30	12	35	0.00	175	0.71	0.44	0.17	0.39	0.000	0.00	Non-Liq.
GWT (m)	10	1.34	Silty Clay	7.93	12	9.43	18.0	131.8	68.9	1.00	0.95	1.00	60	1.00	1.20	14	35	0.00	175	0.64	0.41	0.18	0.45	0.000	0.00	Non-Liq.
1.52	11	0.64	Sand	9.15	8	10.65	16.5	152.8	78.0	1.00	1.00	1.00	60	1.00	1.13	9	15	0.15	150	0.58	0.38	0.10	0.27	1.000	0.54	6.94
a_{max} (g)	12																									
0.51	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
7.6	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
149	25																									
Observed (cm)	26																									
91	27																									
Distance (m)	28																									
20.4	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	7.78																							3.64	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Imperial V. 1979	1	0.62	Fine Sand	1.83	1	3.33	15.5	27.6	24.6	1.00	0.75	1.00	78	1.30	2.00	2	14	0.12	125	0.91	0.34	0.08	0.24	1.000	0.91	2.58
Mw	2	0.61	Fine Sand	2.44	1	3.94	15.5	37.1	28.0	1.00	0.75	1.00	78	1.30	1.89	2	14	0.12	125	0.88	0.38	0.08	0.20	1.000	0.88	2.54
6.5	3	0.92	Fine Sand	3.05	1	4.55	15.5	46.5	31.5	1.00	0.85	1.00	78	1.30	1.78	2	14	0.12	125	0.84	0.41	0.08	0.19	1.000	0.85	2.59
Site	4	1.83	Fine Sand	4.27	2	5.77	15.5	65.4	38.4	1.00	0.85	1.00	78	1.30	1.61	4	14	0.12	125	0.76	0.43	0.08	0.19	1.000	0.79	3.22
Heber Road	5																									
Data Class	6																									
	7																									
B. H.	8																									
69	9																									
GWT (m)	10																									
1.52	11																									
a_{max} (g)	12																									
0.51	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
78	19																									
N (mean)	20																									
1.3	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
125	25																									
Observed (cm)	26																									
91	27																									
Distance (m)	28																									
17.4	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	3.97																							3.31	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Imperial V. 1979	1	1.18	Silty Sand	2.20	11	3.70	18.0	36.6	29.9	1.00	0.75	1.00	60	1.00	1.83	15	35	0.06	175	0.97	0.39	0.25	0.64	0.885	0.89	14.79
Mw	2	1.00	Silty Sand	3.20	16	4.70	18.0	54.6	38.1	1.00	0.85	1.00	60	1.00	1.62	22	23	0.10	200	0.95	0.45	0.39	0.86	0.389	0.84	20.90
6.5	3	1.40	Silty Sand	4.20	12	5.70	18.0	72.6	46.3	1.00	0.85	1.00	60	1.00	1.47	14	35	0.07	175	0.93	0.48	0.22	0.45	0.998	0.79	14.60
Site	4	0.20	Clay	5.20	5	6.70	16.5	89.8	53.7	1.00	0.95	1.00	60	1.00	1.36	7	35	0.03	150	0.90	0.50	0.11	0.22	0.000	0.00	Non-Liq.
Heber Road	5	1.10	Clay	6.20	44	7.70	19.0	107.6	61.6	1.00	0.95	1.00	60	1.00	1.27	53	35	0.00	225	0.86	0.50	5.50	11.06	0.000	0.00	Non-Liq.
Data Class	6																									
	7																									
B. H.	8																									
70	9																									
GWT (m)	10																									
1.52	11																									
a_{max} (g)	12																									
0.51	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
17.5	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
177	25																									
Observed (cm)	26																									
320	27																									
Distance (m)	28																									
26.2	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	4.88																							2.36	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N^d	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Imperial V. 1979	1	1.53	Silty Sand	2.44	12	3.94	18.0	40.9	31.9	1.00	0.75	1.00	60	1.00	1.77	16	30	0.09	175	0.95	0.41	0.26	0.65	0.863	0.88	15.61
Mw	2	1.83	Silty Sand	3.66	13	5.16	18.0	62.8	41.8	1.00	0.85	1.00	60	1.00	1.55	17	19	0.10	175	0.92	0.46	0.24	0.53	0.980	0.82	15.58
6.5	3	1.00	Clay	4.88	7	6.38	16.5	83.9	50.9	1.00	0.95	1.00	60	1.00	1.40	9	35	0.03	150	0.87	0.47	0.14	0.29	0.000	0.00	Non-Liq.
Site	4																									
Heber Road	5																									
Data Class	6																									
	7																									
B. H.	8																									
71	9																									
GWT (m)	10																									
1.52	11																									
a_{max} (g)	12																									
0.51	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
10.7	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
163	25																									
Observed (cm)	26																									
320	27																									
Distance (m)	28																									
26.2	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	4.36																							2.63	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Imperial V. 1979	1	2.15	Sandy Silt	1.00	11	2.50	18.0	17.9	9.6	1.00	0.75	1.00	60	1.00	2.00	16	35	0.05	175	1.00	0.25	0.36	1.43	0.000	0.00	Non-Liq.
Mw	2	0.70	Slty Clay	2.60	15	4.10	18.0	46.7	22.7	1.00	0.85	1.00	60	1.00	2.00	25	35	0.01	200	0.98	0.28	0.65	2.35	0.000	0.00	Non-Liq.
6.6	3	1.50	Clay	3.80	8	5.30	18.0	68.3	32.5	1.00	0.85	1.00	60	1.00	1.75	12	35	0.00	175	0.97	0.28	0.19	0.67	0.000	0.00	Non-Liq.
Site	4	1.40	Fine Sand	5.20	33	6.70	19.0	94.2	44.7	1.00	0.95	1.00	60	1.00	1.50	47	9	0.18	225	0.95	0.27	2.15	7.84	0.000	0.74	45.43
River Park	5	3.00	Fine Sand	7.40	43	8.90	19.0	136.0	64.9	1.00	0.95	1.00	60	1.00	1.24	51	6	0.14	225	0.90	0.26	2.46	9.53	0.000	0.63	46.28
Data Class	6																									
	7																									
B. H.	8																									
260	9																									
GWT (m)	10																									
0.15	11																									
a_{max} (g)	12																									
0.21	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
21.9	21																									
γ_{dry} (kN/m^3)	22																									
17.5	23																									
Vs* (m/s)	24																									
199	25																									
Observed (cm)	26																									
0	27																									
Distance (m)	28																									
0.3	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	8.75																							0.00	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Imperial V. 1979	1	1.70	Sandy Silt	1.00	9	2.50	18.0	17.9	9.6	1.00	0.75	1.00	60	1.00	2.00	14	35	0.05	175	0.99	0.25	0.31	1.22	0.000	0.00	Non-Liq.
Mw	2	1.15	Sandy Silt	2.20	9	3.70	18.0	39.5	19.4	1.00	0.75	1.00	60	1.00	2.00	13	35	0.05	175	0.98	0.27	0.23	0.85	0.000	0.00	Non-Liq.
6.6	3	1.20	Clayey Silt	3.40	10	4.90	18.0	61.1	29.2	1.00	0.85	1.00	60	1.00	1.85	16	35	0.00	175	0.97	0.28	0.27	0.97	0.000	0.00	Non-Liq.
Site	4	1.30	Sand	5.00	14	6.50	18.0	89.9	42.3	1.00	0.95	1.00	60	1.00	1.54	21	11	0.17	200	0.94	0.27	0.29	1.06	0.095	0.75	38.22
River Park	5	1.00	Sand	6.00	32	7.50	19.0	108.4	51.0	1.00	0.95	1.00	60	1.00	1.40	42	14	0.17	225	0.91	0.26	1.55	5.87	0.000	0.70	44.41
Data Class	6	1.00	Sand	7.00	21	8.50	18.0	126.9	59.7	1.00	0.95	1.00	60	1.00	1.29	26	6	0.15	200	0.88	0.26	0.39	1.51	0.001	0.65	39.61
	7																									
B. H.	8																									
261	9																									
GWT (m)	10																									
0.15	11																									
a_{max} (g)	12																									
0.21	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
15.8	21																									
γ_{dry} (kN/m^3)	22																									
17.5	23																									
Vs* (m/s)	24																									
188	25																									
Observed (cm)	26																									
0	27																									
Distance (m)	28																									
0.3	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	7.35																							0.09	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Imperial V. 1979	1	0.80	Silty Sand	0.60	12	2.10	18.0	10.8	4.9	1.00	0.75	1.00	60	1.00	2.00	18	35	0.07	175	1.00	0.30	0.55	1.82	0.000	0.97	38.37
Mw	2	1.00	Clayey Silt	1.60	5	3.10	16.5	28.1	12.4	1.00	0.75	1.00	60	1.00	2.00	8	35	0.01	150	0.99	0.31	0.17	0.54	0.000	0.00	Non-Liq.
6.6	3	1.20	Clay	2.60	24	4.10	19.0	45.8	20.3	1.00	0.85	1.00	60	1.00	2.00	41	35	0.00	225	0.98	0.30	2.52	8.32	0.000	0.00	Non-Liq.
Site	4	2.80	Fine Sand	4.60	28	6.10	19.0	83.8	38.7	1.00	0.95	1.00	60	1.00	1.61	43	11	0.14	225	0.96	0.28	1.68	5.89	0.000	0.77	44.41
River Park	5																									
Data Class	6																									
	7																									
B. H.	8																									
263	9																									
GWT (m)	10																									
0	11																									
a_{max} (g)	12																									
0.21	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
17.3	21																									
γ_{dry} (kN/m^3)	22																									
17.5	23																									
Vs* (m/s)	24																									
200	25																									
Observed (cm)	26																									
0	27																									
Distance (m)	28																									
0.3	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	5.80																							0.00	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Imperial V. 1979	1	2.00	Sandy Silt	1.60	1	3.10	15.5	24.8	9.1	1.00	0.75	1.00	60	1.00	2.00	2	35	0.17	125	0.97	0.36	0.11	0.30	0.000	0.00	Non-Liq.
Mw	2	1.80	Clayey Silt	3.60	3	5.10	16.5	56.8	21.5	1.00	0.85	1.00	60	1.00	2.00	5	35	0.04	150	0.91	0.33	0.12	0.36	0.000	0.00	Non-Liq.
6.6	3	1.80	Silty Sand	5.00	19	6.50	19.0	81.7	32.6	1.00	0.95	1.00	60	1.00	1.75	32	28	0.10	225	0.85	0.29	0.92	3.15	0.000	0.75	42.10
Site	4																									
River Park	5																									
Data Class	6																									
	7																									
B. H.	8																									
264	9																									
GWT (m)	10																									
0	11																									
a_{max} (g)	12																									
0.21	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
7.7	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
156	25																									
Observed (cm)	26																									
0	27																									
Distance (m)	28																									
0.3	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	5.60																							0.00	

SEISMIC EVENT # 8

EARTHQUAKE:	Nihonkai-Chubu
MOMENT MAGNITUDE:	7.7
LOCATION:	Japan
DATE:	May 26, 1983
REFERENCE(S):	Database of Youd et al. (2002)

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Nihonkai-1983	1	0.79	Dune Sand	2.00	12	3.50	18.0	32.6	29.7	1.00	0.75	1.00	45	0.75	1.83	12	0	0.35	175	0.99	0.18	0.11	0.62	0.906	0.90	9.42
Mw	2	1.00	Dune Sand	3.00	11	4.50	18.0	50.6	37.9	1.00	0.85	1.00	45	0.75	1.62	11	0	0.35	175	0.97	0.21	0.09	0.45	0.998	0.85	8.43
7.7	3	1.00	Alluvial Sand	4.00	19	5.50	18.0	68.6	46.1	1.00	0.85	1.00	45	0.75	1.47	18	5	0.35	175	0.96	0.23	0.15	0.66	0.853	0.80	14.75
Site	4	1.00	Alluvial Sand	5.00	20	6.50	18.0	86.6	54.3	1.00	0.95	1.00	45	0.75	1.36	19	5	0.35	175	0.94	0.24	0.16	0.67	0.830	0.75	16.18
Noshiro-N1	5	1.00	Alluvial Sand	6.00	27	7.50	18.0	104.6	62.5	1.00	0.95	1.00	45	0.75	1.26	24	5	0.35	200	0.92	0.25	0.23	0.92	0.267	0.70	20.77
Data Class	6	1.00	Alluvial Sand	7.00	33	8.50	18.0	122.6	70.7	1.00	0.95	1.00	45	0.75	1.19	28	5	0.35	200	0.89	0.25	0.29	1.17	0.036	0.65	40.02
	7	1.00	Alluvial Sand	8.00	40	9.50	19.0	141.1	79.4	1.00	0.95	1.00	45	0.75	1.12	32	5	0.35	225	0.86	0.25	0.39	1.55	0.001	0.60	41.12
B. H.	8	1.00	Alluvial Sand	9.00	42	10.50	19.0	160.1	88.6	1.00	1.00	1.00	45	0.75	1.06	33	5	0.35	225	0.83	0.24	0.42	1.72	0.000	0.55	41.52
77	9	1.00	Alluvial Sand	10.00	50	11.50	19.0	179.1	97.8	1.00	1.00	1.00	45	0.75	1.01	38	5	0.35	225	0.80	0.24	0.58	2.42	0.000	0.50	42.73
GWT (m)	10																									
1.71	11																									
a_{max} (g)	12																									
0.25	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
45	19																									
N (mean)	20																									
28.2	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
186	25																									
Observed (cm)	26																									
216	27																									
Distance (m)	28																									
19.5	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	8.79																							3.01	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Nihonkai-1983	1	0.60	Gravel	3.00	30	4.50	19.0	52.7	51.7	1.00	0.85	1.00	67	1.12	1.39	40	0	1.00	225	0.97	0.16	0.72	4.51	0.000	0.85	43.19
Mw	2	1.00	Gravel	4.00	27	5.50	19.0	71.7	60.9	1.00	0.85	1.00	67	1.12	1.28	33	0	1.00	225	0.95	0.18	0.42	2.28	0.000	0.80	41.35
7.7	3	1.00	Clay	5.00	8	6.50	16.5	89.4	68.8	1.00	0.95	1.00	67	1.12	1.21	10	35	0.01	150	0.93	0.20	0.09	0.48	0.000	0.00	Non-Liq.
Site	4	1.00	Clay	6.00	8	7.50	16.5	105.9	75.5	1.00	0.95	1.00	67	1.12	1.15	10	35	0.01	150	0.90	0.21	0.09	0.43	0.000	0.00	Non-Liq.
Noshiro-N2	5	1.00	Clay	7.00	12	8.50	18.0	123.2	82.9	1.00	0.95	1.00	67	1.12	1.10	14	35	0.01	175	0.87	0.21	0.12	0.58	0.000	0.00	Non-Liq.
Data Class	6	1.00	Alluvial Sand	8.00	10	9.50	18.0	141.2	91.1	1.00	0.95	1.00	67	1.12	1.05	11	5	0.35	175	0.84	0.21	0.08	0.36	1.000	0.60	8.16
	7	1.00	Alluvial Sand	9.00	11	10.50	18.0	159.2	99.3	1.00	1.00	1.00	67	1.12	1.00	12	5	0.35	175	0.80	0.21	0.08	0.39	1.000	0.55	9.37
B. H.	8	1.00	Clay	10.00	8	11.50	16.5	176.4	106.7	1.00	1.00	1.00	67	1.12	0.97	9	35	0.01	150	0.77	0.21	0.07	0.35	0.000	0.00	Non-Liq.
78	9																									
GWT (m)	10																									
2.9	11																									
a_{max} (g)	12																									
0.25	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
67	19																									
N (mean)	20																									
14.3	21																									
γ_{dry} (kN/m^3)	22																									
17.5	23																									
Vs* (m/s)	24																									
179	25																									
Observed (cm)	26																									
249	27																									
Distance (m)	28																									
64.9	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	7.60																							1.15	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Nihonkai-1983	1	0.66	Dune Sand	3.00	7	4.50	16.5	48.1	46.5	1.00	0.85	1.00	67	1.12	1.47	10	0	0.35	150	0.96	0.16	0.08	0.50	0.990	0.85	7.20
Mw	2	1.00	Dune Sand	4.00	11	5.50	18.0	65.3	54.0	1.00	0.85	1.00	67	1.12	1.36	14	0	0.35	175	0.94	0.19	0.11	0.57	0.957	0.80	11.24
7.7	3	1.00	Dune Sand	5.00	7	6.50	16.5	82.6	61.4	1.00	0.95	1.00	67	1.12	1.28	9	0	0.35	150	0.92	0.20	0.07	0.36	1.000	0.75	6.53
Site	4	1.00	Dune Sand	6.00	9	7.50	18.0	99.8	68.8	1.00	0.95	1.00	67	1.12	1.21	12	0	0.35	175	0.88	0.21	0.08	0.39	1.000	0.70	8.55
Noshiro-N2	5	1.00	Alluvial Sand	7.00	14	8.50	18.0	117.8	77.0	1.00	0.95	1.00	67	1.12	1.14	17	5	0.35	175	0.85	0.21	0.12	0.58	0.949	0.65	13.88
Data Class	6	1.00	Alluvial Sand	8.00	17	9.50	18.0	135.8	85.2	1.00	0.95	1.00	67	1.12	1.08	20	5	0.35	175	0.81	0.21	0.15	0.69	0.779	0.60	16.37
	7	1.00	Alluvial Sand	9.00	21	10.50	18.0	153.8	93.4	1.00	1.00	1.00	67	1.12	1.03	24	5	0.35	200	0.78	0.21	0.20	0.98	0.168	0.55	39.01
B. H.	8	1.00	Alluvial Sand	10.00	30	11.50	19.0	172.3	102.1	1.00	1.00	1.00	67	1.12	0.99	33	5	0.35	225	0.74	0.20	0.39	1.94	0.000	0.50	41.43
79	9	1.00	Alluvial Sand	11.00	34	12.50	19.0	191.3	111.3	1.00	1.00	1.00	67	1.12	0.95	36	5	0.35	225	0.71	0.20	0.48	2.42	0.000	0.45	42.21
GWT (m)	10	1.00	Clay	12.00	11	13.50	18.0	209.8	120.0	1.00	1.00	1.00	67	1.12	0.91	11	35	0.01	175	0.68	0.19	0.09	0.45	0.000	0.00	Non-Liq.
2.84	11																									
a_{max} (g)	12																									
0.25	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
67	19																									
N (mean)	20																									
16.1	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
173	25																									
Observed (cm)	26																									
249	27																									
Distance (m)	28																									
18	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	9.66																							3.95	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Nihonkai-1983	1	0.98	Dune Sand	2.00	9	3.50	18.0	33.0	28.3	1.00	0.75	1.00	67	1.12	1.88	14	0	0.35	175	0.98	0.19	0.13	0.68	0.808	0.90	11.21
Mw	2	1.00	Dune Sand	3.00	11	4.50	18.0	51.0	36.4	1.00	0.85	1.00	67	1.12	1.66	17	0	0.35	175	0.97	0.22	0.15	0.68	0.814	0.85	14.24
7.7	3	1.00	Dune Sand	4.00	10	5.50	18.0	69.0	44.6	1.00	0.85	1.00	67	1.12	1.50	14	0	0.35	175	0.95	0.24	0.11	0.47	0.997	0.80	11.23
Site	4	1.00	Dune Sand	5.00	17	6.50	18.0	87.0	52.8	1.00	0.95	1.00	67	1.12	1.38	25	0	0.35	200	0.93	0.25	0.24	0.95	0.218	0.75	39.16
Noshiro-N2	5	1.00	Alluvial Sand	6.00	19	7.50	18.0	105.0	61.0	1.00	0.95	1.00	67	1.12	1.28	26	5	0.35	200	0.90	0.25	0.26	1.02	0.124	0.70	39.43
Data Class	6	1.00	Alluvial Sand	7.00	26	8.50	19.0	123.5	69.7	1.00	0.95	1.00	67	1.12	1.20	33	5	0.35	225	0.87	0.25	0.43	1.73	0.000	0.65	41.40
	7	1.00	Alluvial Sand	8.00	28	9.50	19.0	142.5	78.9	1.00	0.95	1.00	67	1.12	1.13	33	5	0.35	225	0.84	0.25	0.43	1.76	0.000	0.60	41.51
B. H.	8	1.00	Alluvial Sand	9.00	8	10.50	16.5	160.2	86.8	1.00	1.00	1.00	67	1.12	1.07	10	5	0.35	150	0.81	0.24	0.07	0.28	1.000	0.55	6.62
80	9	1.00	Clay	10.00	10	11.50	18.0	177.5	94.3	1.00	1.00	1.00	67	1.12	1.03	12	35	0.01	175	0.77	0.24	0.10	0.40	0.000	0.00	Non-Liq.
GWT (m)	10																									
1.52	11																									
a_{max} (g)	12																									
0.25	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
67	19																									
N (mean)	20																									
15.3	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
180	25																									
Observed (cm)	26																									
444	27																									
Distance (m)	28																									
117.4	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	8.98																							3.00	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N^d	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Nihonkai-1983	1	0.79	Dune Sand	2.00	9	3.50	18.0	32.6	29.7	1.00	0.75	1.00	67	1.12	1.83	14	0	0.35	175	0.98	0.17	0.12	0.70	0.775	0.90	10.85
Mw	2	1.00	Dune Sand	3.00	10	4.50	18.0	50.6	37.9	1.00	0.85	1.00	67	1.12	1.62	15	0	0.35	175	0.97	0.21	0.13	0.61	0.919	0.85	12.41
7.7	3	1.00	Dune Sand	4.00	10	5.50	18.0	68.6	46.1	1.00	0.85	1.00	67	1.12	1.47	14	0	0.35	175	0.95	0.23	0.11	0.47	0.996	0.80	11.00
Site	4	1.00	Alluvial Sand	5.00	15	6.50	18.0	86.6	54.3	1.00	0.95	1.00	67	1.12	1.36	22	5	0.35	200	0.93	0.24	0.19	0.81	0.507	0.75	18.28
Noshiro-N3	5	1.00	Alluvial Sand	6.00	17	7.50	18.0	104.6	62.5	1.00	0.95	1.00	67	1.12	1.26	23	5	0.35	200	0.90	0.24	0.20	0.84	0.437	0.70	19.40
Data Class	6	1.00	Alluvial Sand	7.00	23	8.50	18.0	122.6	70.7	1.00	0.95	1.00	67	1.12	1.19	29	5	0.35	200	0.87	0.24	0.32	1.30	0.010	0.65	40.31
	7	1.00	Alluvial Sand	8.00	28	9.50	19.0	141.1	79.4	1.00	0.95	1.00	67	1.12	1.12	33	5	0.35	225	0.83	0.24	0.43	1.78	0.000	0.60	41.48
B. H.	8	1.00	Clay	9.00	7	10.50	16.5	158.8	87.3	1.00	1.00	1.00	67	1.12	1.07	8	35	0.01	150	0.80	0.24	0.07	0.32	0.000	0.00	Non-Liq.
82	9																									
GWT (m)	10																									
1.71	11																									
a_{max} (g)	12																									
0.25	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
67	19																									
N (mean)	20																									
14.9	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
178	25																									
Observed (cm)	26																									
434	27																									
Distance (m)	28																									
11.6	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	7.79																							2.82	

Earthquake	No.[a]	Sub-Layer H (m)	SoilType	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Nihonkai-1983	1	0.73	Dune Sand	3.00	11	4.50	18.0	48.5	46.2	1.00	0.85	1.00	67	1.12	1.47	15	0	0.35	175	0.97	0.17	0.11	0.69	0.780	0.85	11.68
Mw	2	1.00	Alluvial Sand	4.00	10	5.50	18.0	66.5	54.4	1.00	0.85	1.00	67	1.12	1.36	13	5	0.35	175	0.95	0.19	0.10	0.53	0.984	0.80	9.91
7.7	3	1.00	Alluvial Sand	5.00	13	6.50	18.0	84.5	62.6	1.00	0.95	1.00	67	1.12	1.26	17	5	0.35	175	0.93	0.20	0.14	0.66	0.837	0.75	14.37
Site	4	1.00	Alluvial Sand	6.00	23	7.50	18.0	102.5	70.8	1.00	0.95	1.00	67	1.12	1.19	29	5	0.35	200	0.90	0.21	0.32	1.49	0.001	0.70	40.30
Noshiro-N3	5	1.00	Alluvial Sand	7.00	23	8.50	18.0	120.5	79.0	1.00	0.95	1.00	67	1.12	1.13	27	5	0.35	200	0.87	0.22	0.27	1.26	0.014	0.65	39.88
Data Class	6	1.00	Alluvial Sand	8.00	30	9.50	19.0	139.0	87.7	1.00	0.95	1.00	67	1.12	1.07	34	5	0.35	225	0.84	0.22	0.44	2.03	0.000	0.60	41.66
	7	1.00	Alluvial Sand	9.00	13	10.50	18.0	157.5	96.3	1.00	1.00	1.00	67	1.12	1.02	15	5	0.35	175	0.80	0.21	0.10	0.46	0.997	0.55	11.80
B. H.	8	1.00	Clay	10.00	13	11.50	18.0	175.5	104.5	1.00	1.00	1.00	67	1.12	0.98	14	35	0.01	175	0.77	0.21	0.12	0.56	0.000	0.00	Non-Liq.
83	9	1.00	Clay	11.00	15	12.50	18.0	193.5	112.7	1.00	1.00	1.00	67	1.12	0.94	16	35	0.01	175	0.74	0.21	0.13	0.64	0.000	0.00	Non-Liq.
GWT (m)	10	1.00	Clay	12.00	14	13.50	18.0	211.5	120.9	1.00	1.00	1.00	67	1.12	0.91	14	35	0.01	175	0.71	0.20	0.11	0.56	0.000	0.00	Non-Liq.
2.77	11	1.00	Alluvial Sand	13.00	22	14.50	18.0	229.5	129.1	1.00	1.00	1.00	67	1.12	0.88	22	5	0.35	200	0.68	0.20	0.15	0.77	0.591	0.35	18.31
a_{max} (g)	12	1.00	Alluvial Sand	14.00	43	15.50	19.0	248.0	137.8	1.00	1.00	1.00	67	1.12	0.85	41	5	0.35	225	0.66	0.19	0.66	3.38	0.000	0.30	43.55
0.25	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
67	19																									
N (mean)	20																									
19.1	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
179	25																									
Observed (cm)	26																									
424	27																									
Distance (m)	28																									
377.4	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	11.73																							2.66	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Nihonkai-1983	1	0.60	Gravel	3.00	31	4.50	19.0	52.7	51.7	1.00	0.85	1.00	67	1.12	1.39	41	0	1.00	225	0.97	0.16	0.80	4.96	0.000	0.85	43.55
Mw	2	1.00	Gravel	4.00	26	5.50	19.0	71.7	60.9	1.00	0.85	1.00	67	1.12	1.28	32	0	1.00	225	0.95	0.18	0.38	2.08	0.000	0.80	41.02
7.7	3	1.00	Gravel	5.00	17	6.50	18.0	90.2	69.5	1.00	0.95	1.00	67	1.12	1.20	22	0	1.00	200	0.93	0.20	0.17	0.88	0.349	0.75	18.31
Site	4	1.00	Dune Sand	6.00	6	7.50	16.5	107.4	77.0	1.00	0.95	1.00	67	1.12	1.14	7	0	0.35	150	0.91	0.21	0.06	0.28	1.000	0.70	4.87
Noshiro-N4	5	1.00	Alluvial Sand	7.00	10	8.50	18.0	124.7	84.4	1.00	0.95	1.00	67	1.12	1.09	12	5	0.35	175	0.88	0.21	0.08	0.38	1.000	0.65	8.59
Data Class	6	1.00	Alluvial Sand	8.00	8	9.50	16.5	141.9	91.9	1.00	0.95	1.00	67	1.12	1.04	9	5	0.35	150	0.84	0.21	0.06	0.30	1.000	0.60	6.01
	7	1.00	Alluvial Sand	9.00	11	10.50	18.0	159.2	99.3	1.00	1.00	1.00	67	1.12	1.00	12	5	0.35	175	0.81	0.21	0.08	0.38	1.000	0.55	9.37
B. H.	8	1.00	Clay	10.00	7	11.50	16.5	176.4	106.7	1.00	1.00	1.00	67	1.12	0.97	8	35	0.01	150	0.78	0.21	0.07	0.32	0.000	0.00	Non-Liq.
84	9																									
GWT (m)	10																									
2.9	11																									
a_{max} (g)	12																									
0.25	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
67	19																									
N (mean)	20																									
14.5	21																									
γ_{dry} (kN/m^3)	22																									
17.5	23																									
Vs* (m/s)	24																									
181	25																									
Observed (cm)	26																									
310	27																									
Distance (m)	28																									
57	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	7.60																							2.76	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Nihonkai-1983	1	0.60	Dune Sand	3.00	6	4.50	16.5	48.1	47.1	1.00	0.85	1.00	67	1.12	1.46	8	0	0.35	150	0.95	0.16	0.07	0.45	0.998	0.85	5.59
Mw	2	1.00	Dune Sand	4.00	12	5.50	18.0	65.3	54.5	1.00	0.85	1.00	67	1.12	1.35	15	0	0.35	175	0.93	0.18	0.12	0.64	0.879	0.80	12.43
7.7	3	1.00	Dune Sand	5.00	6	6.50	16.5	82.6	61.9	1.00	0.95	1.00	67	1.12	1.27	8	0	0.35	150	0.90	0.20	0.06	0.33	1.000	0.75	5.43
Site	4	1.00	Dune Sand	6.00	7	7.50	16.5	99.1	68.6	1.00	0.95	1.00	67	1.12	1.21	9	0	0.35	150	0.87	0.20	0.07	0.33	1.000	0.70	6.10
Noshiro-N4	5	1.00	Alluvial Sand	7.00	13	8.50	18.0	116.3	76.1	1.00	0.95	1.00	67	1.12	1.15	16	5	0.35	175	0.83	0.21	0.11	0.55	0.972	0.65	12.80
Data Class	6	1.00	Alluvial Sand	8.00	15	9.50	18.0	134.3	84.3	1.00	0.95	1.00	67	1.12	1.09	17	5	0.35	175	0.79	0.20	0.12	0.60	0.926	0.60	14.27
	7	1.00	Alluvial Sand	9.00	21	10.50	18.0	152.3	92.5	1.00	1.00	1.00	67	1.12	1.04	24	5	0.35	200	0.75	0.20	0.21	1.03	0.120	0.55	39.04
B. H.	8	1.00	Alluvial Sand	10.00	21	11.50	18.0	170.3	100.6	1.00	1.00	1.00	67	1.12	1.00	23	5	0.35	200	0.72	0.20	0.19	0.95	0.216	0.50	38.77
85	9	1.00	Alluvial Sand	11.00	33	12.50	19.0	188.8	109.3	1.00	1.00	1.00	67	1.12	0.96	35	5	0.35	225	0.68	0.19	0.45	2.36	0.000	0.45	42.00
GWT (m)	10	1.00	Clay	12.00	10	13.50	16.5	206.6	117.3	1.00	1.00	1.00	67	1.12	0.92	10	35	0.01	150	0.66	0.19	0.08	0.43	0.000	0.00	Non-Liq.
2.9	11																									
a_{max} (g)	12																									
0.25	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
67	19																									
N (mean)	20																									
14.4	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
167	25																									
Observed (cm)	26																									
310	27																									
Distance (m)	28																									
7.6	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	9.60																							4.02	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Nihonkai-1983	1	1.16	Dune Sand	2.00	9	3.50	18.0	32.0	25.5	1.00	0.75	1.00	67	1.12	1.98	15	0	0.35	175	0.98	0.20	0.14	0.69	0.787	0.90	11.94
Mw	2	1.00	Dune Sand	3.00	11	4.50	18.0	50.0	33.7	1.00	0.85	1.00	67	1.12	1.72	18	0	0.35	175	0.96	0.23	0.16	0.69	0.786	0.85	14.90
7.7	3	1.00	Dune Sand	4.00	10	5.50	18.0	68.0	41.9	1.00	0.85	1.00	67	1.12	1.55	15	0	0.35	175	0.94	0.25	0.12	0.47	0.996	0.80	11.68
Site	4	1.00	Alluvial Sand	5.00	17	6.50	18.0	86.0	50.1	1.00	0.95	1.00	67	1.12	1.41	25	5	0.35	200	0.92	0.26	0.27	1.04	0.109	0.75	39.34
Noshiro-N4	5	1.00	Alluvial Sand	6.00	19	7.50	18.0	104.0	58.3	1.00	0.95	1.00	67	1.12	1.31	26	5	0.35	200	0.89	0.26	0.27	1.06	0.091	0.70	39.59
Data Class	6	1.00	Alluvial Sand	7.00	25	8.50	19.0	122.5	67.0	1.00	0.95	1.00	67	1.12	1.22	32	5	0.35	225	0.86	0.26	0.42	1.64	0.000	0.65	41.23
	7	1.00	Alluvial Sand	8.00	28	9.50	19.0	141.5	76.1	1.00	0.95	1.00	67	1.12	1.15	34	5	0.35	225	0.82	0.25	0.46	1.84	0.000	0.60	41.67
B. H.	8	1.00	Clay	9.00	7	10.50	16.5	159.2	84.1	1.00	1.00	1.00	67	1.12	1.09	9	35	0.01	150	0.79	0.24	0.08	0.32	0.000	0.00	Non-Liq.
86	9																									
GWT (m)	10																									
1.34	11																									
a_{max} (g)	12																									
0.25	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
67	19																									
N (mean)	20																									
15.8	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
175	25																									
Observed (cm)	26																									
579	27																									
Distance (m)	28																									
0.6	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	8.16																							2.43	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N^d	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Nihonkai-1983	1	1.10	Dune Sand	2.00	9	3.50	18.0	33.2	27.3	1.00	0.75	1.00	67	1.12	1.91	14	0	0.35	175	0.99	0.19	0.13	0.67	0.831	0.90	11.44
Mw	2	1.00	Alluvial Sand	3.00	16	4.50	18.0	51.2	35.5	1.00	0.85	1.00	67	1.12	1.68	25	5	0.35	200	0.98	0.23	0.29	1.28	0.012	0.85	39.34
7.7	3	1.00	Alluvial Sand	4.00	20	5.50	18.0	69.2	43.7	1.00	0.85	1.00	67	1.12	1.51	29	5	0.35	200	0.96	0.25	0.36	1.43	0.002	0.80	40.22
Site	4	1.00	Alluvial Sand	5.00	18	6.50	18.0	87.2	51.9	1.00	0.95	1.00	67	1.12	1.39	27	5	0.35	200	0.95	0.26	0.29	1.11	0.062	0.75	39.62
Noshiro-N4	5	1.00	Alluvial Sand	6.00	16	7.50	18.0	105.2	60.1	1.00	0.95	1.00	67	1.12	1.29	22	5	0.35	200	0.92	0.26	0.19	0.73	0.688	0.70	18.57
Data Class	6	1.00	Clay	7.00	7	8.50	16.5	122.5	67.5	1.00	0.95	1.00	67	1.12	1.22	9	35	0.01	150	0.90	0.26	0.08	0.32	0.000	0.00	Non-Liq.
	7	1.00	Clay	8.00	19	9.50	18.0	139.7	75.0	1.00	0.95	1.00	67	1.12	1.16	23	35	0.01	200	0.87	0.26	0.28	1.06	0.000	0.00	Non-Liq.
B. H.	8	1.00	Alluvial Sand	9.00	20	10.50	18.0	157.7	83.1	1.00	1.00	1.00	67	1.12	1.10	24	5	0.35	200	0.84	0.26	0.22	0.83	0.444	0.55	20.92
87	9	1.00	Alluvial Sand	10.00	29	11.50	19.0	176.2	91.8	1.00	1.00	1.00	67	1.12	1.04	34	5	0.35	225	0.80	0.25	0.43	1.70	0.000	0.50	41.61
GWT (m)	10	1.00	Alluvial Sand	11.00	41	12.50	19.0	195.2	101.0	1.00	1.00	1.00	67	1.12	0.99	46	5	0.35	225	0.77	0.24	1.02	4.21	0.000	0.45	44.81
1.4	11																									
a_{max} (g)	12																									
0.25	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
67	19																									
N (mean)	20																									
19.5	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
188	25																									
Observed (cm)	26																									
193	27																									
Distance (m)	28																									
32	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	10.10																							1.61	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Nihonkai-1983	1	0.60	Alluvial Sand	3.00	12	4.50	18.0	48.2	47.2	1.00	0.85	1.00	67	1.12	1.46	17	5	0.35	175	0.96	0.16	0.14	0.86	0.390	0.85	13.54
Mw	2	1.00	Alluvial Sand	4.00	10	5.50	18.0	66.2	55.4	1.00	0.85	1.00	67	1.12	1.34	13	5	0.35	175	0.94	0.18	0.10	0.53	0.980	0.80	9.79
7.7	3	1.00	Alluvial Sand	5.00	13	6.50	18.0	84.2	63.6	1.00	0.95	1.00	67	1.12	1.25	17	5	0.35	175	0.92	0.20	0.13	0.67	0.819	0.75	14.23
Site	4	1.00	Alluvial Sand	6.00	23	7.50	18.0	102.2	71.8	1.00	0.95	1.00	67	1.12	1.18	29	5	0.35	200	0.89	0.21	0.31	1.51	0.001	0.70	40.25
Noshiro-N4	5	1.00	Alluvial Sand	7.00	24	8.50	18.0	120.2	80.0	1.00	0.95	1.00	67	1.12	1.12	28	5	0.35	200	0.86	0.21	0.29	1.41	0.003	0.65	40.16
Data Class	6	1.00	Alluvial Sand	8.00	30	9.50	19.0	138.7	88.7	1.00	0.95	1.00	67	1.12	1.06	34	5	0.35	225	0.82	0.21	0.43	2.06	0.000	0.60	41.61
	7	1.00	Alluvial Sand	9.00	13	10.50	18.0	157.2	97.4	1.00	1.00	1.00	67	1.12	1.01	15	5	0.35	175	0.79	0.21	0.10	0.47	0.996	0.55	11.73
B. H.	8	1.00	Clay	10.00	13	11.50	18.0	175.2	105.5	1.00	1.00	1.00	67	1.12	0.97	14	35	0.01	175	0.75	0.20	0.12	0.57	0.000	0.00	Non-Liq.
88	9																									
GWT (m)	10																									
2.9	11																									
a_{max} (g)	12																									
0.25	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
67	19																									
N (mean)	20																									
17.3	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
175	25																									
Observed (cm)	26																									
135	27																									
Distance (m)	28																									
79.6	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	7.60																							2.15	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Nihonkai-1983	1	0.85	Dune sand	2.00	13	3.50	18.0	32.7	29.3	1.00	0.75	1.00	67	1.12	1.85	20	0	0.35	175	0.98	0.18	0.20	1.10	0.068	0.90	37.88
Mw	2	1.00	Dune sand	3.00	7	4.50	18.0	50.7	37.5	1.00	0.85	1.00	67	1.12	1.63	11	0	0.35	175	0.97	0.21	0.09	0.43	0.999	0.85	7.90
7.7	3	1.00	Dune sand	4.00	5	5.50	16.5	68.0	44.9	1.00	0.85	1.00	67	1.12	1.49	7	0	0.35	150	0.95	0.23	0.07	0.28	1.000	0.80	4.76
Site	4	1.00	Alluvial Sand	5.00	15	6.50	18.0	85.2	52.3	1.00	0.95	1.00	67	1.12	1.38	22	5	0.35	200	0.93	0.25	0.20	0.82	0.483	0.75	18.65
Noshiro-N5	5	1.00	Alluvial Sand	6.00	16	7.50	18.0	103.2	60.5	1.00	0.95	1.00	67	1.12	1.29	22	5	0.35	200	0.91	0.25	0.19	0.76	0.625	0.70	18.49
Data Class	6	1.00	Alluvial Sand	7.00	26	8.50	19.0	121.7	69.2	1.00	0.95	1.00	67	1.12	1.20	33	5	0.35	225	0.88	0.25	0.44	1.75	0.000	0.65	41.43
	7	1.00	Alluvial Sand	8.00	27	9.50	19.0	140.7	78.4	1.00	0.95	1.00	67	1.12	1.13	32	5	0.35	225	0.85	0.25	0.40	1.61	0.000	0.60	41.21
B. H.	8	1.00	Alluvial Sand	9.00	20	10.50	18.0	159.2	87.1	1.00	1.00	1.00	67	1.12	1.07	24	5	0.35	200	0.81	0.24	0.21	0.86	0.389	0.55	20.63
91	9	1.00	Alluvial Sand	10.00	10	11.50	18.0	177.2	95.3	1.00	1.00	1.00	67	1.12	1.02	11	5	0.35	175	0.78	0.24	0.08	0.32	1.000	0.50	8.48
GWT (m)	10																									
1.65	11																									
a_{max} (g)	12																									
0.25	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
67	19																									
N (mean)	20																									
15.5	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
182	25																									
Observed (cm)	26																									
206	27																									
Distance (m)	28																									
180.5	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	8.85																							3.22	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Nihonkai-1983	1	0.91	Dune sand	3.00	3	4.50	15.5	45.2	41.2	1.00	0.85	1.00	67	1.12	1.56	4	0	0.35	125	0.93	0.17	0.05	0.33	1.000	0.85	3.35
Mw	2	1.00	Dune sand	4.00	6	5.50	16.5	61.2	47.4	1.00	0.85	1.00	67	1.12	1.45	8	0	0.35	150	0.90	0.19	0.07	0.37	1.000	0.80	5.57
7.7	3	1.00	Alluvial Sand	5.00	9	6.50	18.0	78.5	54.8	1.00	0.95	1.00	67	1.12	1.35	13	5	0.35	175	0.86	0.20	0.10	0.50	0.992	0.75	9.94
Site	4	1.00	Alluvial Sand	6.00	15	7.50	18.0	96.5	63.0	1.00	0.95	1.00	67	1.12	1.26	20	5	0.35	175	0.81	0.20	0.17	0.82	0.486	0.70	16.85
Noshiro-N5	5	1.00	Alluvial Sand	7.00	21	8.50	18.0	114.5	71.2	1.00	0.95	1.00	67	1.12	1.19	26	5	0.35	200	0.77	0.20	0.26	1.29	0.011	0.65	39.59
Data Class	6	1.00	Alluvial Sand	8.00	21	9.50	18.0	132.5	79.4	1.00	0.95	1.00	67	1.12	1.12	25	5	0.35	200	0.73	0.20	0.23	1.15	0.042	0.60	39.21
	7	1.00	Alluvial Sand	9.00	5	10.50	16.5	149.7	86.8	1.00	1.00	1.00	67	1.12	1.07	6	5	0.35	150	0.69	0.19	0.05	0.27	1.000	0.55	4.12
B. H.	8	1.00	Clay	10.00	9	11.50	16.5	166.2	93.5	1.00	1.00	1.00	67	1.12	1.03	10	35	0.01	150	0.65	0.19	0.09	0.46	0.000	0.00	Non-Liq.
92	9																									
GWT (m)	10																									
2.59	11																									
a_{max} (g)	12																									
0.25	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
67	19																									
N (mean)	20																									
11.1	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
151	25																									
Observed (cm)	26																									
206	27																									
Distance (m)	28																									
54.6	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	7.91																							3.24	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Nihonkai-1983	1	0.52	Dune sand	2.00	10	3.50	18.0	32.0	31.8	1.00	0.75	1.00	67	1.12	1.77	15	0	0.35	175	0.98	0.16	0.13	0.80	0.528	0.90	11.85
Mw	2	1.00	Dune sand	3.00	22	4.50	19.0	50.5	40.5	1.00	0.85	1.00	67	1.12	1.57	33	0	0.35	225	0.97	0.20	0.46	2.35	0.000	0.85	41.34
7.7	3	1.00	Alluvial Sand	4.00	27	5.50	19.0	69.5	49.7	1.00	0.85	1.00	67	1.12	1.42	36	5	0.35	225	0.96	0.22	0.61	2.82	0.000	0.80	42.30
Site	4	1.00	Alluvial Sand	5.00	21	6.50	18.0	88.0	58.4	1.00	0.95	1.00	67	1.12	1.31	29	5	0.35	200	0.94	0.23	0.34	1.47	0.002	0.75	40.34
Noshiro-N6	5	1.00	Alluvial Sand	6.00	22	7.50	18.0	106.0	66.6	1.00	0.95	1.00	67	1.12	1.23	29	5	0.35	200	0.91	0.24	0.31	1.32	0.008	0.70	40.19
Data Class	6	1.00	Clay	7.00	14	8.50	18.0	124.0	74.8	1.00	0.95	1.00	67	1.12	1.16	17	35	0.01	175	0.89	0.24	0.17	0.69	0.000	0.00	Non-Liq.
	7																									
B. H.	8																									
93	9																									
GWT (m)	10																									
1.98	11																									
a_{max} (g)	12																									
0.25	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
67	19																									
N (mean)	20																									
19.3	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
184	25																									
Observed (cm)	26																									
340	27																									
Distance (m)	28																									
327.1	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	5.52																							0.25	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Nihonkai-1983	1	0.79	Dune sand	2.00	12	3.50	18.0	32.6	29.7	1.00	0.75	1.00	67	1.12	1.83	18	0	0.35	175	0.98	0.17	0.17	0.98	0.172	0.90	37.42
Mw	2	1.00	Dune sand	3.00	7	4.50	18.0	50.6	37.9	1.00	0.85	1.00	67	1.12	1.62	11	0	0.35	175	0.97	0.21	0.09	0.43	0.999	0.85	7.83
7.7	3	1.00	Alluvial Sand	4.00	6	5.50	16.5	67.8	45.4	1.00	0.85	1.00	67	1.12	1.48	8	5	0.35	150	0.95	0.23	0.07	0.32	1.000	0.80	5.70
Site	4	1.00	Alluvial Sand	5.00	14	6.50	18.0	85.1	52.8	1.00	0.95	1.00	67	1.12	1.38	20	5	0.35	175	0.93	0.24	0.18	0.73	0.686	0.75	17.21
Noshiro-N7	5	1.00	Alluvial Sand	6.00	16	7.50	18.0	103.1	61.0	1.00	0.95	1.00	67	1.12	1.28	22	5	0.35	200	0.90	0.25	0.19	0.77	0.612	0.70	18.41
Data Class	6	1.00	Alluvial Sand	7.00	26	8.50	19.0	121.6	69.7	1.00	0.95	1.00	67	1.12	1.20	33	5	0.35	225	0.87	0.25	0.43	1.76	0.000	0.65	41.40
	7	1.00	Alluvial Sand	8.00	27	9.50	19.0	140.6	78.9	1.00	0.95	1.00	67	1.12	1.13	32	5	0.35	225	0.84	0.24	0.40	1.63	0.000	0.60	41.19
B. H.	8	1.00	Alluvial Sand	9.00	21	10.50	18.0	159.1	87.6	1.00	1.00	1.00	67	1.12	1.07	25	5	0.35	200	0.80	0.24	0.22	0.93	0.242	0.55	39.23
94	9	1.00	Clay	10.00	12	11.50	18.0	177.1	95.8	1.00	1.00	1.00	67	1.12	1.02	14	35	0.01	175	0.77	0.23	0.11	0.50	0.000	0.00	Non-Liq.
GWT (m)	10																									
1.71	11																									
a_{max} (g)	12																									
0.25	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
67	19																									
N (mean)	20																									
15.7	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
179	25																									
Observed (cm)	26																									
371	27																									
Distance (m)	28																									
81.1	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	8.79																							2.85	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Nihonkai-1983	1	1.28	Dune Sand	2.00	11	3.50	18.0	35.4	27.7	1.00	0.75	1.00	67	1.12	1.90	17	0	0.35	175	0.99	0.20	0.16	0.80	0.532	0.90	14.42
Mw	2	1.00	Alluvial Sand	3.00	22	4.50	19.0	53.9	36.4	1.00	0.85	1.00	67	1.12	1.66	35	5	0.35	225	0.98	0.23	0.59	2.50	0.000	0.85	41.83
7.7	3	1.00	Alluvial Sand	4.00	21	5.50	18.0	72.4	45.1	1.00	0.85	1.00	67	1.12	1.49	30	5	0.35	200	0.96	0.25	0.38	1.51	0.001	0.80	40.48
Site	4	1.00	Alluvial Sand	5.00	35	6.50	19.0	90.9	53.8	1.00	0.95	1.00	67	1.12	1.36	51	5	0.35	225	0.95	0.26	1.79	6.91	0.000	0.75	46.19
Noshiro-N7	5	1.00	Clay	6.00	21	7.50	18.0	109.4	62.5	1.00	0.95	1.00	67	1.12	1.26	28	35	0.01	200	0.92	0.26	0.45	1.69	0.000	0.00	Non-Liq.
Data Class	6	1.00	Clay	7.00	10	8.50	18.0	127.4	70.7	1.00	0.95	1.00	67	1.12	1.19	13	35	0.01	175	0.90	0.26	0.11	0.43	0.000	0.00	Non-Liq.
	7	1.00	Clay	8.00	6	9.50	16.5	144.6	78.1	1.00	0.95	1.00	67	1.12	1.13	7	35	0.01	150	0.87	0.26	0.07	0.27	0.000	0.00	Non-Liq.
B. H.	8	1.00	Clay	9.00	7	10.50	16.5	161.1	84.8	1.00	1.00	1.00	67	1.12	1.09	8	35	0.01	150	0.84	0.26	0.08	0.29	0.000	0.00	Non-Liq.
95	9	1.00	Alluvial Sand	10.00	35	11.50	19.0	178.9	92.8	1.00	1.00	1.00	67	1.12	1.04	41	5	0.35	225	0.80	0.25	0.72	2.84	0.000	0.50	43.46
GWT (m)	10	1.00	Alluvial Sand	11.00	33	12.50	19.0	197.9	101.9	1.00	1.00	1.00	67	1.12	0.99	36	5	0.35	225	0.77	0.24	0.51	2.09	0.000	0.45	42.34
1.22	11																									
a_{max} (g)	12																									
0.25	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
67	19																									
N (mean)	20																									
20.1	21																									
γ_{dry} (kN/m^3)	22																									
17.5	23																									
Vs* (m/s)	24																									
188	25																									
Observed (cm)	26																									
371	27																									
Distance (m)	28																									
396	29																								LSI	
Liquefied?	30																								Lin.	
	SUM	10.28																							0.61	

SEISMIC EVENT # 9

EARTHQUAKE:	Borah Peak
MOMENT MAGNITUDE:	6.9
LOCATION:	USA
DATE:	October 28, 1983
REFERENCE(S):	Database of Youd et al. (2002)

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Borah Peak - 1983	1	0.43	Silty Gravel	1.13	6	2.63	16.5	18.1	17.0	1.00	0.75	1.00	45	0.75	2.00	7	12	17.00	150	0.98	0.41	0.11	0.28	1.000	0.94	4.88
Mw	2	0.60	Silty Sand	1.74	5	3.24	16.5	28.2	21.0	1.00	0.75	1.00	45	0.75	2.00	6	20	4.80	150	0.96	0.50	0.10	0.20	1.000	0.91	4.52
6.9	3	0.58	Silty Sand	2.32	8	3.82	16.5	37.8	24.9	1.00	0.75	1.00	45	0.75	2.00	9	20	4.80	150	0.94	0.56	0.13	0.23	1.000	0.88	7.31
Site	4	0.70	Silty Gravel	2.90	14	4.40	18.0	47.8	29.2	1.00	0.85	1.00	45	0.75	1.85	17	17	15.00	175	0.92	0.59	0.22	0.38	1.000	0.86	14.79
Whishey Springs	5	0.82	Silty Clay	3.72	5	5.22	16.5	61.9	35.3	1.00	0.85	1.00	45	0.75	1.68	5	35	0.04	150	0.89	0.61	0.09	0.16	0.000	0.00	Non-Liq.
Data Class	6																									
	7																									
B. H.	8																									
1	9																									
GWT (m)	10																									
1.01	11																									
a_{max} (g)	12																									
0.6	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
45	19																									
N (mean)	20																									
7.6	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
154	25																									
Observed (cm)	26																									
100	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	3.12																							2.06	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Borah Peak - 1983	1	0.62	Sand+Gravel	1.83	8	3.33	16.5	29.4	26.4	1.00	0.75	1.00	45	0.75	1.95	9	2	5.20	150	0.96	0.24	0.11	0.45	0.998	0.91	5.94
Mw	2	0.76	Sand+Gravel	2.44	7	3.94	16.5	39.5	30.5	1.00	0.75	1.00	45	0.75	1.81	7	2	5.20	150	0.95	0.28	0.09	0.34	1.000	0.88	4.79
6.9	3	0.76	Sand+Gravel	3.35	7	4.85	16.5	54.5	36.6	1.00	0.85	1.00	45	0.75	1.65	7	2	5.20	150	0.92	0.31	0.09	0.29	1.000	0.83	4.95
Site	4	0.77	Sand+Gravel	3.96	20	5.46	18.0	65.0	41.1	1.00	0.85	1.00	45	0.75	1.56	20	5	4.00	175	0.90	0.32	0.23	0.72	0.710	0.80	16.70
Pence Ranch	5	0.92	Sand+Gravel	4.88	19	6.38	18.0	81.6	48.6	1.00	0.95	1.00	45	0.75	1.43	19	5	4.00	175	0.86	0.33	0.22	0.66	0.852	0.76	16.25
Data Class	6																									
	7																									
B. H.	8																									
2	9																									
GWT (m)	10																									
1.52	11																									
a_{max} (g)	12																									
0.35	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
45	19																									
N (mean)	20																									
12.2	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
157	25																									
Observed (cm)	26																									
100	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	3.82																							2.89	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Borah Peak - 1983	1	0.77	Silty Gravel	7.47	12	8.97	16.5	119.8	115.2	1.00	0.95	1.00	45	0.75	0.93	8	20	3.90	150	0.70	0.28	0.08	0.27	1.000	0.63	6.27
Mw	2	0.54	Silty Gravel	8.08	11	9.58	16.5	129.8	119.3	1.00	0.95	1.00	45	0.75	0.92	7	24	3.00	150	0.67	0.28	0.07	0.26	1.000	0.60	5.85
6.9	3	0.46	Silty Gravel	8.54	14	10.04	16.5	137.4	122.4	1.00	1.00	1.00	45	0.75	0.90	9	24	3.00	150	0.65	0.28	0.09	0.31	1.000	0.57	8.17
Site	4	0.46	Silty Gravel	8.99	17	10.49	18.0	145.2	125.7	1.00	1.00	1.00	45	0.75	0.89	11	14	5.00	175	0.63	0.28	0.10	0.34	1.000	0.55	9.26
Whiskey Springs	5	0.46	Silty Gravel	9.45	20	10.95	18.0	153.4	129.5	1.00	1.00	1.00	45	0.75	0.88	13	14	5.00	175	0.60	0.28	0.11	0.39	1.000	0.53	11.11
Data Class	6	0.54	Silty Gravel	9.91	25	11.41	18.0	161.7	133.3	1.00	1.00	1.00	45	0.75	0.87	16	17	4.00	175	0.58	0.28	0.14	0.51	0.988	0.50	14.52
	7	0.61	Silty Gravel	10.52	19	12.02	18.0	172.7	138.3	1.00	1.00	1.00	45	0.75	0.85	12	15	2.00	175	0.56	0.27	0.10	0.36	1.000	0.47	10.12
B. H.	8																									
3	9																									
GWT (m)	10																									
7.01	11																									
a_{max} (g)	12																									
0.6	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
45	19																									
N (mean)	20																									
16.9	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
154	25																									
Observed (cm)	26																									
100	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	3.82																							2.11	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Borah Peak - 1983	1	0.93	Silty Gravel	9.91	20	11.41	18.0	173.7	168.3	1.00	1.00	1.00	45	0.75	0.77	12	16	4.20	175	0.68	0.28	0.09	0.33	1.000	0.50	9.64
Mw	2	0.76	Silty Gravel	10.67	23	12.17	18.0	187.4	174.5	1.00	1.00	1.00	45	0.75	0.76	13	22	3.20	175	0.65	0.27	0.11	0.39	1.000	0.47	11.78
6.9	3	0.77	Silty Gravel	11.43	16	12.93	16.5	200.5	180.2	1.00	1.00	1.00	45	0.75	0.74	9	20	3.60	150	0.62	0.27	0.07	0.27	1.000	0.43	7.24
Site	4	0.77	Silty Gravel	12.20	23	13.70	18.0	213.8	185.9	1.00	1.00	1.00	45	0.75	0.73	13	16	3.20	175	0.60	0.27	0.10	0.36	1.000	0.39	10.77
Whiskey Springs	5	0.76	Silty Gravel	12.96	46	14.46	18.0	227.5	192.1	1.00	1.00	1.00	45	0.75	0.72	25	30	2.40	200	0.57	0.26	0.30	1.12	0.056	0.35	40.18
Data Class	6	0.76	Silty Gravel	13.72	35	15.22	18.0	241.1	198.4	1.00	1.00	1.00	45	0.75	0.71	19	19	4.80	175	0.55	0.26	0.16	0.60	0.935	0.31	17.13
	7																									
B. H.	8																									
4	9																									
GWT (m)	10																									
9.36	11																									
a_{max} (g)	12																									
0.6	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
45	19																									
N (mean)	20																									
27.2	21																									
γ_{dry} (kN/m^3)	22																									
17.5	23																									
Vs* (m/s)	24																									
175	25																									
Observed (cm)	26																									
100	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	4.74																							1.69	

SEISMIC EVENT # 10

EARTHQUAKE:	Superstition Hills
MOMENT MAGNITUDE:	6.6
LOCATION:	USA
DATE:	November 24, 1987
REFERENCE(S):	Database of Youd et al. (2002) Larsen, S. et al. (1991)

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Superstition-1987	1	1.83	Silt	1.52	1	3.02	15.5	23.0	20.0	1.00	0.75	1.00	68	1.13	2.00	2	35	0.03	125	0.95	0.15	0.09	0.60	0.000	0.00	Non-Liq.
Mw	2	0.46	Silty Sand	3.05	3	4.55	16.5	47.4	29.5	1.00	0.85	1.00	68	1.13	1.84	5	22	0.09	150	0.89	0.20	0.10	0.52	0.986	0.85	4.41
6.6	3	0.92	Silty Sand	3.96	5	5.46	16.5	62.4	35.6	1.00	0.85	1.00	68	1.13	1.68	8	22	0.09	150	0.85	0.20	0.12	0.59	0.936	0.80	6.50
Site	4	0.92	Silty Sand	4.88	4	6.38	16.5	77.6	41.7	1.00	0.95	1.00	68	1.13	1.55	7	22	0.09	150	0.80	0.20	0.10	0.51	0.989	0.76	5.33
Wildlife	5	0.92	Silty Sand	5.79	9	7.29	18.0	93.3	48.5	1.00	0.95	1.00	68	1.13	1.44	14	22	0.09	175	0.75	0.20	0.18	0.91	0.288	0.71	12.67
Data Class	6																									
	7																									
B. H.	8																									
110	9																									
GWT (m)	10																									
1.22	11																									
a_{max} (g)	12																									
0.21	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
68	19																									
N (mean)	20																									
4.4	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
139	25																									
Observed (cm)	26																									
20	27																									
Distance (m)	28																									
0.3	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	5.03																							1.94	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Superstition-1987	1	1.88	Silt	1.40	3	2.90	16.5	21.3	19.5	1.00	0.75	1.00	60	1.00	2.00	5	35	0.04	150	0.98	0.15	0.11	0.78	0.000	0.00	Non-Liq.
Mw	2	1.60	Silty Sand	3.90	9	5.40	18.0	64.4	38.1	1.00	0.85	1.00	60	1.00	1.62	12	26	0.09	175	0.92	0.21	0.17	0.82	0.472	0.81	11.46
6.6	3	2.50	Silty Sand	6.00	22	7.50	18.0	102.2	55.3	1.00	0.95	1.00	60	1.00	1.34	28	27	0.09	200	0.84	0.21	0.59	2.79	0.000	0.70	41.05
Site	4																									
Wildlife	5																									
Data Class	6																									
	7																									
B. H.	8																									
111	9																									
GWT (m)	10																									
1.22	11																									
a_{max} (g)	12																									
0.21	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
11.4	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
164	25																									
Observed (cm)	26																									
10	27																									
Distance (m)	28																									
0.3	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	5.98																							0.61	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Superstition-1987	1	0.91	Silty Clay	1.49	1	2.99	15.5	22.5	19.8	1.00	0.75	1.00	68	1.13	2.00	2	35	0.00	125	0.97	0.15	0.09	0.60	0.000	0.00	Non-Liq.
Mw	2	0.45	Sandy Silt	2.41	3	3.91	16.5	37.2	25.5	1.00	0.75	1.00	68	1.13	1.98	5	35	0.05	150	0.94	0.19	0.11	0.59	0.000	0.00	Non-Liq.
6.6	3	1.53	Silty Sand	3.05	6	4.55	18.0	48.2	30.3	1.00	0.85	1.00	68	1.13	1.82	11	34	0.08	175	0.92	0.20	0.17	0.84	0.434	0.85	10.16
Site	4	0.31	Sand	4.24	11	5.74	18.0	69.7	40.0	1.00	0.85	1.00	68	1.13	1.58	17	20	0.10	175	0.87	0.21	0.23	1.13	0.052	0.79	37.43
Wildlife	5	0.70	Silty Sand	5.03	4	6.53	16.5	83.3	45.9	1.00	0.95	1.00	68	1.13	1.48	6	29	0.08	150	0.84	0.21	0.10	0.49	0.993	0.75	5.47
Data Class	6	1.53	Silty Sand	5.79	12	7.29	18.0	96.4	51.6	1.00	0.95	1.00	68	1.13	1.39	18	29	0.08	175	0.80	0.20	0.26	1.28	0.012	0.71	38.08
	7	0.38	Sand	6.71	6	8.21	16.5	112.3	58.4	1.00	0.95	1.00	68	1.13	1.31	8	17	0.10	150	0.75	0.20	0.11	0.53	0.981	0.66	6.49
B. H.	8																									
112	9																									
GWT (m)	10																									
1.22	11																									
a_{max} (g)	12																									
0.21	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
68	19																									
N (mean)	20																									
6.1	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
151	25																									
Observed (cm)	26																									
10	27																									
Distance (m)	28																									
0.3	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	5.79																							1.35	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Superstition-1987	1	1.38	Silt	2.20	2	3.70	15.5	33.5	23.9	1.00	0.75	1.00	60	1.00	2.00	3	35	0.03	125	0.96	0.18	0.09	0.52	0.000	0.00	Non-Liq.
Mw	2	0.90	Silt	3.00	5	4.50	16.5	46.3	28.8	1.00	0.85	1.00	60	1.00	1.86	8	35	0.06	150	0.93	0.20	0.14	0.67	0.000	0.00	Non-Liq.
6.6	3	0.70	Silty Sand	3.50	8	5.00	18.0	54.9	32.5	1.00	0.85	1.00	60	1.00	1.75	12	31	0.09	175	0.92	0.21	0.18	0.86	0.386	0.83	11.43
Site	4	1.10	Silty Sand	4.90	27	6.40	19.0	80.8	44.7	1.00	0.95	1.00	60	1.00	1.50	38	28	0.09	225	0.86	0.21	1.48	6.94	0.000	0.76	44.10
Wildlife	5	0.90	Silty Sand	5.70	10	7.20	18.0	95.6	51.7	1.00	0.95	1.00	60	1.00	1.39	13	35	0.07	175	0.83	0.21	0.18	0.88	0.345	0.72	13.22
Data Class	6	0.70	Silty Sand	6.60	30	8.10	19.0	112.3	59.5	1.00	0.95	1.00	60	1.00	1.30	36	35	0.08	225	0.78	0.20	1.29	6.39	0.000	0.67	43.90
	7																									
B. H.	8																									
113	9																									
GWT (m)	10																									
1.22	11																									
a_{max} (g)	12																									
0.21	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
13.6	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
157	25																									
Observed (cm)	26																									
10	27																									
Distance (m)	28																									
0.3	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	5.68																							0.44	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Superstition-1987	1	1.78	Silt	2.60	1	4.10	15.5	39.7	26.2	1.00	0.85	1.00	60	1.00	1.96	2	35	0.05	125	0.93	0.19	0.08	0.43	0.000	0.00	Non-Liq.
Mw	2	0.95	Silty Sand	3.70	5	5.20	16.5	57.3	33.0	1.00	0.85	1.00	60	1.00	1.74	7	28	0.09	150	0.88	0.21	0.12	0.58	0.951	0.82	6.29
6.6	3	0.40	Silty Sand	4.20	9	5.70	18.0	65.9	36.7	1.00	0.85	1.00	60	1.00	1.65	13	23	0.09	175	0.86	0.21	0.18	0.83	0.447	0.79	11.43
Site	4	0.90	Silty Sand	4.90	21	6.40	18.0	78.5	42.4	1.00	0.95	1.00	60	1.00	1.54	30	28	0.09	200	0.83	0.21	0.74	3.55	0.000	0.76	41.59
Wildlife	5	1.00	Silty Sand	5.70	7	7.20	16.5	92.3	48.4	1.00	0.95	1.00	60	1.00	1.44	10	35	0.07	150	0.78	0.20	0.14	0.67	0.827	0.72	9.20
Data Class	6	0.55	Silty Sand	6.60	23	8.10	18.0	107.8	55.1	1.00	0.95	1.00	60	1.00	1.35	29	35	0.07	200	0.74	0.20	0.72	3.67	0.000	0.67	41.77
	7																									
B. H.	8																									
114	9																									
GWT (m)	10																									
1.22	11																									
a_{max} (g)	12																									
0.21	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
10.9	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
146	25																									
Observed (cm)	26																									
10	27																									
Distance (m)	28																									
0.3	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	5.58																							1.47	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Superstition-1987	1	1.78	Silt	1.52	1	3.02	15.5	23.0	20.0	1.00	0.75	1.00	68	1.13	2.00	2	35	0.02	125	0.97	0.15	0.09	0.59	0.000	0.00	Non-Liq.
Mw	2	0.51	Silty Sand	3.05	10	4.55	18.0	51.2	33.3	1.00	0.85	1.00	68	1.13	1.73	17	35	0.06	175	0.92	0.19	0.28	1.45	0.002	0.85	37.88
6.6	3	0.92	Silty Sand	3.96	9	5.46	18.0	67.6	40.7	1.00	0.85	1.00	68	1.13	1.57	14	21	0.10	175	0.88	0.20	0.18	0.91	0.292	0.80	12.22
Site	4	0.92	Silty Sand	4.88	17	6.38	18.0	84.2	48.3	1.00	0.95	1.00	68	1.13	1.44	26	26	0.09	200	0.84	0.20	0.52	2.58	0.000	0.76	40.45
Wildlife	5	1.47	Silty Sand	5.79	12	7.29	18.0	100.6	55.7	1.00	0.95	1.00	68	1.13	1.34	17	35	0.06	175	0.80	0.20	0.26	1.30	0.010	0.71	38.07
Data Class	6																									
	7																									
B. H.	8																									
115	9																									
GWT (m)	10																									
1.22	11																									
a_{max} (g)	12																									
0.21	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
68	19																									
N (mean)	20																									
9.8	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
151	25																									
Observed (cm)	26																									
10	27																									
Distance (m)	28																									
0.3	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	5.58																							0.23	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Superstition-1987	1	0.38	Silt	1.30	2	2.80	15.5	19.5	18.8	1.00	0.75	1.00	60	1.00	2.00	3	35	0.02	125	0.97	0.14	0.10	0.74	0.000	0.00	Non-Liq.
Mw	2	1.55	Silt	1.90	1	3.40	15.5	28.8	22.2	1.00	0.75	1.00	60	1.00	2.00	2	35	0.05	125	0.95	0.17	0.09	0.50	0.000	0.00	Non-Liq.
6.6	3	0.50	Silty Sand	3.20	6	4.70	16.5	49.6	30.2	1.00	0.85	1.00	60	1.00	1.82	9	21	0.07	150	0.91	0.20	0.14	0.68	0.805	0.84	7.69
Site	4	1.40	Silty Sand	4.00	17	5.50	18.0	63.4	36.2	1.00	0.85	1.00	60	1.00	1.66	24	24	0.09	200	0.88	0.21	0.45	2.16	0.000	0.80	39.69
Wildlife	5	0.40	Silty Sand	5.20	10	6.70	18.0	85.0	46.0	1.00	0.95	1.00	60	1.00	1.47	14	29	0.09	175	0.82	0.21	0.19	0.93	0.241	0.74	36.89
Data Class	6	0.65	Silty Sand	5.70	12	7.20	18.0	94.0	50.1	1.00	0.95	1.00	60	1.00	1.41	16	35	0.07	175	0.80	0.20	0.24	1.16	0.037	0.72	37.70
	7	0.55	Silty Sand	6.50	16	8.00	18.0	108.4	56.6	1.00	0.95	1.00	60	1.00	1.33	20	35	0.09	175	0.75	0.20	0.33	1.65	0.000	0.68	38.95
B. H.	8																									
117	9																									
GWT (m)	10																									
1.22	11																									
a_{max} (g)	12																									
0.21	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
9.1	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
149	25																									
Observed (cm)	26																									
0	27																									
Distance (m)	28																									
0.3	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	5.43																							0.43	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Superstition-1987	1	1.53	Silt + Clay	2.44	1	3.94	15.5	37.2	25.2	1.00	0.75	1.00	78	1.30	1.99	2	35	0.04	125	0.93	0.19	0.09	0.45	0.000	0.00	Non-Liq.
Mw	2	0.41	Sandy Silt	3.05	3	4.55	16.5	48.5	30.5	1.00	0.85	1.00	78	1.30	1.81	6	35	0.06	150	0.91	0.20	0.11	0.58	0.000	0.00	Non-Liq.
6.6	3	0.82	Fine Sand	3.66	7	5.16	18.0	59.0	35.1	1.00	0.85	1.00	78	1.30	1.69	13	20	0.09	175	0.89	0.20	0.18	0.88	0.336	0.82	11.58
Site	4	0.61	Fine Sand	4.27	12	5.77	18.0	70.0	40.1	1.00	0.85	1.00	78	1.30	1.58	21	23	0.10	200	0.86	0.20	0.34	1.65	0.000	0.79	38.75
Wildlife	5	0.71	Fine Sand	4.88	7	6.38	18.0	81.0	45.1	1.00	0.95	1.00	78	1.30	1.49	13	19	0.09	175	0.83	0.20	0.16	0.81	0.511	0.76	11.29
Data Class	6	0.74	Sandy Silt	5.49	2	6.99	15.5	91.2	49.3	1.00	0.95	1.00	78	1.30	1.42	4	35	0.09	125	0.80	0.20	0.08	0.40	0.000	0.00	Non-Liq.
	7	0.38	Silty Sand	6.10	12	7.60	18.0	101.4	53.5	1.00	0.95	1.00	78	1.30	1.37	20	26	0.11	175	0.77	0.20	0.30	1.53	0.001	0.70	38.65
B. H.	8	0.92	Silty Sand	6.71	10	8.21	18.0	112.4	58.5	1.00	0.95	1.00	78	1.30	1.31	16	22	0.09	175	0.74	0.19	0.20	1.06	0.096	0.66	37.32
118	9																									
GWT (m)	10																									
1.22	11																									
a_{max} (g)	12																									
0.21	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
78	19																									
N (mean)	20																									
6.8	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
147	25																									
Observed (cm)	26																									
0	27																									
Distance (m)	28																									
0.3	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	6.10																							0.56	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Superstition-1987	1	1.35	Silt	1.83	0	3.33	15.5	27.8	21.8	1.00	0.75	1.00	68	1.13	2.00	0	35	0.06	125	0.95	0.17	0.08	0.46	0.000	0.00	Non-Liq.
Mw	2	0.59	Sandy Silt	2.74	4	4.24	16.5	43.4	28.5	1.00	0.85	1.00	68	1.13	1.87	7	35	0.06	150	0.92	0.19	0.13	0.68	0.000	0.00	Non-Liq.
6.6	3	0.89	Fine Sand	3.35	5	4.85	16.5	53.4	32.5	1.00	0.85	1.00	68	1.13	1.75	8	31	0.09	150	0.89	0.20	0.14	0.68	0.815	0.83	7.62
Site	4	0.54	Fine Sand	4.27	13	5.77	18.0	69.3	39.4	1.00	0.85	1.00	68	1.13	1.59	20	22	0.10	175	0.85	0.20	0.31	1.52	0.001	0.79	38.42
Wildlife	5	1.14	Fine Sand	4.88	10	6.38	18.0	80.3	44.4	1.00	0.95	1.00	68	1.13	1.50	16	26	0.09	175	0.82	0.20	0.23	1.13	0.053	0.76	37.44
Data Class	6	1.61	Silty Sand	5.79	6	7.29	16.5	96.0	51.2	1.00	0.95	1.00	68	1.13	1.40	9	35	0.06	150	0.77	0.20	0.13	0.65	0.862	0.71	8.61
	7																									
B. H.	8																									
119	9																									
GWT (m)	10																									
1.22	11																									
a_{max} (g)	12																									
0.21	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
68	19																									
N (mean)	20																									
6.3	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
145	25																									
Observed (cm)	26																									
0	27																									
Distance (m)	28																									
0.3	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	6.10																							1.63	

SEISMIC EVENT # 11

EARTHQUAKE:	Loma Prieta
MOMENT MAGNITUDE:	7.0
LOCATION:	USA
DATE:	October 17, 1989
REFERENCE(S):	Seed R. B., et al. (1990) Database of Youd et al. (2002)

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Loma Prieta - 1989	1	0.95	Sand	1.75	5	3.25	16.5	28.1	26.1	1.00	0.75	1.00	60	1.00	1.96	8	4	1.15	150	0.99	0.17	0.10	0.58	0.950	0.91	5.12
Mw	2	1.50	Sand	3.25	18	4.75	18.0	54.0	37.3	1.00	0.85	1.00	60	1.00	1.64	25	4	1.15	200	0.97	0.23	0.33	1.46	0.002	0.84	39.11
7.0	3	1.50	Sand	4.75	17	6.25	18.0	81.0	49.6	1.00	0.95	1.00	60	1.00	1.42	22	4	1.15	200	0.94	0.25	0.26	1.04	0.110	0.76	38.53
Site	4	1.50	Sand	6.25	25	7.75	18.0	108.0	61.9	1.00	0.95	1.00	60	1.00	1.27	30	4	1.15	200	0.91	0.26	0.44	1.71	0.000	0.69	40.63
Moss Landing	5	1.50	Silty Clay	7.75	23	9.25	18.0	135.0	74.2	1.00	0.95	1.00	60	1.00	1.16	25	35	0.01	200	0.86	0.25	0.41	1.61	0.000	0.00	Non-Liq.
Data Class	6	1.50	Silty Clay	9.25	4	10.75	16.5	160.9	85.3	1.00	1.00	1.00	60	1.00	1.08	5	35	0.01	150	0.81	0.25	0.07	0.27	0.000	0.00	Non-Liq.
	7	1.50	Silty Clay	10.75	2	12.25	15.5	184.9	94.6	1.00	1.00	1.00	60	1.00	1.03	2	35	0.01	125	0.75	0.24	0.05	0.22	0.000	0.00	Non-Liq.
B. H.	8	1.50	Clay + Sand	12.25	50	13.75	19.0	210.7	105.8	1.00	1.00	1.00	60	1.00	0.97	49	20	1.16	225	0.70	0.23	2.08	9.13	0.000	0.00	Non-Liq.
EB - 3	9	1.50	Clay + Sand	13.75	50	15.25	19.0	239.2	119.5	1.00	1.00	1.00	60	1.00	0.91	46	20	0.10	225	0.66	0.22	1.59	7.36	0.000	0.00	Non-Liq.
GWT (m)	10	1.50	Clay + Sand	15.25	24	16.75	18.0	267.0	132.6	1.00	1.00	1.00	60	1.00	0.87	21	20	0.10	200	0.64	0.21	0.20	0.98	0.000	0.00	Non-Liq.
1.55	11	1.50	Clay + Sand	16.75	21	18.25	18.0	294.0	144.9	1.00	1.00	1.00	60	1.00	0.83	17	20	0.10	175	0.62	0.20	0.15	0.74	0.000	0.00	Non-Liq.
a_{max} (g)	12	1.50	Clay + Sand	18.25	21	19.75	18.0	321.0	157.1	1.00	1.00	1.00	60	1.00	0.80	17	20	0.10	175	0.60	0.20	0.14	0.69	0.000	0.00	Non-Liq.
0.25	13	1.50	Clay + Sand	19.75	24	21.25	18.0	348.0	169.4	1.00	1.00	1.00	60	1.00	0.77	18	20	0.10	175	0.60	0.20	0.16	0.79	0.000	0.00	Non-Liq.
Sampler[b]	14	1.50	Clay + Sand	21.25	34	22.75	18.0	375.0	181.7	1.00	1.00	1.00	60	1.00	0.74	26	20	0.10	200	0.59	0.20	0.27	1.39	0.000	0.00	Non-Liq.
NA	15	1.50	Clay + Sand	22.75	27	24.25	18.0	402.0	194.0	1.00	1.00	1.00	60	1.00	0.72	19	20	0.10	175	0.58	0.20	0.16	0.84	0.000	0.00	Non-Liq.
B.H. Diam. (mm)	16	2.25	Silty Sand	24.25	48	25.75	19.0	429.7	207.0	1.00	1.00	1.00	60	1.00	0.69	33	10	0.20	225	0.58	0.19	0.43	2.23	0.000	0.00	41.72
95	17	3.00	Silty Sand	27.25	48	28.75	19.0	486.7	234.6	1.00	1.00	1.00	60	1.00	0.65	31	10	0.20	225	0.56	0.19	0.36	1.89	0.000	0.00	41.16
Energy Ratio[c]	18	3.00	Silty Sand	30.25	48	31.75	18.0	542.2	260.7	1.00	1.00	1.00	60	1.00	0.62	30	10	0.20	200	0.55	0.19	0.31	1.66	0.000	0.00	40.71
60	19																									
N (mean)	20																									
27.1	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
187	25																									
Observed (cm)	26																									
25	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	30.20																							0.95	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Loma Prieta - 1989	1	1.21	Sand	2.04	11	3.54	18.0	33.5	28.9	1.00	0.75	1.00	60	1.00	1.86	15	4	1.15	175	0.98	0.18	0.17	0.95	0.221	0.90	36.55
Mw	2	1.39	Sand	3.52	27	5.02	19.0	60.9	41.8	1.00	0.85	1.00	60	1.00	1.55	35	4	1.15	225	0.95	0.22	0.70	3.14	0.000	0.82	41.91
7.0	3	1.48	Sand	4.81	31	6.31	19.0	85.6	53.7	1.00	0.95	1.00	60	1.00	1.36	41	4	1.15	225	0.91	0.24	1.01	4.25	0.000	0.76	43.43
Site	4	1.67	Sand	6.48	16	7.98	18.0	116.4	68.2	1.00	0.95	1.00	60	1.00	1.21	18	4	1.15	175	0.86	0.24	0.17	0.71	0.744	0.68	14.88
Moss Landing	5	1.57	Silty Clay	8.15	0	9.65	15.5	144.3	79.8	1.00	0.95	1.00	60	1.00	1.12	0	35	0.01	125	0.79	0.23	0.05	0.20	0.000	0.00	Non-Liq.
Data Class	6	1.48	Sand	9.63	16	11.13	18.0	169.1	90.1	1.00	1.00	1.00	60	1.00	1.05	16	4	1.15	175	0.73	0.22	0.14	0.62	0.901	0.52	13.43
	7	1.57	Sand	11.11	23	12.61	18.0	195.8	102.2	1.00	1.00	1.00	60	1.00	0.99	23	4	1.15	200	0.68	0.21	0.22	1.06	0.089	0.44	38.72
B. H.	8	1.57	Silty Clay	12.78	3	14.28	15.5	223.7	113.8	1.00	1.00	1.00	60	1.00	0.94	3	35	0.01	125	0.63	0.20	0.05	0.27	0.000	0.00	Non-Liq.
RC - B1	9	1.39	Clay + Sand	14.26	28	15.76	18.0	248.5	124.0	1.00	1.00	1.00	60	1.00	0.90	25	20	0.10	200	0.60	0.20	0.30	1.53	0.000	0.00	Non-Liq.
GWT (m)	10	1.39	Clay + Sand	15.55	17	17.05	18.0	271.8	134.6	1.00	1.00	1.00	60	1.00	0.86	15	20	0.10	175	0.58	0.19	0.12	0.65	0.000	0.00	Non-Liq.
1.57	11	1.49	Clay + Sand	17.04	50	18.54	19.0	299.3	147.6	1.00	1.00	1.00	60	1.00	0.82	41	20	0.10	225	0.57	0.19	1.03	5.54	0.000	0.00	Non-Liq.
a_{max} (g)	12																									
0.25	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
20.2	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
173	25																									
Observed (cm)	26																									
7	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	16.22																							1.83	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Loma Prieta - 1989	1	1.34	Sandy Clay	5.55	5	7.05	18.4	88.8	79.5	1.00	0.95	1.00	60	1.00	1.12	5	35	0.10	125	0.99	0.09	0.07	0.77	0.000	0.00	Non-Liq.
Mw	2	0.79	Silty Sand	6.34	7	7.84	19.2	103.7	86.6	1.00	0.95	1.00	60	1.00	1.07	7	15	0.80	149	0.98	0.10	0.07	0.74	0.666	0.68	5.32
7.0	3	0.85	Silty Sand	7.13	9	8.63	19.2	118.9	94.1	1.00	0.95	1.00	60	1.00	1.03	8	15	0.80	165	0.98	0.10	0.08	0.76	0.626	0.64	6.26
Site	4	0.99	Silty Sand	8.05	10	9.55	19.2	136.5	102.7	1.00	0.95	1.00	60	1.00	0.99	9	15	0.80	175	0.97	0.11	0.08	0.75	0.644	0.60	6.94
Richmond Hall	5	1.14	Silty Sand	9.11	16	10.61	17.6	156.2	111.9	1.00	1.00	1.00	60	1.00	0.95	16	15	0.80	229	0.96	0.11	0.13	1.19	0.030	0.54	36.93
Data Class	6	1.22	Silty Sand	10.33	19	11.83	17.6	177.7	121.4	1.00	1.00	1.00	60	1.00	0.91	17	15	0.80	244	0.94	0.12	0.15	1.26	0.015	0.48	37.34
	7	1.22	Clay	11.55	24	13.05	17.6	199.2	131.0	1.00	1.00	1.00	60	1.00	0.87	21	35	0.10	274	0.92	0.12	0.24	1.99	0.000	0.00	Non-Liq.
B. H.	8	1.22	Clay	12.77	29	14.27	17.6	220.6	140.5	1.00	1.00	1.00	60	1.00	0.84	25	35	0.10	305	0.90	0.12	0.32	2.72	0.000	0.00	Non-Liq.
R1	9	1.26	Clay	13.99	34	15.49	17.6	242.1	150.0	1.00	1.00	1.00	60	1.00	0.82	28	35	0.10	328	0.87	0.12	0.41	3.44	0.000	0.00	Non-Liq.
GWT (m)	10	1.77	Clay	15.30	39	16.80	17.6	265.2	160.3	1.00	1.00	1.00	60	1.00	0.79	31	35	0.10	351	0.85	0.12	0.52	4.36	0.000	0.00	Non-Liq.
4.6	11	2.64	Clay	17.53	52	19.03	20.0	307.1	180.3	1.00	1.00	1.00	60	1.00	0.74	39	35	0.10	732	0.81	0.12	1.01	8.63	0.000	0.00	Non-Liq.
a_{max} (g)	12	3.05	Clay	20.57	62	22.07	20.0	368.2	211.5	1.00	1.00	1.00	60	1.00	0.69	43	35	0.10	792	0.79	0.12	1.35	11.68	0.000	0.00	Non-Liq.
0.13	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
25.4	21																									
γ_{dry} (kN/m^3)	22																									
15.5	23																									
Vs* (m/s)	24																									
239	25																									
Observed (cm)	26																									
	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	17.50																							1.11	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Loma Prieta - 1989	1	1.76	Silty Sand	5.14	7	6.64	18.4	82.9	71.8	1.00	0.95	1.00	60	1.00	1.18	8	15	0.80	152	0.88	0.08	0.08	1.03	0.122	0.74	34.40
Mw	2	1.25	Silty Sand	6.39	8	7.89	18.4	106.0	82.6	1.00	0.95	1.00	60	1.00	1.10	8	15	0.80	157	0.83	0.09	0.08	0.94	0.240	0.68	34.30
7.0	3	1.25	Silty Sand	7.64	8	9.14	18.4	129.0	93.3	1.00	0.95	1.00	60	1.00	1.04	8	15	0.80	162	0.77	0.09	0.08	0.89	0.313	0.62	6.03
Site	4	1.25	Silty Sand	8.88	9	10.38	18.4	152.0	104.1	1.00	1.00	1.00	60	1.00	0.98	9	15	0.80	166	0.72	0.09	0.08	0.91	0.280	0.56	6.40
Treasure Is.	5	1.25	Silty Sand	10.13	9	11.63	18.4	175.1	114.9	1.00	1.00	1.00	60	1.00	0.93	9	15	0.80	171	0.67	0.08	0.08	0.91	0.278	0.49	6.44
Data Class	6	1.44	Silty Sand	11.38	10	12.88	18.4	198.1	125.6	1.00	1.00	1.00	60	1.00	0.89	9	15	0.80	175	0.64	0.08	0.07	0.92	0.267	0.43	6.50
	7	1.69	Silty Sand	13.01	7	14.51	16.8	226.8	138.4	1.00	1.00	1.00	60	1.00	0.85	6	15	0.80	152	0.60	0.08	0.06	0.76	0.634	0.35	4.67
B. H.	8	1.62	Silty Sand	14.77	8	16.27	16.0	255.6	150.0	1.00	1.00	1.00	60	1.00	0.82	7	15	0.80	160	0.57	0.08	0.06	0.77	0.608	0.26	4.91
T1	9	1.49	Sandy Clay	16.26	9	17.76	16.0	279.6	159.3	1.00	1.00	1.00	60	1.00	0.79	7	35	0.10	168	0.56	0.08	0.07	0.87	0.000	0.00	Non-Liq.
GWT (m)	10	1.49	Sandy Clay	17.75	10	19.25	16.0	303.5	168.6	1.00	1.00	1.00	60	1.00	0.77	7	35	0.10	175	0.55	0.08	0.07	0.88	0.000	0.00	Non-Liq.
4.0	11	1.49	Sandy Clay	19.25	11	20.75	16.0	327.4	177.8	1.00	1.00	1.00	60	1.00	0.75	8	35	0.10	183	0.54	0.08	0.07	0.89	0.000	0.00	Non-Liq.
a_{max} (g)	12																									
0.125	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
8.6	21																									
γ_{dry} (kN/m^3)	22																									
15.5	23																									
Vs* (m/s)	24																									
161	25																									
Observed (cm)	26																									
	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	15.99																							1.77	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Loma Prieta - 1989	1	1.32	Sand	2.45	10	3.95	18.0	41.1	31.9	1.00	0.75	1.00	60	1.00	1.77	13	4	1.15	175	0.98	0.20	0.15	0.71	0.736	0.88	10.32
Mw	2	0.76	Sand	3.21	11	4.71	18.0	54.8	38.1	1.00	0.85	1.00	60	1.00	1.62	15	4	1.15	175	0.96	0.23	0.16	0.71	0.743	0.84	12.16
7.0	3	0.71	Sand	3.96	5	5.46	16.5	67.7	43.7	1.00	0.85	1.00	60	1.00	1.51	6	4	1.15	150	0.95	0.24	0.08	0.33	1.000	0.80	4.37
Site	4	0.76	Clayey Silt	4.62	3	6.12	16.5	78.6	48.1	1.00	0.95	1.00	60	1.00	1.44	4	35	0.01	150	0.94	0.25	0.08	0.30	0.000	0.00	Non-Liq.
Moss Landing	5	0.71	Clayey Silt	5.47	6	6.97	16.5	92.6	53.8	1.00	0.95	1.00	60	1.00	1.36	8	35	0.01	150	0.91	0.26	0.10	0.39	0.000	0.00	Non-Liq.
Data Class	6	0.76	Sand	6.04	31	7.54	19.0	102.7	58.3	1.00	0.95	1.00	60	1.00	1.31	39	4	1.15	225	0.90	0.26	0.85	3.30	0.000	0.70	42.91
	7	0.90	Sand	6.98	44	8.48	19.0	120.6	66.9	1.00	0.95	1.00	60	1.00	1.22	51	4	1.15	225	0.87	0.25	2.12	8.36	0.000	0.65	46.32
B. H.	8	0.76	Sand	7.83	35	9.33	19.0	136.7	74.7	1.00	0.95	1.00	60	1.00	1.16	38	4	1.15	225	0.84	0.25	0.79	3.16	0.000	0.61	42.88
UC - B10	9	0.80	Sand	8.49	49	9.99	19.0	149.3	80.8	1.00	0.95	1.00	60	1.00	1.11	52	4	1.15	225	0.81	0.24	2.12	8.71	0.000	0.58	46.51
GWT (m)	10	0.85	Sand	9.43	41	10.93	19.0	167.1	89.4	1.00	1.00	1.00	60	1.00	1.06	43	4	1.15	225	0.78	0.24	1.08	4.61	0.000	0.53	44.21
1.51	11	0.76	Sand	10.19	22	11.69	18.0	181.2	96.0	1.00	1.00	1.00	60	1.00	1.02	22	4	1.15	200	0.75	0.23	0.22	0.94	0.227	0.49	38.51
a_{max} (g)	12																									
0.25	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
23.4	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
182	25																									
Observed (cm)	26																									
28	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	9.06																							1.97	

SEISMIC EVENT # 12

EARTHQUAKE:	Luzon
MOMENT MAGNITUDE:	7.6
LOCATION:	Philippines
DATE:	July 16, 1990
REFERENCE(S):	Tokimatsu, K. et al. (1994)

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Luzon - 1990	1	3.60	Fine Sand	4.62	7	6.12	16.5	73.5	45.7	1.00	0.95	1.00	45	0.75	1.48	7	15	0.20	150	0.86	0.18	0.07	0.41	1.000	0.77	5.43
Mw	2	1.54	Fine Sand	6.15	8	7.65	16.5	98.9	56.0	1.00	0.95	1.00	45	0.75	1.34	8	15	0.20	150	0.79	0.18	0.07	0.41	1.000	0.69	6.02
7.6	3	1.54	Fine Sand	7.69	9	9.19	16.5	124.3	66.3	1.00	0.95	1.00	45	0.75	1.23	8	15	0.20	150	0.72	0.18	0.07	0.41	1.000	0.62	6.04
Site	4	1.54	Fine Sand	9.23	4	10.73	15.5	148.9	75.8	1.00	1.00	1.00	45	0.75	1.15	3	15	0.20	125	0.66	0.17	0.05	0.28	1.000	0.54	3.14
Pantal River	5	1.54	Fine Sand	10.77	13	12.27	18.0	174.6	86.5	1.00	1.00	1.00	45	0.75	1.08	11	15	0.20	175	0.61	0.16	0.08	0.50	0.990	0.46	8.50
Data Class	6	1.54	Fine Sand	12.31	8	13.81	16.5	201.2	97.9	1.00	1.00	1.00	45	0.75	1.01	6	15	0.20	150	0.58	0.15	0.05	0.35	1.000	0.38	4.44
	7	1.54	Clayey Sand	13.85	8	15.35	16.5	226.6	108.2	1.00	1.00	1.00	45	0.75	0.96	6	25	0.10	150	0.55	0.15	0.05	0.36	1.000	0.31	4.68
B. H.	8	1.54	Clayey Sand	15.38	8	16.88	16.5	251.9	118.5	1.00	1.00	1.00	45	0.75	0.92	6	25	0.10	150	0.54	0.15	0.05	0.36	1.000	0.23	4.88
1	9																									
GWT (m)	10																									
1.78	11																									
a_{max} (g)	12																									
0.2	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
45	19																									
N (mean)	20																									
8.2	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
146	25																									
Observed (cm)	26																									
	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	14.37																							7.73	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Luzon - 1990	1	1.54	Clay Deposit	1.15	2	2.65	15.5	17.7	10.1	1.00	0.75	1.00	45	0.75	2.00	2	35	0.05	125	0.98	0.22	0.08	0.38	0.000	0.00	Non-Liq.
Mw	2	1.54	Fine Sand	2.69	4	4.19	16.5	42.3	19.6	1.00	0.85	1.00	45	0.75	2.00	5	15	0.20	150	0.93	0.26	0.08	0.31	1.000	0.87	4.18
7.6	3	1.54	Fine Sand	4.23	4	5.73	16.5	67.7	29.9	1.00	0.85	1.00	45	0.75	1.83	5	15	0.20	150	0.88	0.26	0.07	0.27	1.000	0.79	3.92
Site	4	1.54	Fine Sand	5.77	5	7.27	16.5	93.1	40.2	1.00	0.95	1.00	45	0.75	1.58	6	15	0.20	150	0.81	0.24	0.07	0.28	1.000	0.71	4.50
Pantal River	5	1.54	Fine Sand	7.31	10	8.81	16.5	118.5	50.5	1.00	0.95	1.00	45	0.75	1.41	10	15	0.20	150	0.74	0.23	0.09	0.38	1.000	0.63	7.45
Data Class	6	1.54	Fine Sand	8.85	13	10.35	18.0	145.0	61.9	1.00	1.00	1.00	45	0.75	1.27	12	15	0.20	175	0.68	0.21	0.10	0.49	0.994	0.56	10.10
	7	1.54	Clayey Sand	10.38	18	11.88	18.0	172.7	74.5	1.00	1.00	1.00	45	0.75	1.16	16	25	0.10	175	0.63	0.19	0.14	0.73	0.703	0.48	14.74
B. H.	8	1.54	Clayey Sand	11.92	8	13.42	16.5	199.2	86.0	1.00	1.00	1.00	45	0.75	1.08	7	25	0.10	150	0.59	0.18	0.06	0.36	1.000	0.40	5.63
2	9	1.54	Clayey Sand	13.46	4	14.96	15.5	223.8	95.5	1.00	1.00	1.00	45	0.75	1.02	3	25	0.10	125	0.56	0.17	0.05	0.27	1.000	0.33	3.37
GWT (m)	10																									
0.38	11																									
a_{max} (g)	12																									
0.2	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
45	19																									
N (mean)	20																									
7.6	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
147	25																									
Observed (cm)	26																									
	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	13.85																							7.11	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Luzon - 1990	1	1.25	Clay Deposit	1.15	3	2.65	15.5	17.5	12.8	1.00	0.75	1.00	45	0.75	2.00	3	35	0.05	125	0.98	0.17	0.08	0.48	0.000	0.00	Non-Liq.
Mw	2	1.54	Fine Sand	2.69	2	4.19	15.5	41.4	21.6	1.00	0.85	1.00	45	0.75	2.00	2	15	0.20	125	0.94	0.23	0.06	0.27	1.000	0.87	2.79
7.6	3	1.54	Fine Sand	4.23	6	5.73	16.5	66.0	31.1	1.00	0.85	1.00	45	0.75	1.79	7	15	0.20	150	0.88	0.24	0.08	0.32	1.000	0.79	4.93
Site	4	1.54	Fine Sand	5.77	9	7.27	16.5	91.4	41.4	1.00	0.95	1.00	45	0.75	1.55	10	15	0.20	150	0.82	0.24	0.09	0.39	1.000	0.71	7.49
Pantal River	5	1.54	Fine Sand	7.31	13	8.81	18.0	117.9	52.8	1.00	0.95	1.00	45	0.75	1.38	12	15	0.20	175	0.75	0.22	0.11	0.49	0.994	0.63	10.26
Data Class	6	1.54	Fine Sand	8.85	8	10.35	16.5	144.5	64.3	1.00	1.00	1.00	45	0.75	1.25	7	15	0.20	150	0.69	0.20	0.07	0.33	1.000	0.56	5.35
	7	1.54	Clayey Sand	10.38	13	11.88	18.0	171.0	75.7	1.00	1.00	1.00	45	0.75	1.15	12	25	0.10	175	0.63	0.19	0.10	0.53	0.984	0.48	10.53
B. H.	8	1.54	Clayey Sand	11.92	8	13.42	16.5	197.5	87.2	1.00	1.00	1.00	45	0.75	1.07	6	25	0.10	150	0.60	0.18	0.06	0.34	1.000	0.40	5.13
3	9	1.54	Clayey Sand	13.46	19	14.96	18.0	224.1	98.6	1.00	1.00	1.00	45	0.75	1.01	15	25	0.10	175	0.57	0.17	0.12	0.69	0.790	0.33	13.61
GWT (m)	10																									
0.67	11																									
a_{max} (g)	12																									
0.2	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
45	19																									
N (mean)	20																									
8.9	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
150	25																									
Observed (cm)	26																									
	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	13.56																							7.21	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Luzon - 1990	1	1.35	Clay Deposit	3.08	2	4.58	15.5	46.5	38.9	1.00	0.85	1.00	45	0.75	1.60	2	35	0.05	125	0.92	0.14	0.06	0.39	0.000	0.00	Non-Liq.
Mw	2	1.44	Clay Deposit	4.23	1	5.73	15.5	64.4	45.5	1.00	0.85	1.00	45	0.75	1.48	1	35	0.05	125	0.88	0.16	0.05	0.30	0.000	0.00	Non-Liq.
7.6	3	1.54	Fine Sand	5.96	8	7.46	16.5	92.1	56.2	1.00	0.95	1.00	45	0.75	1.33	7	15	0.20	150	0.80	0.17	0.07	0.40	1.000	0.70	5.30
Site	4	1.44	Fine Sand	7.31	10	8.81	16.5	114.3	65.2	1.00	0.95	1.00	45	0.75	1.24	9	15	0.20	150	0.74	0.17	0.08	0.46	0.997	0.63	6.98
Pantal River	5	1.54	Fine Sand	8.85	12	10.35	16.5	139.7	75.5	1.00	1.00	1.00	45	0.75	1.15	10	15	0.20	175	0.68	0.16	0.08	0.50	0.990	0.56	8.30
Data Class	6	1.54	Fine Sand	10.38	8	11.88	16.5	165.1	85.8	1.00	1.00	1.00	45	0.75	1.08	7	15	0.20	150	0.63	0.16	0.06	0.38	1.000	0.48	5.09
	7	1.54	Fine Sand	11.92	11	13.42	16.5	190.5	96.1	1.00	1.00	1.00	45	0.75	1.02	9	15	0.20	150	0.59	0.15	0.07	0.44	0.999	0.40	6.49
B. H.	8	1.49	Fine Sand	13.46	30	14.96	18.0	217.0	107.5	1.00	1.00	1.00	45	0.75	0.96	22	15	0.20	200	0.56	0.15	0.18	1.25	0.017	0.33	38.68
11	9	1.44	Fine Sand	14.90	29	16.40	18.0	243.0	119.3	1.00	1.00	1.00	45	0.75	0.92	20	15	0.20	175	0.55	0.14	0.16	1.08	0.081	0.25	38.18
GWT (m)	10																									
2.3	11																									
a_{max} (g)	12																									
0.2	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
45	19																									
N (mean)	20																									
12.4	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
148	25																									
Observed (cm)	26																									
	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	13.33																							4.24	

SEISMIC EVENT # 13

EARTHQUAKE:	Northridge
MOMENT MAGNITUDE:	6.7
LOCATION:	USA
DATE:	January 17, 1994
REFERENCE(S):	Aurelius, E. (1994) Database of Youd et al. (2002) Holzer, T. et al. (1999)

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Northridge - 1994	1	0.65	Lean Clay	4.10	3	5.60	18.0	62.1	60.1	1.00	0.85	1.00	60	1.00	1.29	3	35	0.01	125	0.85	0.29	0.07	0.25	0.000	0.00	Non-Liq.
Mw	2	1.00	Lean Clay	5.00	1	6.50	18.0	78.3	67.5	1.00	0.95	1.00	60	1.00	1.22	1	35	0.01	125	0.80	0.31	0.06	0.19	0.000	0.00	Non-Liq.
6.7	3	0.95	Lean Clay	6.10	5	7.60	18.0	98.1	76.5	1.00	0.95	1.00	60	1.00	1.14	5	35	0.00	150	0.73	0.32	0.08	0.26	0.000	0.00	Non-Liq.
Site	4	0.90	Lean Clay	6.90	30	8.40	18.0	112.5	83.1	1.00	0.95	1.00	60	1.00	1.10	31	35	0.01	225	0.69	0.31	0.73	2.32	0.000	0.00	Non-Liq.
Malden Street	5	1.10	Lean Clay	7.90	10	9.40	18.0	130.5	91.3	1.00	0.95	1.00	60	1.00	1.05	10	35	0.01	150	0.63	0.31	0.11	0.38	0.000	0.00	Non-Liq.
Data Class	6	0.95	Clayey Sand	9.10	25	10.60	18.0	152.1	101.1	1.00	1.00	1.00	60	1.00	0.99	25	23	0.52	200	0.57	0.29	0.35	1.20	0.027	0.55	39.89
	7	0.70	Clayey Sand	9.80	30	11.30	18.0	164.7	106.8	1.00	1.00	1.00	60	1.00	0.97	29	21	0.38	200	0.54	0.28	0.47	1.66	0.000	0.51	41.02
B. H.	8																									
3a	9																									
GWT (m)	10																									
3.9	11																									
a_{max} (g)	12																									
0.52	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
14.9	21																									
γ_{dry} (kN/m^3)	22																									
15.00	23																									
Vs* (m/s)	24																									
144	25																									
Observed (cm)	26																									
	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	6.25																							0.01	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N^d	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Northridge - 1994	1	0.95	Lean Clay	4.00	3	5.50	18.0	61.8	55.9	1.00	0.85	1.00	60	1.00	1.34	3	35	0.00	125	0.84	0.32	0.08	0.24	0.000	0.00	Non-Liq.
Mw	2	0.80	Lean Clay	4.70	2	6.20	18.0	74.4	61.6	1.00	0.95	1.00	60	1.00	1.27	2	35	0.01	125	0.81	0.33	0.07	0.20	0.000	0.00	Non-Liq.
6.7	3	0.75	Lean Clay	5.60	2	7.10	18.0	90.6	69.0	1.00	0.95	1.00	60	1.00	1.20	2	34	0.02	125	0.75	0.33	0.06	0.19	0.000	0.00	Non-Liq.
Site	4	0.70	Lean Clay	6.20	9	7.70	18.0	101.4	73.9	1.00	0.95	1.00	60	1.00	1.16	10	30	0.02	150	0.72	0.33	0.12	0.35	0.000	0.00	Non-Liq.
Malden Street	5	0.80	Lean Clay	7.00	10	8.50	18.0	115.8	80.5	1.00	0.95	1.00	60	1.00	1.11	11	32	0.02	175	0.67	0.33	0.12	0.38	0.000	0.00	Non-Liq.
Data Class	6	1.00	Lean Clay	7.80	7	9.30	18.0	130.2	87.0	1.00	0.95	1.00	60	1.00	1.07	7	35	0.00	150	0.63	0.32	0.09	0.29	0.000	0.00	Non-Liq.
	7	0.85	Clayey Sand	9.00	9	10.50	18.0	151.8	96.9	1.00	1.00	1.00	60	1.00	1.02	9	18	0.05	150	0.57	0.30	0.09	0.31	1.000	0.55	7.29
B. H.	8	0.55	Clayey Sand	9.50	22	11.00	18.0	160.8	101.0	1.00	1.00	1.00	60	1.00	1.00	22	25	0.09	200	0.55	0.30	0.28	0.95	0.222	0.53	39.10
5a	9	0.70	Clayey Sand	10.10	46	11.60	18.0	171.6	105.9	1.00	1.00	1.00	60	1.00	0.97	45	11	0.19	225	0.52	0.29	1.43	4.96	0.000	0.50	44.95
GWT (m)	10	0.80	Clayey Sand	10.90	17	12.40	18.0	186.0	112.4	1.00	1.00	1.00	60	1.00	0.94	16	22	0.04	175	0.50	0.28	0.16	0.58	0.946	0.46	14.85
3.4	11																									
a_{max} (g)	12																									
0.52	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
12.7	21																									
γ_{dry} (kN/m^3)	22																									
15.00	23																									
Vs* (m/s)	24																									
143	25																									
Observed (cm)	26																									
	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	7.90																							0.88	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Northridge - 1994	1	2.65	Sandy Silt	7.50	10	9.00	18.0	115.8	105.0	1.00	0.95	1.00	60	1.00	0.98	9	35	0.05	150	0.65	0.24	0.10	0.43	0.000	0.00	Non-Liq.
Mw	2	3.30	Sandy Clay	10.60	4	12.10	18.0	171.6	130.4	1.00	1.00	1.00	60	1.00	0.88	4	35	0.02	125	0.51	0.23	0.06	0.26	0.000	0.00	Non-Liq.
6.7	3	3.50	Silty Sand	14.10	101	15.60	18.0	234.6	159.1	1.00	1.00	1.00	60	1.00	0.79	80	16	0.13	225	0.43	0.22	23.43	108.6	0.000	0.30	45.00
Site	4																									
Malden Street	5																									
Data Class	6																									
	7																									
B. H.	8																									
15	9																									
GWT (m)	10																									
6.4	11																									
a_{max} (g)	12																									
0.52	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
38.3	21																									
γ_{dry} (kN/m^3)	22																									
15.00	23																									
Vs* (m/s)	24																									
143	25																									
Observed (cm)	26																									
	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	9.45																							0.00	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Northridge - 1994	1	3.30	Lean Clay	8.80	7	10.30	18.0	140.4	112.9	1.00	1.00	1.00	60	1.00	0.94	7	35	0.02	150	0.62	0.26	0.08	0.31	0.000	0.00	Non-Liq.
Mw	2	0.80	Sandy Clay	9.80	13	11.30	18.0	158.4	121.1	1.00	1.00	1.00	60	1.00	0.91	12	35	0.04	175	0.57	0.25	0.12	0.49	0.000	0.00	Non-Liq.
6.7	3	1.60	Sandy Clay	10.40	13	11.90	18.0	169.2	126.0	1.00	1.00	1.00	60	1.00	0.89	12	35	0.04	175	0.55	0.25	0.12	0.49	0.000	0.00	Non-Liq.
Site	4	2.60	Silty Sand	13.00	53	14.50	18.0	216.0	147.3	1.00	1.00	1.00	60	1.00	0.82	44	25	0.32	225	0.48	0.24	1.52	6.45	0.000	0.35	45.50
Malden Street	5																									
Data Class	6																									
	7																									
B. H.	8																									
16	9																									
GWT (m)	10																									
6.0	11																									
a_{max} (g)	12																									
0.52	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
21.5	21																									
γ_{dry} (kN/m^3)	22																									
15.00	23																									
Vs* (m/s)	24																									
150	25																									
Observed (cm)	26																									
	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	8.30																							0.00	

SEISMIC EVENT # 14

EARTHQUAKE:	Hyogoken-Nanbu
MOMENT MAGNITUDE:	6.9
LOCATION:	Japan
DATE:	January 17, 1995
REFERENCE(S):	Database of Youd et al. (2002) Hausler, E. and Sitar, N. (2002) Japanese Geotechnical Society (1996)

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Hyogoken - 1995	1	1.50	Granular Fill	3.50	13	5.00	18.0	58.0	48.2	1.00	0.85	1.00	78	1.30	1.44	21	20	1.00	200	0.96	0.45	0.28	0.61	0.916	0.83	19.25
Mw	2	1.00	Granular Fill	4.50	13	6.00	18.0	76.0	56.4	1.00	0.85	1.00	78	1.30	1.33	19	20	1.00	175	0.94	0.50	0.23	0.47	0.996	0.78	17.73
6.9	3	1.00	Granular Fill	5.50	14	7.00	18.0	94.0	64.6	1.00	0.95	1.00	78	1.30	1.24	22	20	1.00	200	0.92	0.52	0.27	0.52	0.985	0.73	20.04
Site	4	1.00	Granular Fill	6.50	12	8.00	18.0	112.0	72.8	1.00	0.95	1.00	78	1.30	1.17	17	20	1.00	175	0.89	0.53	0.19	0.35	1.000	0.68	15.99
Awaji Island	5	1.00	Granular Fill	7.50	22	9.00	18.0	130.0	81.0	1.00	0.95	1.00	78	1.30	1.11	30	20	1.00	225	0.85	0.53	0.52	0.97	0.188	0.63	41.31
Data Class	6	1.00	Granular Fill	8.50	38	10.00	19.0	148.5	89.6	1.00	0.95	1.00	78	1.30	1.06	50	20	1.00	225	0.81	0.53	2.42	4.61	0.000	0.58	46.90
	7	1.00	Granular Fill	9.50	12	11.00	18.0	167.0	98.3	1.00	1.00	1.00	78	1.30	1.01	16	20	1.00	175	0.77	0.51	0.15	0.30	1.000	0.53	14.33
B. H.	8	1.50	Granular Fill	10.50	19	12.00	18.0	185.0	106.5	1.00	1.00	1.00	78	1.30	0.97	24	20	1.00	200	0.73	0.49	0.29	0.58	0.947	0.48	22.31
1	9	1.50	Granular Fill	12.50	28	14.00	18.0	221.0	122.9	1.00	1.00	1.00	78	1.30	0.90	33	20	1.00	225	0.65	0.46	0.57	1.25	0.017	0.38	42.07
GWT (m)	10	1.00	Granular Fill	13.50	12	15.00	18.0	239.0	131.1	1.00	1.00	1.00	78	1.30	0.87	14	20	1.00	175	0.62	0.44	0.12	0.27	1.000	0.33	12.17
2.5	11	1.00	Granular Fill	14.50	25	16.00	18.0	257.0	139.3	1.00	1.00	1.00	78	1.30	0.85	28	20	1.00	200	0.60	0.43	0.36	0.83	0.443	0.28	25.57
a_{max} (g)	12	1.00	Granular Fill	15.50	29	17.00	19.0	275.5	148.0	1.00	1.00	1.00	78	1.30	0.82	31	20	1.00	225	0.58	0.42	0.47	1.11	0.059	0.23	41.54
0.6	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
78	19																									
N (mean)	20																									
19.8	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
189	25																									
Observed (cm)	26																									
0	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	13.50																							5.08	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Hyogoken - 1995	1	1.75	Granular Fill	5.50	23	7.00	19.0	91.8	79.5	1.00	0.95	1.00	78	1.30	1.12	32	20	1.00	225	0.92	0.24	0.60	2.46	0.000	0.73	41.79
Mw	2	1.00	Granular Fill	6.50	33	8.00	19.0	110.8	88.7	1.00	0.95	1.00	78	1.30	1.06	43	20	1.00	225	0.90	0.25	1.46	5.73	0.000	0.68	45.09
6.9	3	1.00	Granular Fill	7.50	23	9.00	18.0	129.3	97.4	1.00	0.95	1.00	78	1.30	1.01	29	20	1.00	200	0.86	0.26	0.44	1.68	0.000	0.63	40.90
Site	4	1.00	Granular Fill	8.50	23	10.00	18.0	147.3	105.6	1.00	0.95	1.00	78	1.30	0.97	28	20	1.00	200	0.83	0.26	0.39	1.49	0.001	0.58	40.58
Chou-ku	5	1.50	Granular Fill	9.50	40	11.00	19.0	165.8	114.2	1.00	1.00	1.00	78	1.30	0.94	49	20	1.00	225	0.79	0.26	2.10	8.07	0.000	0.53	46.64
Data Class	6	1.50	Granular Fill	11.50	37	13.00	19.0	203.8	132.6	1.00	1.00	1.00	78	1.30	0.87	42	20	1.00	225	0.71	0.25	1.15	4.62	0.000	0.43	44.65
	7	1.00	Granular Fill	12.50	22	14.00	18.0	222.3	141.3	1.00	1.00	1.00	78	1.30	0.84	24	20	1.00	200	0.68	0.24	0.27	1.11	0.063	0.38	39.54
B. H.	8	1.00	Granular Fill	13.50	42	15.00	19.0	240.8	150.0	1.00	1.00	1.00	78	1.30	0.82	45	20	1.00	225	0.65	0.24	1.40	5.86	0.000	0.33	45.46
1	9	1.00	Granular Fill	14.50	12	16.00	18.0	259.3	158.7	1.00	1.00	1.00	78	1.30	0.79	12	20	1.00	175	0.63	0.24	0.10	0.43	0.999	0.28	10.88
GWT (m)	10	1.00	Granular Fill	15.50	13	17.00	18.0	277.3	166.9	1.00	1.00	1.00	78	1.30	0.77	13	20	1.00	175	0.61	0.23	0.11	0.46	0.998	0.23	11.60
4.25	11	1.00	Granular Fill	16.50	29	18.00	18.0	295.3	175.1	1.00	1.00	1.00	78	1.30	0.76	28	20	1.00	200	0.60	0.23	0.36	1.58	0.000	0.18	40.82
a_{max} (g)	12	1.00	Granular Fill	17.50	17	19.00	18.0	313.3	183.3	1.00	1.00	1.00	78	1.30	0.74	16	20	1.00	175	0.59	0.23	0.13	0.58	0.947	0.13	14.93
0.35	13	1.00	Granular Fill	18.50	23	20.00	18.0	331.3	191.5	1.00	1.00	1.00	78	1.30	0.72	22	20	1.00	200	0.58	0.23	0.20	0.89	0.329	0.08	20.13
Sampler[b]	14	1.00	Granular Fill	19.50	22	21.00	18.0	349.3	199.6	1.00	1.00	1.00	78	1.30	0.71	20	20	1.00	175	0.58	0.23	0.18	0.78	0.567	0.03	18.81
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
78	19																									
N (mean)	20																									
25.6	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
188	25																									
Observed (cm)	26																									
0	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	15.75																							0.68	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Hyogoken - 1995	1	3.00	Granular Fill	5.50	3	7.00	16.5	89.0	69.4	1.00	0.95	1.00	78	1.30	1.20	5	15	0.97	150	0.80	0.36	0.07	0.19	1.000	0.73	3.98
Mw	2	2.00	Granular Fill	7.50	3	9.00	16.5	122.0	82.8	1.00	0.95	1.00	78	1.30	1.10	5	15	0.97	150	0.70	0.36	0.06	0.17	1.000	0.63	3.75
6.9	3	2.00	Granular Fill	9.50	4	11.00	16.5	155.0	96.1	1.00	1.00	1.00	78	1.30	1.02	6	13	1.17	150	0.60	0.34	0.07	0.19	1.000	0.53	4.35
Site	4	2.00	Granular Fill	11.50	8	13.00	16.5	188.0	109.5	1.00	1.00	1.00	78	1.30	0.96	10	10	1.38	150	0.53	0.32	0.08	0.26	1.000	0.43	7.04
LP Gas Tank Yard	5	2.00	Granular Fill	13.50	4	15.00	16.5	221.0	122.9	1.00	1.00	1.00	78	1.30	0.90	5	15	0.97	150	0.48	0.30	0.06	0.19	1.000	0.33	4.05
Data Class	6	2.00	Granular Fill	15.50	4	17.00	16.5	254.0	136.3	1.00	1.00	1.00	78	1.30	0.86	5	15	0.97	150	0.46	0.30	0.06	0.19	1.000	0.23	3.90
	7	2.00	Granular Fill	17.50	10	19.00	18.0	288.5	151.2	1.00	1.00	1.00	78	1.30	0.81	11	8	1.97	175	0.44	0.30	0.08	0.28	1.000	0.13	7.89
B. H.	8																									
1	9																									
GWT (m)	10																									
3.5	11																									
a_{max} (g)	12																									
0.54	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
78	19																									
N (mean)	20																									
5.4	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
152	25																									
Observed (cm)	26																									
130	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	15.00																							6.67	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Hyogoken - 1995	1	3.00	Granular Fill	5.50	3	7.00	16.5	89.0	69.4	1.00	0.95	1.00	78	1.30	1.20	5	15	0.97	150	0.80	0.36	0.07	0.19	1.000	0.73	3.98
Mw	2	2.00	Granular Fill	7.50	3	9.00	16.5	122.0	82.8	1.00	0.95	1.00	78	1.30	1.10	5	15	0.97	150	0.70	0.36	0.06	0.17	1.000	0.63	3.75
6.9	3	2.00	Granular Fill	9.50	4	11.00	16.5	155.0	96.1	1.00	1.00	1.00	78	1.30	1.02	6	13	1.17	150	0.60	0.34	0.07	0.19	1.000	0.53	4.35
Site	4	2.00	Granular Fill	11.50	8	13.00	16.5	188.0	109.5	1.00	1.00	1.00	78	1.30	0.96	10	10	1.38	150	0.53	0.32	0.08	0.26	1.000	0.43	7.04
LP Gas Tank Yard	5	2.00	Granular Fill	13.50	4	15.00	16.5	221.0	122.9	1.00	1.00	1.00	78	1.30	0.90	5	15	0.97	150	0.48	0.30	0.06	0.19	1.000	0.33	4.05
Data Class	6	2.00	Granular Fill	15.50	4	17.00	16.5	254.0	136.3	1.00	1.00	1.00	78	1.30	0.86	5	15	0.97	150	0.46	0.30	0.06	0.19	1.000	0.23	3.90
	7	2.00	Granular Fill	17.50	10	19.00	18.0	288.5	151.2	1.00	1.00	1.00	78	1.30	0.81	11	8	1.97	175	0.44	0.30	0.08	0.28	1.000	0.13	7.89
B. H.	8																									
2	9																									
GWT (m)	10																									
3.5	11																									
a_{max} (g)	12																									
0.54	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
78	19																									
N (mean)	20																									
5.4	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
152	25																									
Observed (cm)	26																									
133	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	15.00																							6.67	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Hyogoken - 1995	1	3.00	Granular Fill	5.50	3	7.00	16.5	89.0	69.4	1.00	0.95	1.00	78	1.30	1.20	5	15	0.97	150	0.80	0.36	0.07	0.19	1.000	0.73	3.98
Mw	2	2.00	Granular Fill	7.50	3	9.00	16.5	122.0	82.8	1.00	0.95	1.00	78	1.30	1.10	5	15	0.97	150	0.70	0.36	0.06	0.17	1.000	0.63	3.75
6.9	3	2.00	Granular Fill	9.50	4	11.00	16.5	155.0	96.1	1.00	1.00	1.00	78	1.30	1.02	6	13	1.17	150	0.60	0.34	0.07	0.19	1.000	0.53	4.35
Site	4	2.00	Granular Fill	11.50	8	13.00	16.5	188.0	109.5	1.00	1.00	1.00	78	1.30	0.96	10	10	1.38	150	0.53	0.32	0.08	0.26	1.000	0.43	7.04
LP Gas Tank Yard	5	2.00	Granular Fill	13.50	4	15.00	16.5	221.0	122.9	1.00	1.00	1.00	78	1.30	0.90	5	15	0.97	150	0.48	0.30	0.06	0.19	1.000	0.33	4.05
Data Class	6	2.00	Granular Fill	15.50	4	17.00	16.5	254.0	136.3	1.00	1.00	1.00	78	1.30	0.86	5	15	0.97	150	0.46	0.30	0.06	0.19	1.000	0.23	3.90
	7	2.00	Granular Fill	17.50	10	19.00	18.0	288.5	151.2	1.00	1.00	1.00	78	1.30	0.81	11	8	1.97	175	0.44	0.30	0.08	0.28	1.000	0.13	7.89
B. H.	8																									
3	9																									
GWT (m)	10																									
3.5	11																									
a_{max} (g)	12																									
0.54	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
78	19																									
N (mean)	20																									
5.4	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
152	25																									
Observed (cm)	26																									
146	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	15.00																							6.67	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Hyogoken - 1995	1	3.00	Granular Fill	5.50	3	7.00	16.5	89.0	69.4	1.00	0.95	1.00	78	1.30	1.20	5	15	0.97	150	0.80	0.36	0.07	0.19	1.000	0.73	3.98
Mw	2	2.00	Granular Fill	7.50	3	9.00	16.5	122.0	82.8	1.00	0.95	1.00	78	1.30	1.10	5	15	0.97	150	0.70	0.36	0.06	0.17	1.000	0.63	3.75
6.9	3	2.00	Granular Fill	9.50	4	11.00	16.5	155.0	96.1	1.00	1.00	1.00	78	1.30	1.02	6	13	1.17	150	0.60	0.34	0.07	0.19	1.000	0.53	4.35
Site	4	2.00	Granular Fill	11.50	8	13.00	16.5	188.0	109.5	1.00	1.00	1.00	78	1.30	0.96	10	10	1.38	150	0.53	0.32	0.08	0.26	1.000	0.43	7.04
LP Gas Tank Yard	5	2.00	Granular Fill	13.50	4	15.00	16.5	221.0	122.9	1.00	1.00	1.00	78	1.30	0.90	5	15	0.97	150	0.48	0.30	0.06	0.19	1.000	0.33	4.05
Data Class	6	2.00	Granular Fill	15.50	4	17.00	16.5	254.0	136.3	1.00	1.00	1.00	78	1.30	0.86	5	15	0.97	150	0.46	0.30	0.06	0.19	1.000	0.23	3.90
	7	2.00	Granular Fill	17.50	10	19.00	18.0	288.5	151.2	1.00	1.00	1.00	78	1.30	0.81	11	8	1.97	175	0.44	0.30	0.08	0.28	1.000	0.13	7.89
B. H.	8																									
4	9																									
GWT (m)	10																									
3.5	11																									
a_{max} (g)	12																									
0.54	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
78	19																									
N (mean)	20																									
5.4	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
152	25																									
Observed (cm)	26																									
247	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	15.00																							6.67	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Hyogoken - 1995	1	3.00	Granular Fill	5.50	3	7.00	16.5	89.0	69.4	1.00	0.95	1.00	78	1.30	1.20	5	15	0.97	150	0.80	0.36	0.07	0.19	1.000	0.73	3.98
Mw	2	2.00	Granular Fill	7.50	3	9.00	16.5	122.0	82.8	1.00	0.95	1.00	78	1.30	1.10	5	15	0.97	150	0.70	0.36	0.06	0.17	1.000	0.63	3.75
6.9	3	2.00	Granular Fill	9.50	4	11.00	16.5	155.0	96.1	1.00	1.00	1.00	78	1.30	1.02	6	13	1.17	150	0.60	0.34	0.07	0.19	1.000	0.53	4.35
Site	4	2.00	Granular Fill	11.50	8	13.00	16.5	188.0	109.5	1.00	1.00	1.00	78	1.30	0.96	10	10	1.38	150	0.53	0.32	0.08	0.26	1.000	0.43	7.04
LP Gas Tank Yard	5	2.00	Granular Fill	13.50	4	15.00	16.5	221.0	122.9	1.00	1.00	1.00	78	1.30	0.90	5	15	0.97	150	0.48	0.30	0.06	0.19	1.000	0.33	4.05
Data Class	6	2.00	Granular Fill	15.50	4	17.00	16.5	254.0	136.3	1.00	1.00	1.00	78	1.30	0.86	5	15	0.97	150	0.46	0.30	0.06	0.19	1.000	0.23	3.90
	7	2.00	Granular Fill	17.50	10	19.00	18.0	288.5	151.2	1.00	1.00	1.00	78	1.30	0.81	11	8	1.97	175	0.44	0.30	0.08	0.28	1.000	0.13	7.89
B. H.	8																									
5	9																									
GWT (m)	10																									
3.5	11																									
a_{max} (g)	12																									
0.54	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
78	19																									
N (mean)	20																									
5.4	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
152	25																									
Observed (cm)	26																									
282	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	15.00																							6.67	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Hyogoken - 1995	1	0.78	Granular Fill	1.00	21	2.50	19.0	17.2	13.3	1.00	0.75	1.00	78	1.30	2.00	41	20	1.00	225	1.00	0.31	2.05	6.59	0.000	0.95	44.41
Mw	2	0.75	Granular Fill	1.75	21	3.25	18.0	31.1	19.8	1.00	0.75	1.00	78	1.30	2.00	41	20	1.00	225	0.99	0.38	1.83	4.88	0.000	0.91	44.41
6.9	3	0.75	Granular Fill	2.50	20	4.00	18.0	44.6	25.9	1.00	0.75	1.00	78	1.30	1.96	38	20	1.00	225	0.99	0.41	1.37	3.34	0.000	0.88	43.65
Site	4	0.75	Granular Fill	3.25	20	4.75	18.0	58.1	32.1	1.00	0.85	1.00	78	1.30	1.77	39	20	1.00	225	0.99	0.43	1.37	3.19	0.000	0.84	43.86
Nishinomiya	5	0.75	Granular Fill	4.00	22	5.50	18.0	71.6	38.2	1.00	0.85	1.00	78	1.30	1.62	39	20	1.00	225	0.98	0.44	1.34	3.03	0.000	0.80	43.94
Data Class	6	0.75	Granular Fill	4.75	29	6.25	18.0	85.1	44.4	1.00	0.95	1.00	78	1.30	1.50	54	20	1.00	225	0.98	0.45	4.14	9.21	0.000	0.76	48.11
	7	0.75	Granular Fill	5.50	27	7.00	18.0	98.6	50.5	1.00	0.95	1.00	78	1.30	1.41	47	20	1.00	225	0.97	0.45	2.29	5.05	0.000	0.73	46.14
B. H.	8	0.75	Granular Fill	6.25	26	7.75	18.0	112.1	56.6	1.00	0.95	1.00	78	1.30	1.33	43	20	1.00	225	0.96	0.46	1.57	3.45	0.000	0.69	44.91
1	9	0.75	Granular Fill	7.00	25	8.50	18.0	125.6	62.8	1.00	0.95	1.00	78	1.30	1.26	39	20	1.00	225	0.95	0.45	1.13	2.49	0.000	0.65	43.84
GWT (m)	10																									
0.6	11																									
a_{max} (g)	12																									
0.37	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
78	19																									
N (mean)	20																									
23.4	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
216	25																									
Observed (cm)	26																									
0	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	6.78																							0.00	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Hyogoken - 1995	1	0.90	Granular Fill	3.00	10	4.50	18.0	48.8	44.9	1.00	0.85	1.00	78	1.30	1.49	16	10	1.40	175	0.93	0.35	0.18	0.52	0.985	0.85	14.01
Mw	2	1.50	Granular Fill	4.00	13	5.50	18.0	66.8	53.1	1.00	0.85	1.00	78	1.30	1.37	20	10	3.30	175	0.89	0.39	0.23	0.58	0.954	0.80	17.13
6.9	3	2.00	Granular Fill	6.00	10	7.50	18.0	102.8	69.4	1.00	0.95	1.00	78	1.30	1.20	15	10	2.40	175	0.80	0.41	0.14	0.35	1.000	0.70	12.36
Site	4	2.00	Granular Fill	8.00	7	9.50	16.5	137.3	84.3	1.00	0.95	1.00	78	1.30	1.09	9	7	0.67	150	0.69	0.40	0.09	0.22	1.000	0.60	6.62
Port Island E-E'	5	2.00	Granular Fill	10.00	8	11.50	16.5	170.3	97.7	1.00	1.00	1.00	78	1.30	1.01	10	9	3.40	150	0.60	0.37	0.09	0.25	1.000	0.50	7.79
Data Class	6	2.00	Granular Fill	12.00	7	13.50	16.5	203.3	111.1	1.00	1.00	1.00	78	1.30	0.95	9	6	3.70	150	0.53	0.34	0.08	0.22	1.000	0.40	5.90
	7	2.00	Granular Fill	14.00	4	15.50	16.5	236.3	124.5	1.00	1.00	1.00	78	1.30	0.90	5	18	0.90	150	0.49	0.33	0.06	0.18	1.000	0.30	3.88
B. H.	8																									
1	9																									
GWT (m)	10																									
2.6	11																									
a_{max} (g)	12																									
0.54	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
78	19																									
N (mean)	20																									
8.4	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
157	25																									
Observed (cm)	26																									
33	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	12.40																							6.90	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Hyogoken - 1995	1	0.90	Granular Fill	3.00	10	4.50	18.0	48.8	44.9	1.00	0.85	1.00	78	1.30	1.49	16	10	1.40	175	0.93	0.35	0.18	0.52	0.985	0.85	14.01
Mw	2	1.50	Granular Fill	4.00	13	5.50	18.0	66.8	53.1	1.00	0.85	1.00	78	1.30	1.37	20	10	3.30	175	0.89	0.39	0.23	0.58	0.954	0.80	17.13
6.9	3	2.00	Granular Fill	6.00	10	7.50	18.0	102.8	69.4	1.00	0.95	1.00	78	1.30	1.20	15	10	2.40	175	0.80	0.41	0.14	0.35	1.000	0.70	12.36
Site	4	2.00	Granular Fill	8.00	7	9.50	16.5	137.3	84.3	1.00	0.95	1.00	78	1.30	1.09	9	7	0.67	150	0.69	0.40	0.09	0.22	1.000	0.60	6.62
Port Island E-E'	5	2.00	Granular Fill	10.00	8	11.50	16.5	170.3	97.7	1.00	1.00	1.00	78	1.30	1.01	10	9	3.40	150	0.60	0.37	0.09	0.25	1.000	0.50	7.79
Data Class	6	2.00	Granular Fill	12.00	7	13.50	16.5	203.3	111.1	1.00	1.00	1.00	78	1.30	0.95	9	6	3.70	150	0.53	0.34	0.08	0.22	1.000	0.40	5.90
	7	2.00	Granular Fill	14.00	4	15.50	16.5	236.3	124.5	1.00	1.00	1.00	78	1.30	0.90	5	18	0.90	150	0.49	0.33	0.06	0.18	1.000	0.30	3.88
B. H.	8																									
2	9																									
GWT (m)	10																									
2.6	11																									
a_{max} (g)	12																									
0.54	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
78	19																									
N (mean)	20																									
8.4	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
157	25																									
Observed (cm)	26																									
102	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	12.40																							6.90	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Hyogoken - 1995	1	0.90	Granular Fill	3.00	10	4.50	18.0	48.8	44.9	1.00	0.85	1.00	78	1.30	1.49	16	10	1.40	175	0.93	0.35	0.18	0.52	0.985	0.85	14.01
Mw	2	1.50	Granular Fill	4.00	13	5.50	18.0	66.8	53.1	1.00	0.85	1.00	78	1.30	1.37	20	10	3.30	175	0.89	0.39	0.23	0.58	0.954	0.80	17.13
6.9	3	2.00	Granular Fill	6.00	10	7.50	18.0	102.8	69.4	1.00	0.95	1.00	78	1.30	1.20	15	10	2.40	175	0.80	0.41	0.14	0.35	1.000	0.70	12.36
Site	4	2.00	Granular Fill	8.00	7	9.50	16.5	137.3	84.3	1.00	0.95	1.00	78	1.30	1.09	9	7	0.67	150	0.69	0.40	0.09	0.22	1.000	0.60	6.62
Port Island E-E'	5	2.00	Granular Fill	10.00	8	11.50	16.5	170.3	97.7	1.00	1.00	1.00	78	1.30	1.01	10	9	3.40	150	0.60	0.37	0.09	0.25	1.000	0.50	7.79
Data Class	6	2.00	Granular Fill	12.00	7	13.50	16.5	203.3	111.1	1.00	1.00	1.00	78	1.30	0.95	9	6	3.70	150	0.53	0.34	0.08	0.22	1.000	0.40	5.90
	7	2.00	Granular Fill	14.00	4	15.50	16.5	236.3	124.5	1.00	1.00	1.00	78	1.30	0.90	5	18	0.90	150	0.49	0.33	0.06	0.18	1.000	0.30	3.88
B. H.	8																									
3	9																									
GWT (m)	10																									
2.6	11																									
a_{max} (g)	12																									
0.54	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
78	19																									
N (mean)	20																									
8.4	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
157	25																									
Observed (cm)	26																									
146	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	12.40																							6.90	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Hyogoken - 1995	1	0.90	Granular Fill	3.00	25	4.50	19.0	49.2	45.3	1.00	0.85	1.00	78	1.30	1.49	41	15	1.17	225	0.94	0.36	1.36	3.78	0.000	0.85	44.16
Mw	2	1.00	Granular Fill	4.00	2	5.50	15.5	66.5	52.7	1.00	0.85	1.00	78	1.30	1.38	3	10	0.37	125	0.91	0.40	0.06	0.15	1.000	0.80	2.90
6.9	3	1.00	Granular Fill	5.00	6	6.50	16.5	82.5	58.9	1.00	0.95	1.00	78	1.30	1.30	10	9	1.27	150	0.87	0.43	0.10	0.23	1.000	0.75	7.04
Site	4	1.00	Granular Fill	6.00	5	7.50	16.5	99.0	65.6	1.00	0.95	1.00	78	1.30	1.23	8	17	0.86	150	0.83	0.44	0.09	0.20	1.000	0.70	5.79
Port Island G-G'	5	1.00	Granular Fill	7.00	9	8.50	18.0	116.2	73.0	1.00	0.95	1.00	78	1.30	1.17	13	15	1.09	175	0.78	0.44	0.13	0.29	1.000	0.65	11.03
Data Class	6	1.00	Granular Fill	8.00	8	9.50	18.0	134.2	81.2	1.00	0.95	1.00	78	1.30	1.11	11	17	1.14	175	0.73	0.42	0.11	0.25	1.000	0.60	9.11
	7	1.00	Granular Fill	9.00	15	10.50	18.0	152.2	89.4	1.00	1.00	1.00	78	1.30	1.06	21	10	1.19	200	0.68	0.41	0.21	0.52	0.987	0.55	17.99
B. H.	8	1.00	Granular Fill	10.00	11	11.50	18.0	170.2	97.6	1.00	1.00	1.00	78	1.30	1.01	14	11	1.13	175	0.64	0.39	0.13	0.33	1.000	0.50	12.12
4	9	1.00	Granular Fill	11.00	9	12.50	18.0	188.2	105.8	1.00	1.00	1.00	78	1.30	0.97	11	21	0.48	175	0.60	0.37	0.11	0.28	1.000	0.45	9.91
GWT (m)	10	1.00	Granular Fill	12.00	13	13.50	18.0	206.2	114.0	1.00	1.00	1.00	78	1.30	0.94	16	10	1.04	175	0.57	0.36	0.14	0.38	1.000	0.40	13.36
2.6	11	1.00	Granular Fill	13.00	15	14.50	18.0	224.2	122.2	1.00	1.00	1.00	78	1.30	0.90	18	18	0.83	175	0.54	0.35	0.16	0.47	0.996	0.35	16.03
a_{max} (g)	12	1.00	Granular Fill	14.00	10	15.50	18.0	242.2	130.4	1.00	1.00	1.00	78	1.30	0.88	11	10	1.10	175	0.52	0.34	0.09	0.27	1.000	0.30	8.90
0.54	13	1.00	Granular Fill	15.00	7	16.50	16.5	259.5	137.8	1.00	1.00	1.00	78	1.30	0.85	8	18	1.24	150	0.50	0.33	0.07	0.22	1.000	0.25	5.96
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
78	19																									
N (mean)	20																									
10.4	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
164	25																									
Observed (cm)	26																									
100	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	12.90																							6.29	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Hyogoken - 1995	1	0.90	Granular Fill	3.00	25	4.50	19.0	49.2	45.3	1.00	0.85	1.00	78	1.30	1.49	41	15	1.17	225	0.94	0.36	1.36	3.78	0.000	0.85	44.16
Mw	2	1.00	Granular Fill	4.00	2	5.50	15.5	66.5	52.7	1.00	0.85	1.00	78	1.30	1.38	3	10	0.37	125	0.91	0.40	0.06	0.15	1.000	0.80	2.90
6.9	3	1.00	Granular Fill	5.00	6	6.50	16.5	82.5	58.9	1.00	0.95	1.00	78	1.30	1.30	10	9	1.27	150	0.87	0.43	0.10	0.23	1.000	0.75	7.04
Site	4	1.00	Granular Fill	6.00	5	7.50	16.5	99.0	65.6	1.00	0.95	1.00	78	1.30	1.23	8	17	0.86	150	0.83	0.44	0.09	0.20	1.000	0.70	5.79
Port Island G-G'	5	1.00	Granular Fill	7.00	9	8.50	18.0	116.2	73.0	1.00	0.95	1.00	78	1.30	1.17	13	15	1.09	175	0.78	0.44	0.13	0.29	1.000	0.65	11.03
Data Class	6	1.00	Granular Fill	8.00	8	9.50	18.0	134.2	81.2	1.00	0.95	1.00	78	1.30	1.11	11	17	1.14	175	0.73	0.42	0.11	0.25	1.000	0.60	9.11
	7	1.00	Granular Fill	9.00	15	10.50	18.0	152.2	89.4	1.00	1.00	1.00	78	1.30	1.06	21	10	1.19	200	0.68	0.41	0.21	0.52	0.987	0.55	17.99
B. H.	8	1.00	Granular Fill	10.00	11	11.50	18.0	170.2	97.6	1.00	1.00	1.00	78	1.30	1.01	14	11	1.13	175	0.64	0.39	0.13	0.33	1.000	0.50	12.12
5	9	1.00	Granular Fill	11.00	9	12.50	18.0	188.2	105.8	1.00	1.00	1.00	78	1.30	0.97	11	21	0.48	175	0.60	0.37	0.11	0.28	1.000	0.45	9.91
GWT (m)	10	1.00	Granular Fill	12.00	13	13.50	18.0	206.2	114.0	1.00	1.00	1.00	78	1.30	0.94	16	10	1.04	175	0.57	0.36	0.14	0.38	1.000	0.40	13.36
2.6	11	1.00	Granular Fill	13.00	15	14.50	18.0	224.2	122.2	1.00	1.00	1.00	78	1.30	0.90	18	18	0.83	175	0.54	0.35	0.16	0.47	0.996	0.35	16.03
a_{max} (g)	12	1.00	Granular Fill	14.00	10	15.50	18.0	242.2	130.4	1.00	1.00	1.00	78	1.30	0.88	11	10	1.10	175	0.52	0.34	0.09	0.27	1.000	0.30	8.90
0.54	13	1.00	Granular Fill	15.00	7	16.50	16.5	259.5	137.8	1.00	1.00	1.00	78	1.30	0.85	8	18	1.24	150	0.50	0.33	0.07	0.22	1.000	0.25	5.96
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
78	19																									
N (mean)	20																									
10.4	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
164	25																									
Observed (cm)	26																									
147	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	12.90																							6.29	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Hyogoken - 1995	1	0.90	Granular Fill	3.00	21	4.50	19.0	57.0	53.1	1.00	0.85	1.00	78	1.30	1.37	32	15	1.17	225	0.96	0.36	0.62	1.73	0.000	0.85	41.55
Mw	2	1.00	Granular Fill	4.00	12	5.50	18.0	75.5	61.8	1.00	0.85	1.00	78	1.30	1.27	17	26	0.67	175	0.93	0.40	0.20	0.50	0.992	0.80	16.14
6.9	3	1.00	Granular Fill	5.00	9	6.50	18.0	93.5	70.0	1.00	0.95	1.00	78	1.30	1.20	13	26	0.51	175	0.90	0.42	0.14	0.34	1.000	0.75	12.41
Site	4	1.00	Granular Fill	6.00	11	7.50	18.0	111.5	78.1	1.00	0.95	1.00	78	1.30	1.13	15	20	1.01	175	0.87	0.44	0.16	0.36	1.000	0.70	13.96
Port Island N-N'	5	1.00	Granular Fill	7.00	9	8.50	18.0	129.5	86.3	1.00	0.95	1.00	78	1.30	1.08	12	10	0.27	175	0.83	0.44	0.11	0.25	1.000	0.65	9.48
Data Class	6	1.00	Granular Fill	8.00	11	9.50	18.0	147.5	94.5	1.00	0.95	1.00	78	1.30	1.03	14	12	0.26	175	0.78	0.43	0.13	0.29	1.000	0.60	11.71
	7	1.00	Granular Fill	9.00	9	10.50	18.0	165.5	102.7	1.00	1.00	1.00	78	1.30	0.99	12	8	0.37	175	0.74	0.42	0.10	0.23	1.000	0.55	8.87
B. H.	8	1.00	Granular Fill	10.00	11	11.50	18.0	183.5	110.9	1.00	1.00	1.00	78	1.30	0.95	14	10	0.45	175	0.69	0.40	0.11	0.28	1.000	0.50	11.12
6	9	1.00	Granular Fill	11.00	9	12.50	18.0	201.5	119.1	1.00	1.00	1.00	78	1.30	0.92	11	8	0.24	175	0.65	0.39	0.09	0.23	1.000	0.45	8.04
GWT (m)	10	1.00	Granular Fill	12.00	7	13.50	16.5	218.8	126.5	1.00	1.00	1.00	78	1.30	0.89	8	12	0.24	150	0.62	0.38	0.07	0.19	1.000	0.40	5.86
2.6	11	1.00	Granular Fill	13.00	9	14.50	16.5	235.3	133.2	1.00	1.00	1.00	78	1.30	0.87	10	10	0.37	150	0.59	0.36	0.08	0.23	1.000	0.35	7.62
a_{max} (g)	12	1.00	Granular Fill	14.00	8	15.50	16.5	251.8	139.9	1.00	1.00	1.00	78	1.30	0.85	9	8	0.88	150	0.56	0.36	0.07	0.20	1.000	0.30	6.16
0.54	13	1.00	Granular Fill	15.00	14	16.50	18.0	269.0	147.4	1.00	1.00	1.00	78	1.30	0.82	15	10	0.40	175	0.55	0.35	0.12	0.34	1.000	0.25	12.53
Sampler[b]	14	1.00	Granular Fill	16.00	9	17.50	16.5	286.3	154.8	1.00	1.00	1.00	78	1.30	0.80	9	9	0.82	150	0.53	0.35	0.07	0.22	1.000	0.20	6.78
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
78	19																									
N (mean)	20																									
10.6	21																									
γ_{dry} (kN/m^3)	22																									
19.0	23																									
Vs* (m/s)	24																									
176	25																									
Observed (cm)	26																									
88	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	13.90																							6.49	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Hyogoken - 1995	1	0.90	Granular Fill	3.00	21	4.50	19.0	57.0	53.1	1.00	0.85	1.00	78	1.30	1.37	32	15	1.17	225	0.96	0.36	0.62	1.73	0.000	0.85	41.55
Mw	2	1.00	Granular Fill	4.00	12	5.50	18.0	75.5	61.8	1.00	0.85	1.00	78	1.30	1.27	17	26	0.67	175	0.93	0.40	0.20	0.50	0.992	0.80	16.14
6.9	3	1.00	Granular Fill	5.00	9	6.50	18.0	93.5	70.0	1.00	0.95	1.00	78	1.30	1.20	13	26	0.51	175	0.90	0.42	0.14	0.34	1.000	0.75	12.41
Site	4	1.00	Granular Fill	6.00	11	7.50	18.0	111.5	78.1	1.00	0.95	1.00	78	1.30	1.13	15	20	1.01	175	0.87	0.44	0.16	0.36	1.000	0.70	13.96
Port Island N-N'	5	1.00	Granular Fill	7.00	9	8.50	18.0	129.5	86.3	1.00	0.95	1.00	78	1.30	1.08	12	10	0.27	175	0.83	0.44	0.11	0.25	1.000	0.65	9.48
Data Class	6	1.00	Granular Fill	8.00	11	9.50	18.0	147.5	94.5	1.00	0.95	1.00	78	1.30	1.03	14	12	0.26	175	0.78	0.43	0.13	0.29	1.000	0.60	11.71
	7	1.00	Granular Fill	9.00	9	10.50	18.0	165.5	102.7	1.00	1.00	1.00	78	1.30	0.99	12	8	0.37	175	0.74	0.42	0.10	0.23	1.000	0.55	8.87
B. H.	8	1.00	Granular Fill	10.00	11	11.50	18.0	183.5	110.9	1.00	1.00	1.00	78	1.30	0.95	14	10	0.45	175	0.69	0.40	0.11	0.28	1.000	0.50	11.12
7	9	1.00	Granular Fill	11.00	9	12.50	18.0	201.5	119.1	1.00	1.00	1.00	78	1.30	0.92	11	8	0.24	175	0.65	0.39	0.09	0.23	1.000	0.45	8.04
GWT (m)	10	1.00	Granular Fill	12.00	7	13.50	16.5	218.8	126.5	1.00	1.00	1.00	78	1.30	0.89	8	12	0.24	150	0.62	0.38	0.07	0.19	1.000	0.40	5.86
2.6	11	1.00	Granular Fill	13.00	9	14.50	16.5	235.3	133.2	1.00	1.00	1.00	78	1.30	0.87	10	10	0.37	150	0.59	0.36	0.08	0.23	1.000	0.35	7.62
a_{max} (g)	12	1.00	Granular Fill	14.00	8	15.50	16.5	251.8	139.9	1.00	1.00	1.00	78	1.30	0.85	9	8	0.88	150	0.56	0.36	0.07	0.20	1.000	0.30	6.16
0.54	13	1.00	Granular Fill	15.00	14	16.50	18.0	269.0	147.4	1.00	1.00	1.00	78	1.30	0.82	15	10	0.40	175	0.55	0.35	0.12	0.34	1.000	0.25	12.53
Sampler[b]	14	1.00	Granular Fill	16.00	9	17.50	16.5	286.3	154.8	1.00	1.00	1.00	78	1.30	0.80	9	9	0.82	150	0.53	0.35	0.07	0.22	1.000	0.20	6.78
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
78	19																									
N (mean)	20																									
10.6	21																									
γ_{dry} (kN/m^3)	22																									
19.0	23																									
Vs* (m/s)	24																									
176	25																									
Observed (cm)	26																									
117	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	13.90																							6.49	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Hyogoken - 1995	1	0.90	Granular Fill	3.00	21	4.50	19.0	57.0	53.1	1.00	0.85	1.00	78	1.30	1.37	32	15	1.17	225	0.96	0.36	0.62	1.73	0.000	0.85	41.55
Mw	2	1.00	Granular Fill	4.00	12	5.50	18.0	75.5	61.8	1.00	0.85	1.00	78	1.30	1.27	17	26	0.67	175	0.93	0.40	0.20	0.50	0.992	0.80	16.14
6.9	3	1.00	Granular Fill	5.00	9	6.50	18.0	93.5	70.0	1.00	0.95	1.00	78	1.30	1.20	13	26	0.51	175	0.90	0.42	0.14	0.34	1.000	0.75	12.41
Site	4	1.00	Granular Fill	6.00	11	7.50	18.0	111.5	78.1	1.00	0.95	1.00	78	1.30	1.13	15	20	1.01	175	0.87	0.44	0.16	0.36	1.000	0.70	13.96
Port Island N-N'	5	1.00	Granular Fill	7.00	9	8.50	18.0	129.5	86.3	1.00	0.95	1.00	78	1.30	1.08	12	10	0.27	175	0.83	0.44	0.11	0.25	1.000	0.65	9.48
Data Class	6	1.00	Granular Fill	8.00	11	9.50	18.0	147.5	94.5	1.00	0.95	1.00	78	1.30	1.03	14	12	0.26	175	0.78	0.43	0.13	0.29	1.000	0.60	11.71
	7	1.00	Granular Fill	9.00	9	10.50	18.0	165.5	102.7	1.00	1.00	1.00	78	1.30	0.99	12	8	0.37	175	0.74	0.42	0.10	0.23	1.000	0.55	8.87
B. H.	8	1.00	Granular Fill	10.00	11	11.50	18.0	183.5	110.9	1.00	1.00	1.00	78	1.30	0.95	14	10	0.45	175	0.69	0.40	0.11	0.28	1.000	0.50	11.12
8	9	1.00	Granular Fill	11.00	9	12.50	18.0	201.5	119.1	1.00	1.00	1.00	78	1.30	0.92	11	8	0.24	175	0.65	0.39	0.09	0.23	1.000	0.45	8.04
GWT (m)	10	1.00	Granular Fill	12.00	7	13.50	16.5	218.8	126.5	1.00	1.00	1.00	78	1.30	0.89	8	12	0.24	150	0.62	0.38	0.07	0.19	1.000	0.40	5.86
2.6	11	1.00	Granular Fill	13.00	9	14.50	16.5	235.3	133.2	1.00	1.00	1.00	78	1.30	0.87	10	10	0.37	150	0.59	0.36	0.08	0.23	1.000	0.35	7.62
a_{max} (g)	12	1.00	Granular Fill	14.00	8	15.50	16.5	251.8	139.9	1.00	1.00	1.00	78	1.30	0.85	9	8	0.88	150	0.56	0.36	0.07	0.20	1.000	0.30	6.16
0.54	13	1.00	Granular Fill	15.00	14	16.50	18.0	269.0	147.4	1.00	1.00	1.00	78	1.30	0.82	15	10	0.40	175	0.55	0.35	0.12	0.34	1.000	0.25	12.53
Sampler[b]	14	1.00	Granular Fill	16.00	9	17.50	16.5	286.3	154.8	1.00	1.00	1.00	78	1.30	0.80	9	9	0.82	150	0.53	0.35	0.07	0.22	1.000	0.20	6.78
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
78	19																									
N (mean)	20																									
10.6	21																									
γ_{dry} (kN/m^3)	22																									
19.0	23																									
Vs* (m/s)	24																									
176	25																									
Observed (cm)	26																									
132	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	13.90																							6.49	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Hyogoken - 1995	1	0.90	Granular Fill	3.00	4	4.50	16.5	48.2	44.3	1.00	0.85	1.00	78	1.30	1.50	7	22	0.94	150	0.92	0.35	0.09	0.26	1.000	0.85	5.31
Mw	2	1.00	Granular Fill	4.00	2	5.50	15.5	64.2	50.5	1.00	0.85	1.00	78	1.30	1.41	3	11	3.12	125	0.88	0.39	0.06	0.16	1.000	0.80	2.95
6.9	3	1.00	Granular Fill	5.00	6	6.50	16.5	80.2	56.7	1.00	0.95	1.00	78	1.30	1.33	10	14	1.87	150	0.84	0.42	0.11	0.25	1.000	0.75	7.68
Site	4	1.00	Granular Fill	6.00	6	7.50	16.5	96.7	63.3	1.00	0.95	1.00	78	1.30	1.26	9	9	4.38	150	0.79	0.42	0.09	0.22	1.000	0.70	6.69
Rokko O-O'	5	1.00	Granular Fill	7.00	13	8.50	18.0	114.0	70.8	1.00	0.95	1.00	78	1.30	1.19	19	17	1.97	175	0.74	0.42	0.21	0.51	0.989	0.65	17.33
Data Class	6	1.00	Granular Fill	8.00	10	9.50	18.0	132.0	79.0	1.00	0.95	1.00	78	1.30	1.13	14	19	2.92	175	0.68	0.40	0.14	0.34	1.000	0.60	12.35
	7	1.00	Granular Fill	9.00	5	10.50	16.5	149.2	86.4	1.00	1.00	1.00	78	1.30	1.08	7	26	0.32	150	0.63	0.38	0.08	0.21	1.000	0.55	5.81
B. H.	8	1.00	Granular Fill	10.00	7	11.50	16.5	165.7	93.1	1.00	1.00	1.00	78	1.30	1.04	9	11	9.30	150	0.59	0.37	0.09	0.24	1.000	0.50	6.99
1	9	1.00	Granular Fill	11.00	5	12.50	16.5	182.2	99.8	1.00	1.00	1.00	78	1.30	1.00	7	8	1.90	150	0.55	0.36	0.07	0.19	1.000	0.45	4.54
GWT (m)	10	1.00	Granular Fill	12.00	10	13.50	18.0	199.5	107.2	1.00	1.00	1.00	78	1.30	0.97	13	20	0.71	175	0.52	0.34	0.11	0.33	1.000	0.40	11.05
2.6	11	1.00	Granular Fill	13.00	7	14.50	16.5	216.7	114.7	1.00	1.00	1.00	78	1.30	0.93	8	22	1.73	150	0.50	0.33	0.08	0.25	1.000	0.35	6.94
a_{max} (g)	12	1.00	Granular Fill	14.00	25	15.50	18.0	234.0	122.1	1.00	1.00	1.00	78	1.30	0.90	29	17	5.96	200	0.48	0.32	0.42	1.29	0.011	0.30	40.95
0.54	13	1.00	Granular Fill	15.00	5	16.50	16.5	251.2	129.6	1.00	1.00	1.00	78	1.30	0.88	6	17	1.92	150	0.47	0.32	0.06	0.19	1.000	0.25	4.45
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
78	19																									
N (mean)	20																									
8.1	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
155	25																									
Observed (cm)	26																									
89	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	12.90																							6.76	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Hyogoken - 1995	1	0.90	Granular Fill	3.00	4	4.50	16.5	48.2	44.3	1.00	0.85	1.00	78	1.30	1.50	7	22	0.94	150	0.92	0.35	0.09	0.26	1.000	0.85	5.31
Mw	2	1.00	Granular Fill	4.00	2	5.50	15.5	64.2	50.5	1.00	0.85	1.00	78	1.30	1.41	3	11	3.12	125	0.88	0.39	0.06	0.16	1.000	0.80	2.95
6.9	3	1.00	Granular Fill	5.00	6	6.50	16.5	80.2	56.7	1.00	0.95	1.00	78	1.30	1.33	10	14	1.87	150	0.84	0.42	0.11	0.25	1.000	0.75	7.68
Site	4	1.00	Granular Fill	6.00	6	7.50	16.5	96.7	63.3	1.00	0.95	1.00	78	1.30	1.26	9	9	4.38	150	0.79	0.42	0.09	0.22	1.000	0.70	6.69
Rokko P-P'	5	1.00	Granular Fill	7.00	13	8.50	18.0	114.0	70.8	1.00	0.95	1.00	78	1.30	1.19	19	17	1.97	175	0.74	0.42	0.21	0.51	0.989	0.65	17.33
Data Class	6	1.00	Granular Fill	8.00	10	9.50	18.0	132.0	79.0	1.00	0.95	1.00	78	1.30	1.13	14	19	2.92	175	0.68	0.40	0.14	0.34	1.000	0.60	12.35
	7	1.00	Granular Fill	9.00	5	10.50	16.5	149.2	86.4	1.00	1.00	1.00	78	1.30	1.08	7	26	0.32	150	0.63	0.38	0.08	0.21	1.000	0.55	5.81
B. H.	8	1.00	Granular Fill	10.00	7	11.50	16.5	165.7	93.1	1.00	1.00	1.00	78	1.30	1.04	9	11	9.30	150	0.59	0.37	0.09	0.24	1.000	0.50	6.99
2	9	1.00	Granular Fill	11.00	5	12.50	16.5	182.2	99.8	1.00	1.00	1.00	78	1.30	1.00	7	8	1.90	150	0.55	0.36	0.07	0.19	1.000	0.45	4.54
GWT (m)	10	1.00	Granular Fill	12.00	10	13.50	18.0	199.5	107.2	1.00	1.00	1.00	78	1.30	0.97	13	20	0.71	175	0.52	0.34	0.11	0.33	1.000	0.40	11.05
2.6	11	1.00	Granular Fill	13.00	7	14.50	16.5	216.7	114.7	1.00	1.00	1.00	78	1.30	0.93	8	22	1.73	150	0.50	0.33	0.08	0.25	1.000	0.35	6.94
a_{max} (g)	12	1.00	Granular Fill	14.00	25	15.50	18.0	234.0	122.1	1.00	1.00	1.00	78	1.30	0.90	29	17	5.96	200	0.48	0.32	0.42	1.29	0.011	0.30	40.95
0.54	13	1.00	Granular Fill	15.00	5	16.50	16.5	251.2	129.6	1.00	1.00	1.00	78	1.30	0.88	6	17	1.92	150	0.47	0.32	0.06	0.19	1.000	0.25	4.45
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
78	19																									
N (mean)	20																									
8.1	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
155	25																									
Observed (cm)	26																									
40	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	12.90																							6.76	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Hyogoken - 1995	1	0.90	Granular Fill	3.00	4	4.50	16.5	48.2	44.3	1.00	0.85	1.00	78	1.30	1.50	7	22	0.94	150	0.92	0.35	0.09	0.26	1.000	0.85	5.31
Mw	2	1.00	Granular Fill	4.00	2	5.50	15.5	64.2	50.5	1.00	0.85	1.00	78	1.30	1.41	3	11	3.12	125	0.88	0.39	0.06	0.16	1.000	0.80	2.95
6.9	3	1.00	Granular Fill	5.00	6	6.50	16.5	80.2	56.7	1.00	0.95	1.00	78	1.30	1.33	10	14	1.87	150	0.84	0.42	0.11	0.25	1.000	0.75	7.68
Site	4	1.00	Granular Fill	6.00	6	7.50	16.5	96.7	63.3	1.00	0.95	1.00	78	1.30	1.26	9	9	4.38	150	0.79	0.42	0.09	0.22	1.000	0.70	6.69
Rokko Q-Q'	5	1.00	Granular Fill	7.00	13	8.50	18.0	114.0	70.8	1.00	0.95	1.00	78	1.30	1.19	19	17	1.97	175	0.74	0.42	0.21	0.51	0.989	0.65	17.33
Data Class	6	1.00	Granular Fill	8.00	10	9.50	18.0	132.0	79.0	1.00	0.95	1.00	78	1.30	1.13	14	19	2.92	175	0.68	0.40	0.14	0.34	1.000	0.60	12.35
	7	1.00	Granular Fill	9.00	5	10.50	16.5	149.2	86.4	1.00	1.00	1.00	78	1.30	1.08	7	26	0.32	150	0.63	0.38	0.08	0.21	1.000	0.55	5.81
B. H.	8	1.00	Granular Fill	10.00	7	11.50	16.5	165.7	93.1	1.00	1.00	1.00	78	1.30	1.04	9	11	9.30	150	0.59	0.37	0.09	0.24	1.000	0.50	6.99
3	9	1.00	Granular Fill	11.00	5	12.50	16.5	182.2	99.8	1.00	1.00	1.00	78	1.30	1.00	7	8	1.90	150	0.55	0.36	0.07	0.19	1.000	0.45	4.54
GWT (m)	10	1.00	Granular Fill	12.00	10	13.50	18.0	199.5	107.2	1.00	1.00	1.00	78	1.30	0.97	13	20	0.71	175	0.52	0.34	0.11	0.33	1.000	0.40	11.05
2.6	11	1.00	Granular Fill	13.00	7	14.50	16.5	216.7	114.7	1.00	1.00	1.00	78	1.30	0.93	8	22	1.73	150	0.50	0.33	0.08	0.25	1.000	0.35	6.94
a_{max} (g)	12	1.00	Granular Fill	14.00	25	15.50	18.0	234.0	122.1	1.00	1.00	1.00	78	1.30	0.90	29	17	5.96	200	0.48	0.32	0.42	1.29	0.011	0.30	40.95
0.54	13	1.00	Granular Fill	15.00	5	16.50	16.5	251.2	129.6	1.00	1.00	1.00	78	1.30	0.88	6	17	1.92	150	0.47	0.32	0.06	0.19	1.000	0.25	4.45
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
78	19																									
N (mean)	20																									
8.1	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
155	25																									
Observed (cm)	26																									
92	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	12.90																							6.76	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Hyogoken - 1995	1	0.90	Granular Fill	3.00	4	4.50	16.5	48.2	44.3	1.00	0.85	1.00	78	1.30	1.50	7	22	0.94	150	0.92	0.35	0.09	0.26	1.000	0.85	5.31
Mw	2	1.00	Granular Fill	4.00	2	5.50	15.5	64.2	50.5	1.00	0.85	1.00	78	1.30	1.41	3	11	3.12	125	0.88	0.39	0.06	0.16	1.000	0.80	2.95
6.9	3	1.00	Granular Fill	5.00	6	6.50	16.5	80.2	56.7	1.00	0.95	1.00	78	1.30	1.33	10	14	1.87	150	0.84	0.42	0.11	0.25	1.000	0.75	7.68
Site	4	1.00	Granular Fill	6.00	6	7.50	16.5	96.7	63.3	1.00	0.95	1.00	78	1.30	1.26	9	9	4.38	150	0.79	0.42	0.09	0.22	1.000	0.70	6.69
Rokko R-R'	5	1.00	Granular Fill	7.00	13	8.50	18.0	114.0	70.8	1.00	0.95	1.00	78	1.30	1.19	19	17	1.97	175	0.74	0.42	0.21	0.51	0.989	0.65	17.33
Data Class	6	1.00	Granular Fill	8.00	10	9.50	18.0	132.0	79.0	1.00	0.95	1.00	78	1.30	1.13	14	19	2.92	175	0.68	0.40	0.14	0.34	1.000	0.60	12.35
	7	1.00	Granular Fill	9.00	5	10.50	16.5	149.2	86.4	1.00	1.00	1.00	78	1.30	1.08	7	26	0.32	150	0.63	0.38	0.08	0.21	1.000	0.55	5.81
B. H.	8	1.00	Granular Fill	10.00	7	11.50	16.5	165.7	93.1	1.00	1.00	1.00	78	1.30	1.04	9	11	9.30	150	0.59	0.37	0.09	0.24	1.000	0.50	6.99
4	9	1.00	Granular Fill	11.00	5	12.50	16.5	182.2	99.8	1.00	1.00	1.00	78	1.30	1.00	7	8	1.90	150	0.55	0.36	0.07	0.19	1.000	0.45	4.54
GWT (m)	10	1.00	Granular Fill	12.00	10	13.50	18.0	199.5	107.2	1.00	1.00	1.00	78	1.30	0.97	13	20	0.71	175	0.52	0.34	0.11	0.33	1.000	0.40	11.05
2.6	11	1.00	Granular Fill	13.00	7	14.50	16.5	216.7	114.7	1.00	1.00	1.00	78	1.30	0.93	8	22	1.73	150	0.50	0.33	0.08	0.25	1.000	0.35	6.94
a_{max} (g)	12	1.00	Granular Fill	14.00	25	15.50	18.0	234.0	122.1	1.00	1.00	1.00	78	1.30	0.90	29	17	5.96	200	0.48	0.32	0.42	1.29	0.011	0.30	40.95
0.54	13	1.00	Granular Fill	15.00	5	16.50	16.5	251.2	129.6	1.00	1.00	1.00	78	1.30	0.88	6	17	1.92	150	0.47	0.32	0.06	0.19	1.000	0.25	4.45
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
78	19																									
N (mean)	20																									
8.1	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
155	25																									
Observed (cm)	26																									
65	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	12.90																							6.76	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Hyogoken - 1995	1	0.90	Granular Fill	3.00	4	4.50	16.5	48.2	44.3	1.00	0.85	1.00	78	1.30	1.50	7	22	0.94	150	0.92	0.35	0.09	0.26	1.000	0.85	5.31
Mw	2	1.00	Granular Fill	4.00	2	5.50	15.5	64.2	50.5	1.00	0.85	1.00	78	1.30	1.41	3	11	3.12	125	0.88	0.39	0.06	0.16	1.000	0.80	2.95
6.9	3	1.00	Granular Fill	5.00	6	6.50	16.5	80.2	56.7	1.00	0.95	1.00	78	1.30	1.33	10	14	1.87	150	0.84	0.42	0.11	0.25	1.000	0.75	7.68
Site	4	1.00	Granular Fill	6.00	6	7.50	16.5	96.7	63.3	1.00	0.95	1.00	78	1.30	1.26	9	9	4.38	150	0.79	0.42	0.09	0.22	1.000	0.70	6.69
Rokko S-S'	5	1.00	Granular Fill	7.00	13	8.50	18.0	114.0	70.8	1.00	0.95	1.00	78	1.30	1.19	19	17	1.97	175	0.74	0.42	0.21	0.51	0.989	0.65	17.33
Data Class	6	1.00	Granular Fill	8.00	10	9.50	18.0	132.0	79.0	1.00	0.95	1.00	78	1.30	1.13	14	19	2.92	175	0.68	0.40	0.14	0.34	1.000	0.60	12.35
	7	1.00	Granular Fill	9.00	5	10.50	16.5	149.2	86.4	1.00	1.00	1.00	78	1.30	1.08	7	26	0.32	150	0.63	0.38	0.08	0.21	1.000	0.55	5.81
B. H.	8	1.00	Granular Fill	10.00	7	11.50	16.5	165.7	93.1	1.00	1.00	1.00	78	1.30	1.04	9	11	9.30	150	0.59	0.37	0.09	0.24	1.000	0.50	6.99
5	9	1.00	Granular Fill	11.00	5	12.50	16.5	182.2	99.8	1.00	1.00	1.00	78	1.30	1.00	7	8	1.90	150	0.55	0.36	0.07	0.19	1.000	0.45	4.54
GWT (m)	10	1.00	Granular Fill	12.00	10	13.50	18.0	199.5	107.2	1.00	1.00	1.00	78	1.30	0.97	13	20	0.71	175	0.52	0.34	0.11	0.33	1.000	0.40	11.05
2.6	11	1.00	Granular Fill	13.00	7	14.50	16.5	216.7	114.7	1.00	1.00	1.00	78	1.30	0.93	8	22	1.73	150	0.50	0.33	0.08	0.25	1.000	0.35	6.94
a_{max} (g)	12	1.00	Granular Fill	14.00	25	15.50	18.0	234.0	122.1	1.00	1.00	1.00	78	1.30	0.90	29	17	5.96	200	0.48	0.32	0.42	1.29	0.011	0.30	40.95
0.54	13	1.00	Granular Fill	15.00	5	16.50	16.5	251.2	129.6	1.00	1.00	1.00	78	1.30	0.88	6	17	1.92	150	0.47	0.32	0.06	0.19	1.000	0.25	4.45
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
78	19																									
N (mean)	20																									
8.1	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
155	25																									
Observed (cm)	26																									
44	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	12.90																							6.76	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Hyogoken - 1995	1	0.90	Granular Fill	3.00	4	4.50	16.5	48.2	44.3	1.00	0.85	1.00	78	1.30	1.50	7	22	0.94	150	0.92	0.35	0.09	0.26	1.000	0.85	5.31
Mw	2	1.00	Granular Fill	4.00	2	5.50	15.5	64.2	50.5	1.00	0.85	1.00	78	1.30	1.41	3	11	3.12	125	0.88	0.39	0.06	0.16	1.000	0.80	2.95
6.9	3	1.00	Granular Fill	5.00	6	6.50	16.5	80.2	56.7	1.00	0.95	1.00	78	1.30	1.33	10	14	1.87	150	0.84	0.42	0.11	0.25	1.000	0.75	7.68
Site	4	1.00	Granular Fill	6.00	6	7.50	16.5	96.7	63.3	1.00	0.95	1.00	78	1.30	1.26	9	9	4.38	150	0.79	0.42	0.09	0.22	1.000	0.70	6.69
Rokko T-T'	5	1.00	Granular Fill	7.00	13	8.50	18.0	114.0	70.8	1.00	0.95	1.00	78	1.30	1.19	19	17	1.97	175	0.74	0.42	0.21	0.51	0.989	0.65	17.33
Data Class	6	1.00	Granular Fill	8.00	10	9.50	18.0	132.0	79.0	1.00	0.95	1.00	78	1.30	1.13	14	19	2.92	175	0.68	0.40	0.14	0.34	1.000	0.60	12.35
	7	1.00	Granular Fill	9.00	5	10.50	16.5	149.2	86.4	1.00	1.00	1.00	78	1.30	1.08	7	26	0.32	150	0.63	0.38	0.08	0.21	1.000	0.55	5.81
B. H.	8	1.00	Granular Fill	10.00	7	11.50	16.5	165.7	93.1	1.00	1.00	1.00	78	1.30	1.04	9	11	9.30	150	0.59	0.37	0.09	0.24	1.000	0.50	6.99
6	9	1.00	Granular Fill	11.00	5	12.50	16.5	182.2	99.8	1.00	1.00	1.00	78	1.30	1.00	7	8	1.90	150	0.55	0.36	0.07	0.19	1.000	0.45	4.54
GWT (m)	10	1.00	Granular Fill	12.00	10	13.50	18.0	199.5	107.2	1.00	1.00	1.00	78	1.30	0.97	13	20	0.71	175	0.52	0.34	0.11	0.33	1.000	0.40	11.05
2.6	11	1.00	Granular Fill	13.00	7	14.50	16.5	216.7	114.7	1.00	1.00	1.00	78	1.30	0.93	8	22	1.73	150	0.50	0.33	0.08	0.25	1.000	0.35	6.94
a_{max} (g)	12	1.00	Granular Fill	14.00	25	15.50	18.0	234.0	122.1	1.00	1.00	1.00	78	1.30	0.90	29	17	5.96	200	0.48	0.32	0.42	1.29	0.011	0.30	40.95
0.54	13	1.00	Granular Fill	15.00	5	16.50	16.5	251.2	129.6	1.00	1.00	1.00	78	1.30	0.88	6	17	1.92	150	0.47	0.32	0.06	0.19	1.000	0.25	4.45
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
78	19																									
N (mean)	20																									
8.1	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
155	25																									
Observed (cm)	26																									
96	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	12.90																							6.76	

SEISMIC EVENT # 15

EARTHQUAKE:	Kocaeli (Izmit)
MOMENT MAGNITUDE:	7.4
LOCATION:	Turkey
DATE:	August 17, 1999
REFERENCE(S):	Cetin, K. O. et al. (2002) Cetin, K. O. et al. (2004) Kanibir, A. (2003) PEER Website

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Kocaeli	1	0.85	Fill	0.78	5	2.28	16.5	12.3	8.4	1.00	0.75	1.00	45	0.75	2.00	6	35	0.1	150	0.99	0.38	0.12	0.33	0.000	0.00	Non-Liq.
Mw	2	0.92	Silty Sand	1.67	9	3.17	16.5	27.0	14.3	1.00	0.75	1.00	45	0.75	2.00	10	19	0.5	175	0.97	0.48	0.14	0.29	1.000	0.92	8.41
7.4	3	1.03	Silty Sand	2.62	10	4.12	18.0	43.4	21.4	1.00	0.85	1.00	45	0.75	2.00	13	6	1.0	175	0.95	0.50	0.14	0.28	1.000	0.87	9.89
Site	4	1.09	Silty Sand	3.72	14	5.22	18.0	63.2	30.4	1.00	0.85	1.00	45	0.75	1.81	16	27	0.1	175	0.92	0.50	0.20	0.40	1.000	0.81	15.54
Sapanca Lake	5	1.04	Silt	4.80	6	6.30	16.5	81.8	38.4	1.00	0.95	1.00	45	0.75	1.61	7	35	0.1	150	0.89	0.49	0.09	0.18	0.000	0.00	Non-Liq.
Data Class	6	0.93	Silt	5.80	15	7.30	18.0	99.1	45.9	1.00	0.95	1.00	45	0.75	1.48	16	35	0.1	175	0.85	0.48	0.18	0.38	0.000	0.00	Non-Liq.
	7	1.03	Silt	6.65	14	8.15	18.0	114.4	52.8	1.00	0.95	1.00	45	0.75	1.38	14	35	0.1	175	0.81	0.46	0.15	0.32	0.000	0.00	Non-Liq.
B. H.	8	1.08	Silty Sand	7.85	11	9.35	16.5	135.1	61.8	1.00	0.95	1.00	45	0.75	1.27	10	15	1.0	150	0.76	0.43	0.09	0.21	1.000	0.61	7.90
JS2	9	0.96	Silt	8.80	15	10.30	18.0	151.4	68.8	1.00	1.00	1.00	45	0.75	1.21	14	35	0.1	175	0.72	0.41	0.14	0.33	0.000	0.00	Non-Liq.
GWT (m)	10	1.00	Silty Sand	9.77	10	11.27	16.5	168.2	76.1	1.00	1.00	1.00	45	0.75	1.15	9	15	1.0	150	0.68	0.39	0.08	0.19	1.000	0.51	6.48
0.38	11	1.03	Silt	10.80	16	12.30	18.0	185.9	83.7	1.00	1.00	1.00	45	0.75	1.09	13	35	0.1	175	0.64	0.37	0.12	0.33	0.000	0.00	Non-Liq.
a_{max} (g)	12																									
0.4	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
45	19																									
N (mean)	20																									
11	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
163	25																									
Observed (cm)	26																									
121	27																									
Distance (m)	28																									
0	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	10.94																							3.79	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Kocaeli	1	1.28	Silty Sand	1.77	8	3.27	16.5	27.7	20.3	1.00	0.75	1.00	45	0.75	2.00	9	7	1.0	150	0.96	0.34	0.11	0.32	1.000	0.91	6.27
Mw	2	0.98	Silty Sand	2.82	10	4.32	18.0	45.8	28.1	1.00	0.85	1.00	45	0.75	1.89	12	22	0.5	175	0.93	0.39	0.14	0.35	1.000	0.86	10.69
7.4	3	0.99	Silty Sand	3.72	5	5.22	16.5	61.3	34.8	1.00	0.85	1.00	45	0.75	1.69	5	24	0.5	150	0.90	0.41	0.08	0.19	1.000	0.81	4.55
Site	4	1.04	Silty Sand	4.80	4	6.30	15.5	78.6	41.5	1.00	0.95	1.00	45	0.75	1.55	4	26	0.1	150	0.86	0.42	0.07	0.16	1.000	0.76	4.03
Sapanca Lake	5	1.40	Silt	5.80	6	7.30	16.5	94.6	47.7	1.00	0.95	1.00	45	0.75	1.45	6	35	0.1	150	0.81	0.42	0.08	0.19	0.000	0.00	Non-Liq.
Data Class	6	1.11	Silt	7.60	9	9.10	16.5	124.3	59.7	1.00	0.95	1.00	45	0.75	1.29	8	35	0.1	150	0.72	0.39	0.09	0.23	0.000	0.00	Non-Liq.
	7	0.58	Silty Sand	8.02	15	9.52	18.0	131.5	62.9	1.00	0.95	1.00	45	0.75	1.26	13	34	0.1	175	0.70	0.38	0.14	0.36	1.000	0.60	13.40
B. H.	8	0.89	Silty Sand	8.75	16	10.25	18.0	144.7	68.8	1.00	1.00	1.00	45	0.75	1.21	14	34	0.1	175	0.67	0.37	0.15	0.40	1.000	0.56	14.46
JS3	9	1.05	Silty Sand	9.80	8	11.30	16.5	162.8	76.7	1.00	1.00	1.00	45	0.75	1.14	7	34	0.1	150	0.63	0.35	0.07	0.21	1.000	0.51	6.17
GWT (m)	10																									
1.02	11																									
a_{max} (g)	12																									
0.4	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
45	19																									
N (mean)	20																									
9	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
152	25																									
Observed (cm)	26																									
137	27																									
Distance (m)	28																									
0	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	9.31																							4.98	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Kocaeli	1	0.56	Fill	0.85	15	2.35	18.0	13.1	12.1	1.00	0.75	1.00	45	0.75	2.00	17	35	0.1	175	0.99	0.28	0.29	1.05	0.000	0.00	Non-Liq.
Mw	2	0.96	Silty Sand	1.77	22	3.27	18.0	29.6	19.6	1.00	0.75	1.00	45	0.75	2.00	25	8	1.0	200	0.98	0.38	0.37	0.96	0.198	0.91	39.26
7.4	3	1.00	Silty Gravel	2.77	10	4.27	18.0	47.6	27.8	1.00	0.85	1.00	45	0.75	1.90	12	5	3.0	175	0.96	0.43	0.12	0.29	1.000	0.86	9.14
Site	4	0.98	Silty Sand	3.77	10	5.27	18.0	65.6	36.0	1.00	0.85	1.00	45	0.75	1.67	11	7	1.0	175	0.94	0.45	0.10	0.23	1.000	0.81	7.85
Sapanca Lake	5	1.02	Silty Sand	4.72	3	6.22	15.5	81.5	42.6	1.00	0.95	1.00	45	0.75	1.53	3	35	0.1	125	0.91	0.45	0.06	0.14	1.000	0.76	3.68
Data Class	6	1.04	Silty Sand	5.80	12	7.30	18.0	99.6	50.1	1.00	0.95	1.00	45	0.75	1.41	12	35	0.1	175	0.88	0.45	0.13	0.29	1.000	0.71	11.98
	7	0.96	Silt	6.80	11	8.30	16.5	116.9	57.5	1.00	0.95	1.00	45	0.75	1.32	10	35	0.1	175	0.84	0.44	0.11	0.24	0.000	0.00	Non-Liq.
B. H.	8	0.93	Silty Sand	7.72	15	9.22	18.0	132.7	64.4	1.00	0.95	1.00	45	0.75	1.25	13	17	0.5	175	0.80	0.43	0.12	0.27	1.000	0.61	11.56
JS4	9	1.07	Silty Sand	8.65	39	10.15	19.0	149.9	72.4	1.00	1.00	1.00	45	0.75	1.17	34	17	0.5	225	0.76	0.41	0.62	1.50	0.001	0.57	42.36
GWT (m)	10	1.20	Silty Sand	9.85	31	11.35	18.0	172.1	82.9	1.00	1.00	1.00	45	0.75	1.10	26	17	0.5	200	0.71	0.39	0.29	0.76	0.631	0.51	23.40
0.75	11																									
a_{max} (g)	12																									
0.4	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
45	19																									
N (mean)	20																									
17	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
172	25																									
Observed (cm)	26																									
292	27																									
Distance (m)	28																									
0	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	9.70																							4.29	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Kocaeli	1	0.60	Fill	1.00	12	2.50	18.0	15.8	13.3	1.00	0.75	1.00	45	0.75	2.00	14	35	0.1	175	0.99	0.30	0.21	0.70	0.000	0.00	Non-Liq.
Mw	2	0.90	Silty Gravel	1.70	14	3.20	18.0	28.4	19.0	1.00	0.75	1.00	45	0.75	2.00	16	5	3.0	175	0.98	0.38	0.18	0.48	0.996	0.92	12.74
7.4	3	1.01	Silty Gravel	2.80	16	4.30	18.0	48.2	28.0	1.00	0.85	1.00	45	0.75	1.89	19	5	3.0	200	0.96	0.43	0.21	0.49	0.993	0.86	16.11
Site	4	1.00	Silty Sand	3.72	17	5.22	18.0	64.7	35.6	1.00	0.85	1.00	45	0.75	1.68	18	2	3.0	175	0.94	0.45	0.18	0.40	1.000	0.81	15.07
Sapanca Lake	5	0.93	Silty Gravel	4.80	15	6.30	18.0	84.2	44.4	1.00	0.95	1.00	45	0.75	1.50	16	5	3.0	175	0.92	0.45	0.15	0.32	1.000	0.76	13.02
Data Class	6	0.91	Silty Sand	5.57	14	7.07	18.0	98.0	50.7	1.00	0.95	1.00	45	0.75	1.40	14	1	3.0	175	0.89	0.45	0.12	0.26	1.000	0.72	11.03
	7	1.05	Silty Sand	6.62	22	8.12	18.0	116.9	59.3	1.00	0.95	1.00	45	0.75	1.30	20	11	1.0	200	0.85	0.44	0.20	0.46	0.998	0.67	17.85
B. H.	8																									
JS5	9																									
GWT (m)	10																									
0.75	11																									
a_{max} (g)	12																									
0.4	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
45	19																									
N (mean)	20																									
16	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
174	25																									
Observed (cm)	26																									
292	27																									
Distance (m)	28																									
0	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	6.40																							4.56	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Kocaeli	1	0.42	Silty Sand	2.62	10	4.12	16.5	39.5	38.3	1.00	0.85	1.00	45	0.75	1.62	10	31	0.1	175	0.92	0.25	0.12	0.47	0.996	0.87	9.67
Mw	2	1.10	Silty Sand	3.22	6	4.72	16.5	49.4	42.3	1.00	0.85	1.00	45	0.75	1.54	6	17	0.5	150	0.90	0.27	0.07	0.27	1.000	0.84	4.55
7.4	3	1.25	Silty Sand	4.82	6	6.32	16.5	75.8	53.0	1.00	0.95	1.00	45	0.75	1.37	6	17	0.5	150	0.82	0.31	0.07	0.22	1.000	0.76	4.55
Site	4	0.90	Silty Sand	5.72	4	7.22	15.5	90.2	58.6	1.00	0.95	1.00	45	0.75	1.31	4	2	3.0	125	0.78	0.31	0.05	0.17	1.000	0.71	3.05
Sapanca Lake	5	1.04	Silty Sand	6.62	10	8.12	16.5	104.6	64.2	1.00	0.95	1.00	45	0.75	1.25	9	31	0.1	150	0.73	0.31	0.09	0.29	1.000	0.67	8.12
Data Class	6	1.04	Silt	7.80	14	9.30	18.0	124.9	72.9	1.00	0.95	1.00	45	0.75	1.17	12	35	0.1	175	0.67	0.30	0.11	0.38	0.000	0.00	Non-Liq.
	7	1.00	Silt	8.70	11	10.20	16.5	140.5	79.6	1.00	1.00	1.00	45	0.75	1.12	9	35	0.1	150	0.63	0.29	0.09	0.31	0.000	0.00	Non-Liq.
B. H.	8	1.10	Silt	9.80	12	11.30	16.5	158.6	87.0	1.00	1.00	1.00	45	0.75	1.07	10	35	0.1	150	0.59	0.28	0.09	0.32	0.000	0.00	Non-Liq.
JS6	9																									
GWT (m)	10																									
2.5	11																									
a_{max} (g)	12																									
0.4	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
45	19																									
N (mean)	20																									
9	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
143	25																									
Observed (cm)	26																									
274	27																									
Distance (m)	28																									
0	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	7.85																							3.57	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Kocaeli	1	1.47	Silty Sand	1.22	8	2.72	16.5	19.7	10.7	1.00	0.75	1.00	45	0.75	2.00	9	21	0.5	150	0.99	0.48	0.14	0.30	1.000	0.94	7.39
Mw	2	1.04	Silty Sand	2.32	18	3.82	18.0	38.7	18.8	1.00	0.75	1.00	45	0.75	2.00	20	10	1.0	200	0.98	0.52	0.27	0.52	0.987	0.88	17.64
7.4	3	0.92	Gravel	3.30	22	4.80	18.0	56.3	26.9	1.00	0.85	1.00	45	0.75	1.93	27	2	3.0	200	0.96	0.53	0.38	0.73	0.692	0.84	23.38
Site	4	0.90	Gravel	4.15	15	5.65	18.0	71.6	33.8	1.00	0.85	1.00	45	0.75	1.72	16	2	3.0	175	0.95	0.52	0.16	0.30	1.000	0.79	13.41
Sapanca Lake	5	0.98	Gravel	5.10	24	6.60	18.0	88.7	41.6	1.00	0.95	1.00	45	0.75	1.55	27	2	3.0	200	0.93	0.51	0.32	0.62	0.901	0.75	22.69
Data Class	6	1.01	Gravel	6.10	18	7.60	18.0	106.7	49.8	1.00	0.95	1.00	45	0.75	1.42	18	2	3.0	175	0.90	0.50	0.16	0.32	1.000	0.70	15.08
	7	1.06	Silty Sand	7.12	24	8.62	18.0	125.1	58.2	1.00	0.95	1.00	45	0.75	1.31	22	21	0.5	200	0.87	0.48	0.26	0.54	0.977	0.64	21.02
B. H.	8	0.99	Sand	8.22	23	9.72	18.0	144.9	67.2	1.00	0.95	1.00	45	0.75	1.22	20	6	1.0	175	0.83	0.46	0.18	0.39	1.000	0.59	16.92
JS7	9	0.89	Silty Sand	9.10	33	10.60	18.0	160.7	74.4	1.00	1.00	1.00	45	0.75	1.16	29	5	3.0	200	0.79	0.44	0.33	0.75	0.646	0.55	24.57
GWT (m)	10	0.90	Silty Sand	10.00	48	11.50	19.0	177.3	82.2	1.00	1.00	1.00	45	0.75	1.10	40	5	3.0	225	0.76	0.43	0.76	1.78	0.000	0.50	43.22
0.3	11																									
a_{max} (g)	12																									
0.4	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
45	19																									
N (mean)	20																									
23	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
183	25																									
Observed (cm)	26																									
292	27																									
Distance (m)	28																									
0	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	10.15																							6.45	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Kocaeli	1	0.76	Silt	2.30	3	3.80	15.5	34.7	31.7	1.00	0.75	1.00	45	0.75	1.78	3	35	0.1	125	0.95	0.27	0.07	0.25	0.000	0.00	Non-Liq.
Mw	2	1.06	Silty Sand	3.22	8	4.72	16.5	49.4	37.4	1.00	0.85	1.00	45	0.75	1.64	8	13	1.0	150	0.92	0.32	0.09	0.28	1.000	0.84	6.12
7.4	3	1.00	Silty Sand	4.42	6	5.92	16.5	69.2	45.4	1.00	0.85	1.00	45	0.75	1.48	6	13	1.0	150	0.88	0.35	0.07	0.20	1.000	0.78	4.26
Site	4	0.95	Silty Sand	5.22	14	6.72	18.0	83.0	51.4	1.00	0.95	1.00	45	0.75	1.40	14	31	0.1	175	0.84	0.35	0.15	0.42	1.000	0.74	13.57
Sapanca Lake	5	1.03	Silty Sand	6.32	25	7.82	18.0	102.8	60.4	1.00	0.95	1.00	45	0.75	1.29	23	24	0.5	200	0.79	0.35	0.28	0.80	0.533	0.68	21.86
Data Class	6	0.98	Silty Sand	7.27	20	8.77	18.0	119.9	68.2	1.00	0.95	1.00	45	0.75	1.21	17	20	0.5	175	0.74	0.34	0.16	0.48	0.995	0.64	15.87
	7	1.00	Silty Sand	8.27	25	9.77	18.0	137.9	76.4	1.00	0.95	1.00	45	0.75	1.14	20	30	0.1	200	0.70	0.33	0.22	0.69	0.795	0.59	20.12
B. H.	8	1.00	Silty Sand	9.27	11	10.77	16.5	155.1	83.8	1.00	1.00	1.00	45	0.75	1.09	9	24	0.5	150	0.65	0.32	0.08	0.26	1.000	0.54	7.66
JS8	9																									
GWT (m)	10																									
2.0	11																									
a_{max} (g)	12																									
0.4	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
45	19																									
N (mean)	20																									
14	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
154	25																									
Observed (cm)	26																									
167	27																									
Distance (m)	28																									
0	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	7.77																							4.36	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Kocaeli	1	0.98	Sand	1.20	7	2.70	16.5	18.7	14.3	1.00	0.75	1.00	45	0.75	2.00	8	5	3.0	150	0.98	0.34	0.11	0.32	1.000	0.94	5.28
Mw	2	1.00	Sand	2.25	10	3.75	18.0	36.8	22.1	1.00	0.75	1.00	45	0.75	2.00	11	5	3.0	175	0.97	0.42	0.12	0.29	1.000	0.89	8.29
7.4	3	0.99	Gravel	3.20	24	4.70	18.0	53.9	29.9	1.00	0.85	1.00	45	0.75	1.83	28	2	3.0	200	0.94	0.44	0.39	0.89	0.326	0.84	23.98
Site	4	1.01	Silty Sand	4.22	6	5.72	16.5	71.5	37.4	1.00	0.85	1.00	45	0.75	1.63	6	8	1.0	150	0.92	0.45	0.07	0.16	1.000	0.79	4.39
Sapanca Lake	5	1.68	Silty Sand	5.22	14	6.72	18.0	88.7	44.9	1.00	0.95	1.00	45	0.75	1.49	15	19	0.5	175	0.88	0.45	0.15	0.33	1.000	0.74	13.37
Data Class	6	1.79	Gravel	7.57	20	9.07	18.0	131.0	64.1	1.00	0.95	1.00	45	0.75	1.25	18	8	1.0	175	0.79	0.42	0.16	0.37	1.000	0.62	15.05
	7	1.03	Silty Sand	8.80	18	10.30	18.0	153.2	74.2	1.00	1.00	1.00	45	0.75	1.16	16	8	1.0	175	0.73	0.39	0.13	0.32	1.000	0.56	12.99
B. H.	8	0.82	Silty Sand	9.62	19	11.12	18.0	167.9	80.9	1.00	1.00	1.00	45	0.75	1.11	16	8	1.0	175	0.70	0.38	0.13	0.33	1.000	0.52	13.15
JS9	9																									
GWT (m)	10																									
0.75	11																									
a_{max} (g)	12																									
0.4	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
45	19																									
N (mean)	20																									
15	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
167	25																									
Observed (cm)	26																									
206	27																									
Distance (m)	28																									
0	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	9.28																							6.22	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Kocaeli	1	1.02	Silty Sand	3.22	9	4.72	16.5	49.1	44.0	1.00	0.85	1.00	45	0.75	1.51	9	11	1.0	150	0.90	0.26	0.09	0.33	1.000	0.84	6.25
Mw	2	1.28	Silty Sand	4.22	6	5.72	16.5	65.6	50.7	1.00	0.85	1.00	45	0.75	1.40	5	8	1.0	150	0.85	0.29	0.06	0.22	1.000	0.79	3.90
7.4	3	1.35	Silty Sand	5.77	14	7.27	18.0	92.3	62.2	1.00	0.95	1.00	45	0.75	1.27	13	19	0.5	175	0.77	0.30	0.11	0.38	1.000	0.71	11.06
Site	4	1.00	Silty Sand	6.92	7	8.42	16.5	112.2	70.8	1.00	0.95	1.00	45	0.75	1.19	6	29	0.1	150	0.71	0.29	0.07	0.23	1.000	0.65	5.14
Sapanca Lake	5	0.99	Silty Sand	7.77	6	9.27	16.5	126.2	76.4	1.00	0.95	1.00	45	0.75	1.14	5	22	0.5	150	0.67	0.29	0.06	0.20	1.000	0.61	4.15
Data Class	6	1.02	Silt	8.90	11	10.40	16.5	144.8	84.0	1.00	1.00	1.00	45	0.75	1.09	9	35	0.1	150	0.62	0.28	0.09	0.31	0.000	0.00	Non-Liq.
	7	0.90	Silty Sand	9.80	5	11.30	15.5	159.2	89.6	1.00	1.00	1.00	45	0.75	1.06	4	35	0.1	125	0.59	0.27	0.06	0.20	1.000	0.51	4.07
B. H.	8																									
JS10	9																									
GWT (m)	10																									
2.70	11																									
a_{max} (g)	12																									
0.4	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
45	19																									
N (mean)	20																									
8	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
143	25																									
Observed (cm)	26																									
220	27																									
Distance (m)	28																									
0	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	7.55																							4.54	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Kocaeli	1	0.67	Silty Sand	0.77	8	2.27	16.5	11.8	10.1	1.00	0.75	1.00	45	0.75	2.00	9	20	0.5	150	1.00	0.30	0.14	0.47	0.996	0.96	7.31
Mw	2	1.00	Silty Sand	1.77	16	3.27	18.0	29.1	17.6	1.00	0.75	1.00	45	0.75	2.00	18	20	0.5	175	0.99	0.42	0.25	0.59	0.937	0.91	16.61
7.4	3	1.00	Gravel	2.77	39	4.27	19.0	47.6	26.3	1.00	0.85	1.00	45	0.75	1.95	49	2	3.0	225	0.98	0.46	1.93	4.19	0.000	0.86	45.62
Site	4	1.17	Silty Sand	3.77	12	5.27	18.0	66.1	35.0	1.00	0.85	1.00	45	0.75	1.69	13	31	0.1	175	0.96	0.47	0.15	0.32	1.000	0.81	12.53
Sapanca Lake	5	1.07	Silty Sand	5.10	28	6.60	18.0	90.0	45.9	1.00	0.95	1.00	45	0.75	1.48	30	31	0.1	200	0.94	0.48	0.57	1.19	0.028	0.75	41.66
Data Class	6	0.80	Silty Sand	5.90	38	7.40	19.0	104.8	52.8	1.00	0.95	1.00	45	0.75	1.38	37	24	0.5	225	0.92	0.48	0.94	1.98	0.000	0.71	43.56
	7	0.95	Silty Sand	6.70	33	8.20	18.0	119.6	59.8	1.00	0.95	1.00	45	0.75	1.29	30	17	0.5	225	0.90	0.47	0.47	1.01	0.138	0.67	41.24
B. H.	8	1.10	Gravel	7.80	48	9.30	19.0	139.9	69.3	1.00	0.95	1.00	45	0.75	1.20	41	2	3.0	225	0.86	0.45	0.84	1.85	0.000	0.61	43.59
JS12	9																									
GWT (m)	10																									
0.60	11																									
a_{max} (g)	12																									
0.4	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
45	19																									
N (mean)	20																									
28	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
189	25																									
Observed (cm)	26																									
1.3	27																									
Distance (m)	28																									
0	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	7.75																							2.55	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Kocaeli	1	1.27	Fill	0.77	7	2.27	16.5	12.7	5.2	1.00	0.75	1.00	45	0.75	2.00	8	35	0.1	150	0.99	0.64	0.17	0.27	0.000	0.00	Non-Liq.
Mw	2	1.00	Silty Sand	1.77	6	3.27	16.5	29.2	11.8	1.00	0.75	1.00	45	0.75	2.00	7	14	1.0	150	0.98	0.63	0.11	0.17	1.000	0.91	4.98
7.4	3	1.00	Silty Sand	2.77	3	4.27	15.5	45.2	18.0	1.00	0.85	1.00	45	0.75	2.00	4	20	0.5	125	0.96	0.63	0.08	0.13	1.000	0.86	3.51
Site	4	1.00	Silty Sand	3.77	9	5.27	18.0	62.0	25.0	1.00	0.85	1.00	45	0.75	2.00	11	27	0.1	175	0.94	0.61	0.14	0.23	1.000	0.81	10.58
Sapanca Lake	5	0.97	Silty Sand	4.77	19	6.27	18.0	80.0	33.2	1.00	0.95	1.00	45	0.75	1.74	24	35	0.1	200	0.92	0.58	0.39	0.68	0.816	0.76	23.76
Data Class	6	1.02	Silty Gravel	5.70	20	7.20	18.0	96.7	40.8	1.00	0.95	1.00	45	0.75	1.57	22	5	3.0	200	0.89	0.55	0.24	0.44	0.999	0.72	18.95
	7	1.15	Silt	6.80	44	8.30	19.0	117.0	50.3	1.00	0.95	1.00	45	0.75	1.41	44	35	0.1	225	0.85	0.51	2.03	3.95	0.000	0.00	Non-Liq.
B. H.	8	1.20	Silt	8.00	48	9.50	19.0	139.8	61.4	1.00	0.95	1.00	45	0.75	1.28	44	35	0.1	225	0.80	0.48	1.84	3.87	0.000	0.00	Non-Liq.
JS13	9																									
GWT (m)	10																									
0.00	11																									
a_{max} (g)	12																									
0.4	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
45	19																									
N (mean)	20																									
20	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
175	25																									
Observed (cm)	26																									
213	27																									
Distance (m)	28																									
0	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	8.60																							3.91	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Kocaeli	1	1.10	Silty Sand	1.70	8	5.20	18.0	28.4	22.5	1.00	1.00	1.00	55	0.92	2.00	15	12	1.6	175	0.97	0.32	0.17	0.53	0.982	0.92	12.41
Mw	2	1.70	Silty Sand	3.10	4	6.72	16.5	52.6	32.9	1.00	1.00	1.00	60	1.00	1.74	7	15	1.2	150	0.93	0.39	0.08	0.22	1.000	0.85	5.19
7.4	3	1.60	Clay	3.80	3	8.24	16.5	64.1	37.6	1.00	1.00	1.00	65	1.08	1.63	5	35	0.0	150	0.91	0.40	0.08	0.20	0.000	0.00	Non-Liq.
Site	4	1.50	Clay	5.70	4	9.77	16.5	95.5	50.3	1.00	1.00	1.00	65	1.08	1.41	6	35	0.0	150	0.83	0.41	0.08	0.19	0.000	0.00	Non-Liq.
Police Station	5	1.20	Clay	7.30	3	11.29	15.5	121.1	60.2	1.00	1.00	1.00	65	1.08	1.29	4	35	0.0	125	0.75	0.39	0.06	0.16	0.000	0.00	Non-Liq.
Data Class	6	1.00	Sand	8.70	17	12.82	18.0	144.5	69.9	1.00	1.00	1.00	65	1.08	1.20	22	11	1.0	200	0.69	0.37	0.22	0.59	0.945	0.57	19.42
	7	1.70	Silty Clay	10.20	9	12.82	18.0	171.5	82.2	1.00	1.00	1.00	65	1.08	1.10	11	35	0.0	175	0.63	0.34	0.10	0.30	0.000	0.00	Non-Liq.
B. H.	8																									
PS2	9																									
GWT (m)	10																									
1.1	11																									
a_{max} (g)	12																									
0.4	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
	19																									
N (mean)	20																									
6.9	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
156	25																									
Observed (cm)	26																									
117	27																									
Distance (m)	28																									
0	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	9.80																							2.96	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Kocaeli	1	1.76	Silty Sand	1.72	9	3.22	16.5	26.9	19.8	1.00	0.75	1.00	45	0.75	2.00	10	16	0.5	175	0.97	0.34	0.13	0.37	1.000	0.91	8.15
Mw	2	2.34	Silt	3.80	7	5.30	16.5	61.2	33.7	1.00	0.85	1.00	45	0.75	1.72	8	35	0.1	150	0.91	0.43	0.10	0.23	0.000	0.00	Non-Liq.
7.4	3	2.60	Silt	6.40	11	7.90	18.0	106.1	53.1	1.00	0.95	1.00	45	0.75	1.37	11	35	0.1	175	0.81	0.42	0.11	0.27	0.000	0.00	Non-Liq.
Site	4																									
Sapanca Lake	5																									
Data Class	6																									
	7																									
B. H.	8																									
S1/2	9																									
GWT (m)	10																									
1.00	11																									
a_{max} (g)	12																									
0.4	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
45	19																									
N (mean)	20																									
9	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
159	25																									
Observed (cm)	26																									
173	27																									
Distance (m)	28																									
0	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	6.70																							1.61	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Kocaeli	1	0.98	Gravelly Sand	1.15	7	2.65	16.5	18.2	11.8	1.00	0.75	1.00	45	0.75	2.00	8	5	2.0	150	0.97	0.39	0.11	0.29	1.000	0.94	5.28
Mw	2	1.03	Silty Sand	1.80	3	3.30	15.5	28.6	15.9	1.00	0.75	1.00	45	0.75	2.00	3	17	0.5	125	0.95	0.45	0.08	0.18	1.000	0.91	3.22
7.4	3	1.46	Silty Sand	3.20	4	4.70	16.5	51.0	24.5	1.00	0.85	1.00	45	0.75	2.00	5	8	1.0	150	0.90	0.49	0.08	0.16	1.000	0.84	3.76
Site	4	1.51	Silty Sand	4.72	5	6.22	16.5	76.1	34.7	1.00	0.95	1.00	45	0.75	1.70	6	8	1.0	150	0.83	0.47	0.07	0.16	1.000	0.76	4.27
Sapanca Lake	5	1.50	Silty Sand	6.22	6	7.72	16.5	100.9	44.7	1.00	0.95	1.00	45	0.75	1.50	6	8	1.0	150	0.75	0.44	0.07	0.16	1.000	0.69	4.47
Data Class	6																									
	7																									
B. H.	8																									
S1/8	9																									
GWT (m)	10																									
0.50	11																									
a_{max} (g)	12																									
0.4	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
45	19																									
N (mean)	20																									
5	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
144	25																									
Observed (cm)	26																									
292	27																									
Distance (m)	28																									
0	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	6.47																							5.27	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Kocaeli	1	2.50	Silty Sand	1.80	8	3.30	16.5	29.7	12.0	1.00	0.75	1.00	45	0.75	2.00	9	14	1.0	150	0.98	0.63	0.13	0.21	1.000	0.91	6.80
Mw	2	1.45	Clayey Silt	3.20	16	4.70	18.0	53.9	22.5	1.00	0.85	1.00	45	0.75	2.00	20	35	0.1	200	0.96	0.60	0.33	0.56	0.000	0.00	Non-Liq.
7.4	3	1.51	Silty Sand	4.70	35	6.20	19.0	81.6	35.5	1.00	0.95	1.00	45	0.75	1.68	42	16	0.5	225	0.93	0.55	1.35	2.43	0.000	0.77	44.44
Site	4	1.52	Silty Sand	6.22	17	7.72	18.0	109.7	48.7	1.00	0.95	1.00	45	0.75	1.43	17	19	0.5	175	0.88	0.52	0.18	0.35	1.000	0.69	15.86
Sapanca Lake	5																									
Data Class	6																									
	7																									
B. H.	8																									
S2/1	9																									
GWT (m)	10																									
0.00	11																									
a_{max} (g)	12																									
0.4	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
45	19																									
N (mean)	20																									
19	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
178	25																									
Observed (cm)	26																									
137	27																									
Distance (m)	28																									
0	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	6.98																							3.32	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Kocaeli	1	2.30	Fill	1.80	2	3.30	15.5	27.7	14.0	1.00	0.75	1.00	45	0.75	2.00	2	35	0.1	125	0.97	0.50	0.08	0.16	0.000	0.00	Non-Liq.
Mw	2	1.45	Silty Clay	3.60	12	5.10	18.0	57.9	26.5	1.00	0.85	1.00	45	0.75	1.94	15	35	0.1	175	0.93	0.53	0.20	0.37	0.000	0.00	Non-Liq.
7.4	3	1.50	Silt	4.70	14	6.20	18.0	77.7	35.5	1.00	0.95	1.00	45	0.75	1.68	17	35	0.1	175	0.90	0.51	0.21	0.42	0.000	0.00	Non-Liq.
Site	4	1.51	Silt	6.60	32	8.10	19.0	112.8	52.0	1.00	0.95	1.00	45	0.75	1.39	32	35	0.1	225	0.83	0.47	0.69	1.48	0.000	0.00	Non-Liq.
Sapanca Lake	5	1.30	Gravelly Sand	7.72	14	9.22	18.0	133.5	61.7	1.00	0.95	1.00	45	0.75	1.27	13	23	0.5	175	0.78	0.44	0.12	0.27	1.000	0.61	11.50
Data Class	6	1.48	Gravel	9.20	23	10.70	18.0	160.2	73.8	1.00	1.00	1.00	45	0.75	1.16	20	2	3.0	200	0.71	0.40	0.17	0.42	0.999	0.54	16.87
	7																									
B. H.	8																									
S2/3	9																									
GWT (m)	10																									
0.40	11																									
a_{max} (g)	12																									
0.4	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
45	19																									
N (mean)	20																									
16	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
166	25																									
Observed (cm)	26																									
147	27																									
Distance (m)	28																									
0	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	9.54																							1.60	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Kocaeli	1	1.15	Sandy Gravel	1.70	24	3.20	18.0	26.7	22.8	1.00	0.75	1.00	45	0.75	2.00	27	10	1.0	200	0.97	0.29	0.43	1.47	0.002	0.92	39.97
Mw	2	1.51	Sandy Gravel	3.20	14	4.70	18.0	53.7	35.1	1.00	0.85	1.00	45	0.75	1.69	15	14	1.0	175	0.93	0.37	0.16	0.42	0.999	0.84	13.03
7.4	3	1.51	Silty Sand	4.72	8	6.22	16.5	79.9	46.4	1.00	0.95	1.00	45	0.75	1.47	8	21	0.5	150	0.87	0.39	0.09	0.23	1.000	0.76	6.72
Site	4	1.50	Clay	6.22	7	7.72	16.5	104.7	56.4	1.00	0.95	1.00	45	0.75	1.33	7	35	0.1	150	0.80	0.39	0.08	0.20	0.000	0.00	Non-Liq.
Sapanca Lake	5																									
Data Class	6																									
	7																									
B. H.	8																									
S4/3	9																									
GWT (m)	10																									
1.30	11																									
a_{max} (g)	12																									
0.4	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
45	19																									
N (mean)	20																									
13	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
155	25																									
Observed (cm)	26																									
78	27																									
Distance (m)	28																									
0	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	5.67																							2.42	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Kocaeli	1	1.80	Silty Sand	1.70	4	5.2	16.5	27.6	19.8	1.00	1.00	1.00	55	0.92	2.00	7	16	1.30	150	0.94	0.34	0.10	0.29	1.000	0.92	5.51
Mw	2	0.80	Clayey Silt	2.66	3	5.2	16.5	43.4	26.2	1.00	1.00	1.00	55	0.92	1.95	5	35	0.01	150	0.90	0.39	0.09	0.23	0.000	0.00	Non-Liq.
7.4	3	2.60	Silty Clay	4.70	1	8.24	15.5	76.1	38.8	1.00	1.00	1.00	65	1.08	1.61	2	35	0.01	125	0.80	0.41	0.06	0.14	0.000	0.00	Non-Liq.
Site	4	2.60	Silty Clay	6.70	1	11.29	15.5	107.1	50.2	1.00	1.00	1.00	65	1.08	1.41	2	35	0.01	125	0.68	0.38	0.05	0.14	0.000	0.00	Non-Liq.
Soccer Field	5																									
Data Class	6																									
	7																									
B. H.	8																									
SF5	9																									
GWT (m)	10																									
0.9	11																									
a_{max} (g)	12																									
0.4	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
	19																									
N (mean)	20																									
2.3	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
134	25																									
Observed (cm)	26																									
33	27																									
Distance (m)	28																									
0	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	7.80																							1.65	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Kocaeli	1	1.90	Silt + Sand	1.70	2	5.2	15.5	26.8	17.9	1.00	1.00	1.00	55	0.92	2.00	4	35	0.05	125	0.95	0.37	0.08	0.23	1.000	0.92	3.90
Mw	2	0.70	Silty Clay	2.70	2	5.2	15.5	42.3	23.6	1.00	1.00	1.00	55	0.92	2.00	4	35	0.01	125	0.91	0.43	0.08	0.18	0.000	0.00	Non-Liq.
7.4	3	1.20	Silty Clay	3.70	0	6.4	16.5	58.3	29.8	1.00	1.00	1.00	60	1.00	1.83	0	35	0.01	150	0.87	0.44	0.05	0.12	0.000	0.00	Non-Liq.
Site	4	2.20	Silty Clay	5.20	0	7.4	16.5	83.0	39.8	1.00	1.00	1.00	60	1.00	1.58	0	35	0.01	150	0.80	0.43	0.05	0.11	0.000	0.00	Non-Liq.
Soccer Field	5	1.40	Silty Clay	7.70	0	8.4	16.5	124.3	56.6	1.00	1.00	1.00	65	1.08	1.33	0	35	0.01	150	0.67	0.38	0.04	0.12	0.000	0.00	Non-Liq.
Data Class	6																									
	7																									
B. H.	8																									
SF6	9																									
GWT (m)	10																									
0.8	11																									
a_{max} (g)	12																									
0.4	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
	19																									
N (mean)	20																									
0.8	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
141	25																									
Observed (cm)	26																									
120	27																									
Distance (m)	28																									
0	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	7.40																							1.74	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N^d	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Kocaeli	1	1.20	M. to C. Sand	1.10	3	4.27	16.5	17.4	11.5	1.00	1.00	1.00	55	0.92	2.00	6	5	6.4	150	0.99	0.39	0.09	0.24	1.000	0.95	3.86
Mw	2	0.90	M. to C. Sand	2.20	5	5.80	16.5	35.6	18.9	1.00	1.00	1.00	56	0.93	2.00	9	5	8.0	150	0.97	0.48	0.11	0.23	1.000	0.89	6.40
7.4	3	0.90	M. to C. Sand	2.80	10	5.80	18.0	45.9	23.3	1.00	1.00	1.00	59	0.98	2.00	20	5	9.5	175	0.96	0.49	0.23	0.47	0.996	0.86	16.49
Site	4	0.60	Sandy Silt	3.60	14	7.32	18.0	60.3	29.9	1.00	1.00	1.00	55	0.92	1.83	23	35	0.1	200	0.94	0.49	0.40	0.81	0.000	0.00	Non-Liq.
Hotel Sapanca	5	1.10	Silty Sand	4.70	10	8.84	18.0	80.1	38.9	1.00	1.00	1.00	56	0.93	1.60	15	7	4.7	175	0.91	0.49	0.14	0.29	1.000	0.77	12.19
Data Class	6	1.10	Silty Sand	5.40	7	8.84	18.0	92.7	44.6	1.00	1.00	1.00	64	1.07	1.50	11	4	3.2	175	0.89	0.48	0.10	0.21	1.000	0.73	8.22
	7	1.10	Silty Sand	6.40	9	10.37	18.0	110.7	52.8	1.00	1.00	1.00	64	1.07	1.38	13	7	3.1	175	0.85	0.46	0.11	0.25	1.000	0.68	10.45
B. H.	8	1.60	Silty Sand	7.80	11	11.89	18.0	135.9	64.3	1.00	1.00	1.00	64	1.07	1.25	15	11	3.0	175	0.79	0.44	0.12	0.28	1.000	0.61	12.28
SH4	9	1.50	Silty Sand	9.30	11	13.42	18.0	162.9	76.6	1.00	1.00	1.00	64	1.07	1.14	13	7	3.9	175	0.73	0.41	0.10	0.26	1.000	0.54	10.64
GWT (m)	10	1.50	Silty Sand	11.10	20	14.94	18.0	195.3	91.3	1.00	1.00	1.00	66	1.10	1.05	23	7	4.5	200	0.67	0.37	0.21	0.56	0.963	0.45	19.84
0.5	11																									
a_{max} (g)	12																									
0.4	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
SH	19																									
N (mean)	20																									
10	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
171	25																									
Observed (cm)	26																									
130	27																									
Distance (m)	28																									
0	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	11.50																							7.52	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Kocaeli	1	0.75	Sandy Gravel	1.30	3	4.27	16.5	22.7	22.2	1.00	1.00	1.00	60	1.00	2.00	6	1	8.40	150	0.99	0.26	0.08	0.31	1.000	0.94	4.13
Mw	2	1.20	Silty Sand	2.60	5	5.80	16.5	44.2	30.9	1.00	1.00	1.00	60	1.00	1.80	9	5	3.00	150	0.97	0.36	0.09	0.26	1.000	0.87	6.12
7.4	3	0.90	Silty Sand	3.40	8	7.32	18.0	58.0	36.9	1.00	1.00	1.00	63	1.05	1.65	14	4	3.90	175	0.95	0.39	0.13	0.33	1.000	0.83	10.87
Site	4	0.80	Silty Sand	4.20	9	7.32	18.0	72.4	43.4	1.00	1.00	1.00	66	1.10	1.52	15	6	4.50	175	0.93	0.40	0.14	0.34	1.000	0.79	12.14
Hotel Sapanca	5	0.80	Silty Sand	5.00	9	8.84	18.0	86.8	50.0	1.00	1.00	1.00	65	1.08	1.41	14	6	4.50	175	0.91	0.41	0.12	0.29	1.000	0.75	10.93
Data Class	6	0.90	Silty Sand	5.90	16	10.37	18.0	103.0	57.3	1.00	1.00	1.00	60	1.00	1.32	21	13	1.50	200	0.88	0.41	0.22	0.53	0.981	0.71	18.83
	7	1.00	Silty Sand	6.80	17	11.89	18.0	119.2	64.7	1.00	1.00	1.00	68	1.13	1.24	24	11	1.60	200	0.85	0.41	0.26	0.64	0.884	0.66	21.20
B. H.	8	1.00	Silty Sand	7.80	13	11.89	18.0	137.2	72.9	1.00	1.00	1.00	65	1.08	1.17	16	12	2.00	175	0.81	0.39	0.14	0.36	1.000	0.61	14.23
SH7	9	1.10	Silty Sand	9.00	12	13.42	18.0	158.8	82.7	1.00	1.00	1.00	63	1.05	1.10	14	6	3.10	175	0.76	0.38	0.10	0.28	1.000	0.55	10.98
GWT (m)	10	1.40	Silty Sand	10.30	10	13.42	18.0	182.2	93.4	1.00	1.00	1.00	63	1.05	1.03	11	9	2.00	175	0.71	0.36	0.08	0.23	1.000	0.49	8.28
1.25	11	1.40	Silty Sand	11.80	11	14.94	18.0	209.2	105.7	1.00	1.00	1.00	61	1.02	0.97	11	5	0.84	175	0.66	0.34	0.08	0.23	1.000	0.41	7.92
a_{max} (g)	12	1.10	Silty Sand	13.50	13	16.46	18.0	239.8	119.6	1.00	1.00	1.00	65	1.08	0.91	13	14	0.84	175	0.61	0.32	0.09	0.29	1.000	0.33	10.81
0.4	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
	19																									
N (mean)	20																									
10.5	21																									
γ_{dry} (kN/m^3)	22																									
17.5	23																									
Vs* (m/s)	24																									
174	25																									
Observed (cm)	26																									
70	27																									
Distance (m)	28																									
0	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	12.35																							7.76	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Kocaeli	1	1.00	Silty Sand	1.50	9	4.27	18.0	24.6	21.7	1.00	1.00	1.00	60	1.00	2.00	18	14	1.9	175	0.98	0.29	0.23	0.78	0.578	0.93	15.93
Mw	2	1.10	Silty Sand	2.62	11	5.80	18.0	44.8	30.8	1.00	1.00	1.00	64	1.07	1.80	21	9	5.8	200	0.96	0.36	0.25	0.69	0.791	0.87	18.35
7.4	3	0.90	Silty Sand	3.50	7	7.32	18.0	60.6	38.0	1.00	1.00	1.00	65	1.08	1.62	12	10	1.8	175	0.94	0.39	0.12	0.31	1.000	0.83	9.82
Site	4	0.80	Silty Sand	4.40	2	7.32	15.5	75.7	44.3	1.00	1.00	1.00	53	0.88	1.50	3	6	1.8	125	0.91	0.40	0.05	0.13	1.000	0.78	2.67
Hotel Sapanca	5	1.10	Silty Sand	5.40	13	8.84	18.0	92.4	51.2	1.00	1.00	1.00	56	0.93	1.40	17	11	1.9	175	0.88	0.41	0.16	0.39	1.000	0.73	14.57
Data Class	6	1.00	Silty Sand	6.40	13	10.37	18.0	110.4	59.4	1.00	1.00	1.00	56	0.93	1.30	16	8	3.0	175	0.84	0.40	0.14	0.33	1.000	0.68	13.06
	7	0.90	Silty Sand	7.40	13	11.89	18.0	128.4	67.6	1.00	1.00	1.00	57	0.95	1.22	15	12	1.1	175	0.80	0.39	0.13	0.32	1.000	0.63	12.77
B. H.	8	1.00	Silty Sand	8.40	6	11.89	16.5	145.7	75.0	1.00	1.00	1.00	62	1.03	1.15	7	7	2.4	150	0.75	0.38	0.06	0.17	1.000	0.58	4.91
SH11	9	1.20	Silty Sand	9.40	11	13.42	18.0	162.9	82.5	1.00	1.00	1.00	63	1.05	1.10	13	21	0.4	175	0.71	0.36	0.11	0.30	1.000	0.53	11.32
GWT (m)	10	1.00	Silty Sand	10.61	19	13.42	18.0	184.7	92.4	1.00	1.00	1.00	60	1.00	1.04	20	15	2.0	175	0.66	0.35	0.17	0.51	0.990	0.47	17.77
1.2	11																									
a_{max} (g)	12																									
0.4	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
	19																									
N (mean)	20																									
10.4	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
167	25																									
Observed (cm)	26																									
70	27																									
Distance (m)	28																									
0	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	10.00																							6.39	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Kocaeli	1	0.70	Silty Clay	1.20	3	4.27	15.5	19.0	15.1	1.00	1.00	1.00	37	0.62	2.00	4	35	0.01	125	0.98	0.24	0.09	0.37	0.000	0.00	Non-Liq.
Mw	2	0.90	Silty Clay	1.95	4	5.80	16.5	31.0	19.7	1.00	1.00	1.00	53	0.88	2.00	7	35	0.01	150	0.96	0.30	0.11	0.37	0.000	0.00	Non-Liq.
7.4	3	1.80	Silty Clay	3.35	2	7.32	15.5	53.4	28.4	1.00	1.00	1.00	52	0.87	1.88	3	35	0.01	125	0.93	0.34	0.07	0.21	0.000	0.00	Non-Liq.
Site	4	0.40	Clayey Silt	4.15	7	7.32	18.0	66.8	33.9	1.00	1.00	1.00	65	1.08	1.72	13	35	0.01	175	0.90	0.35	0.16	0.46	0.000	0.00	Non-Liq.
Yakin Street	5	2.10	Silty Clay	5.95	3	8.84	16.5	97.9	47.3	1.00	1.00	1.00	65	1.08	1.45	5	35	0.01	150	0.83	0.33	0.07	0.21	0.000	0.00	Non-Liq.
Data Class	6	1.20	Sandy Silt	6.95	10	10.37	18.0	115.1	54.8	1.00	1.00	1.00	60	1.00	1.35	14	35	0.03	175	0.78	0.32	0.14	0.45	0.000	0.00	Non-Liq.
	7	1.40	Silty Sand	8.45	36	11.89	19.0	142.9	67.8	1.00	1.00	1.00	61	1.02	1.21	44	8	0.12	225	0.72	0.29	1.21	4.09	0.000	0.58	44.69
B. H.	8	1.20	Silty Sand	9.95	25	12.82	18.0	170.6	80.8	1.00	1.00	1.00	62	1.03	1.11	29	6	0.33	200	0.66	0.27	0.33	1.22	0.021	0.50	40.27
YS2	9																									
GWT (m)	10																									
0.8	11																									
a_{max} (g)	12																									
0.3	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
-	19																									
N (mean)	20																									
11.3	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
157	25																									
Observed (cm)	26																									
14	27																									
Distance (m)	28																									
0	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	9.70																							0.01	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Kocaeli	1	3.28	Silty Clay	1.20	2	4.40	15.5	19.0	15.3	1.00	1.00	1.00	50	0.83	2.00	3	35	0.01	125	0.99	0.24	0.09	0.36	0.000	0.00	Non-Liq.
Mw	2	0.30	Silt + Sand	4.05	6	7.32	16.5	64.6	32.9	1.00	1.00	1.00	51	0.85	1.74	9	35	0.02	150	0.92	0.35	0.11	0.32	1.000	0.80	8.45
7.4	3	1.40	Silty Clay	4.95	3	8.84	15.5	79.0	38.5	1.00	1.00	1.00	53	0.88	1.61	4	35	0.00	125	0.90	0.36	0.07	0.20	0.000	0.00	Non-Liq.
Site	4	2.20	Silty Clay	6.45	16	10.37	18.0	104.1	48.9	1.00	1.00	1.00	59	0.98	1.43	22	35	0.01	200	0.84	0.35	0.32	0.92	0.000	0.00	Non-Liq.
Yakin Street	5	0.80	Sandy Silt	7.95	29	11.89	19.0	131.9	61.9	1.00	1.00	1.00	60	1.00	1.27	37	35	0.02	225	0.78	0.32	1.02	3.17	0.000	0.00	Non-Liq.
Data Class	6	1.50	Sand	9.45	74	12.82	19.0	160.4	75.7	1.00	1.00	1.00	57	0.95	1.15	81	8	0.30	225	0.72	0.30	19.53	65.86	0.000	0.53	54.71
	7	1.50	Sand	10.95	38	14.94	19.0	188.9	89.5	1.00	1.00	1.00	54	0.90	1.06	36	10	0.61	225	0.66	0.27	0.60	2.21	0.000	0.45	42.51
B. H.	8	2.00	Sand	12.45	35	16.46	19.0	217.4	103.3	1.00	1.00	1.00	62	1.03	0.98	36	7	0.50	225	0.62	0.26	0.53	2.08	0.000	0.38	42.20
YS4	9	1.70	Clay	14.95	11	17.92	16.5	261.8	123.1	1.00	1.00	1.00	62	1.03	0.90	10	35	0.00	150	0.58	0.24	0.09	0.36	0.000	0.00	Non-Liq.
GWT (m)	10																									
0.82	11																									
a_{max} (g)	12																									
0.3	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
-	19																									
N (mean)	20																									
23.8	21																									
γ_{dry} (kN/m^3)	22																									
16.0	23																									
Vs* (m/s)	24																									
167	25																									
Observed (cm)	26																									
11	27																									
Liquefied?	28																									
Yes	29																								LSI	
	30																								Lin.	
	SUM	14.68																							0.24	

SEISMIC EVENT # 16

EARTHQUAKE:	Chi-Chi
MOMENT MAGNITUDE:	7.6
LOCATION:	Taiwan
DATE:	September 20, 1999
REFERENCE(S):	Juang, H., Clemsom University Website Yuan, H. L. et al. (2003)

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Chi Chi 1999	1	2.15	Silty Sand	2.80	2	4.30	19.7	48.1	35.4	1.00	0.85	1.00	60	1.00	1.68	3	35	0.06	125	0.90	0.34	0.06	0.18	1.000	0.86	3.46
Mw	2	1.50	Silty Sand	4.50	3	6.00	19.8	81.7	52.2	1.00	0.85	1.00	60	1.00	1.38	4	35	0.01	125	0.81	0.35	0.06	0.17	1.000	0.78	3.82
7.6	3	1.30	Silty Sand	5.80	19	7.30	19.5	107.2	65.0	1.00	0.95	1.00	60	1.00	1.24	22	35	0.03	200	0.74	0.34	0.28	0.81	0.500	0.71	22.67
Site	4																									
Caotun-Nantou	5																									
Data Class	6																									
	7																									
B. H.	8																									
CN1	9																									
GWT (m)	10																									
1.50	11																									
a_{max} (g)	12																									
0.428	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
8.0	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
135	25																									
Observed (cm)	26																									
157	27																									
Distance (m)	28																									
219.5	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	4.95																							3.47	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Chi Chi 1999	1	2.15	Silty Sand	2.80	8	4.30	19.6	48.0	35.2	1.00	0.85	1.00	60	1.00	1.68	11	15	0.19	175	0.96	0.36	0.11	0.31	1.000	0.86	9.44
Mw	2	1.50	Silty Sand	4.50	18	6.00	19.4	81.1	51.7	1.00	0.85	1.00	60	1.00	1.39	21	18	0.17	200	0.91	0.40	0.23	0.57	0.962	0.78	19.57
7.6	3	1.35	Silty Sand	5.80	6	7.30	19.3	106.3	64.1	1.00	0.95	1.00	60	1.00	1.25	7	35	0.08	150	0.87	0.40	0.08	0.19	1.000	0.71	6.48
Site	4	1.40	Silty Sand	7.20	39	8.70	19.7	133.6	77.7	1.00	0.95	1.00	60	1.00	1.13	42	14	0.30	225	0.81	0.39	1.00	2.58	0.000	0.64	44.38
Caotun-Nantou	5																									
Data Class	6																									
	7																									
B. H.	8																									
CN2	9																									
GWT (m)	10																									
1.50	11																									
a_{max} (g)	12																									
0.428	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
17.8	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
168	25																									
Observed (cm)	26																									
157	27																									
Distance (m)	28																									
219.5	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	6.40																							3.93	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N^d	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Chi Chi 1999	1	2.15	Silty Sand	2.80	2	4.30	19.7	48.1	35.4	1.00	0.85	1.00	60	1.00	1.68	3	35	0.06	125	0.90	0.34	0.06	0.18	1.000	0.86	3.46
Mw	2	1.50	Silty Sand	4.50	3	6.00	19.8	81.7	52.2	1.00	0.85	1.00	60	1.00	1.38	4	35	0.01	125	0.81	0.35	0.06	0.17	1.000	0.78	3.82
7.6	3	1.30	Silty Sand	5.80	19	7.30	19.5	107.2	65.0	1.00	0.95	1.00	60	1.00	1.24	22	35	0.03	200	0.74	0.34	0.28	0.81	0.500	0.71	22.67
Site	4																									
Caotun-Nantou	5																									
Data Class	6																									
	7																									
B. H.	8																									
CN3	9																									
GWT (m)	10																									
1.50	11																									
a_{max} (g)	12																									
0.428	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
8.0	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
135	25																									
Observed (cm)	26																									
157	27																									
Distance (m)	28																									
219.5	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	4.95																							3.47	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Chi Chi 1999	1	2.15	Silty Sand	2.80	8	4.30	19.6	48.0	35.2	1.00	0.85	1.00	60	1.00	1.68	11	15	0.19	175	0.96	0.36	0.11	0.31	1.000	0.86	9.44
Mw	2	1.50	Silty Sand	4.50	18	6.00	19.4	81.1	51.7	1.00	0.85	1.00	60	1.00	1.39	21	18	0.17	200	0.91	0.40	0.23	0.57	0.962	0.78	19.57
7.6	3	1.35	Silty Sand	5.80	6	7.30	19.3	106.3	64.1	1.00	0.95	1.00	60	1.00	1.25	7	35	0.08	150	0.87	0.40	0.08	0.19	1.000	0.71	6.48
Site	4	1.40	Silty Sand	7.20	39	8.70	19.7	133.6	77.7	1.00	0.95	1.00	60	1.00	1.13	42	14	0.30	225	0.81	0.39	1.00	2.58	0.000	0.64	44.38
Caotun-Nantou	5																									
Data Class	6																									
	7																									
B. H.	8																									
CN4	9																									
GWT (m)	10																									
1.50	11																									
a_{max} (g)	12																									
0.428	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
17.8	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
168	25																									
Observed (cm)	26																									
157	27																									
Distance (m)	28																									
219.5	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	6.40																							3.93	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Chi Chi 1999	1	2.20	Silty Sand	3.20	10	4.70	19.4	55.5	38.8	1.00	0.85	1.00	60	1.00	1.61	14	27	0.10	175	0.96	0.38	0.14	0.37	1.000	0.84	12.93
Mw	2	1.30	Silty Sand	4.20	41	5.70	22.1	76.2	49.7	1.00	0.85	1.00	60	1.00	1.42	49	14	5.42	225	0.94	0.40	2.02	5.06	0.000	0.79	46.44
7.6	3	1.60	Silty Sand	5.80	33	7.30	22.1	111.6	69.4	1.00	0.95	1.00	60	1.00	1.20	38	17	1.43	225	0.89	0.40	0.76	1.91	0.000	0.71	43.30
Site	4																									
Nantou	5																									
Data Class	6																									
	7																									
B. H.	8																									
N1	9																									
GWT (m)	10																									
1.50	11																									
a_{max} (g)	12																									
0.428	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
28.0	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
176	25																									
Observed (cm)	26																									
157	27																									
Distance (m)	28																									
219.5	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	5.10																							1.85	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Chi Chi 1999	1	1.75	Silty Sand	2.80	4	4.30	26.4	53.4	43.6	1.00	0.85	1.00	70	1.17	1.52	6	35	0.01	150	0.94	0.32	0.08	0.24	1.000	0.86	5.51
Mw	2	1.50	Silty Sand	4.30	7	5.80	26.2	92.8	68.2	1.00	0.85	1.00	70	1.17	1.21	8	35	0.06	150	0.89	0.34	0.08	0.24	1.000	0.79	7.91
7.6	3	1.50	Silty Sand	5.80	10	7.30	26.2	132.0	92.8	1.00	0.95	1.00	70	1.17	1.04	12	35	0.04	175	0.83	0.33	0.10	0.30	1.000	0.71	11.35
Site	4	1.50	Silty Sand	7.30	51	8.80	26.6	171.6	117.6	1.00	0.95	1.00	70	1.17	0.92	52	21	4.36	225	0.76	0.31	2.25	7.30	0.000	0.64	47.67
Nantou	5																									
Data Class	6																									
	7																									
B. H.	8																									
N2	9																									
GWT (m)	10																									
1.80	11																									
a_{max} (g)	12																									
0.428	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
70	19																									
N (mean)	20																									
18.0	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
157	25																									
Observed (cm)	26																									
157	27																									
Distance (m)	28																									
219.5	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	6.25																							3.75	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Chi Chi 1999	1	1.30	Silty Sand	4.80	9	6.30	19.6	75.7	67.8	1.00	0.95	1.00	60	1.00	1.21	10	20	0.15	175	0.90	0.28	0.09	0.31	1.000	0.76	8.77
Mw	2	1.70	Silty Sand	5.80	7	7.30	19.9	95.4	77.8	1.00	0.95	1.00	60	1.00	1.13	8	18	0.16	150	0.87	0.30	0.07	0.23	1.000	0.71	5.79
7.6	3	2.00	Silty Sand	8.20	33	9.70	21.4	144.9	103.7	1.00	0.95	1.00	60	1.00	0.98	31	16	2.50	225	0.77	0.30	0.39	1.30	0.010	0.59	41.29
Site	4	1.40	Fine Sand	9.80	13	11.30	19.3	177.5	120.6	1.00	1.00	1.00	60	1.00	0.91	12	35	0.02	175	0.70	0.29	0.09	0.33	1.000	0.51	11.72
Nantou	5	1.35	Silty Clay	11.00	21	12.50	20.8	201.5	132.9	1.00	1.00	1.00	60	1.00	0.87	18	35	0.03	175	0.66	0.28	0.16	0.57	0.000	0.00	Non-Liq.
Data Class	6	1.40	Silty Clay	12.50	20	14.00	20.4	232.4	149.0	1.00	1.00	1.00	60	1.00	0.82	16	35	0.01	175	0.62	0.27	0.13	0.49	0.000	0.00	Non-Liq.
	7	1.15	Silty Clay	13.80	28	15.30	20.6	259.0	162.9	1.00	1.00	1.00	60	1.00	0.78	22	30	0.14	200	0.59	0.26	0.20	0.75	0.000	0.00	Non-Liq.
B. H.	8	1.20	Silty Sand	14.80	39	16.30	18.9	278.8	172.8	1.00	1.00	1.00	60	1.00	0.76	30	30	0.14	200	0.57	0.26	0.37	1.43	0.003	0.26	41.61
N3	9	1.20	Silty Sand	16.20	40	17.70	20.1	306.1	186.4	1.00	1.00	1.00	60	1.00	0.73	29	35	0.06	200	0.56	0.26	0.37	1.46	0.002	0.19	41.72
GWT (m)	10	1.00	Medium sand	17.20	90	18.70	21.5	326.8	197.4	1.00	1.00	1.00	60	1.00	0.71	64	16	2.90	225	0.55	0.25	4.64	18.26	0.000	0.14	50.76
4.00	11																									
a_{max} (g)	12																									
0.428	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
30.0	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
168	25																									
Observed (cm)	26																									
157	27																									
Distance (m)	28																									
219.5	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	13.70																							2.92	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Chi Chi 1999	1	1.50	Silty Sand	5.80	7	7.30	19.5	90.6	82.8	1.00	0.95	1.00	60	1.00	1.10	7	25	0.15	150	0.84	0.26	0.07	0.26	1.000	0.71	6.02
Mw	2	1.50	Silty Sand	7.20	19	8.70	22.3	119.9	98.3	1.00	0.95	1.00	60	1.00	1.01	18	19	1.50	175	0.78	0.27	0.15	0.56	0.966	0.64	16.70
7.6	3	1.50	Fine Sand	8.80	12	10.30	18.6	152.7	115.4	1.00	1.00	1.00	60	1.00	0.93	11	35	0.12	175	0.71	0.26	0.09	0.34	1.000	0.56	10.98
Site	4	1.50	Fine Sand	10.20	17	11.70	20.2	179.8	128.8	1.00	1.00	1.00	60	1.00	0.88	15	35	0.06	175	0.66	0.26	0.12	0.47	0.996	0.49	15.11
Nantou	5	1.50	Silty Clay	11.80	13	13.30	20.3	212.2	145.5	1.00	1.00	1.00	60	1.00	0.83	11	35	0.04	175	0.61	0.25	0.08	0.33	0.000	0.00	Non-Liq.
Data Class	6	1.50	Silty Clay	13.20	17	14.70	18.6	239.4	159.0	1.00	1.00	1.00	60	1.00	0.79	13	35	0.03	175	0.58	0.24	0.10	0.42	0.000	0.00	Non-Liq.
	7	1.50	Silty Sand	14.80	19	16.30	19.1	269.6	173.5	1.00	1.00	1.00	60	1.00	0.76	14	35	0.03	175	0.55	0.24	0.11	0.45	0.998	0.26	14.52
B. H.	8	1.50	Silty Sand	16.20	22	17.70	19.6	296.7	186.9	1.00	1.00	1.00	60	1.00	0.73	16	35	0.03	175	0.54	0.24	0.12	0.51	0.990	0.19	16.29
N4	9	1.50	Medium sand	17.80	35	19.30	19.3	327.8	202.3	1.00	1.00	1.00	60	1.00	0.70	25	35	0.05	200	0.53	0.24	0.24	1.02	0.124	0.11	40.29
GWT (m)	10	1.40	Medium sand	19.20	45	20.70	19.8	355.2	215.9	1.00	1.00	1.00	60	1.00	0.68	31	29	0.14	225	0.52	0.24	0.37	1.55	0.001	0.04	41.85
5.00	11																									
a_{max} (g)	12																									
0.428	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
20.6	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
161	25																									
Observed (cm)	26																									
157	27																									
Distance (m)	28																									
219.5	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	14.90																							4.26	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Chi Chi 1999	1	2.20	Silty Sand	4.20	5	5.70	18.6	68.1	54.4	1.00	0.85	1.00	60	1.00	1.36	6	35	0.03	150	0.93	0.33	0.07	0.21	1.000	0.79	5.31
Mw	2	1.50	Silty Sand	5.80	10	7.30	19.4	98.5	69.1	1.00	0.95	1.00	60	1.00	1.20	11	14	0.16	175	0.89	0.35	0.09	0.26	1.000	0.71	9.32
7.6	3	1.20	Silty Sand	7.20	11	8.70	18.9	125.4	82.2	1.00	0.95	1.00	60	1.00	1.10	12	35	0.01	175	0.84	0.36	0.10	0.29	1.000	0.64	11.38
Site	4	1.30	Silty Sand	8.20	12	9.70	22.7	146.2	93.2	1.00	0.95	1.00	60	1.00	1.04	12	13	0.58	175	0.80	0.35	0.09	0.25	1.000	0.59	9.61
Nantou	5	1.50	Fine Sand	9.80	21	11.30	19.4	179.9	111.2	1.00	1.00	1.00	60	1.00	0.95	20	35	0.06	175	0.73	0.33	0.19	0.58	0.948	0.51	20.23
Data Class	6	1.50	Silty Clay	11.20	25	12.70	20.3	207.7	125.3	1.00	1.00	1.00	60	1.00	0.89	22	35	0.07	200	0.68	0.32	0.23	0.73	0.000	0.00	Non-Liq.
	7	1.50	Silty Clay	12.80	35	14.30	20.4	240.2	142.1	1.00	1.00	1.00	60	1.00	0.84	29	35	0.07	200	0.64	0.30	0.40	1.34	0.000	0.00	Non-Liq.
B. H.	8	1.70	Silty Clay	14.20	46	15.70	19.7	268.3	156.4	1.00	1.00	1.00	60	1.00	0.80	37	19	0.18	225	0.61	0.29	0.59	2.01	0.000	0.00	Non-Liq.
N5	9	1.75	Silty Sand	16.20	68	17.70	21.2	309.1	177.7	1.00	1.00	1.00	60	1.00	0.75	51	35	0.14	225	0.58	0.28	2.42	8.57	0.000	0.19	48.34
GWT (m)	10	1.50	Medium sand	17.70	76	19.20	19.8	339.9	193.7	1.00	1.00	1.00	60	1.00	0.72	55	22	0.17	225	0.57	0.28	2.47	8.87	0.000	0.12	48.50
2.80	11																									
a_{max} (g)	12																									
0.428	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
30.9	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
175	25																									
Observed (cm)	26																									
157	27																									
Distance (m)	28																									
219.5	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	15.65																							5.06	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Chi Chi 1999	1	3.00	Silty Sand	3.60	13	5.10	23.3	74.0	50.4	1.00	0.85	1.00	60	1.00	1.41	16	14	6.10	175	0.97	0.39	0.14	0.35	1.000	0.82	13.52
Mw	2	1.30	Silty Sand	4.80	23	6.30	21.7	101.0	65.7	1.00	0.95	1.00	60	1.00	1.23	27	20	0.26	200	0.95	0.41	0.34	0.84	0.426	0.76	25.07
7.6	3	1.50	Silty Sand	6.20	16	7.70	22.6	132.0	82.9	1.00	0.95	1.00	60	1.00	1.10	17	15	2.40	175	0.92	0.41	0.13	0.33	1.000	0.69	14.75
Site	4	1.50	Silty Sand	7.80	23	9.30	21.4	167.2	102.4	1.00	0.95	1.00	60	1.00	0.99	22	25	0.80	200	0.87	0.39	0.21	0.52	0.986	0.61	20.71
Nantou	5	1.50	Fine Sand	9.20	20	10.70	21.3	197.0	118.5	1.00	1.00	1.00	60	1.00	0.92	18	35	0.18	175	0.82	0.38	0.17	0.44	0.999	0.54	18.66
Data Class	6	1.60	Silty Clay	10.80	18	12.30	20.3	230.3	136.1	1.00	1.00	1.00	60	1.00	0.86	15	35	0.09	175	0.77	0.36	0.12	0.34	0.000	0.00	Non-Liq.
	7	1.50	Silty Clay	12.40	34	13.90	19.4	262.0	152.1	1.00	1.00	1.00	60	1.00	0.81	28	35	0.11	200	0.71	0.34	0.34	0.99	0.000	0.00	Non-Liq.
B. H.	8	1.40	Silty Clay	13.80	23	15.30	20.6	290.0	166.4	1.00	1.00	1.00	60	1.00	0.78	18	35	0.09	175	0.68	0.33	0.14	0.44	0.000	0.00	Non-Liq.
N6	9	2.20	Silty Sand	15.20	76	16.70	21.1	319.2	181.8	1.00	1.00	1.00	60	1.00	0.74	56	25	0.25	225	0.65	0.32	3.09	9.72	0.000	0.24	49.23
GWT (m)	10	2.30	Medium sand	18.20	55	19.70	21.8	383.4	216.6	1.00	1.00	1.00	60	1.00	0.68	37	7	7.90	225	0.62	0.30	0.47	1.54	0.001	0.09	42.69
1.20	11	1.50	Medium sand	19.80	71	21.30	21.5	418.0	235.5	1.00	1.00	1.00	60	1.00	0.65	46	13	0.17	225	0.61	0.30	1.01	3.36	0.000	0.01	45.51
a_{max} (g)	12	2.20	Medium sand	21.20	20	22.70	20.4	447.3	251.1	1.00	1.00	1.00	60	1.00	0.63	13	35	0.19	175	0.60	0.30	0.08	0.28	1.000	0.00	12.57
0.428	13	3.00	Medium sand	24.20	71	25.70	22.4	511.5	285.9	1.00	1.00	1.00	60	1.00	0.59	42	21	6.00	225	0.59	0.29	0.78	2.66	0.000	0.00	44.77
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
35.6	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
190	25																									
Observed (cm)	26																									
157	27																									
Distance (m)	28																									
219.5	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	24.50																							5.63	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Chi Chi 1999	1	2.85	Silty Sand	2.80	6	4.30	18.4	49.4	28.3	1.00	0.85	1.00	60	1.00	1.88	10	22	0.18	150	0.97	0.47	0.11	0.23	1.000	0.86	8.11
Mw	2	1.50	Silty Sand	4.20	14	5.70	20.9	76.9	42.0	1.00	0.85	1.00	60	1.00	1.54	18	35	0.10	175	0.95	0.48	0.22	0.46	0.998	0.79	18.64
7.6	3	1.50	Silty Sand	5.80	11	7.30	20.0	109.6	59.0	1.00	0.95	1.00	60	1.00	1.30	14	18	0.59	175	0.91	0.47	0.12	0.25	1.000	0.71	11.94
Site	4	1.60	Silty Sand	7.20	23	8.70	21.3	138.4	74.2	1.00	0.95	1.00	60	1.00	1.16	25	23	0.18	200	0.87	0.45	0.30	0.66	0.841	0.64	24.01
Nantou	5	1.50	Fine Sand	9.00	16	10.50	19.7	175.3	93.4	1.00	1.00	1.00	60	1.00	1.03	17	35	0.00	175	0.81	0.42	0.15	0.36	1.000	0.55	16.78
Data Class	6	1.40	Fine Sand	10.20	17	11.70	21.7	200.1	106.4	1.00	1.00	1.00	60	1.00	0.97	16	20	0.02	175	0.76	0.40	0.13	0.32	1.000	0.49	15.08
	7	1.50	Silty Clay	11.80	39	13.30	20.0	233.4	124.1	1.00	1.00	1.00	60	1.00	0.90	35	21	0.18	225	0.71	0.37	0.56	1.50	0.000	0.00	Non-Liq.
B. H.	8	1.50	Silty Clay	13.20	35	14.70	21.3	262.3	139.2	1.00	1.00	1.00	60	1.00	0.85	30	26	0.17	200	0.67	0.35	0.37	1.06	0.000	0.00	Non-Liq.
N7	9	1.50	Silty Sand	14.80	39	16.30	22.2	297.1	158.3	1.00	1.00	1.00	60	1.00	0.79	31	13	9.00	225	0.64	0.33	0.34	1.01	0.134	0.26	41.22
GWT (m)	10	2.20	Silty Sand	16.20	62	17.70	22.1	328.1	175.6	1.00	1.00	1.00	60	1.00	0.75	47	20	1.40	225	0.62	0.32	1.30	4.03	0.000	0.19	46.10
0.65	11	2.30	Medium sand	19.20	19	20.70	21.2	393.0	211.0	1.00	1.00	1.00	60	1.00	0.69	13	35	0.01	175	0.60	0.31	0.09	0.29	1.000	0.04	13.07
a_{max} (g)	12	1.60	Medium sand	20.80	54	22.30	21.5	427.1	229.4	1.00	1.00	1.00	60	1.00	0.66	36	27	0.20	225	0.59	0.30	0.54	1.77	0.000	0.00	43.25
0.428	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
27.9	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
185	25																									
Observed (cm)	26																									
157	27																									
Distance (m)	28																									
219.5	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	20.95																							7.21	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Chi Chi 1999	1	1.35	Silty Sand	5.50	9	7.00	21.0	85.5	80.6	1.00	0.95	1.00	60	1.00	1.11	10	35	0.06	150	0.80	0.24	0.09	0.36	1.000	0.73	9.16
Mw	2	1.65	Silty Sand	7.20	11	8.70	20.0	120.3	98.7	1.00	0.95	1.00	60	1.00	1.01	11	21	0.15	175	0.72	0.24	0.08	0.33	1.000	0.64	9.01
7.6	3	1.60	Fine Sand	8.80	41	10.30	22.1	154.0	116.7	1.00	1.00	1.00	60	1.00	0.93	38	11	10.00	225	0.65	0.24	0.62	2.60	0.000	0.56	43.06
Site	4																									
Nantou	5																									
Data Class	6																									
	7																									
B. H.	8																									
N8	9																									
GWT (m)	10																									
5.00	11																									
a_{max} (g)	12																									
0.428	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
20.3	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
146	25																									
Observed (cm)	26																									
157	27																									
Distance (m)	28																									
219.5	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	4.60																							2.03	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Chi Chi 1999	1	1.20	Silty Sand	3.00	5	4.50	20.2	48.1	42.2	1.00	0.85	1.00	60	1.00	1.54	7	24	0.14	150	0.93	0.30	0.08	0.25	1.000	0.85	5.34
Mw	2	1.40	Silty Sand	4.20	16	5.70	19.7	72.0	54.4	1.00	0.85	1.00	60	1.00	1.36	18	24	0.14	175	0.89	0.33	0.19	0.57	0.960	0.79	17.50
7.6	3	1.60	Silty Sand	5.80	56	7.30	22.1	105.5	72.2	1.00	0.95	1.00	60	1.00	1.18	63	16	4.50	225	0.83	0.34	5.47	16.28	0.000	0.71	50.35
Site	4																									
Nantou	5																									
Data Class	6																									
	7																									
B. H.	8																									
N10	9																									
GWT (m)	10																									
2.40	11																									
a_{max} (g)	12																									
0.428	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
25.7	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
156	25																									
Observed (cm)	26																									
157	27																									
Distance (m)	28																									
219.5	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	4.20																							2.08	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Chi Chi 1999	1	1.85	Silty Sand	3.50	3	5.00	19.2	55.4	48.6	1.00	0.85	1.00	60	1.00	1.43	4	35	0.02	125	0.92	0.29	0.06	0.21	1.000	0.83	3.89
Mw	2	1.85	Silty Sand	5.80	4	7.30	19.8	100.3	70.9	1.00	0.95	1.00	60	1.00	1.19	5	35	0.12	150	0.83	0.33	0.06	0.18	1.000	0.71	4.42
7.6	3	1.50	Silty Sand	7.20	12	8.70	19.8	128.0	84.9	1.00	0.95	1.00	60	1.00	1.09	12	35	0.01	175	0.77	0.32	0.11	0.34	1.000	0.64	12.30
Site	4	1.50	Fine Sand	8.80	22	10.30	18.7	158.8	100.0	1.00	1.00	1.00	60	1.00	1.00	22	35	0.01	200	0.69	0.31	0.24	0.77	0.594	0.56	22.30
Nantou	5	1.50	Fine Sand	10.20	21	11.70	19.2	185.4	112.8	1.00	1.00	1.00	60	1.00	0.94	20	35	0.02	175	0.64	0.29	0.19	0.65	0.866	0.49	20.09
Data Class	6	1.50	Silty Clay	11.80	21	13.30	19.1	216.0	127.7	1.00	1.00	1.00	60	1.00	0.88	19	35	0.01	175	0.59	0.28	0.17	0.59	0.000	0.00	Non-Liq.
	7	1.50	Silty Clay	13.20	23	14.70	19.6	243.1	141.1	1.00	1.00	1.00	60	1.00	0.84	19	35	0.01	175	0.56	0.27	0.17	0.64	0.000	0.00	Non-Liq.
B. H.	8	1.60	Silty Sand	14.80	35	16.30	20.3	275.0	157.3	1.00	1.00	1.00	60	1.00	0.80	28	35	0.09	200	0.54	0.26	0.35	1.32	0.008	0.26	41.30
N12	9																									
GWT (m)	10																									
2.80	11																									
a_{max} (g)	12																									
0.428	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
17.6	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
157	25																									
Observed (cm)	26																									
157	27																									
Distance (m)	28																									
219.5	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	12.80																							4.94	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Chi Chi 1999	1	3.30	Silty Sand	3.80	10	5.30	18.9	66.0	43.4	1.00	0.85	1.00	60	1.00	1.52	13	30	0.11	175	0.94	0.40	0.13	0.33	1.000	0.81	12.39
Mw	2	1.70	Silty Sand	5.80	10	7.30	18.0	102.9	60.8	1.00	0.95	1.00	60	1.00	1.28	12	30	0.10	175	0.88	0.41	0.11	0.27	1.000	0.71	11.62
7.6	3	1.50	Silty Sand	7.20	17	8.70	20.3	129.8	73.9	1.00	0.95	1.00	60	1.00	1.16	19	6	0.32	175	0.83	0.40	0.15	0.37	1.000	0.64	15.78
Site	4	1.65	Fine Sand	8.80	4	10.30	19.9	161.9	90.3	1.00	1.00	1.00	60	1.00	1.05	4	35	0.02	150	0.76	0.38	0.05	0.14	1.000	0.56	4.22
Nantou	5	1.50	Fine Sand	10.50	4	12.00	20.6	196.3	108.0	1.00	1.00	1.00	60	1.00	0.96	4	35	0.01	125	0.70	0.35	0.05	0.14	1.000	0.48	4.00
Data Class	6	1.35	Silty Clay	11.80	15	13.30	19.7	222.5	121.5	1.00	1.00	1.00	60	1.00	0.91	14	35	0.01	175	0.65	0.33	0.11	0.33	0.000	0.00	Non-Liq.
	7	1.50	Silty Clay	13.20	13	14.70	20.0	250.3	135.5	1.00	1.00	1.00	60	1.00	0.86	11	35	0.01	175	0.62	0.32	0.09	0.27	0.000	0.00	Non-Liq.
B. H.	8	1.50	Silty Sand	14.80	18	16.30	19.3	281.7	151.2	1.00	1.00	1.00	60	1.00	0.81	15	35	0.01	175	0.59	0.31	0.11	0.37	1.000	0.26	14.75
N14	9	1.50	Silty Sand	16.20	19	17.70	20.0	309.2	165.0	1.00	1.00	1.00	60	1.00	0.78	15	35	0.01	175	0.57	0.30	0.11	0.37	1.000	0.19	14.91
GWT (m)	10	1.30	Medium sand	17.80	31	19.30	20.0	341.2	181.3	1.00	1.00	1.00	60	1.00	0.74	23	35	0.12	200	0.56	0.29	0.22	0.75	0.659	0.11	23.29
1.50	11	3.70	Medium sand	18.80	70	20.30	22.1	362.2	192.5	1.00	1.00	1.00	60	1.00	0.72	50	16	7.00	225	0.56	0.29	1.58	5.40	0.000	0.06	46.89
a_{max} (g)	12	6.40	Medium sand	25.20	18	26.70	19.6	495.5	263.0	1.00	1.00	1.00	60	1.00	0.62	11	16	0.14	175	0.53	0.28	0.06	0.22	1.000	0.00	9.16
0.428	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
19.1	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
172	25																									
Observed (cm)	26																									
157	27																									
Distance (m)	28																									
219.5	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	26.90																							7.25	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Chi Chi 1999	1	2.60	Silty Sand	2.80	58	4.30	21.4	49.0	38.2	1.00	0.85	1.00	60	1.00	1.62	80	19	1.80	225	0.97	0.35	27.87	80.58	0.000	0.86	55.51
Mw	2	2.20	Silty Sand	5.80	15	7.30	21.2	112.8	72.6	1.00	0.95	1.00	60	1.00	1.17	17	22	0.31	175	0.90	0.39	0.15	0.38	1.000	0.71	15.55
7.6	3	1.40	Silty Sand	7.20	74	8.70	21.3	142.5	88.5	1.00	0.95	1.00	60	1.00	1.06	75	19	0.60	225	0.85	0.38	14.68	38.35	0.000	0.64	54.06
Site	4																									
Nantou	5																									
Data Class	6																									
	7																									
B. H.	8																									
N-2	9																									
GWT (m)	10																									
1.70	11																									
a_{max} (g)	12																									
0.428	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
49.0	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
180	25																									
Observed (cm)	26																									
157	27																									
Distance (m)	28																									
219.5	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	6.20																							1.56	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Chi Chi 1999	1	0.47	Silty Sand	1.50	5	3.00	17.8	22.8	21.7	1.00	0.75	1.00	60	1.00	2.00	8	35	0.03	150	0.96	0.52	0.10	0.20	1.000	0.93	6.89
Mw	2	0.70	Silty Sand	2.20	22	3.70	19.9	36.0	28.0	1.00	0.75	1.00	60	1.00	1.89	31	10	0.24	225	0.94	0.62	0.53	0.86	0.381	0.89	27.33
7.6	3																									
Site	4																									
Wufeng	5																									
Data Class	6																									
	7																									
B. H.	8																									
W1	9																									
GWT (m)	10																									
1.38	11																									
a_{max} (g)	12																									
0.789	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
13.5	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
148	25																									
Observed (cm)	26																									
	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	1.17																							0.67	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Chi Chi 1999	1	4.90	Silty Sand	2.20	2	3.70	19.2	36.8	28.0	1.00	0.75	1.00	60	1.00	1.89	3	22	0.14	125	0.96	0.65	0.06	0.09	1.000	0.89	3.11
Mw	2	4.80	Silty Sand	10.20	40	11.70	21.4	199.1	111.8	1.00	1.00	1.00	60	1.00	0.95	38	17	0.38	225	0.64	0.58	0.68	1.17	0.035	0.49	43.35
7.6	3	2.30	Silty Sand	11.80	62	13.30	19.6	231.8	128.8	1.00	1.00	1.00	60	1.00	0.88	55	15	0.34	225	0.58	0.53	2.41	4.52	0.000	0.41	48.00
Site	4	2.20	Silty Clay	14.80	16	16.30	19.0	289.8	157.3	1.00	1.00	1.00	60	1.00	0.80	13	35	0.01	175	0.51	0.48	0.09	0.20	0.000	0.00	Non-Liq.
Wufeng	5	1.50	Silty Clay	16.20	18	17.70	19.6	316.8	170.6	1.00	1.00	1.00	60	1.00	0.77	14	35	0.01	175	0.49	0.47	0.10	0.22	0.000	0.00	Non-Liq.
Data Class	6	1.50	Medium sand	17.80	24	19.30	20.5	348.9	187.0	1.00	1.00	1.00	60	1.00	0.73	18	35	0.07	175	0.48	0.46	0.14	0.30	1.000	0.11	17.82
	7	1.50	Medium sand	19.20	22	20.70	20.7	377.7	202.1	1.00	1.00	1.00	60	1.00	0.70	15	35	0.06	175	0.47	0.45	0.11	0.25	1.000	0.04	15.64
B. H.	8	1.50	Medium sand	20.80	9	22.30	18.4	409.0	217.7	1.00	1.00	1.00	60	1.00	0.68	6	35	0.00	150	0.47	0.45	0.05	0.11	1.000	0.00	5.58
W3	9	1.50	Medium sand	22.20	17	23.70	18.6	434.9	229.9	1.00	1.00	1.00	60	1.00	0.66	11	35	0.08	175	0.46	0.45	0.07	0.17	1.000	0.00	11.03
GWT (m)	10	1.50	Medium sand	23.80	10	25.30	18.5	464.6	243.9	1.00	1.00	1.00	60	1.00	0.64	6	35	0.01	150	0.45	0.44	0.05	0.11	1.000	0.00	5.84
1.30	11	1.50	Medium sand	25.20	8	26.70	19.7	491.4	256.9	1.00	1.00	1.00	60	1.00	0.62	5	35	0.08	150	0.45	0.44	0.04	0.10	1.000	0.00	4.74
a_{max} (g)	12	1.50	Medium sand	26.80	27	28.30	19.7	522.9	272.7	1.00	1.00	1.00	60	1.00	0.61	16	35	0.08	175	0.44	0.43	0.11	0.26	1.000	0.00	16.56
0.789	13	1.50	Medium sand	28.20	17	29.70	20.5	551.0	287.1	1.00	1.00	1.00	60	1.00	0.59	10	35	0.07	175	0.43	0.43	0.06	0.15	1.000	0.00	9.73
Sampler[b]	14	1.60	Medium sand	29.80	24	31.30	19.6	583.1	303.5	1.00	1.00	1.00	60	1.00	0.57	14	35	0.01	175	0.43	0.42	0.09	0.21	1.000	0.00	13.82
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
21.1	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
166	25																									
Observed (cm)	26																									
	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	29.30																							4.67	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Chi Chi 1999	1	2.40	Silty Sand	3.00	13	4.50	20.7	55.2	37.6	1.00	0.85	1.00	60	1.00	1.63	18	35	0.09	175	0.94	0.71	0.22	0.31	1.000	0.85	18.31
Mw	2	1.10	Silty Sand	4.20	7	5.70	20.7	80.0	50.6	1.00	0.85	1.00	60	1.00	1.41	8	35	0.02	150	0.90	0.73	0.09	0.12	1.000	0.79	7.86
7.6	3	1.00	Silty Sand	5.20	29	6.70	21.0	100.9	61.6	1.00	0.95	1.00	60	1.00	1.27	35	24	2.00	225	0.86	0.72	0.71	0.99	0.162	0.74	42.93
Site	4																									
Wufeng	5																									
Data Class	6																									
	7																									
B. H.	8																									
W5	9																									
GWT (m)	10																									
1.20	11																									
a_{max} (g)	12																									
0.789	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
16.3	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
162	25																									
Observed (cm)	26																									
	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	4.50																							3.03	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Chi Chi 1999	1	1.60	Silty Sand	3.80	12	5.30	20.2	60.1	54.2	1.00	0.85	1.00	60	1.00	1.36	14	20	0.40	175	0.93	0.53	0.12	0.23	1.000	0.81	12.40
Mw	2	1.70	Silty Sand	5.80	12	7.30	19.8	100.1	74.6	1.00	0.95	1.00	60	1.00	1.16	13	35	0.08	175	0.87	0.60	0.12	0.20	1.000	0.71	13.20
7.6	3	1.50	Silty Sand	7.20	13	8.70	20.4	128.2	89.0	1.00	0.95	1.00	60	1.00	1.06	13	35	0.10	175	0.81	0.60	0.11	0.19	1.000	0.64	13.08
Site	4	1.50	Silty Sand	8.80	13	10.30	20.4	160.8	105.9	1.00	1.00	1.00	60	1.00	0.97	13	35	0.04	175	0.73	0.57	0.10	0.18	1.000	0.56	12.58
Wufeng	5	1.50	Silty Sand	10.20	12	11.70	20.4	189.4	120.7	1.00	1.00	1.00	60	1.00	0.91	11	35	0.04	175	0.67	0.54	0.09	0.16	1.000	0.49	10.71
Data Class	6	1.50	Silty Sand	11.80	26	13.30	19.9	221.6	137.2	1.00	1.00	1.00	60	1.00	0.85	22	27	0.14	200	0.61	0.50	0.20	0.40	1.000	0.41	21.53
	7	1.50	Silty Clay	13.20	30	14.70	20.0	249.5	151.4	1.00	1.00	1.00	60	1.00	0.81	24	20	0.12	200	0.57	0.48	0.22	0.46	0.000	0.00	Non-Liq.
B. H.	8	2.80	Silty Clay	14.80	37	16.30	21.9	283.0	169.2	1.00	1.00	1.00	60	1.00	0.77	28	35	0.08	200	0.54	0.46	0.36	0.77	0.000	0.00	Non-Liq.
W7	9	3.00	Medium sand	18.80	29	20.30	20.2	367.1	214.0	1.00	1.00	1.00	60	1.00	0.68	20	35	0.09	175	0.50	0.44	0.16	0.36	1.000	0.06	20.14
GWT (m)	10	1.70	Medium sand	20.80	17	22.30	20.6	407.8	235.2	1.00	1.00	1.00	60	1.00	0.65	11	35	0.09	175	0.49	0.43	0.07	0.17	1.000	0.00	10.89
3.20	11	1.50	Medium sand	22.20	21	23.70	20.4	436.5	250.1	1.00	1.00	1.00	60	1.00	0.63	13	35	0.46	175	0.48	0.43	0.09	0.20	1.000	0.00	13.29
a_{max} (g)	12	1.50	Medium sand	23.80	30	25.30	19.9	468.7	266.7	1.00	1.00	1.00	60	1.00	0.61	18	35	0.07	175	0.47	0.43	0.13	0.31	1.000	0.00	18.66
0.789	13	1.50	Medium sand	25.20	30	26.70	20.6	497.1	281.3	1.00	1.00	1.00	60	1.00	0.60	18	35	0.05	175	0.47	0.42	0.13	0.30	1.000	0.00	18.16
Sampler[b]	14	1.50	Medium sand	26.80	23	28.30	20.6	530.0	298.5	1.00	1.00	1.00	60	1.00	0.58	13	35	0.03	175	0.46	0.42	0.08	0.20	1.000	0.00	13.32
NA	15	1.50	Medium sand	28.20	27	29.70	20.8	559.0	313.7	1.00	1.00	1.00	60	1.00	0.56	15	35	0.04	175	0.45	0.41	0.10	0.23	1.000	0.00	15.39
B.H. Diam. (mm)	16	1.60	Medium sand	29.80	54	31.30	19.2	590.9	330.0	1.00	1.00	1.00	60	1.00	0.55	30	35	0.11	200	0.45	0.41	0.33	0.80	0.515	0.00	29.43
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
24.1	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
173	25																									
Observed (cm)	26																									
	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	27.40																							5.83	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Chi Chi 1999	1	3.95	Silty Sand	5.00	13	6.50	20.4	91.4	61.5	1.00	0.95	1.00	60	1.00	1.28	16	35	0.02	175	0.87	0.66	0.16	0.24	1.000	0.75	15.93
Mw	2	1.90	Silty Sand	6.80	10	8.30	20.1	127.8	80.3	1.00	0.95	1.00	60	1.00	1.12	11	15	0.16	175	0.78	0.64	0.08	0.13	1.000	0.66	8.55
7.6	3	1.70	Silty Sand	8.80	11	10.30	20.4	168.3	101.1	1.00	1.00	1.00	60	1.00	0.99	11	35	0.04	175	0.69	0.58	0.09	0.16	1.000	0.56	10.73
Site	4	1.40	Silty Sand	10.20	13	11.70	20.5	196.9	116.0	1.00	1.00	1.00	60	1.00	0.93	12	35	0.05	175	0.62	0.54	0.10	0.18	1.000	0.49	11.97
Wufeng	5																									
Data Class	6																									
	7																									
B. H.	8																									
W9	9																									
GWT (m)	10																									
1.95	11																									
a_{max} (g)	12																									
0.789	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
11.8	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
163	25																									
Observed (cm)	26																									
	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	8.95																							5.85	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N^d	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Chi Chi 1999	1	3.40	Silty Sand	3.80	9	5.30	19.4	67.6	44.0	1.00	0.85	1.00	60	1.00	1.51	12	35	0.03	175	0.94	0.74	0.12	0.16	1.000	0.81	11.38
Mw	2	1.70	Silty Sand	5.80	11	7.30	19.5	106.5	63.3	1.00	0.95	1.00	60	1.00	1.26	13	22	0.13	175	0.88	0.76	0.11	0.15	1.000	0.71	11.85
7.6	3	1.50	Silty Sand	7.20	14	8.70	20.6	134.5	77.6	1.00	0.95	1.00	60	1.00	1.13	15	35	0.04	175	0.82	0.73	0.14	0.19	1.000	0.64	15.24
Site	4	1.50	Silty Sand	8.80	23	10.30	20.9	167.7	95.1	1.00	1.00	1.00	60	1.00	1.03	24	35	0.04	200	0.75	0.68	0.28	0.41	1.000	0.56	23.83
Wufeng	5	1.50	Silty Sand	10.20	18	11.70	19.7	196.1	109.8	1.00	1.00	1.00	60	1.00	0.95	17	35	0.04	175	0.69	0.63	0.15	0.24	1.000	0.49	17.43
Data Class	6	1.50	Silty Sand	11.80	24	13.30	20.8	228.5	126.5	1.00	1.00	1.00	60	1.00	0.89	21	35	0.07	200	0.62	0.58	0.21	0.36	1.000	0.41	21.65
	7	1.50	Silty Clay	13.20	17	14.70	19.8	256.9	141.1	1.00	1.00	1.00	60	1.00	0.84	14	35	0.03	175	0.58	0.54	0.11	0.21	0.000	0.00	Non-Liq.
B. H.	8	1.50	Silty Clay	14.80	23	16.30	20.5	289.1	157.6	1.00	1.00	1.00	60	1.00	0.80	18	35	0.12	175	0.55	0.52	0.15	0.30	0.000	0.00	Non-Liq.
W10	9	1.50	Silty Clay	16.20	39	17.70	20.5	317.8	172.6	1.00	1.00	1.00	60	1.00	0.76	30	35	0.13	200	0.53	0.50	0.39	0.79	0.000	0.00	Non-Liq.
GWT (m)	10	1.50	Medium sand	17.80	18	19.30	20.4	350.5	189.6	1.00	1.00	1.00	60	1.00	0.73	13	35	0.04	175	0.51	0.49	0.09	0.19	1.000	0.11	13.06
1.40	11	1.50	Medium sand	19.20	19	20.70	19.9	378.7	204.0	1.00	1.00	1.00	60	1.00	0.70	13	35	0.04	175	0.50	0.48	0.09	0.19	1.000	0.04	13.31
a_{max} (g)	12	1.50	Medium sand	20.80	26	22.30	19.2	409.9	219.6	1.00	1.00	1.00	60	1.00	0.67	18	35	0.07	175	0.50	0.48	0.13	0.27	1.000	0.00	17.81
0.789	13	1.50	Medium sand	22.20	24	23.70	20.3	437.6	233.5	1.00	1.00	1.00	60	1.00	0.65	16	35	0.02	175	0.49	0.47	0.11	0.23	1.000	0.00	15.88
Sampler[b]	14	1.50	Medium sand	23.80	19	25.30	20.4	470.1	250.4	1.00	1.00	1.00	60	1.00	0.63	12	35	0.01	175	0.48	0.47	0.08	0.17	1.000	0.00	11.90
NA	15	1.85	Medium sand	25.20	43	26.70	21.8	499.6	266.1	1.00	1.00	1.00	60	1.00	0.61	26	35	0.05	200	0.48	0.46	0.26	0.57	0.959	0.00	26.43
B.H. Diam. (mm)	16	1.80	Medium sand	27.50	22	29.00	19.7	547.3	291.3	1.00	1.00	1.00	60	1.00	0.59	13	35	0.02	175	0.47	0.45	0.08	0.18	1.000	0.00	12.87
95	17	1.15	Medium sand	28.80	25	30.30	19.8	573.0	304.2	1.00	1.00	1.00	60	1.00	0.57	14	35	0.01	175	0.46	0.45	0.09	0.20	1.000	0.00	14.42
Energy Ratio[c]	18	1.00	Medium sand	29.80	23	31.30	20.2	593.0	314.4	1.00	1.00	1.00	60	1.00	0.56	13	35	0.01	175	0.46	0.44	0.08	0.18	1.000	0.00	12.95
60	19																									
N (mean)	20																									
22.1	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
176	25																									
Observed (cm)	26																									
	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	28.90																							7.34	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Chi Chi 1999	1	1.25	Silty Sand	1.50	3	3.00	20.0	25.5	19.6	1.00	0.75	1.00	60	1.00	2.00	5	35	0.04	150	0.98	0.66	0.08	0.13	1.000	0.93	4.41
Mw	2	1.35	Silty Sand	2.80	7	4.30	19.4	51.1	32.5	1.00	0.85	1.00	60	1.00	1.76	10	35	0.08	175	0.96	0.78	0.12	0.16	1.000	0.86	10.18
7.6	3	1.50	Silty Sand	4.20	4	5.70	20.6	79.1	46.7	1.00	0.85	1.00	60	1.00	1.46	5	35	0.02	150	0.93	0.80	0.07	0.08	1.000	0.79	4.73
Site	4	1.50	Silty Sand	5.80	10	7.30	20.6	112.0	64.0	1.00	0.95	1.00	60	1.00	1.25	12	35	0.08	175	0.87	0.78	0.11	0.14	1.000	0.71	11.76
Wufeng	5	1.50	Silty Sand	7.20	19	8.70	20.8	141.0	79.2	1.00	0.95	1.00	60	1.00	1.12	20	35	0.08	200	0.82	0.74	0.22	0.29	1.000	0.64	20.60
Data Class	6	1.50	Silty Sand	8.80	19	10.30	19.1	172.9	95.4	1.00	1.00	1.00	60	1.00	1.02	19	35	0.03	175	0.74	0.69	0.19	0.28	1.000	0.56	19.77
	7	1.50	Silty Sand	10.20	24	11.70	18.4	199.2	107.9	1.00	1.00	1.00	60	1.00	0.96	23	35	0.04	200	0.68	0.64	0.26	0.40	1.000	0.49	23.37
B. H.	8	1.50	Silty Sand	11.80	17	13.30	20.4	230.2	123.3	1.00	1.00	1.00	60	1.00	0.90	15	35	0.05	175	0.62	0.59	0.13	0.21	1.000	0.41	15.47
W11	9	1.50	Silty Clay	13.20	20	14.70	20.5	258.8	138.1	1.00	1.00	1.00	60	1.00	0.85	17	35	0.10	175	0.58	0.55	0.14	0.26	0.000	0.00	Non-Liq.
GWT (m)	10	1.50	Silty Clay	14.80	12	16.30	19.4	290.7	154.4	1.00	1.00	1.00	60	1.00	0.80	10	35	0.02	150	0.54	0.53	0.07	0.14	0.000	0.00	Non-Liq.
0.90	11	1.50	Silty Clay	16.20	14	17.70	20.5	318.6	168.5	1.00	1.00	1.00	60	1.00	0.77	11	35	0.04	175	0.52	0.51	0.08	0.15	0.000	0.00	Non-Liq.
a_{max} (g)	12	1.50	Medium sand	17.80	27	19.30	20.4	351.3	185.5	1.00	1.00	1.00	60	1.00	0.73	20	35	0.03	175	0.51	0.49	0.17	0.34	1.000	0.11	20.14
0.789	13	1.50	Medium sand	19.20	18	20.70	21.3	380.5	201.0	1.00	1.00	1.00	60	1.00	0.71	13	35	0.03	175	0.50	0.49	0.09	0.18	1.000	0.04	12.66
Sampler[b]	14	1.30	Medium sand	20.80	50	22.30	21.1	414.3	219.1	1.00	1.00	1.00	60	1.00	0.68	34	35	0.08	225	0.49	0.48	0.52	1.09	0.072	0.00	43.09
NA	15	1.50	Medium sand	21.80	61	23.30	21.4	435.6	230.5	1.00	1.00	1.00	60	1.00	0.66	40	35	0.09	225	0.49	0.47	0.89	1.88	0.000	0.00	45.04
B.H. Diam. (mm)	16	2.00	Medium sand	23.80	19	25.30	18.2	475.2	250.5	1.00	1.00	1.00	60	1.00	0.63	12	35	0.05	175	0.48	0.47	0.08	0.17	1.000	0.00	11.90
95	17	2.00	Medium sand	25.80	17	27.30	19.9	513.3	269.0	1.00	1.00	1.00	60	1.00	0.61	10	35	0.01	175	0.47	0.46	0.07	0.14	1.000	0.00	10.09
Energy Ratio[c]	18	2.00	Medium sand	27.80	15	29.30	19.4	552.6	288.7	1.00	1.00	1.00	60	1.00	0.59	9	35	0.01	150	0.46	0.45	0.06	0.13	1.000	0.00	8.38
60	19	2.00	Medium sand	29.80	59	31.30	19.7	591.7	308.2	1.00	1.00	1.00	60	1.00	0.57	34	35	0.09	225	0.45	0.45	0.47	1.05	0.101	0.00	43.04
N (mean)	20																									
21.8	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
175	25																									
Observed (cm)	26																									
	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	29.90																							7.94	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Chi Chi 1999	1	2.40	Silty Sand	6.00	10	7.50	20.7	100.2	82.6	1.00	0.95	1.00	60	1.00	1.10	10	35	0.05	175	0.88	0.55	0.09	0.17	1.000	0.70	10.19
Mw	2	1.40	Silty Sand	7.20	12	8.70	20.7	125.0	95.6	1.00	0.95	1.00	60	1.00	1.02	12	35	0.04	175	0.83	0.56	0.10	0.18	1.000	0.64	11.52
7.6	3	1.50	Silty Sand	8.80	13	10.30	20.3	157.8	112.7	1.00	1.00	1.00	60	1.00	0.94	12	35	0.10	175	0.76	0.55	0.10	0.18	1.000	0.56	12.16
Site	4	1.50	Silty Sand	10.20	18	11.70	20.5	186.3	127.5	1.00	1.00	1.00	60	1.00	0.89	16	35	0.15	175	0.70	0.52	0.13	0.25	1.000	0.49	16.13
Wufeng	5	1.50	Silty Sand	11.80	25	13.30	21.7	220.1	145.5	1.00	1.00	1.00	60	1.00	0.83	21	35	0.11	200	0.64	0.49	0.19	0.39	1.000	0.41	21.04
Data Class	6	1.50	Silty Clay	13.20	26	14.70	20.9	249.8	161.5	1.00	1.00	1.00	60	1.00	0.79	20	35	0.13	200	0.59	0.47	0.18	0.39	0.000	0.00	Non-Liq.
	7	1.50	Silty Clay	14.80	38	16.30	21.1	283.4	179.4	1.00	1.00	1.00	60	1.00	0.75	28	35	0.04	200	0.56	0.45	0.35	0.77	0.000	0.00	Non-Liq.
B. H.	8	1.50	Silty Clay	16.20	31	17.70	21.1	312.9	195.2	1.00	1.00	1.00	60	1.00	0.72	22	35	0.07	200	0.54	0.44	0.20	0.45	0.000	0.00	Non-Liq.
W12	9	1.80	Medium sand	17.80	72	19.30	21.0	346.5	213.1	1.00	1.00	1.00	60	1.00	0.69	49	35	0.07	225	0.52	0.44	1.99	4.57	0.000	0.11	47.82
GWT (m)	10	2.00	Medium sand	19.80	45	21.30	21.2	388.7	235.6	1.00	1.00	1.00	60	1.00	0.65	29	35	0.05	200	0.51	0.43	0.35	0.81	0.505	0.01	29.08
4.20	11	2.00	Medium sand	21.80	63	23.30	20.9	430.7	258.0	1.00	1.00	1.00	60	1.00	0.62	39	35	0.11	225	0.50	0.43	0.80	1.85	0.000	0.00	44.74
a_{max} (g)	12	2.00	Medium sand	23.80	42	25.30	21.1	472.6	280.4	1.00	1.00	1.00	60	1.00	0.60	25	35	0.04	200	0.49	0.43	0.23	0.54	0.975	0.00	25.25
0.789	13	2.00	Medium sand	25.80	30	27.30	20.2	513.9	302.0	1.00	1.00	1.00	60	1.00	0.58	17	35	0.04	175	0.48	0.42	0.12	0.28	1.000	0.00	17.52
Sampler[b]	14	2.00	Medium sand	27.80	49	29.30	20.9	555.0	323.4	1.00	1.00	1.00	60	1.00	0.56	27	35	0.13	200	0.47	0.42	0.27	0.64	0.875	0.00	27.24
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
33.9	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
179	25																									
Observed (cm)	26																									
	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	24.60																							4.78	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Chi Chi 1999	1	1.10	Silty Sand	1.20	2	2.70	19.0	19.2	16.3	1.00	0.75	1.00	60	1.00	2.00	3	30	0.20	125	0.98	0.59	0.08	0.13	1.000	0.94	3.39
Mw	2	1.50	Silty Sand	2.80	3	4.30	19.4	49.9	31.3	1.00	0.85	1.00	60	1.00	1.79	5	35	0.10	150	0.93	0.76	0.07	0.10	1.000	0.86	4.45
7.6	3	1.50	Silty Sand	4.20	5	5.70	19.9	77.4	45.1	1.00	0.85	1.00	60	1.00	1.49	6	35	0.05	150	0.88	0.77	0.08	0.10	1.000	0.79	5.77
Site	4	1.50	Silty Sand	5.80	5	7.30	20.0	109.4	61.3	1.00	0.95	1.00	60	1.00	1.28	6	35	0.04	150	0.80	0.74	0.07	0.09	1.000	0.71	5.55
Wufeng	5	1.50	Silty Sand	7.20	5	8.70	20.3	137.5	75.7	1.00	0.95	1.00	60	1.00	1.15	5	35	0.04	150	0.73	0.68	0.06	0.09	1.000	0.64	5.08
Data Class	6	1.50	Silty Sand	8.80	10	10.30	19.5	169.4	91.9	1.00	1.00	1.00	60	1.00	1.04	10	35	0.04	175	0.65	0.61	0.09	0.15	1.000	0.56	10.17
	7	1.50	Silty Sand	10.20	9	11.70	20.1	197.1	105.9	1.00	1.00	1.00	60	1.00	0.97	9	35	0.03	150	0.59	0.56	0.08	0.13	1.000	0.49	8.29
B. H.	8	1.50	Silty Sand	11.80	12	13.30	19.2	228.5	121.6	1.00	1.00	1.00	60	1.00	0.91	11	35	0.01	175	0.53	0.51	0.09	0.17	1.000	0.41	10.67
W13	9	1.50	Silty Clay	13.20	11	14.70	21.0	256.7	136.0	1.00	1.00	1.00	60	1.00	0.86	9	35	0.04	150	0.50	0.48	0.07	0.15	0.000	0.00	Non-Liq.
GWT (m)	10	1.50	Silty Clay	14.80	12	16.30	19.1	288.7	152.4	1.00	1.00	1.00	60	1.00	0.81	10	35	0.05	150	0.47	0.46	0.07	0.16	0.000	0.00	Non-Liq.
0.90	11	1.50	Silty Clay	16.20	7	17.70	18.8	315.3	165.2	1.00	1.00	1.00	60	1.00	0.78	5	35	0.02	150	0.46	0.45	0.05	0.11	0.000	0.00	Non-Liq.
a_{max} (g)	12	1.50	Medium sand	17.80	10	19.30	20.5	346.7	180.9	1.00	1.00	1.00	60	1.00	0.74	7	35	0.04	150	0.45	0.44	0.06	0.13	1.000	0.11	6.82
0.789	13	1.50	Medium sand	19.20	19	20.70	19.9	375.0	195.5	1.00	1.00	1.00	60	1.00	0.72	14	35	0.02	175	0.44	0.44	0.10	0.22	1.000	0.04	13.62
Sampler[b]	14	1.50	Medium sand	20.80	12	22.30	20.3	407.1	211.9	1.00	1.00	1.00	60	1.00	0.69	8	35	0.02	150	0.44	0.43	0.06	0.14	1.000	0.00	7.73
NA	15	1.50	Medium sand	22.20	18	23.70	19.7	435.1	226.2	1.00	1.00	1.00	60	1.00	0.66	12	35	0.02	175	0.43	0.43	0.08	0.19	1.000	0.00	11.86
B.H. Diam. (mm)	16	1.50	Medium sand	23.80	14	25.30	20.0	466.9	242.2	1.00	1.00	1.00	60	1.00	0.64	9	35	0.05	150	0.42	0.42	0.06	0.15	1.000	0.00	8.57
95	17	1.50	Medium sand	25.20	68	26.70	20.6	495.3	256.9	1.00	1.00	1.00	60	1.00	0.62	42	35	0.08	225	0.42	0.41	1.05	2.54	0.000	0.00	45.72
Energy Ratio[c]	18	1.50	Medium sand	26.80	22	28.30	20.5	528.1	274.0	1.00	1.00	1.00	60	1.00	0.60	13	35	0.03	175	0.41	0.40	0.09	0.21	1.000	0.00	13.30
60	19	1.50	Medium sand	28.20	12	29.70	19.9	556.4	288.6	1.00	1.00	1.00	60	1.00	0.59	7	35	0.03	150	0.40	0.40	0.05	0.12	1.000	0.00	6.43
N (mean)	20	1.60	Medium sand	29.80	14	31.30	19.8	588.1	304.6	1.00	1.00	1.00	60	1.00	0.57	8	35	0.03	150	0.40	0.39	0.05	0.13	1.000	0.00	7.48
13.5	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
156	25																									
Observed (cm)	26																									
	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	29.70																							7.95	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Chi Chi 1999	1	1.40	Silty Sand	1.20	4	2.70	18.3	20.0	14.1	1.00	0.75	1.00	60	1.00	2.00	5	35	0.02	150	0.98	0.17	0.10	0.57	0.961	0.94	4.92
Mw	2	1.50	Silty Sand	2.80	3	4.30	18.9	49.7	28.2	1.00	0.85	1.00	60	1.00	1.88	5	35	0.08	150	0.94	0.21	0.08	0.38	1.000	0.86	4.61
7.6	3	1.50	Silty Sand	4.20	3	5.70	18.3	75.8	40.5	1.00	0.85	1.00	60	1.00	1.57	4	35	0.00	150	0.90	0.21	0.07	0.31	1.000	0.79	4.10
Site	4	1.50	Silty Clay	5.80	5	7.30	18.1	105.0	54.0	1.00	0.95	1.00	60	1.00	1.36	6	35	0.01	150	0.84	0.20	0.07	0.37	0.000	0.00	Non-Liq.
Yuanlin	5	1.50	Silty Clay	7.20	4	8.70	18.0	130.3	65.5	1.00	0.95	1.00	60	1.00	1.24	5	35	0.01	150	0.78	0.19	0.06	0.32	0.000	0.00	Non-Liq.
Data Class	6	1.50	Silty Sand	8.80	10	10.30	19.2	160.1	79.6	1.00	1.00	1.00	60	1.00	1.12	11	35	0.02	175	0.71	0.18	0.10	0.57	0.962	0.56	11.02
	7	1.50	Silty Sand	10.20	9	11.70	17.8	186.0	91.8	1.00	1.00	1.00	60	1.00	1.04	9	35	0.00	150	0.66	0.17	0.08	0.50	0.992	0.49	9.01
B. H.	8	1.50	Silty Sand	11.80	10	13.30	18.0	214.7	104.8	1.00	1.00	1.00	60	1.00	0.98	10	35	0.08	150	0.62	0.16	0.08	0.52	0.985	0.41	9.43
Y18	9	1.50	Silty Sand	13.20	10	14.70	19.5	241.0	117.4	1.00	1.00	1.00	60	1.00	0.92	9	30	0.12	150	0.59	0.15	0.07	0.49	0.994	0.34	8.41
GWT (m)	10	1.50	Silty Sand	14.80	22	16.30	20.9	273.3	134.0	1.00	1.00	1.00	60	1.00	0.86	19	8	2.30	175	0.57	0.14	0.13	0.91	0.290	0.26	16.22
0.60	11	1.50	Silty Sand	16.20	12	17.70	18.8	301.1	148.0	1.00	1.00	1.00	60	1.00	0.82	10	35	0.00	150	0.56	0.14	0.08	0.53	0.981	0.19	9.54
a_{max} (g)	12	1.50	Silty Clay	17.80	10	19.30	19.5	331.7	163.0	1.00	1.00	1.00	60	1.00	0.78	8	35	0.01	150	0.55	0.14	0.06	0.44	0.000	0.00	Non-Liq.
0.19	13	1.50	Silty Clay	19.20	11	20.70	20.2	359.5	177.0	1.00	1.00	1.00	60	1.00	0.75	8	35	0.01	150	0.55	0.14	0.06	0.45	0.000	0.00	Non-Liq.
Sampler[b]	14	1.50	Silty Clay	20.80	17	22.30	19.5	391.2	193.1	1.00	1.00	1.00	60	1.00	0.72	12	30	0.12	175	0.54	0.14	0.08	0.61	0.000	0.00	Non-Liq.
NA	15	1.50	Silty Clay	22.20	9	23.70	18.7	418.0	206.1	1.00	1.00	1.00	60	1.00	0.70	6	35	0.05	150	0.54	0.13	0.05	0.37	0.000	0.00	Non-Liq.
B.H. Diam. (mm)	16	1.50	Silty Sand	23.80	10	25.30	18.3	447.6	220.0	1.00	1.00	1.00	60	1.00	0.67	7	35	0.00	150	0.53	0.13	0.05	0.39	1.000	0.00	6.13
95	17	2.20	Silty Sand	25.20	12	26.70	20.2	474.6	233.3	1.00	1.00	1.00	60	1.00	0.65	8	35	0.08	150	0.52	0.13	0.06	0.42	0.999	0.00	7.29
Energy Ratio[c]	18	2.30	Silty Sand	28.20	28	29.70	22.1	537.9	267.2	1.00	1.00	1.00	60	1.00	0.61	17	20	0.34	175	0.51	0.13	0.10	0.82	0.474	0.00	15.74
60	19	1.60	Silty Sand	29.80	21	31.30	19.3	571.0	284.6	1.00	1.00	1.00	60	1.00	0.59	12	15	0.20	175	0.50	0.12	0.07	0.54	0.977	0.00	10.46
N (mean)	20																									
11.0	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
155	25																									
Observed (cm)	26																									
	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	30.00																							6.78	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N^d	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Chi Chi 1999	1	1.29	Silty Sand	1.20	2	2.70	19.8	20.4	15.5	1.00	0.75	1.00	60	1.00	2.00	3	7	0.52	125	0.98	0.16	0.07	0.43	0.999	0.94	2.82
Mw	2	1.50	Silty Sand	2.80	4	4.30	18.7	51.2	30.7	1.00	0.85	1.00	60	1.00	1.81	6	35	0.01	150	0.95	0.19	0.08	0.44	0.999	0.86	5.61
7.6	3	2.10	Silty Sand	4.20	9	5.70	26.5	82.8	48.5	1.00	0.85	1.00	60	1.00	1.44	11	35	0.07	175	0.90	0.19	0.11	0.59	0.938	0.79	10.77
Site	4	2.30	Silty Clay	7.00	9	8.50	19.3	146.9	85.2	1.00	0.95	1.00	60	1.00	1.08	9	35	0.01	150	0.79	0.17	0.08	0.49	0.000	0.00	Non-Liq.
Yuanlin	5	2.40	Silty Sand	8.80	6	10.30	20.1	182.3	103.0	1.00	1.00	1.00	60	1.00	0.99	6	35	0.02	150	0.72	0.16	0.06	0.38	1.000	0.56	5.43
Data Class	6	2.20	Silty Sand	11.80	6	13.30	17.5	238.8	130.0	1.00	1.00	1.00	60	1.00	0.88	5	35	0.05	150	0.62	0.14	0.05	0.37	1.000	0.41	4.93
	7	1.50	Silty Sand	13.20	9	14.70	18.5	264.0	141.5	1.00	1.00	1.00	60	1.00	0.84	8	35	0.06	150	0.60	0.14	0.06	0.46	0.998	0.34	6.97
B. H.	8	1.65	Silty Sand	14.80	11	16.30	19.5	294.4	156.2	1.00	1.00	1.00	60	1.00	0.80	9	11	0.22	150	0.58	0.13	0.06	0.43	0.999	0.26	6.38
Y21	9	1.50	Silty Sand	16.50	8	18.00	18.6	326.8	171.9	1.00	1.00	1.00	60	1.00	0.76	6	35	0.01	150	0.56	0.13	0.05	0.40	1.000	0.18	5.58
GWT (m)	10	1.35	Silty Clay	17.80	13	19.30	19.7	351.7	184.1	1.00	1.00	1.00	60	1.00	0.74	10	35	0.01	150	0.56	0.13	0.07	0.53	0.000	0.00	Non-Liq.
0.71	11	1.50	Silty Clay	19.20	8	20.70	19.9	379.5	198.1	1.00	1.00	1.00	60	1.00	0.71	6	35	0.01	150	0.55	0.13	0.05	0.37	0.000	0.00	Non-Liq.
a_{max} (g)	12	1.50	Silty Clay	20.80	15	22.30	26.2	416.3	219.2	1.00	1.00	1.00	60	1.00	0.68	10	26	0.24	175	0.55	0.13	0.06	0.51	0.000	0.00	Non-Liq.
0.19	13	1.50	Silty Clay	22.20	17	23.70	20.1	448.7	237.9	1.00	1.00	1.00	60	1.00	0.65	11	24	0.22	175	0.54	0.13	0.07	0.54	0.000	0.00	Non-Liq.
Sampler[b]	14	1.50	Silty Sand	23.80	18	25.30	20.0	480.7	254.2	1.00	1.00	1.00	60	1.00	0.63	11	8	0.22	175	0.53	0.12	0.06	0.49	0.994	0.00	8.61
NA	15	1.50	Silty Sand	25.20	19	26.70	20.5	509.1	268.8	1.00	1.00	1.00	60	1.00	0.61	12	10	0.36	175	0.53	0.12	0.06	0.50	0.991	0.00	9.10
B.H. Diam. (mm)	16	1.50	Silty Sand	26.80	22	28.30	20.6	541.9	286.0	1.00	1.00	1.00	60	1.00	0.59	13	20	0.14	175	0.52	0.12	0.07	0.60	0.927	0.00	11.53
95	17	1.50	Silty Sand	28.20	22	29.70	20.5	570.7	301.0	1.00	1.00	1.00	60	1.00	0.58	13	20	0.17	175	0.51	0.12	0.07	0.59	0.945	0.00	11.19
Energy Ratio[c]	18	1.60	Silty Sand	29.80	11	31.30	18.6	602.0	316.6	1.00	1.00	1.00	60	1.00	0.56	6	35	0.01	150	0.50	0.12	0.04	0.38	1.000	0.00	5.65
60	19																									
N (mean)	20																									
11.6	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
156	25																									
Observed (cm)	26																									
	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	29.89																							7.50	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Chi Chi 1999	1	2.70	Silty Sand	2.80	7	4.30	18.1	48.3	28.6	1.00	0.85	1.00	60	1.00	1.87	11	35	0.01	175	0.95	0.20	0.13	0.67	0.834	0.86	10.93
Mw	2	1.50	Silty Sand	4.20	4	5.70	18.1	73.6	40.3	1.00	0.85	1.00	60	1.00	1.58	5	35	0.01	150	0.92	0.21	0.07	0.35	1.000	0.79	5.00
7.6	3	1.50	Silty Clay	5.80	6	7.30	19.4	103.7	54.6	1.00	0.95	1.00	60	1.00	1.35	8	35	0.05	150	0.86	0.20	0.08	0.41	0.000	0.00	Non-Liq.
Site	4	1.50	Silty Clay	7.20	4	8.70	18.1	129.9	67.2	1.00	0.95	1.00	60	1.00	1.22	5	35	0.01	150	0.81	0.19	0.06	0.31	0.000	0.00	Non-Liq.
Yuanlin	5	1.50	Silty Sand	8.80	10	10.30	19.1	159.7	81.3	1.00	1.00	1.00	60	1.00	1.11	11	35	0.00	175	0.74	0.18	0.10	0.55	0.974	0.56	10.90
Data Class	6	1.50	Silty Sand	10.20	11	11.70	18.5	186.1	93.9	1.00	1.00	1.00	60	1.00	1.03	11	35	0.01	175	0.69	0.17	0.10	0.57	0.959	0.49	11.19
	7	2.30	Silty Sand	11.80	12	13.30	20.8	217.5	109.6	1.00	1.00	1.00	60	1.00	0.96	11	13	0.30	175	0.65	0.16	0.08	0.50	0.991	0.41	9.26
B. H.	8	3.00	Silty Sand	14.80	11	16.30	19.3	277.6	140.3	1.00	1.00	1.00	60	1.00	0.84	9	35	0.03	150	0.60	0.15	0.07	0.50	0.992	0.26	8.89
Y25	9	2.20	Silty Clay	17.80	14	19.30	19.9	336.4	169.7	1.00	1.00	1.00	60	1.00	0.77	11	35	0.01	175	0.57	0.14	0.08	0.56	0.000	0.00	Non-Liq.
GWT (m)	10	1.50	Silty Clay	19.20	13	20.70	21.2	365.2	184.7	1.00	1.00	1.00	60	1.00	0.74	10	35	0.06	150	0.57	0.14	0.07	0.50	0.000	0.00	Non-Liq.
0.80	11	1.50	Silty Clay	20.80	17	22.30	19.4	397.6	201.4	1.00	1.00	1.00	60	1.00	0.70	12	35	0.09	175	0.56	0.14	0.08	0.60	0.000	0.00	Non-Liq.
a_{max} (g)	12	1.50	Silty Clay	22.20	12	23.70	18.6	424.3	214.3	1.00	1.00	1.00	60	1.00	0.68	8	35	0.01	150	0.56	0.14	0.06	0.43	0.000	0.00	Non-Liq.
0.19	13	1.50	Silty Sand	23.80	13	25.30	20.2	455.3	229.7	1.00	1.00	1.00	60	1.00	0.66	9	35	0.03	150	0.55	0.13	0.06	0.44	0.999	0.00	8.10
Sampler[b]	14	1.50	Silty Sand	25.20	16	26.70	19.1	482.8	243.4	1.00	1.00	1.00	60	1.00	0.64	10	35	0.01	175	0.54	0.13	0.07	0.51	0.989	0.00	9.97
NA	15	1.50	Silty Sand	26.80	20	28.30	19.7	513.9	258.8	1.00	1.00	1.00	60	1.00	0.62	12	12	0.19	175	0.54	0.13	0.07	0.51	0.988	0.00	10.15
B.H. Diam. (mm)	16	1.50	Silty Sand	28.20	18	29.70	20.5	542.0	273.2	1.00	1.00	1.00	60	1.00	0.61	11	12	0.27	175	0.53	0.13	0.06	0.45	0.998	0.00	8.58
95	17	1.60	Silty Sand	29.80	21	31.30	20.0	574.4	289.9	1.00	1.00	1.00	60	1.00	0.59	12	12	0.21	175	0.52	0.13	0.06	0.51	0.989	0.00	10.05
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
12.3	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
163	25																									
Observed (cm)	26																									
	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	29.80																							6.35	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N^d	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Chi Chi 1999	1	1.00	Silty Sand	1.20	3	2.70	18.0	18.6	16.6	1.00	0.75	1.00	60	1.00	2.00	5	35	0.02	150	0.98	0.14	0.09	0.64	0.872	0.94	4.41
Mw	2	1.50	Silty Sand	2.80	4	4.30	20.4	49.3	31.7	1.00	0.85	1.00	60	1.00	1.78	6	19	0.18	150	0.95	0.18	0.08	0.42	0.999	0.86	4.74
7.6	3	1.50	Silty Sand	4.20	6	5.70	19.1	77.0	45.6	1.00	0.85	1.00	60	1.00	1.48	8	35	0.06	150	0.90	0.19	0.09	0.45	0.998	0.79	6.95
Site	4	1.50	Silty Clay	5.80	5	7.30	19.3	107.7	60.6	1.00	0.95	1.00	60	1.00	1.28	6	35	0.06	150	0.84	0.19	0.07	0.38	0.000	0.00	Non-Liq.
Yuanlin	5	1.50	Silty Clay	7.20	9	8.70	19.8	135.1	74.3	1.00	0.95	1.00	60	1.00	1.16	10	35	0.06	150	0.79	0.18	0.09	0.52	0.000	0.00	Non-Liq.
Data Class	6	1.50	Silty Sand	8.80	9	10.30	19.6	166.6	90.1	1.00	1.00	1.00	60	1.00	1.05	9	35	0.04	150	0.72	0.16	0.08	0.51	0.989	0.56	9.11
	7	1.50	Silty Sand	10.20	9	11.70	19.1	193.7	103.5	1.00	1.00	1.00	60	1.00	0.98	9	35	0.02	150	0.67	0.15	0.08	0.49	0.993	0.49	8.40
B. H.	8	1.50	Silty Sand	11.80	10	13.30	18.1	223.5	117.5	1.00	1.00	1.00	60	1.00	0.92	9	35	0.03	150	0.63	0.15	0.08	0.52	0.987	0.41	8.82
Y26	9	1.50	Silty Sand	13.20	10	14.70	18.5	249.1	129.5	1.00	1.00	1.00	60	1.00	0.88	9	35	0.04	150	0.60	0.14	0.07	0.50	0.991	0.34	8.34
GWT (m)	10	1.50	Silty Sand	14.80	8	16.30	19.5	279.6	144.2	1.00	1.00	1.00	60	1.00	0.83	7	35	0.08	150	0.58	0.14	0.06	0.42	0.999	0.26	6.06
1.00	11	1.50	Silty Sand	16.20	10	17.70	19.5	306.9	157.7	1.00	1.00	1.00	60	1.00	0.80	8	30	0.10	150	0.57	0.14	0.06	0.45	0.998	0.19	7.01
a_{max} (g)	12	1.50	Silty Clay	17.80	13	19.30	19.8	338.3	173.5	1.00	1.00	1.00	60	1.00	0.76	10	35	0.00	150	0.56	0.13	0.07	0.54	0.000	0.00	Non-Liq.
0.19	13	1.50	Silty Clay	19.20	16	20.70	18.8	365.3	186.8	1.00	1.00	1.00	60	1.00	0.73	12	35	0.00	175	0.55	0.13	0.08	0.62	0.000	0.00	Non-Liq.
Sampler[b]	14	1.50	Silty Clay	20.80	14	22.30	20.3	396.6	202.4	1.00	1.00	1.00	60	1.00	0.70	10	35	0.04	150	0.55	0.13	0.07	0.52	0.000	0.00	Non-Liq.
NA	15	1.50	Silty Clay	22.20	15	23.70	21.2	425.6	217.7	1.00	1.00	1.00	60	1.00	0.68	10	35	0.04	175	0.54	0.13	0.07	0.53	0.000	0.00	Non-Liq.
B.H. Diam. (mm)	16	1.50	Silty Sand	23.80	16	25.30	20.3	458.8	235.1	1.00	1.00	1.00	60	1.00	0.65	10	35	0.07	175	0.53	0.13	0.07	0.54	0.977	0.00	10.17
95	17	1.50	Silty Sand	25.20	16	26.70	21.4	487.9	250.5	1.00	1.00	1.00	60	1.00	0.63	10	35	0.05	175	0.53	0.13	0.07	0.52	0.984	0.00	9.81
Energy Ratio[c]	18	1.50	Silty Sand	26.80	17	28.30	19.8	520.9	267.8	1.00	1.00	1.00	60	1.00	0.61	10	35	0.05	175	0.52	0.12	0.07	0.53	0.980	0.00	10.12
60	19	1.50	Silty Sand	28.20	24	29.70	21.1	549.5	282.6	1.00	1.00	1.00	60	1.00	0.59	14	12	0.40	175	0.51	0.12	0.08	0.62	0.908	0.00	12.02
N (mean)	20	1.60	Silty Sand	29.80	19	31.30	21.1	583.2	300.7	1.00	1.00	1.00	60	1.00	0.58	11	9	0.29	175	0.51	0.12	0.06	0.47	0.997	0.00	8.37
11.7	21																630	1.62								
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
157	25																									
Observed (cm)	26																									
	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	29.60																							6.64	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Chi Chi 1999	1	1.20	Silty Sand	2.80	2	4.30	19.1	44.1	39.2	1.00	0.85	1.00	60	1.00	1.60	2	35	0.01	125	0.94	0.13	0.06	0.43	0.999	0.86	3.06
Mw	2	1.50	Silty Sand	4.20	4	5.70	19.9	71.4	52.7	1.00	0.85	1.00	60	1.00	1.38	4	31	0.13	150	0.89	0.15	0.06	0.40	1.000	0.79	4.01
7.6	3	1.50	Silty Clay	5.80	5	7.30	18.5	102.1	67.8	1.00	0.95	1.00	60	1.00	1.21	5	35	0.10	150	0.83	0.15	0.06	0.41	0.000	0.00	Non-Liq.
Site	4	1.50	Silty Clay	7.20	4	8.70	18.5	128.0	80.0	1.00	0.95	1.00	60	1.00	1.12	4	35	0.07	125	0.76	0.15	0.05	0.35	0.000	0.00	Non-Liq.
Yuanlin	5	1.50	Silty Sand	8.80	3	10.30	18.8	157.9	94.1	1.00	1.00	1.00	60	1.00	1.03	3	35	0.03	125	0.70	0.14	0.05	0.33	1.000	0.56	3.58
Data Class	6	1.50	Silty Sand	10.20	6	11.70	19.8	184.9	107.4	1.00	1.00	1.00	60	1.00	0.96	5	31	0.12	150	0.65	0.14	0.05	0.40	1.000	0.49	4.78
	7	2.30	Silty Sand	11.80	6	13.30	19.8	216.6	123.4	1.00	1.00	1.00	60	1.00	0.90	5	35	0.05	150	0.61	0.13	0.05	0.41	1.000	0.41	5.03
B. H.	8	2.20	Silty Sand	14.80	18	16.30	20.8	277.5	154.8	1.00	1.00	1.00	60	1.00	0.80	14	9	0.24	175	0.56	0.12	0.09	0.72	0.723	0.26	11.90
Y28	9	1.50	Silty Sand	16.20	18	17.70	20.8	306.5	170.2	1.00	1.00	1.00	60	1.00	0.77	14	9	0.48	175	0.55	0.12	0.08	0.67	0.817	0.19	11.23
GWT (m)	10	1.50	Silty Clay	17.80	17	19.30	20.7	339.7	187.6	1.00	1.00	1.00	60	1.00	0.73	12	8	0.50	175	0.54	0.12	0.07	0.59	0.000	0.00	Non-Liq.
2.30	11	1.50	Silty Clay	19.20	13	20.70	19.9	368.1	202.3	1.00	1.00	1.00	60	1.00	0.70	9	35	0.01	150	0.54	0.12	0.06	0.54	0.000	0.00	Non-Liq.
a_{max} (g)	12	1.50	Silty Clay	20.80	14	22.30	20.3	400.2	218.8	1.00	1.00	1.00	60	1.00	0.68	9	35	0.07	150	0.53	0.12	0.07	0.54	0.000	0.00	Non-Liq.
0.19	13	1.50	Silty Clay	22.20	16	23.70	20.3	428.6	233.4	1.00	1.00	1.00	60	1.00	0.65	10	35	0.08	175	0.53	0.12	0.07	0.59	0.000	0.00	Non-Liq.
Sampler[b]	14	1.50	Silty Sand	23.80	16	25.30	21.4	462.0	251.1	1.00	1.00	1.00	60	1.00	0.63	10	7	0.82	175	0.52	0.12	0.05	0.46	0.997	0.00	7.32
NA	15	1.50	Silty Sand	25.20	16	26.70	21.6	492.0	267.4	1.00	1.00	1.00	60	1.00	0.61	10	6	0.70	150	0.51	0.12	0.05	0.45	0.998	0.00	6.91
B.H. Diam. (mm)	16	1.50	Silty Sand	26.80	19	28.30	21.2	526.2	285.9	1.00	1.00	1.00	60	1.00	0.59	11	9	0.38	175	0.51	0.11	0.06	0.51	0.989	0.00	8.65
95	17	1.50	Silty Sand	28.20	24	29.70	19.9	554.9	300.9	1.00	1.00	1.00	60	1.00	0.58	14	8	0.40	175	0.50	0.11	0.07	0.62	0.911	0.00	11.17
Energy Ratio[c]	18	1.60	Silty Sand	29.80	16	31.30	19.5	586.5	316.7	1.00	1.00	1.00	60	1.00	0.56	9	35	0.01	150	0.49	0.11	0.06	0.50	0.991	0.00	8.56
60	19																									
N (mean)	20																									
11.9	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
151	25																									
Observed (cm)	26																									
	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	28.30																							5.38	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Chi Chi 1999	1	1.20	Silty Sand	2.20	6	3.70	21.0	34.2	32.2	1.00	0.75	1.00	60	1.00	1.76	8	15	0.37	150	0.96	0.13	0.09	0.69	0.797	0.89	5.91
Mw	2	1.80	Silty Sand	4.20	3	5.70	18.6	73.8	52.2	1.00	0.85	1.00	60	1.00	1.38	4	35	0.01	125	0.90	0.16	0.06	0.37	1.000	0.79	3.82
7.6	3	1.50	Silty Clay	5.80	4	7.30	19.1	104.0	66.7	1.00	0.95	1.00	60	1.00	1.22	5	35	0.07	150	0.84	0.16	0.06	0.37	0.000	0.00	Non-Liq.
Site	4	1.50	Silty Clay	7.20	11	8.70	20.5	131.7	80.7	1.00	0.95	1.00	60	1.00	1.11	12	9	0.49	175	0.78	0.16	0.09	0.55	0.000	0.00	Non-Liq.
Yuanlin	5	1.50	Silty Sand	8.80	6	10.30	18.7	163.0	96.3	1.00	1.00	1.00	60	1.00	1.02	6	35	0.01	150	0.71	0.15	0.06	0.41	1.000	0.56	5.59
Data Class	6	1.50	Silty Sand	10.20	13	11.70	18.9	189.4	108.9	1.00	1.00	1.00	60	1.00	0.96	12	34	0.12	175	0.66	0.14	0.10	0.71	0.740	0.49	12.30
	7	1.50	Silty Sand	11.80	21	13.30	20.5	220.9	124.8	1.00	1.00	1.00	60	1.00	0.90	19	18	0.45	175	0.62	0.14	0.14	1.06	0.090	0.41	37.96
B. H.	8	1.50	Silty Sand	13.20	24	14.70	21.2	250.1	140.2	1.00	1.00	1.00	60	1.00	0.84	20	7	0.65	200	0.59	0.13	0.14	1.08	0.078	0.34	37.99
Y29	9	1.50	Silty Sand	14.80	26	16.30	21.9	284.5	159.0	1.00	1.00	1.00	60	1.00	0.79	21	20	0.40	200	0.57	0.13	0.16	1.26	0.015	0.26	38.55
GWT (m)	10	1.50	Silty Sand	16.20	18	17.70	21.4	314.8	175.5	1.00	1.00	1.00	60	1.00	0.75	14	10	0.55	175	0.56	0.12	0.08	0.65	0.858	0.19	11.13
2.00	11	1.50	Silty Clay	17.80	23	19.30	21.3	348.9	193.9	1.00	1.00	1.00	60	1.00	0.72	17	6	0.69	175	0.55	0.12	0.10	0.78	0.000	0.00	Non-Liq.
a_{max} (g)	12	1.50	Silty Clay	19.20	11	20.70	20.6	378.2	209.4	1.00	1.00	1.00	60	1.00	0.69	8	29	0.18	150	0.55	0.12	0.05	0.44	0.000	0.00	Non-Liq.
0.19	13	1.50	Silty Clay	20.80	11	22.30	19.5	410.2	225.8	1.00	1.00	1.00	60	1.00	0.67	7	35	0.04	150	0.54	0.12	0.05	0.44	0.000	0.00	Non-Liq.
Sampler[b]	14	1.50	Silty Clay	22.20	12	23.70	20.3	438.1	239.9	1.00	1.00	1.00	60	1.00	0.65	8	35	0.04	150	0.54	0.12	0.05	0.45	0.000	0.00	Non-Liq.
NA	15	1.50	Silty Sand	23.80	14	25.30	20.3	470.5	256.7	1.00	1.00	1.00	60	1.00	0.62	9	35	0.05	150	0.53	0.12	0.06	0.49	0.994	0.00	8.28
B.H. Diam. (mm)	16	1.50	Silty Sand	25.20	9	26.70	18.0	497.4	269.8	1.00	1.00	1.00	60	1.00	0.61	5	35	0.00	150	0.52	0.12	0.04	0.37	1.000	0.00	5.09
95	17	1.50	Silty Sand	26.80	9	28.30	19.4	527.3	284.0	1.00	1.00	1.00	60	1.00	0.59	5	35	0.01	150	0.52	0.12	0.04	0.36	1.000	0.00	4.99
Energy Ratio[c]	18	1.50	Silty Sand	28.20	12	29.70	18.7	554.0	297.0	1.00	1.00	1.00	60	1.00	0.58	7	35	0.02	150	0.51	0.12	0.05	0.41	1.000	0.00	6.34
60	19	1.60	Silty Sand	29.80	13	31.30	18.8	584.0	311.3	1.00	1.00	1.00	60	1.00	0.57	7	35	0.01	150	0.50	0.12	0.05	0.42	0.999	0.00	6.74
N (mean)	20																									
12.9	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
155	25																									
Observed (cm)	26																									
	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	28.60																							4.00	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N^d	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Chi Chi 1999	1	1.90	Silty Sand	2.20	4	3.70	18.8	37.2	26.4	1.00	0.75	1.00	60	1.00	1.95	5	35	0.06	150	0.97	0.17	0.08	0.48	0.995	0.89	4.82
Mw	2	1.50	Silty Sand	3.80	6	5.30	19.5	67.9	41.4	1.00	0.85	1.00	60	1.00	1.55	8	17	0.17	150	0.93	0.19	0.08	0.43	0.999	0.81	6.04
7.6	3	1.50	Silty Clay	5.20	6	6.70	20.0	95.5	55.3	1.00	0.95	1.00	60	1.00	1.35	8	35	0.07	150	0.88	0.19	0.08	0.44	0.000	0.00	Non-Liq.
Site	4	1.50	Silty Clay	6.80	7	8.30	21.3	128.5	72.6	1.00	0.95	1.00	60	1.00	1.17	8	15	0.35	150	0.82	0.18	0.07	0.38	0.000	0.00	Non-Liq.
Yuanlin	5	1.50	Silty Clay	8.20	12	9.70	21.5	158.4	88.8	1.00	0.95	1.00	60	1.00	1.06	12	15	0.25	175	0.76	0.17	0.09	0.54	0.000	0.00	Non-Liq.
Data Class	6	1.50	Silty Sand	9.80	11	11.30	18.3	190.2	104.9	1.00	1.00	1.00	60	1.00	0.98	11	35	0.00	175	0.70	0.16	0.09	0.57	0.962	0.51	10.51
	7	1.50	Silty Sand	11.20	17	12.70	20.5	217.4	118.3	1.00	1.00	1.00	60	1.00	0.92	16	20	0.15	175	0.66	0.15	0.12	0.77	0.600	0.44	14.22
B. H.	8	1.50	Silty Sand	12.80	22	14.30	20.4	250.1	135.3	1.00	1.00	1.00	60	1.00	0.86	19	7	0.90	175	0.62	0.14	0.13	0.90	0.299	0.36	16.01
Y30	9	1.50	Silty Sand	14.20	18	15.70	20.2	278.5	150.0	1.00	1.00	1.00	60	1.00	0.82	15	18	0.18	175	0.60	0.14	0.10	0.72	0.731	0.29	13.07
GWT (m)	10	1.50	Silty Sand	15.80	24	17.30	22.2	312.5	168.2	1.00	1.00	1.00	60	1.00	0.77	19	18	0.38	175	0.58	0.13	0.13	0.97	0.190	0.21	37.87
1.10	11	1.50	Silty Clay	17.20	22	18.70	22.5	343.8	185.9	1.00	1.00	1.00	60	1.00	0.73	16	10	0.52	175	0.57	0.13	0.10	0.74	0.000	0.00	Non-Liq.
a_{max} (g)	12	1.50	Silty Clay	18.80	17	20.30	17.7	376.0	202.4	1.00	1.00	1.00	60	1.00	0.70	12	35	0.00	175	0.57	0.13	0.08	0.63	0.000	0.00	Non-Liq.
0.19	13	1.50	Silty Clay	20.20	14	21.70	19.5	402.1	214.7	1.00	1.00	1.00	60	1.00	0.68	10	35	0.01	150	0.56	0.13	0.07	0.51	0.000	0.00	Non-Liq.
Sampler[b]	14	1.50	Silty Clay	21.80	11	23.30	20.2	433.8	230.8	1.00	1.00	1.00	60	1.00	0.66	7	35	0.06	150	0.56	0.13	0.05	0.41	0.000	0.00	Non-Liq.
NA	15	1.50	Silty Sand	23.20	9	24.70	18.2	460.7	243.9	1.00	1.00	1.00	60	1.00	0.64	6	35	0.05	150	0.55	0.13	0.05	0.36	1.000	0.00	5.31
B.H. Diam. (mm)	16	1.50	Silty Sand	24.80	12	26.30	21.3	492.3	259.8	1.00	1.00	1.00	60	1.00	0.62	7	35	0.00	150	0.54	0.13	0.05	0.41	1.000	0.00	6.83
95	17	1.50	Silty Sand	26.20	26	27.70	22.1	522.7	276.4	1.00	1.00	1.00	60	1.00	0.60	16	20	0.18	175	0.54	0.13	0.09	0.73	0.699	0.00	14.23
Energy Ratio[c]	18	1.80	Silty Sand	27.80	22	29.30	21.4	557.4	295.5	1.00	1.00	1.00	60	1.00	0.58	13	24	0.15	175	0.53	0.12	0.07	0.60	0.936	0.00	11.70
60	19	2.00	Silty Sand	29.80	23	31.30	21.6	600.3	318.8	1.00	1.00	1.00	60	1.00	0.56	13	16	0.37	175	0.52	0.12	0.07	0.56	0.964	0.00	11.00
N (mean)	20																									
14.9	21																460	3.85								
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
162	25																									
Observed (cm)	26																									
	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	29.70																							4.57	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Chi Chi 1999	1	1.20	Silty Sand	2.80	6	4.30	19.9	44.4	39.5	1.00	0.85	1.00	60	1.00	1.59	8	35	0.38	150	0.96	0.13	0.09	0.70	0.756	0.86	7.58
Mw	2	1.50	Silty Sand	4.20	9	5.70	20.4	72.6	54.0	1.00	0.85	1.00	60	1.00	1.36	10	26	0.16	175	0.92	0.15	0.10	0.64	0.876	0.79	9.34
7.6	3	1.50	Silty Clay	5.80	4	7.30	18.8	104.0	69.7	1.00	0.95	1.00	60	1.00	1.20	5	35	0.07	150	0.87	0.16	0.06	0.37	0.000	0.00	Non-Liq.
Site	4	2.10	Silty Clay	7.20	6	8.70	18.7	130.3	82.2	1.00	0.95	1.00	60	1.00	1.10	6	35	0.02	150	0.81	0.16	0.07	0.41	0.000	0.00	Non-Liq.
Yuanlin	5	3.15	Silty Sand	10.00	11	11.50	20.0	184.5	108.9	1.00	1.00	1.00	60	1.00	0.96	11	35	0.04	175	0.71	0.15	0.09	0.59	0.944	0.50	10.29
Data Class	6	2.75	Silty Sand	13.50	16	15.00	19.6	253.8	143.9	1.00	1.00	1.00	60	1.00	0.83	13	35	0.07	175	0.62	0.13	0.10	0.76	0.632	0.33	13.35
	7	1.65	Silty Sand	15.50	29	17.00	20.7	294.0	164.5	1.00	1.00	1.00	60	1.00	0.78	23	21	0.31	200	0.59	0.13	0.19	1.43	0.003	0.23	39.16
B. H.	8	1.35	Silty Sand	16.80	20	18.30	20.5	320.8	178.5	1.00	1.00	1.00	60	1.00	0.75	15	15	0.30	175	0.58	0.13	0.09	0.72	0.712	0.16	13.03
Y35	9	1.50	Silty Clay	18.20	12	19.70	19.9	349.1	193.1	1.00	1.00	1.00	60	1.00	0.72	9	8	0.20	150	0.58	0.13	0.05	0.41	0.000	0.00	Non-Liq.
GWT (m)	10	2.30	Silty Clay	19.80	20	21.30	19.9	380.9	209.2	1.00	1.00	1.00	60	1.00	0.69	14	35	0.01	175	0.57	0.13	0.10	0.75	0.000	0.00	Non-Liq.
2.30	11	2.20	Silty Sand	22.80	19	24.30	19.3	439.7	238.6	1.00	1.00	1.00	60	1.00	0.65	12	35	0.04	175	0.56	0.13	0.08	0.64	0.880	0.00	12.22
a_{max} (g)	12	2.00	Silty Sand	24.20	15	25.70	20.2	467.3	252.5	1.00	1.00	1.00	60	1.00	0.63	9	35	0.02	150	0.55	0.13	0.06	0.48	0.995	0.00	8.71
0.19	13	2.80	Silty Sand	26.80	18	28.30	18.0	517.0	276.7	1.00	1.00	1.00	60	1.00	0.60	11	35	0.00	175	0.54	0.12	0.07	0.55	0.972	0.00	10.60
Sampler[b]	14	3.00	Silty Sand	29.80	33	31.30	19.4	573.2	303.4	1.00	1.00	1.00	60	1.00	0.57	19	9	0.37	175	0.53	0.12	0.10	0.85	0.397	0.00	16.28
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
15.5	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
164	25																									
Observed (cm)	26																									
	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	29.00																							4.03	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Chi Chi 1999	1	1.50	Silty Sand	1.20	1	2.70	17.6	19.8	13.0	1.00	0.75	1.00	60	1.00	2.00	1	35	0.03	125	0.98	0.19	0.07	0.37	1.000	0.94	2.59
Mw	2	1.50	Silty Sand	2.80	4	4.30	16.9	47.4	24.9	1.00	0.85	1.00	60	1.00	2.00	6	35	0.03	150	0.95	0.22	0.09	0.39	1.000	0.86	5.46
7.6	3	1.50	Silty Sand	4.20	3	5.70	18.1	71.9	35.6	1.00	0.85	1.00	60	1.00	1.68	4	35	0.01	150	0.91	0.23	0.07	0.30	1.000	0.79	4.26
Site	4	1.50	Silty Clay	5.80	3	7.30	17.9	100.8	48.8	1.00	0.95	1.00	60	1.00	1.43	4	35	0.02	150	0.86	0.22	0.06	0.29	0.000	0.00	Non-Liq.
Yuanlin	5	1.50	Silty Clay	7.20	5	8.70	16.8	125.1	59.3	1.00	0.95	1.00	60	1.00	1.30	6	35	0.01	150	0.80	0.21	0.07	0.34	0.000	0.00	Non-Liq.
Data Class	6	1.50	Silty Sand	8.80	6	10.30	18.5	153.3	71.9	1.00	1.00	1.00	60	1.00	1.18	7	35	0.01	150	0.74	0.19	0.07	0.37	1.000	0.56	6.44
	7	1.50	Silty Sand	10.20	14	11.70	20.3	180.5	85.3	1.00	1.00	1.00	60	1.00	1.08	15	15	0.38	175	0.69	0.18	0.12	0.65	0.858	0.49	13.22
B. H.	8	1.50	Silty Sand	11.80	15	13.30	20.4	213.0	102.1	1.00	1.00	1.00	60	1.00	0.99	15	20	0.34	175	0.64	0.16	0.11	0.68	0.798	0.41	13.42
Y43	9	2.00	Silty Sand	13.20	20	14.70	20.4	241.5	116.9	1.00	1.00	1.00	60	1.00	0.92	18	10	0.65	175	0.61	0.16	0.13	0.85	0.399	0.34	15.96
GWT (m)	10	1.80	Silty Sand	15.80	23	17.30	21.5	295.9	145.8	1.00	1.00	1.00	60	1.00	0.83	19	12	0.60	175	0.58	0.15	0.13	0.92	0.271	0.21	16.72
0.50	11	1.20	Silty Sand	16.80	15	18.30	20.0	316.7	156.8	1.00	1.00	1.00	60	1.00	0.80	12	18	0.25	175	0.57	0.14	0.08	0.55	0.973	0.16	10.27
a_{max} (g)	12	1.50	Silty Clay	18.20	10	19.70	19.2	344.1	170.5	1.00	1.00	1.00	60	1.00	0.77	8	35	0.01	150	0.57	0.14	0.06	0.42	0.000	0.00	Non-Liq.
0.19	13	2.30	Silty Clay	19.80	11	21.30	18.1	374.0	184.6	1.00	1.00	1.00	60	1.00	0.74	8	35	0.04	150	0.56	0.14	0.06	0.43	0.000	0.00	Non-Liq.
Sampler[b]	14	2.70	Silty Sand	22.80	24	24.30	18.8	429.4	210.6	1.00	1.00	1.00	60	1.00	0.69	17	35	0.02	175	0.55	0.14	0.12	0.87	0.354	0.00	16.76
NA	15	2.70	Silty Sand	25.20	26	26.70	20.6	476.7	234.4	1.00	1.00	1.00	60	1.00	0.65	17	31	0.14	175	0.54	0.13	0.12	0.87	0.361	0.00	16.79
B.H. Diam. (mm)	16	3.00	Silty Sand	28.20	20	29.70	18.8	535.8	264.0	1.00	1.00	1.00	60	1.00	0.62	12	35	0.01	175	0.52	0.13	0.08	0.60	0.929	0.00	12.23
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
12.4	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
160	25																									
Observed (cm)	26																									
	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	29.20																							6.41	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Chi Chi 1999	1	2.10	Silty Sand	2.80	4	4.30	18.8	47.3	33.6	1.00	0.85	1.00	60	1.00	1.72	6	35	0.09	150	0.96	0.17	0.08	0.48	0.995	0.86	5.39
Mw	2	1.50	Silty Sand	4.20	4	5.70	17.6	72.9	45.4	1.00	0.85	1.00	60	1.00	1.48	5	35	0.02	150	0.93	0.18	0.07	0.38	1.000	0.79	4.78
7.6	3	1.50	Silty Clay	5.80	6	7.30	17.7	101.2	58.0	1.00	0.95	1.00	60	1.00	1.31	7	35	0.04	150	0.88	0.19	0.08	0.42	0.000	0.00	Non-Liq.
Site	4	1.50	Silty Clay	7.20	8	8.70	20.0	127.6	70.7	1.00	0.95	1.00	60	1.00	1.19	9	18	0.28	150	0.82	0.18	0.08	0.42	0.000	0.00	Non-Liq.
Yuanlin	5	1.50	Silty Sand	8.80	5	10.30	21.1	160.4	87.8	1.00	1.00	1.00	60	1.00	1.07	5	25	0.20	150	0.76	0.17	0.06	0.33	1.000	0.56	4.55
Data Class	6	1.50	Silty Sand	10.20	13	11.70	18.3	188.0	101.7	1.00	1.00	1.00	60	1.00	0.99	13	35	0.03	175	0.71	0.16	0.11	0.67	0.833	0.49	12.87
	7	1.50	Silty Sand	11.80	15	13.30	19.7	218.4	116.4	1.00	1.00	1.00	60	1.00	0.93	14	16	0.25	175	0.66	0.15	0.10	0.64	0.885	0.41	12.05
B. H.	8	1.50	Silty Sand	13.20	21	14.70	20.6	246.6	130.9	1.00	1.00	1.00	60	1.00	0.87	18	14	0.21	175	0.63	0.15	0.13	0.90	0.305	0.34	16.28
Y44	9	1.50	Silty Sand	14.80	18	16.30	20.1	279.2	147.7	1.00	1.00	1.00	60	1.00	0.82	15	13	0.42	175	0.61	0.14	0.10	0.67	0.818	0.26	12.66
GWT (m)	10	1.50	Silty Sand	16.20	22	17.70	20.1	307.3	162.1	1.00	1.00	1.00	60	1.00	0.79	17	10	0.42	175	0.60	0.14	0.11	0.79	0.542	0.19	14.78
1.40	11	1.50	Silty Clay	17.80	13	19.30	19.8	339.2	178.3	1.00	1.00	1.00	60	1.00	0.75	10	35	0.02	150	0.59	0.14	0.07	0.51	0.000	0.00	Non-Liq.
a_{max} (g)	12	2.20	Silty Clay	19.20	15	20.70	19.2	366.5	191.9	1.00	1.00	1.00	60	1.00	0.72	11	35	0.03	175	0.58	0.14	0.08	0.56	0.000	0.00	Non-Liq.
0.19	13	3.00	Silty Clay	22.20	13	23.70	19.8	425.0	220.9	1.00	1.00	1.00	60	1.00	0.67	9	35	0.02	150	0.57	0.14	0.06	0.45	0.000	0.00	Non-Liq.
Sampler[b]	14	3.80	Silty Sand	25.20	18	26.70	18.2	482.0	248.6	1.00	1.00	1.00	60	1.00	0.63	11	35	0.01	175	0.55	0.13	0.07	0.56	0.966	0.00	11.25
NA	15	4.60	Silty Sand	29.80	96	31.30	21.8	574.0	295.4	1.00	1.00	1.00	60	1.00	0.58	56	35	0.04	225	0.53	0.13	3.18	24.86	0.000	0.00	49.81
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
18.1	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
167	25																									
Observed (cm)	26																									
	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	30.70																							5.61	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Chi Chi 1999	1	2.20	Silty Sand	2.80	4	4.30	18.3	47.0	32.3	1.00	0.85	1.00	60	1.00	1.76	6	35	0.03	150	0.95	0.17	0.08	0.48	0.995	0.86	5.49
Mw	2	1.50	Silty Sand	4.20	4	5.70	17.9	72.4	43.9	1.00	0.85	1.00	60	1.00	1.51	5	35	0.05	150	0.91	0.18	0.07	0.38	1.000	0.79	4.84
7.6	3	1.50	Silty Clay	5.80	4	7.30	18.1	101.2	57.1	1.00	0.95	1.00	60	1.00	1.32	5	35	0.02	150	0.85	0.19	0.06	0.35	0.000	0.00	Non-Liq.
Site	4	2.50	Silty Clay	7.20	5	8.70	18.8	127.1	69.2	1.00	0.95	1.00	60	1.00	1.20	6	28	0.10	150	0.79	0.18	0.06	0.35	0.000	0.00	Non-Liq.
Yuanlin	5	2.30	Silty Sand	10.80	14	12.30	18.0	193.4	100.2	1.00	1.00	1.00	60	1.00	1.00	14	35	0.01	175	0.66	0.16	0.12	0.76	0.616	0.46	14.05
Data Class	6	1.20	Silty Sand	11.80	15	13.30	18.4	211.6	108.6	1.00	1.00	1.00	60	1.00	0.96	14	35	0.06	175	0.63	0.15	0.12	0.80	0.532	0.41	14.48
	7	1.50	Silty Sand	13.20	14	14.70	18.9	237.8	121.0	1.00	1.00	1.00	60	1.00	0.91	13	35	0.08	175	0.60	0.15	0.10	0.70	0.774	0.34	12.69
B. H.	8	1.50	Silty Sand	14.80	21	16.30	19.2	268.3	135.8	1.00	1.00	1.00	60	1.00	0.86	18	9	0.59	175	0.58	0.14	0.12	0.86	0.381	0.26	15.38
Y45	9	1.50	Silty Sand	16.20	23	17.70	20.7	296.2	150.0	1.00	1.00	1.00	60	1.00	0.82	19	11	0.59	175	0.57	0.14	0.13	0.93	0.256	0.19	16.35
GWT (m)	10	1.50	Silty Clay	17.80	11	19.30	19.1	328.0	166.2	1.00	1.00	1.00	60	1.00	0.78	9	35	0.01	150	0.56	0.14	0.07	0.48	0.000	0.00	Non-Liq.
1.30	11	2.20	Silty Clay	19.20	16	20.70	17.6	353.7	178.1	1.00	1.00	1.00	60	1.00	0.75	12	35	0.05	175	0.56	0.14	0.09	0.63	0.000	0.00	Non-Liq.
a_{max} (g)	12	2.30	Silty Clay	22.20	13	23.70	19.3	409.2	204.1	1.00	1.00	1.00	60	1.00	0.70	9	24	0.23	150	0.54	0.13	0.06	0.45	0.000	0.00	Non-Liq.
0.19	13	1.60	Silty Sand	23.80	8	25.30	18.1	439.1	218.4	1.00	1.00	1.00	60	1.00	0.68	5	35	0.01	150	0.54	0.13	0.05	0.35	1.000	0.00	5.04
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
11.7	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
158	25																									
Observed (cm)	26																									
	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	23.30																							4.60	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Chi Chi 1999	1	1.00	Silty Sand	1.20	24	2.70	21.9	19.4	17.4	1.00	0.75	1.00	60	1.00	2.00	36	35	0.30	225	0.98	0.13	1.28	9.47	0.000	0.94	43.76
Mw	2	1.50	Silty Sand	2.80	5	4.30	19.0	52.1	34.4	1.00	0.85	1.00	60	1.00	1.70	7	35	0.13	150	0.95	0.18	0.09	0.51	0.989	0.86	6.60
7.6	3	1.50	Silty Sand	4.20	4	5.70	18.2	78.1	46.7	1.00	0.85	1.00	60	1.00	1.46	5	35	0.01	150	0.90	0.19	0.07	0.37	1.000	0.79	4.73
Site	4	1.50	Silty Clay	5.80	3	7.30	18.8	107.8	60.7	1.00	0.95	1.00	60	1.00	1.28	4	35	0.03	125	0.84	0.18	0.06	0.31	0.000	0.00	Non-Liq.
Yuanlin	5	1.50	Silty Clay	7.20	2	8.70	17.9	133.5	72.7	1.00	0.95	1.00	60	1.00	1.17	2	35	0.04	125	0.78	0.18	0.05	0.27	0.000	0.00	Non-Liq.
Data Class	6	1.50	Silty Sand	8.80	2	10.30	18.2	162.4	85.9	1.00	1.00	1.00	60	1.00	1.08	2	35	0.01	125	0.72	0.17	0.05	0.27	1.000	0.56	3.12
	7	1.50	Silty Sand	10.20	4	11.70	18.9	188.4	98.2	1.00	1.00	1.00	60	1.00	1.01	4	35	0.03	150	0.67	0.16	0.05	0.32	1.000	0.49	4.12
B. H.	8	1.50	Silty Sand	11.80	12	13.30	18.8	218.6	112.7	1.00	1.00	1.00	60	1.00	0.94	11	17	0.24	175	0.62	0.15	0.08	0.54	0.977	0.41	9.47
Y46	9	1.50	Silty Sand	13.20	22	14.70	22.1	247.2	127.5	1.00	1.00	1.00	60	1.00	0.89	19	33	0.30	175	0.60	0.14	0.18	1.23	0.020	0.34	38.66
GWT (m)	10	1.50	Silty Sand	14.80	27	16.30	22.5	282.9	147.5	1.00	1.00	1.00	60	1.00	0.82	22	18	0.39	200	0.58	0.14	0.18	1.33	0.007	0.26	38.94
1.00	11	2.00	Silty Sand	16.20	25	17.70	20.8	313.2	164.1	1.00	1.00	1.00	60	1.00	0.78	20	12	0.85	175	0.56	0.13	0.13	1.01	0.141	0.19	37.96
a_{max} (g)	12	2.30	Silty Clay	18.80	8	20.30	19.2	365.2	190.6	1.00	1.00	1.00	60	1.00	0.72	6	35	0.02	150	0.55	0.13	0.05	0.38	0.000	0.00	Non-Liq.
0.19	13	3.20	Silty Clay	20.80	12	22.30	18.1	402.5	208.3	1.00	1.00	1.00	60	1.00	0.69	8	35	0.04	150	0.55	0.13	0.06	0.46	0.000	0.00	Non-Liq.
Sampler[b]	14	3.70	Silty Sand	25.20	21	26.70	19.9	486.2	248.8	1.00	1.00	1.00	60	1.00	0.63	13	16	0.23	175	0.52	0.13	0.08	0.60	0.935	0.00	11.45
NA	15	2.30	Silty Sand	28.20	18	29.70	18.9	544.4	277.6	1.00	1.00	1.00	60	1.00	0.60	11	6	0.48	175	0.51	0.12	0.06	0.45	0.998	0.00	7.94
B.H. Diam. (mm)	16	1.60	Silty Sand	29.80	17	31.30	18.3	574.2	291.7	1.00	1.00	1.00	60	1.00	0.59	10	35	0.02	150	0.50	0.12	0.06	0.51	0.988	0.00	9.64
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
12.9	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
156	25																									
Observed (cm)	26																									
	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	29.60																							4.70	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Chi Chi 1999	1	1.20	Silty Sand	2.80	4	4.30	19.0	44.0	39.1	1.00	0.85	1.00	60	1.00	1.60	5	30	0.13	150	0.96	0.13	0.07	0.55	0.975	0.86	4.83
Mw	2	2.00	Silty Sand	4.20	3	5.70	18.0	69.9	51.3	1.00	0.85	1.00	60	1.00	1.40	4	35	0.03	125	0.92	0.16	0.06	0.38	1.000	0.79	3.84
7.6	3	2.30	Silty Clay	6.80	5	8.30	18.6	117.6	73.4	1.00	0.95	1.00	60	1.00	1.17	5	35	0.02	150	0.83	0.16	0.06	0.37	0.000	0.00	Non-Liq.
Site	4	1.65	Silty Sand	8.80	6	10.30	17.8	154.0	90.3	1.00	1.00	1.00	60	1.00	1.05	6	35	0.01	150	0.75	0.16	0.06	0.38	1.000	0.56	5.33
Yuanlin	5	1.50	Silty Sand	10.10	15	11.60	20.3	178.8	102.3	1.00	1.00	1.00	60	1.00	0.99	14	23	0.14	175	0.71	0.15	0.11	0.73	0.704	0.50	13.21
Data Class	6	1.55	Silty Sand	11.80	11	13.30	19.0	212.2	119.0	1.00	1.00	1.00	60	1.00	0.92	10	31	0.15	175	0.66	0.14	0.08	0.55	0.973	0.41	9.43
	7	1.50	Silty Sand	13.20	10	14.70	20.2	239.7	132.7	1.00	1.00	1.00	60	1.00	0.87	9	35	0.02	150	0.63	0.14	0.07	0.50	0.991	0.34	8.22
B. H.	8	1.50	Silty Sand	14.80	17	16.30	20.1	271.9	149.3	1.00	1.00	1.00	60	1.00	0.82	14	35	0.04	175	0.60	0.14	0.11	0.78	0.571	0.26	13.97
Y47	9	1.50	Silty Sand	16.20	11	17.70	19.2	299.4	163.0	1.00	1.00	1.00	60	1.00	0.78	8	30	0.20	150	0.59	0.13	0.06	0.46	0.997	0.19	7.30
GWT (m)	10	1.50	Silty Clay	17.80	19	19.30	19.3	330.2	178.2	1.00	1.00	1.00	60	1.00	0.75	14	20	0.15	175	0.58	0.13	0.09	0.69	0.000	0.00	Non-Liq.
2.30	11	1.50	Silty Clay	19.20	47	20.70	20.4	358.0	192.2	1.00	1.00	1.00	60	1.00	0.72	34	29	0.18	225	0.58	0.13	0.50	3.80	0.000	0.00	Non-Liq.
a_{max} (g)	12	2.30	Silty Clay	20.80	67	22.30	20.3	390.5	209.0	1.00	1.00	1.00	60	1.00	0.69	46	35	0.09	225	0.57	0.13	1.55	11.80	0.000	0.00	Non-Liq.
0.19	13	3.00	Silty Sand	23.80	80	25.30	20.8	452.1	241.2	1.00	1.00	1.00	60	1.00	0.64	52	28	0.24	225	0.56	0.13	2.03	15.76	0.000	0.00	48.01
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
22.5	21																									
γ_{dry} (kN/m^3)	22																									
15.0	23																									
Vs* (m/s)	24																									
165	25																									
Observed (cm)	26																									
	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	23.00																							5.66	

SEISMIC EVENT # 17

EARTHQUAKE:	Tokachi-Oki
MOMENT MAGNITUDE:	7.9
LOCATION:	Japan
DATE:	September 26, 2003
REFERENCE(S):	Sasajima, T. et al. (2003) Sasajima, T. et al. (2005)

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Tokachi-oki 2003	1	0.88	Fill Sand	3.00	20	4.50	18.0	47.5	43.7	1.00	0.85	1.00	60	1.00	1.51	26	5	1.00	200	0.97	0.21	0.27	1.25	0.016	0.85	21.99
Mw	2	1.00	Fill Sand	4.00	25	5.50	18.0	65.5	51.9	1.00	0.85	1.00	60	1.00	1.39	29	5	1.00	200	0.96	0.24	0.34	1.40	0.004	0.80	25.24
7.9	3	1.00	Fill Sand	5.00	23	6.50	18.0	83.5	60.1	1.00	0.95	1.00	60	1.00	1.29	28	5	1.00	200	0.94	0.26	0.29	1.13	0.052	0.75	24.14
Site	4	1.00	Fill Sand	6.00	28	7.50	19.0	102.0	68.8	1.00	0.95	1.00	60	1.00	1.21	32	5	1.00	225	0.91	0.27	0.38	1.41	0.003	0.70	27.36
Kushiro Port	5	1.00	Fill Sand	7.00	30	8.50	19.0	121.0	78.0	1.00	0.95	1.00	60	1.00	1.13	32	5	1.00	225	0.88	0.28	0.38	1.36	0.005	0.65	27.52
Data Class	6	1.00	Fill Sand	8.00	29	9.50	18.0	139.5	86.7	1.00	0.95	1.00	60	1.00	1.07	30	5	1.00	175	0.85	0.28	0.30	1.08	0.079	0.60	25.32
	7	1.00	Fill Sand	9.00	20	10.50	18.0	157.5	94.9	1.00	1.00	1.00	60	1.00	1.03	21	5	1.00	175	0.81	0.27	0.14	0.53	0.982	0.55	17.30
B. H.	8	1.00	Fill Sand	10.00	21	11.50	18.0	175.5	103.1	1.00	1.00	1.00	60	1.00	0.99	21	5	1.00	200	0.78	0.27	0.14	0.53	0.980	0.50	17.44
P1	9	1.00	Fill Sand	11.00	10	12.50	16.5	192.7	110.5	1.00	1.00	1.00	60	1.00	0.95	10	5	1.00	150	0.75	0.26	0.06	0.23	1.000	0.45	6.56
GWT (m)	10	1.00	Fill Sand	12.00	21	13.50	18.0	210.0	117.9	1.00	1.00	1.00	60	1.00	0.92	19	5	1.00	175	0.72	0.26	0.12	0.48	0.995	0.40	16.18
2.62	11	1.00	Fill Sand	13.00	37	14.50	19.0	228.5	126.6	1.00	1.00	1.00	60	1.00	0.89	33	5	1.00	225	0.69	0.25	0.34	1.36	0.005	0.35	28.01
a_{max} (g)	12	1.00	Fill Sand	14.00	20	15.50	18.0	247.0	135.3	1.00	1.00	1.00	60	1.00	0.86	17	5	1.00	175	0.67	0.25	0.10	0.41	1.000	0.30	14.14
0.31	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
23.7	21																									
γ_{dry} (kN/m^3)	22																									
15.5	23																									
Vs* (m/s)	24																									
182	25																									
Observed (cm)	26																									
23	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	11.88																							2.29	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
Tokachi-oki 2003	1	0.85	Fill Sand	3.00	20	4.50	18.0	47.4	43.9	1.00	0.85	1.00	60	1.00	1.51	26	5	1.00	200	0.98	0.21	0.26	1.25	0.016	0.85	21.94
Mw	2	1.00	Fill Sand	4.00	23	5.50	18.0	65.4	52.1	1.00	0.85	1.00	60	1.00	1.39	27	5	1.00	200	0.96	0.24	0.28	1.16	0.039	0.80	23.19
7.9	3	1.00	Fill Sand	5.00	23	6.50	18.0	83.4	60.3	1.00	0.95	1.00	60	1.00	1.29	28	5	1.00	200	0.94	0.26	0.29	1.12	0.057	0.75	24.09
Site	4	1.00	Fill Sand	6.00	29	7.50	19.0	101.9	69.0	1.00	0.95	1.00	60	1.00	1.20	33	5	1.00	225	0.92	0.27	0.42	1.52	0.001	0.70	28.23
Kushiro Port	5	1.00	Fill Sand	7.00	26	8.50	18.0	120.4	77.7	1.00	0.95	1.00	60	1.00	1.13	28	5	1.00	200	0.90	0.28	0.27	0.97	0.188	0.65	24.00
Data Class	6	1.00	Fill Sand	8.00	27	9.50	18.0	138.4	85.9	1.00	0.95	1.00	60	1.00	1.08	28	5	1.00	200	0.87	0.28	0.26	0.91	0.277	0.60	23.70
	7	1.00	Fill Sand	9.00	28	10.50	18.0	156.4	94.1	1.00	1.00	1.00	60	1.00	1.03	29	5	1.00	200	0.83	0.28	0.27	0.98	0.171	0.55	24.71
B. H.	8	1.00	Fill Sand	10.00	46	11.50	19.0	174.9	102.8	1.00	1.00	1.00	60	1.00	0.99	45	5	1.00	225	0.80	0.27	0.95	3.45	0.000	0.50	37.05
T1	9	1.00	Fill Sand	11.00	16	12.50	18.0	193.4	111.5	1.00	1.00	1.00	60	1.00	0.95	15	5	1.00	175	0.77	0.27	0.09	0.34	1.000	0.45	12.16
GWT (m)	10																									
2.65	11																									
a_{max} (g)	12																									
0.31	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
26.4	21																									
γ_{dry} (kN/m^3)	22																									
15.5	23																									
Vs* (m/s)	24																									
187	25																									
Observed (cm)	26																									
23	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	8.85																							0.92	

SEISMIC EVENT # 18

EARTHQUAKE:	San Simeon
MOMENT MAGNITUDE:	6.5
LOCATION:	USA
DATE:	December 22, 2003
REFERENCE(S):	Holzer, T. et al. (2004)

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N^d	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
San Simeon - 2003	1	1.15	Fill	1.75	3	3.25	16.5	27.2	20.8	1.00	0.75	1.00	60	1.00	2.00	5	35	0.05	150	0.97	0.10	0.12	1.18	0.000	0.00	Non-Liq.
Mw	2	1.00	Sand	2.75	2	4.25	15.5	43.2	27.0	1.00	0.85	1.00	60	1.00	1.92	3	15	0.90	125	0.94	0.12	0.09	0.75	0.646	0.86	3.12
6.5	3	1.00	Fluvial Dep.	3.75	14	5.25	18.0	60.0	34.0	1.00	0.85	1.00	60	1.00	1.72	20	35	0.05	200	0.91	0.13	0.4	3.2	0.000	0.00	Non-Liq.
Site	4	1.00	Fluvial Dep.	4.75	15	6.25	18.0	78.0	42.2	1.00	0.95	1.00	60	1.00	1.54	22	35	0.05	200	0.87	0.13	0.42	3.4	0.000	0.00	Non-Liq.
Oceano	5	1.00	Fluvial Dep.	5.75	22	7.25	18.0	96.0	50.4	1.00	0.95	1.00	60	1.00	1.41	29	35	0.05	200	0.83	0.12	0.77	6.2	0.000	0.00	Non-Liq.
Data Class	6	1.00	Fluvial Dep.	6.75	18	8.25	18.0	114.0	58.5	1.00	0.95	1.00	60	1.00	1.31	22	35	0.05	200	0.78	0.12	0.38	3.21	0.000	0.00	Non-Liq.
	7	1.00	Fluvial Dep.	7.75	3	9.25	15.5	130.7	65.5	1.00	0.95	1.00	60	1.00	1.24	4	35	0.05	125	0.74	0.11	0.08	0.68	0.000	0.00	Non-Liq.
B. H.	8	1.00	Fluvial Dep.	8.75	2	10.25	15.5	146.2	71.2	1.00	1.00	1.00	60	1.00	1.19	2	35	0.05	125	0.69	0.11	0.07	0.62	0.000	0.00	Non-Liq.
2	9	1.00	Fluvial Dep.	9.75	2	11.25	15.5	161.7	76.9	1.00	1.00	1.00	60	1.00	1.14	2	35	0.05	125	0.65	0.11	0.06	0.60	0.000	0.00	Non-Liq.
GWT (m)	10	1.00	Fluvial Dep.	10.75	37	12.25	19.0	179.0	84.3	1.00	1.00	1.00	60	1.00	1.09	40	35	0.05	225	0.62	0.10	1.68	16.51	0.000	0.00	Non-Liq.
1.1	11	1.00	Fluvial Dep.	11.75	90	13.25	19.0	198.0	93.5	1.00	1.00	1.00	60	1.00	1.03	93	35	0.05	225	0.59	0.10	149.8	1547	0.000	0.00	Non-Liq.
a_{max} (g)	12	1.00	Fluvial Dep.	12.75	21	14.25	18.0	216.5	102.2	1.00	1.00	1.00	60	1.00	0.99	21	35	0.05	200	0.56	0.09	0.30	3.23	0.000	0.00	Non-Liq.
0.12	13	1.00	Fluvial Dep.	13.75	3	15.25	15.5	233.2	109.1	1.00	1.00	1.00	60	1.00	0.96	3	35	0.05	125	0.54	0.09	0.06	0.70	0.000	0.00	Non-Liq.
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
17.8	21																									
γ_{dry} (kN/m^3)	22																									
15.00	23																									
Vs* (m/s)	24																									
158	25																									
Observed (cm)	26																									
	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	13.15																							0.56	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
San Simeon - 2003	1	1.30	Fill	2.60	3	4.10	15.5	39.4	31.6	1.00	0.85	1.00	60	1.00	1.78	4	35	0.05	125	0.95	0.09	0.10	1.05	0.000	0.00	Non-Liq.
Mw	2	1.00	Sand	3.60	2	5.10	15.5	54.9	37.2	1.00	0.85	1.00	60	1.00	1.64	3	15	0.90	125	0.92	0.11	0.08	0.74	0.678	0.82	2.92
6.5	3	1.00	Fluvial Dep.	4.60	22	6.10	19.0	72.2	44.7	1.00	0.95	1.00	60	1.00	1.50	31	35	0.05	225	0.88	0.11	0.93	8.38	0.000	0.00	Non-Liq.
Site	4	1.00	Fluvial Dep.	5.60	82	7.10	19.0	91.2	53.9	1.00	0.95	1.00	60	1.00	1.36	106	35	0.05	225	0.84	0.11	534	4834	0.000	0.00	Non-Liq.
Oceano	5	1.00	Fluvial Dep.	6.60	27	8.10	19.0	110.2	63.1	1.00	0.95	1.00	60	1.00	1.26	32	35	0.05	225	0.79	0.11	0.89	8.30	0.000	0.00	Non-Liq.
Data Class	6	1.00	Fluvial Dep.	7.60	90	9.10	19.0	129.2	72.3	1.00	0.95	1.00	60	1.00	1.18	101	35	0.05	225	0.74	0.10	306	2951	0.000	0.00	Non-Liq.
	7	1.00	Fluvial Dep.	8.60	3	10.10	15.5	146.4	79.7	1.00	1.00	1.00	60	1.00	1.12	3	35	0.05	125	0.70	0.10	0.07	0.72	0.000	0.00	Non-Liq.
B. H.	8	1.00	Fluvial Dep.	9.60	2	11.10	15.5	161.9	85.4	1.00	1.00	1.00	60	1.00	1.08	2	35	0.05	125	0.66	0.10	0.06	0.66	0.000	0.00	Non-Liq.
3	9	1.00	Fluvial Dep.	10.60	91	12.10	19.0	179.2	92.8	1.00	1.00	1.00	60	1.00	1.04	94	35	0.05	225	0.62	0.09	168.8	1810	0.000	0.00	Non-Liq.
GWT (m)	10	1.00	Fluvial Dep.	11.60	81	13.10	19.0	198.2	102.0	1.00	1.00	1.00	60	1.00	0.99	80	35	0.05	225	0.59	0.09	48.5	544	0.000	0.00	Non-Liq.
1.8	11	1.00	Fluvial Dep.	12.60	92	14.10	19.0	217.2	111.2	1.00	1.00	1.00	60	1.00	0.95	87	35	0.05	225	0.56	0.09	86.6	1007	0.000	0.00	Non-Liq.
a_{max} (g)	12	1.00	Fluvial Dep.	13.60	2	15.10	15.5	234.4	118.6	1.00	1.00	1.00	60	1.00	0.92	2	35	0.05	125	0.55	0.08	0.06	0.68	0.000	0.00	Non-Liq.
0.12	13	1.00	Fluvial Dep.	14.60	3	16.10	15.5	249.9	124.3	1.00	1.00	1.00	60	1.00	0.90	3	35	0.05	125	0.53	0.08	0.06	0.73	0.000	0.00	Non-Liq.
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
38.4	21																									
γ_{dry} (kN/m^3)	22																									
15.00	23																									
Vs* (m/s)	24																									
157	25																									
Observed (cm)	26																									
	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	13.30																							0.56	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
San Simeon - 2003	1	1.25	Fill	3.10	3	4.60	15.5	46.9	39.5	1.00	0.85	1.00	60	1.00	1.59	4	35	0.05	150	0.90	0.08	0.09	1.12	0.000	0.00	Non-Liq.
Mw	2	1.00	Sand	4.10	2	5.60	15.5	62.4	45.2	1.00	0.85	1.00	60	1.00	1.49	3	15	0.90	125	0.86	0.09	0.07	0.78	0.578	0.80	2.82
6.5	3	1.00	Fluvial Dep.	5.10	22	6.60	18.0	79.1	52.1	1.00	0.95	1.00	60	1.00	1.38	29	35	0.05	200	0.81	0.10	0.73	7.57	0.000	0.00	Non-Liq.
Site	4	1.00	Fluvial Dep.	6.10	90	7.60	19.0	97.6	60.8	1.00	0.95	1.00	60	1.00	1.28	110	35	0.05	225	0.76	0.10	695	7306	0.000	0.00	Non-Liq.
Oceano	5	1.00	Fluvial Dep.	7.10	3	8.60	15.5	114.9	68.3	1.00	0.95	1.00	60	1.00	1.21	3	35	0.05	125	0.71	0.09	0.08	0.82	0.000	0.00	Non-Liq.
Data Class	6	1.00	Fluvial Dep.	8.10	2	9.60	15.5	130.4	74.0	1.00	0.95	1.00	60	1.00	1.16	2	35	0.05	125	0.66	0.09	0.07	0.74	0.000	0.00	Non-Liq.
	7	1.00	Fluvial Dep.	9.10	2	10.60	15.5	145.9	79.7	1.00	1.00	1.00	60	1.00	1.12	2	35	0.05	125	0.62	0.09	0.07	0.75	0.000	0.00	Non-Liq.
B. H.	8	1.00	Fluvial Dep.	10.10	9	11.60	16.5	161.9	85.8	1.00	1.00	1.00	60	1.00	1.08	9	35	0.05	150	0.58	0.09	0.12	1.39	0.000	0.00	Non-Liq.
4	9	1.00	Fluvial Dep.	11.10	79	12.60	19.0	179.6	93.8	1.00	1.00	1.00	60	1.00	1.03	82	35	0.05	225	0.55	0.08	55.9	680	0.000	0.00	Non-Liq.
GWT (m)	10	1.00	Fluvial Dep.	12.10	12	13.60	18.0	198.1	102.5	1.00	1.00	1.00	60	1.00	0.99	12	35	0.05	175	0.53	0.08	0.14	1.76	0.000	0.00	Non-Liq.
2.35	11	1.00	Fluvial Dep.	13.10	2	14.60	15.5	214.9	109.4	1.00	1.00	1.00	60	1.00	0.96	2	35	0.05	125	0.51	0.08	0.06	0.75	0.000	0.00	Non-Liq.
a_{max} (g)	12	1.00	Fluvial Dep.	14.10	2	15.60	15.5	230.4	115.1	1.00	1.00	1.00	60	1.00	0.93	2	35	0.05	125	0.49	0.08	0.06	0.75	0.000	0.00	Non-Liq.
0.12	13	1.00	Fluvial Dep.	15.10	11	16.60	18.0	247.1	122.0	1.00	1.00	1.00	60	1.00	0.91	10	35	0.05	150	0.48	0.08	0.11	1.48	0.000	0.00	Non-Liq.
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
18.4	21																									
γ_{dry} (kN/m^3)	22																									
15.00	23																									
Vs* (m/s)	24																									
144	25																									
Observed (cm)	26																									
	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	13.25																							0.46	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
San Simeon - 2003	1	2.30	Sand	2.50	16	4.00	18.0	42.2	26.9	1.00	0.75	1.00	60	1.00	1.93	23	15	0.90	200	0.98	0.12	0.43	3.59	0.000	0.88	39.08
Mw	2	1.50	Sand	4.00	6	5.50	16.5	68.0	38.1	1.00	0.85	1.00	60	1.00	1.62	8	15	0.90	150	0.96	0.13	0.12	0.90	0.309	0.80	6.19
6.5	3	1.50	Sand	5.50	2	7.00	15.5	92.0	47.4	1.00	0.95	1.00	60	1.00	1.45	3	15	0.90	125	0.92	0.14	0.07	0.52	0.986	0.73	2.91
Site	4	1.50	Sand	7.00	45	8.50	19.0	117.9	58.5	1.00	0.95	1.00	60	1.00	1.31	56	15	0.90	225	0.88	0.14	4.68	33.82	0.000	0.65	48.35
Oceano	5	2.00	Fluvial Dep.	8.50	33	10.00	19.0	146.4	72.3	1.00	0.95	1.00	60	1.00	1.18	37	35	0.05	225	0.83	0.13	1.29	9.83	0.000	0.00	Non-Liq.
Data Class	6	2.00	Fluvial Dep.	11.00	57	12.50	19.0	193.9	95.3	1.00	1.00	1.00	60	1.00	1.02	59	35	0.05	225	0.74	0.12	7.87	67.2	0.000	0.00	Non-Liq.
	7	1.50	Fluvial Dep.	12.50	44	14.00	19.0	222.4	109.1	1.00	1.00	1.00	60	1.00	0.96	42	35	0.05	225	0.69	0.11	1.83	16.7	0.000	0.00	Non-Liq.
B. H.	8	1.50	Fluvial Dep.	14.00	73	15.50	19.0	250.9	122.9	1.00	1.00	1.00	60	1.00	0.90	66	35	0.05	225	0.65	0.10	13.5	130.1	0.000	0.00	Non-Liq.
7	9																									
GWT (m)	10																									
0.95	11																									
a_{max} (g)	12																									
0.12	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
34.5	21																									
γ_{dry} (kN/m^3)	22																									
15.00	23																									
Vs* (m/s)	24																									
187	25																									
Observed (cm)	26																									
	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	13.80																							1.44	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
San Simeon - 2003	1	2.30	Fill	2.30	2	3.80	15.5	35.3	20.1	1.00	0.75	1.00	60	1.00	2.00	2	35	0.05	125	0.97	0.13	0.10	0.73	0.702	0.00	Non-Liq.
Mw	2	1.50	Sand	3.80	3	5.30	16.5	59.3	29.4	1.00	0.85	1.00	60	1.00	1.85	5	15	0.90	150	0.95	0.15	0.10	0.69	0.795	0.81	4.19
6.5	3	1.50	Sand	5.30	11	6.80	18.0	85.2	40.5	1.00	0.95	1.00	60	1.00	1.57	16	15	0.90	175	0.91	0.15	0.22	1.45	0.002	0.74	37.03
Site	4	1.50	Sand	6.80	33	8.30	19.0	112.9	53.5	1.00	0.95	1.00	60	1.00	1.37	43	15	0.90	225	0.86	0.14	1.67	11.85	0.000	0.66	44.60
Oceano	5	1.50	Fluvial Dep.	8.30	91	9.80	19.0	141.4	67.3	1.00	0.95	1.00	60	1.00	1.22	106	35	0.05	225	0.80	0.13	476.8	3639	0.000	0.00	Non-Liq.
Data Class	6	1.50	Fluvial Dep.	9.80	112	11.30	19.0	169.9	81.1	1.00	1.00	1.00	60	1.00	1.11	124	35	0.05	225	0.74	0.12	2265	18743	0.000	0.00	Non-Liq.
	7	1.50	Fluvial Dep.	11.30	112	12.80	19.0	198.4	94.9	1.00	1.00	1.00	60	1.00	1.03	115	35	0.05	225	0.69	0.11	971.1	8693	0.000	0.00	Non-Liq.
B. H.	8	1.50	Fluvial Dep.	12.80	112	14.30	19.0	226.9	108.7	1.00	1.00	1.00	60	1.00	0.96	107	35	0.05	225	0.64	0.10	490.6	4701	0.000	0.00	Non-Liq.
8	9																									
GWT (m)	10																									
0.75	11																									
a_{max} (g)	12																									
0.12	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
59.5	21																									
γ_{dry} (kN/m^3)	22																									
15.00	23																									
Vs* (m/s)	24																									
178	25																									
Observed (cm)	26																									
	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	12.80																							0.97	

Earthquake	No.[a]	Sub-Layer H (m)	Soil Type	SPT-N Depth (m)	SPT-N	Rod Length (m)	γ (kN/m^3)	σ_v (kN/m^2)	σ_v' (kN/m^2)	C_S	C_R	C_B	Energy (%)	C_E	C_N[d]	$(N_1)_{60}$	FC(%)[f]	D_{50} (mm)	V_S (m/s)	r_d	CSR	CRR	F. S.	PL	WF-L	Φ'mob.
San Simeon - 2003	1	2.30	Fill	2.60	3	4.10	16.5	41.3	26.1	1.00	0.85	1.00	60	1.00	1.96	6	35	0.05	150	0.97	0.12	0.12	1.01	0.000	0.00	Non-Liq.
Mw	2	1.50	Fill	4.10	2	5.60	15.5	65.3	35.4	1.00	0.85	1.00	60	1.00	1.68	2	35	0.05	125	0.94	0.13	0.08	0.61	0.000	0.00	Non-Liq.
6.5	3	1.50	Sand	5.60	16	7.10	18.0	90.5	45.8	1.00	0.95	1.00	60	1.00	1.48	23	15	0.90	200	0.89	0.14	0.36	2.65	0.000	0.72	39.02
Site	4	1.50	Sand	7.10	57	8.60	19.0	118.2	58.8	1.00	0.95	1.00	60	1.00	1.30	71	15	0.90	225	0.84	0.13	15.57	118.8	0.000	0.65	52.63
Oceano	5	1.50	Sand	8.60	33	10.10	19.0	146.7	72.6	1.00	1.00	1.00	60	1.00	1.17	39	15	0.90	225	0.78	0.12	1.11	9.08	0.000	0.57	43.44
Data Class	6	1.50	Fluvial Dep.	10.10	91	11.60	19.0	175.2	86.4	1.00	1.00	1.00	60	1.00	1.08	98	35	0.05	225	0.71	0.11	235	2075	0.000	0.00	Non-Liq.
	7	1.50	Fluvial Dep.	11.60	24	13.10	18.0	203.0	99.5	1.00	1.00	1.00	60	1.00	1.00	24	35	0.05	200	0.66	0.11	0.39	3.69	0.000	0.00	Non-Liq.
B. H.	8	1.50	Fluvial Dep.	13.10	11	14.60	18.0	230.0	111.7	1.00	1.00	1.00	60	1.00	0.95	10	35	0.05	175	0.62	0.10	0.12	1.17	0.000	0.00	Non-Liq.
9	9																									
GWT (m)	10																									
1.05	11																									
a_{max} (g)	12																									
0.12	13																									
Sampler[b]	14																									
NA	15																									
B.H. Diam. (mm)	16																									
95	17																									
Energy Ratio[c]	18																									
60	19																									
N (mean)	20																									
29.6	21																									
γ_{dry} (kN/m^3)	22																									
15.00	23																									
Vs* (m/s)	24																									
175	25																									
Observed (cm)	26																									
	27																									
Distance (m)	28																									
	29																								LSI	
Liquefied ?	30																								Lin.	
	SUM	12.80																							0.00	