CALIBRATION OF THE FINITE ELEMENT MODEL OF A LONG SPAN CANTILEVER THROUGH TRUSS BRIDGE USING ARTIFICIAL NEURAL NETWORKS

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CALIBRATION OF THE FINITE ELEMENT MODEL OF A LONG SPAN CANTILEVER THROUGH TRUSS BRIDGE USING ARTIFICIAL NEURAL NETWORKS

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I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

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ABSTRACT

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In recent years, Artificial Neural Networks (ANN) have become widely popular tools in various disciplines of engineering, including civil engineering. In this thesis, Multi-layer perceptron with back-propagation type of network is utilized in calibration of the finite element model of a long span cantilever through truss called Commodore Barry Bridge (CBB).

The essence of calibration lies in the phenomena of comparing and correlating the structural response of an analytical model with experimental results as closely as possible. Since CBB is a very large structure having complex structural mechanisms, formulation of mathematical expressions representing the relation between dynamics of the structure and the structural parameters is very complicated. Furthermore, when the errors in the structural model and noise in the experimental data are taken into account, a calibration study becomes more tedious. At this point, ANNs are useful tools since they have the capability of learning with noisy data and ability to approximate functions.

In this study, firstly sensitivity analyses are conducted such that variations in dynamic properties of the bridge are observed with the changes in its structural parameters. In the second part, inverse relation between sensitive structural parameters and modal frequencies of CBB is approximated by training of a neural network. This successfully trained network is then fed up with experimental frequencies to acquire the as-is structural parameters and model updating is achieved accordingly.

Keywords: Artificial Neural Networks, Commodore Barry Bridge, Calibration,
Sensitivity Analysis

ÖZ

UZUN AÇIKLIKLI KONSOL KAFES KİRİŞLİ BİR KÖPRÜNÜN SONLU ELMANLAR MODELİNİN YAPAY SİNİR AĞLARI İLE KALİBRASYONU

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Son yıllarda yapay sinir ağları (YSA) birçok mühendislik dalında olduğu gibi inşaat mühendisliğinde de yaygın olarak kullanılmaktadır. Bu tezde de çok katmanlı, ileri beslemeli, geri yayınım algoritmalı YSA mimarisi uzun açıklıklı konsol kafes kirişli bir köprü olan Commodore Barry Bridge (CBB) sonlu elemanlar modelinin kalibrasyonunda kullanılmıştır.

Kalibrasyon, yapının analitik modelinin yapısal parametrelerini güncelleyerek elde edilen dinamik özellikleri (frekanslar ve ilgili mod şekilleri), saha ölçümleri ile elde edilen dinamik parametrelere olabildiğince yaklaştırmak olarak tanımlanabilir. CBB oldukça büyük bir yapı olması ve kompleks yapısal mekanizmaları içermesi bakımından, yapısal parametreler ve dinamik özellikler arasındaki matematiksel ilişkiyi kurmak oldukça güçtür. Modellemeden kaynaklanabilecek hatalar ve saha ölçüm verilerinin içerebileceği gürültülerde göz önünde bulundurulduğunda yapının kalibrasyonu daha da güçleşmektedir. İşte bu noktada yapay sinir ağları sahip oldukları özellikler ile bu çalışma için önemli bir araç olarak ortaya çıkmaktadır.

Çalışmada ilk olarak hassaslık analizleri ile köprünün yapısal parametrelerinin belli bir oranda değiştirilmesiyle dinamik özelliklerde ortaya çıkan değişimler gözlenmiştir. İkinci kısımda ise yapısal parametreler ile dinamik özellikler arasındaki ters ilişki yapay sinir ağlarının eğitilmesi ile elde edilmiş ve eğitilmiş sinir ağı da saha ölçümlerinde kaydedilen frekanslar ile beslenerek köprünün mevcut durumdaki yapısal parametreleri elde edilmiş ve son aşamada köprünün analitik modeli güncellenmiştir.

Anahtar Kelimeler: Yapay Sinir Ağları, Commodore Barry Bridge, Kalibrasyon, Hassaslık Analizi

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LIST OF SYMBOLS / ABBREVATIONS

ANN	Artificial Neural Network
CBB	Commodore Barry Bridge
MLP	Multi Layer Perceptron
BP	Back-Propagation
DBD	Delta-Bar-Delta
CG	Conjugate Gradient
LM	Levenberg-Marquardt
MSE	Mean Squared Error
NMSE	Normalized Mean Squared Error
MAE	Mean Absolute Error
SSE	Sum Squared Error
FRF	Frequency Response Function
ASCE	American Society of Civil Engineers
RBF	Radial Basis Function
Ψ	Transfer Function
w	Weight
Θ	Bias
η	Learning rate
α	Momentum term
PCA	Principle Component Analysis
I/O	Input/Output
FE	Finite Element
DOFs	Degree of Freedoms
MAC	Modal Assurance Criterion
r	Correlation Coefficient
CAD	Computer Aided Design

DI3	Drexel Intelligent Infrastructure and Transportation Safety Institute
SSF	Submatrix Scaling Factor
I_x	Moment of Inertia about x-axis
I_y	Moment of Inertia about y-axis
E	Modulus of Elasticity
J	Torsion Constant
M	Mass of the Deck

CHAPTER 1

INTRODUCTION

Today computers are indispensable tools for engineering activities. They have been made use of in many applications by engineers such as advanced (e.g. finite element analysis, nonlinear analysis), graphical and CAD applications. Over the last 15 years, artificial neural network techniques have appeared as a useful tool that could be an alternative method for time consuming computations in such engineering applications. Furthermore, Neural networks can effectively deal with the problems with incomplete and noisy data which are often encountered in civil engineering problems. Neural networks are artificial intelligence tools which have the learning and generalization ability from examples and experience to bring out solutions to problems. This learning can be achieved even if the input data is incomplete or contains error, which is often typical of the design process. Neural networks have become popular tools for various civil engineering problems due to their outstanding features. The first article about the use of neural network in civil engineering discipline was published by Adeli and Yeh in 1989 [1]. Ever since then, they have been successfully applied to various fields of structural engineering discipline, such as structural optimization, model updating, damage detection, structural analysis and strength prediction.

The essence of calibration lies in the phenomena of comparing and correlating the structural response of an analytical model with experimental results. The discrepancies observed between the analytical model and experimental measurements may be due to a number of geometrical and structural parameters, as well as behavioral parameters, that differ between the model and the actual structure. The calibration process aims at identifying these parameters and updating them in the analytical model to improve its performance in simulating the actual behavior of the existing structure as closely as possible. Since engineering structures may suffer from damage and deterioration throughout their service life, damage detection and structural identification i.e. calibration can take essential role which improves safety and provide with reliability for modern structures. Commodore Barry Bridge (CBB) is one of the unique structures since the bridge is the longest cantilever through truss bridge in the United States and serves more than six million vehicles annually, a significant percentage of which is heavy truck traffic. Therefore, calibration of FE model of this bridge becomes vital. Calibration studies are generally complicated for such a structure of this size and complexity. Since artificial neural networks are powerful tools for such sophisticated analysis and works, they are utilized here for calibration of CBB. In other words, the use of neural networks in the calibration of Commodore Barry Bridge is investigated in this thesis.

The thesis consists of seven chapters. In the first chapter, scope and aim of the study is presented. In the second chapter, a literature survey is conducted where major studies on the use of artificial neural networks in structural identification and damage detection of engineering structures are reviewed.

In the third chapter, basic concepts of artificial neural networks are presented. This chapter includes brief description of networks, detailed explanation of Multilayer perceptron (MLP) networks, back-propagation and error minimization algorithms, training and post training procedures and some essential concepts and issues. The following chapter is focused on Commodore Barry Bridge and its finite element model. Specifically, it contains general information about the bridge, its structural components, critical mechanisms and representations in the FE model of the bridge. Besides modal properties of the nominal FE model and experimental modes are presented and compared.

In the fifth chapter, parametric studies which can be regarded as the first step of the calibration study is discussed. The structural parameters defined in the fourth chapter are assigned randomly to values within ranges of possible variations, and then changes in modal parameters of the bridge are obtained and examined. Based on parametric studies, structural parameters which affect the modal parameters most are identified. These parameters then are used in calibration study as the outputs of the neural network. Static sensitivity analyses are also conducted for some parameters to determine their sensitive ranges.

In the sixth chapter, formation, training and utilization of the network for calibration of Commodore Barry Bridge are articulated. Selecting input and output pairs for the network, identifying the network's parameters, searching the best architecture, training, testing of the network are discussed and finally model updating of the CBB is achieved.

And finally, the last chapter concludes the thesis, emphasizing important findings and results of the study.

CHAPTER 2

LITERATURE SURVEY

Neural networks have been used in the fields of classification, prediction, function approximation and optimization problems. These characteristics of neural networks have been utilized in most of engineering applications. The first article about the use of neural network in civil engineering discipline was published by Adeli and Yeh in 1989 [1]. A literature survey clearly indicates that Artificial Neural Networks have been widely used tool in civil engineering area. According to Ian Flood [2], the term "neural" appears in more than 12% of the papers published in ASCE journal of computing from 1995 to 2005. He also states that there has been no loss of interest in ANNs by investigating the distribution of publications by year. Furthermore, citation indices clinch this assessment. Ian Flood points out that the papers about artificial neural networks occupy three of the top five most frequently cited articles among issues of the ASCE Journal of Computing. In structural engineering discipline, artificial neural networks have been utilized in the field of structural optimization, model updating, damage detection, structural analysis and so on. In the following, only those studies in the literature which are directly relevant the topic of the current thesis, i.e. model updating, damage detection, will be presented briefly.

Zang and Imregun [3] discuss the performance of ANNs on detection of structural damage using Frequency Response Function (FRF) data. They use MLP-BP type of network. Inputs are 4096 FRF data and outputs are whether member is damaged or healthy. They reduced measured FRF data via principal component analysis in order to achieve data compression and removing some of the noise. The network topology they use is 4096-2049-2 and learning rate and momentum parameters are specified as

0.6 and 0.3, respectively. Training, verification and testing performance of network was successful.

Suh, Shim and Kim [4] investigate the ability of crack identification using hybrid neuro-genetic technique. They use the relationship between the crack parameters (location and depth) and the first three measured eigenfrequencies of the structure. Consequently network has two inputs, namely, crack location and depth; three outputs as first three frequencies. MLP type of network is selected where momentum coefficient is specified as 0.9 and adaptive learning rate is used. The network topology they use is 2-13-3. The NN is utilized for approximation of eigenfrequencies as the functions of crack parameters and genetic algorithm is utilized for determining the crack parameters which minimize the difference from measured eigenfrequencies. They confirm the effectiveness of this technique on two example problem.

Feng et al [5] use MLP-BP type of network to update the preliminary FE model to the baseline model based on the measured dynamic characteristics of the bridge. In their study, input patterns consist of natural frequencies and mode shapes, output patterns consist of correction coefficients of structural parameters. They indicate that the neural network technique is effective in identifying the structural parameters based on vibration measurement, despite the incomplete measurement of the mode shapes.

Chang, Chang and Xu [6] propose a model updating methodology based on an adaptive neural network model. They also use a MLP type of network in conjunction with a modified BP algorithm in which the learning rate is dynamically adjusted and a jump factor is introduced. In their study, network is first trained off-line using some training data, then is adaptively retrained on-line during the model updating process. They apply adaptive NN updating procedure to a suspension bridge model and verify the results both numerically and experimentally. According to their study, they state that neural network approach is an applicable tool for model updating of complex structures.

Jacques Cattan and Jamshid Mohammadi [7] apply the neural network approach to handle the relation between subjective ratings and bridge parameters as well as the between subjective and analytical ratings. Performance of neural network is compared with conventional statistical methods and the fuzzy-logic approach. MLP-BP type of network is selected with values of 0.6 and 0.85 for the learning rate and momentum, respectively. Bridge characteristics and analytical ratings are selected as the inputs while outputs are subjective ratings which show whether bridge is damaged or healthy. It is concluded that neural network outperforms other two methods.

Ni et al. [8] mention about the construction of appropriate input patterns for hierarchical use of neural networks. They select a MLP-BP type of network with incremental update technique. They also validate their proposals on example problem. Results show that the proposed approach provides an suitable framework for neural-network-based structural health monitoring.

Yun et al.'s [9] research deals with the modeling of damage to the beam-to-column connections of a steel frame structure and the identification of the joint damage based on the modal data using a neural network technique. They use a MLP-BP type of network. The input patterns contain the measured modal properties, and the output patterns consist of the joint damage severities. Both numerical and experimental examples were carried out. The results of joint damage assessment using the present neural networks technique are found to be very reliable.

Barai and Pandey [10] present the application of neural networks in damage detection of trussed bridge structures. They select MLP-BP type of network with a learning rate of 0.9 and a momentum coefficient of 0.7. Input layer consists of measured parameters i.e. vertical displacements of bridge and outputs are the identified parameters i.e. cross-sectional areas. From their observation, it is concluded that MLP-BP is very suitable tool for the structural damage detection.

Ghaboussi and Garrett [11] utilize the neural networks to extract and store the information of the patterns in the response of undamaged and damaged structure.

They use a MLP-BP type of network with a learning rate value of 0.2. In their case study, a simple three story frame is used. Input to neural network is selected as fourier spectra at the relative acceleration recorded at the top floor. Output contains information about the extent of the damage. They indicate that use of neural networks in damage assessment has a promising future.

Çevik et al. [12] makes use of neural networks in determining the relationship between structural parameters and the dynamic properties of suspension bridges. They select a MLP-BP type of network with a learning rate and a momentum coefficient equal to 0.9 and 0.7, respectively. Input patterns are structural parameters and output patterns are the first three modal frequencies. It is shown that, neural network easily handle this relationship well.

Yun and Bahng [13] utilize the neural networks to estimate the stiffness parameters of a complex structural system. They overcome the problems associated with many unknown parameters in a large structural system via substructural identification and submatrix scaling factor (SSF). They select a MLP-BP type of network. Inputs are the modal data and the corresponding SSFs constitute the outputs. Two numerical examples were carried out on a two span truss and multi storey frame. The results show that their present approach is suitable for the identification of the very large structural systems.

Omkar et al. [14] make use of a modular neural network approach to identify the crack parameters in a cantilever beam. Modular neural network is composed of two networks. The first network is used for determining the crack location with the first three frequencies as inputs and crack location as output, whereas the second network is used for estimation of crack depth. Input patterns consist of output of the first network and the first natural frequency and, the outputs are crack depths. They also compare RBF and MLP type of network. They carry out numerical examples which show that the proposed technique is able to identify the damage parameters accurately, and RBF network performs better than MLP network.

Yam et al. [15] present an integrated method for damage detection of composite structures using their vibration responses, wavelet transform and artificial neural network identification. They select a MLP-BP type of network. Input pairs are composed of structural damage feature proxy and the outputs are the corresponding damage status. According to their case study, it is concluded that ANN is a effective tool for determining the relationship between structural vibration response and the damage status.

J.M. Ko et al [16] present a multi stage scheme for damage identification for the Kap Shui Mun Bridge. In the first and third stages of their study, they utilize neural networks for damage alarming and the extent of damage in damaged members. They selected a MLP-BP type of network. In the first stage, natural frequencies and novelty indices are selected as input and output pairs respectively for damage alarming. In the third stage, in order to identify the damage extent a set of modal parameters are considered as inputs to the network, whereas the extent of damage in the damaged members are the outputs.

There are many other application examples of neural networks in civil engineering area. Apart from those presented here, more than seventy papers published in the literature are overviewed in an effort to identify the features of neural network models used, and to classify them according to a set of network parameters. The result of this study is produced in Table 2.1 in a tabular form.

Table 2.1 Classification of NN Studies in terms of Network Parameters

Authors	Network Type	Learning rule	Activation Function		η	α	Training Mode	Normalization	Remarks
			Hidden	Output					
Cattan and Mohammadi (1997) [7]	MLP	Gradient Descent	?	?	0.6(I) 0.65(II)	0.85(I) 0.7(II)	on-line	?	determination of sample size
Kim and Yoon (2000) [17]	MLP	Quickprop	?	?	*	*	?	?	(*) According to Quickprop algorithm
Hong, Chang and Lee (2001) [18]	MLP	Gradient Descent	Sig	Sig	0.4-0.5	0.7-0.9	on-line	[0.1,0.9]	weights are initialized less than 0.1
Chen et al (1995) [19]	MLP	Gradient Descent	Sig	Sig	0.7	-	both*	?	(*) off-line pretrained network
Huang and Loh (2001) [20]	MLP	Levenberg-Marquardt	*	*	*	-	?	?	Linear and Nonlinear networks are trained
Ko, Sun and Ni (2001) [16]	MLP	Gradient Descent	Sig	Lin	?	?	?	?	Bottleneck architecture is used
Xu and Humar (2006) [21]	MLP	Scaled conjugate gradient	Sig	Lin	?	?	off-line	?	Validation data set is used
Ni, Wang and Ko (2002) [8]	MLP	?	?	?	?	?	?	?	
Ghaboussi and Garrett (1990) [81]	MLP	Gradient Descent	Sig	Lin	0.2	-	on-line	?	incremental training
Masri et al (1996) [22]	MLP	Adaptive random search	*	*	?	?	?	?	Linear and Nonlinear networks are trained
Yam, Yan, Jiang (2003) {15]	MLP	Gradient Descent	Sig	Sig	constant	constant	on-line	?	
Lam, Yuen and Beck (2006) [23]	MLP	Gradient Descent	Sig	Sig	?	?	?	?	Number of hidden neurons and training pairs, bayesian ANN design
Fang, Luo and Tang (2005) [24]	MLP	Gradient Descent	Sig	Sig	*	-	off-line	?	(*) learning rate improvement and initialization of small random weights
Chen (2005) [25]	MLP	Levenberg-Marquardt	Lin	Lin	constant	-	?	[-1, 1]	marquard-levenberg alg. is applied to yield weights and biases, MAC
Hung and Kao (2002) [26]	MLP	Gradient Descent	Sig	Sig	*	-	off-line	?	(*) L-BFGS learning alg. And using optimal weights
Omkar et al (2004) [14]	PCA, RBF, MLP	Gradient Descent	Various		0,03	-	*	[-0.8,+0.8]	
Yam et al. (2003) [27]	MLP	Gradient Descent	Sig	Sig	constant	constant	on-line	?	Number of hidden neurons and training pairs
Huang et al. (2003) [28]	MLP	L-BFGS	Non-lin	Non-lin	*	-	?	[0,9]	(*) L-BFGS learning alg.is used
Xu et al. (2004) [29]	MLP	Gradient Descent	?	?	Dynamic	Dynamic	off-line	?	small and randomly initialized weights, Number of hidden neurons
Kao and Hung (2003) [30]	MLP	L-BFGS	step	step	0.5 and *	-	off-line	?	(*) L-BFGS learning algorithm is used
Hung et al. (2003) [31]	Wavelet NN	-	-	-	-	-	-	[-1, 1]	
Chang et al. (2000) [6]	MLP	Gradient Descent	Sig	Sig	Dynamic	Dynamic	both*	**	Jump factor, (*)off-line pretrained network, (**)Normalization, re-training,
Cheng Yeh (1998) [32]	MLP*	Gradient Descent	Various*		Dynamic	Dynamic	?	**	(*) augmented NN, (**)Normalization, randomly sampled training data
Barai and pandey (1995) [10]	MLP	Gradient Descent	Sig	Sig	0,9	0,7	?	[0, 1]	weight initialization
Rafiq et al (2001) [33]	RBF, NRBF, MLP	Gradient Descent	Various		Dynamic	-	both*	*	No. Of hidden neurons. Preprocessing of training data, hypercube concept
Oreta and Kawashima (2003) [34]	MLP	Gradient Descent	Sig	Sig	0.1-0.2	0.05-0.1	?	*	Number of training data and hidden neurons, scaling of data

Table 2.1 (cont'd)

Authors	Network Type	Learning rule	Activation Function		η	α	Training Mode	Normalization	Remarks
			Hidden	Output					
Çevik et al (2002) [12]	MLP	Gradient Descent	Sig	Sig	0,9	0,7	?	?	
Yun and bahng (2000) [13]	MLP	Gradient Descent	?	?	?	?	?	?	Number of training data and hidden neurons, hypercube technique
Rogers (1994) [35]	MLP	?	?	?	?	?	?	?	simulating structural analysis with NN
Hartmann et al (2004) [36]	MLP	RPROP	Sig	Lin	?	?		?	Number of training patterns, PCA
Papadrakakis et al (1998) [37]	MLP	Gradient Descent	Sig	Sig	Dynamic	Dynamic	off-line	?	No. Of hidden neurons. Training set selection, relationship btw. α and η
Zhang and Subbarrayan (2002) [38]	MLP	?	?	?	-	-	*	*	Scaling, training (theory)
Hung and jan (1999) [39]	MS-CMAC								
Jenkins (2002) [40]	MLP	?	Lin	Lin	?	?	?	[-1, 1]	
Ghaboussi et al (1998) [11]	MLP	?	?	?	-	-	-	-	Autoprogressive training
Rao and Datta (2006) [41]	MLP	Gradient Descent	Tanh	Tanh	0,0001	0,01	off-line	?	Randomize weights initializing, SNSS package is utilized for training
Kaveh and Servati (2001) [42]	MLP	?	*	*	*	*	*	*	*Several theorical comparisons (tanh-sig)
Worden (1997) [43]	MLP	Gradient Descent	Tanh	Tanh	?	?	?	?	Bottleneck architecture, Auto associative N.
Yun et al (2001) [8]	MLP	Gradient Descent	?	?	?	?	?	?	Hypercube sampling
Tang, Chen and Yen (2003) [44]	MLP	?	*	*	Dynamic	Dynamic	?	[-1,1];[0.2-0.8]	(*)MFLN (Augmented NN), Range of weights
Topping et al. (1997) [45]	MLP	Gradient Descent	Sig	Sig	constant	constant	Both	0.9, 0.1	Paralelization, network properties
Hadi (2002) [46]	MLP	Levenberg-Marquardt	Sig	Sig	0,01	-	-	?	LM vs Pure BP, No. Of hidden neurons
Ramu and Johnson (1994) [47]	MLP	Gradient Descent	Sig	Sig	Dynamic	-	off-line	?	number of training patterns
Tsai and Hsu (2002) [48]	MLP	Gradient Descent	Sig	Sig	Dynamic	0,7	?	?	
Papadrakakis et al. (2005) [49]	MLP	Levenberg-Marquardt	?	?	-	-	-	?	
Anderson et al. (1997) [50]	MLP	Gradient Descent	?	?	*	*	?	[-1,1];[0,1]	(*)initial values of η, α, normalization
Mourad et al (1998) [51]	MLP	Gradient Descent	Sig	Sig	0,5	0,5	?	?	Number of hidden neurons
Ricotti and zio (1998) [52]	MLP	Gradient Descent	Sig	Sig	0,6	0,8	?	0.2,0.8	weights are initialized between -0.3,0.3
Ramasamy et al (1994) [53]	MLP	Gradient Descent	Sig	Sig	?	?	?	[0,1]	
Jenkins (1998) [54]	MLP	Gradient Descent	Lin	Lin	Dynamic	-	?	[-1,1]	
Hoit et al (1994) [55]	MLP	Gradient Descent	Sig	Sig	?	?	on-line	[0,1]	
Kim and Yum (2003) [56]	MLP	Gradient Descent	Sig	Sig	constant	constant	?	?	Randomly initialized weights (-0.5,0.5)

Table 2.1 (cont'd)

Authors	Network Type	Learning rule	Activation Function		η	α	Training Mode	Normalization	Remarks
			Hidden	Output					
Kuzniar (2002) [57]	MLP	RPROP	Sig	Sig	-	-	-	[0.1, 0.9]	
Lee and Yun (2006) [58]	MLP	Gradient Descent	Sig	Sig	?	?	?	?	
Lee et al. (2005) [59]	MLP	Gradient Descent	Sig	Sig	?	?	?	?	Number of training patterns
Feng et al. (2004) [4]	MLP	?	?	?	?	?	?	?	Hypercube sampling
Hajela and berke (1990) [60]	MLP	Gradient Descent	Sig	Sig	?	?	?	?	
Consolazio (2000) [61]	MLP	Gradient Descent	Sig, tanh	sig, tanh	adaptive	constant	-	[0,1],[-1,1]	Piecewise normalization, Subdividing task
Mukherjee (1995) [62]	MLP	Gradient Descent	Sig	Sig	constant	?	on-line	0,1	Treshold value (θ)
Biedermann (1997) [63]	MLP	Gradient Descent			?	?	?	[-1,1];[-0.8,0.8]	Scaling
Tang (1995) [64]	MLP	Gradient Descent	?	?	Dynamic	constant	?	?	Adaptive BP
Li et al (2000) [65]	GRNN	-	Gaussian	Lin	-	-	-	?	
Salajegheh and Gholizadeh (2005) [66]	RBF, GRNN, CP	-	Various				-		
Iranamesh, Kaveh (1999) [67]	CPN	-	-	-	-	-	-		
Adeli and Park (1995) [68]	CPN	-	-	-	-	-	-		
Adeli and Tashakori (2002) [69]	CPN	-	-	-	-	-	-		
Arslan and Hajela (1996) [70]	CPN	-	-	-	-	-	-		
Kallasy (2002) [71]	NANN*	-	*	*	*	*	-	?	(*) New Architecture of NN
Zang and Imregun (2000) [2]	PCA, MLP	Gradient Descent	Sig	Sig	0,6	0,3	?	?	number of training patterns
Papadrakakis et al. (2004) [72]	MLP	Levenberg-Marquardt	Sig	Sig	-	-	-	?	Adaptive sigmoid fuctions, learning algorithms
Li (2000) [73]	?	?	?	?	?	?	?	?	
Park and Adeli (1997) [74]	CPN	-	-	-	-	-	-	-	
Adeli and Jiang (2006) [75]	*	Levenberg-Marquardt	*	*	*	*			(*) Dynamic fuzzy wavelet NN Model
Szewczyk and Noor (1995) [76]	MLP	?	Sig	?	?	?	?	?	Effective training
Suh and Shim (2000) [3]	MLP	Gradient Descent	Sig	Sig	adaptive	0,9	?	[0,1;0,9]	Hybrid neuro-genetic algorthm
Adeli and Karim (1997) [77]	*	*	*	*	*	*	*		(*) Neural Dynamics Optimization model
Papadrakakis and lagaros (2002) [78]	MLP	Gradient Descent	Sig	Sig	?	?	?	?	Some theroetical explanations
Brown et al. (2001) [79]	Elman NN	-	-	-	-	-	-	-	NN is used for Prediction purpose

CHAPTER 3

ARTIFICIAL NEURAL NETWORKS

3.1 General

Artificial neural networks are inspired from biological neural networks. The basic component of neural networks is called as neuron or processing element which carries out some computational works. Neurons constitute the layers which are connected through weights. Artificial neural networks are utilized in many real-life applications such as function approximation, pattern recognition, classification, data processing, clustering data mining and so on. System identification and control, decision making, pattern recognition (e.g. face-iris identification), object recognition, sequence recognition (e.g. handwritten text recognition), financial applications (e.g. stock market predictions), medical diagnosis, etc. are the examples of their application areas.

3.2 Basic Concepts of Artificial Neural Networks

Neural networks are composed of series of interconnected layers. Each layer of the network is comprised of its corresponding several individual artificial neurons. An artificial neuron can govern the local memory and perform the limited information processing operations [80]. Artificial neurons are analogous to the basic computational unit in the human brain as shown in the Figure 3.1.

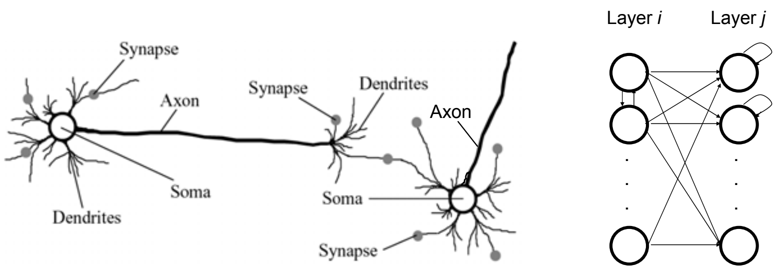


Figure 3.1 a) Biological Neuron and b) Artificial representation

A neuron is composed of four main components, namely: dendrites, synapses, soma and axon. Dendrites carry signals into the neuron, and are represented by input signals. Synapses represented by weights connect to neurons. Soma governs whether neuron fires or not. Finally, axon represented by output signals carries signals. Equivalency between biological and artificial networks is shown in Table 3.1.

Table 3.1 Equivalency between Biological and Artificial Networks

Biological Neural Network	***Artificial Neural Network***
Soma	Neuron
Dendrite	Input
Axon	Output
Synapse	Weight

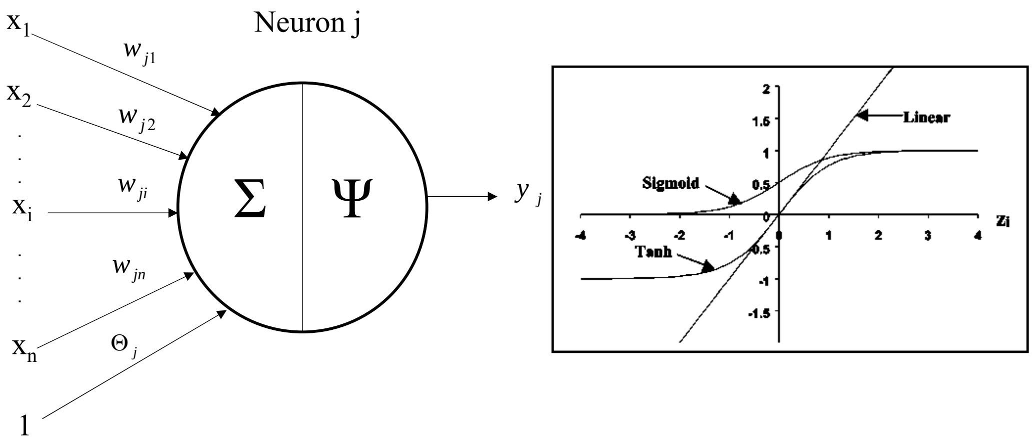


Figure 3.2 a) Artificial Neuron b) Activation Functions (Rafiq et al. [33])

An artificial neuron receives inputs x_i from an external source or its neighboring neurons as shown in Figure 3.2a. Each input has its own weight w_{ji}. Weighted sum of neuron's inputs is subjected to an activation function Ψ and output is calculated as formulated in Equations (3.1) and (3.2).

$$y_j = \Psi(u_j) = \frac{1}{1 + \exp(-\gamma_j u_j)} \tag{3.1}$$

$$u_j = \sum_{i=1}^{n} w_{ji} x_i + \Theta_j \tag{3.2}$$

where y_i is the calculated output of the j-th neuron and can serve as input to other neurons. The function Ψ is the neuron's activation function, which can be either a linear or a non-linear function as illustrated in Figure 3.2b. The notation Θ_j represents the bias term.

Networks can be divided into two main categories in terms of direction of data flow (i.e. order of connections between neurons) as, feed-forward networks and recurrent or feedback networks.

In feed-forward networks direction of data flow is from input layer to output layer. No feedback connections are present. Neurons are connected to other neurons in the following layer. Feed-forward networks are most widely used type of networks in civil engineering area since they are suitable for function approximation and classification problems that are mostly encountered in civil engineering applications.

The networks which contain feedback or recurrent connections are called as recurrent networks. The data flow is not restricted to be in the feed-forward direction, instead there are some connections between neurons from the upper layer to preceding layer as well as the some inner loop connections. Feedback networks are especially useful for modeling dynamic processes.

The learning algorithms in neural networks can be distinguished in three main categories as, supervised, unsupervised and reinforcement learning. In supervised learning, network is fed up with both known input and output pairs, then it adjusts its weights to minimize the desired and computed outputs. In unsupervised learning, only input data is entered to network and network tries to determine some features of the data, such as clustering algorithms like Principle Component Analysis (PCA) or Kohonen algorithm [81]. Finally, reinforcement learning can be defined as composition of both supervised and unsupervised learning. In this type of learning, the network is provided with the input and activation is propagated forward. The network is let to know only whether it has produced a wrong or right answer. If it has produced a wrong answer, weights are adjusted so that a right answer is more likely in future presentations.

The aim of this study is to determine the inverse relationship between modal properties and structural parameters of CBB using ANNs. Since this problem can be defined as a function approximation problem, multi layer feed-forward networks are selected due to their convenience for such problems. Therefore, the following sections focus on details on Multi-Layer perceptron networks.

3.3 Multi-Layer Perceptron Networks

Multi layer perceptron networks are a class of feed forward networks. It consists of an input layer, one or more hidden layer(s) and an output layer. Input layer is the layer which receives input vectors from the external source. Output layer is the layer which yields the result of prediction to outside world. The role of hidden layer is to link input layer to output layer, extracting and recalling the beneficial features and sub-features from the inputs to calculate the values of output patterns. Each neuron is connected to other neurons in the following layer.

The training process in the MLP networks requires presenting input patterns with known outputs i.e. supervised learning takes place. The algorithm changes the weights of the connections in order to minimize the error between desired outputs and network's outputs. Cross-validation process is to measure the network's performance for unseen data during training process. Finally, testing process involves presenting unseen data to network once the training of the network is completed and gives an idea about network's overall performance.

After the neural network is successfully trained and tested, it is able to respond for unseen input data to estimate the required output.

3.3.1 Training of MLP Networks – Back-propagation Algorithm

In neural network community back-propagation term is used in several of different meanings. For example, back-propagation is used to refer to multi-layer perceptron networks. Sometimes it is also used for training of network using gradient descent algorithm to update the weights. Actually back-propagation defines the evaluation of derivatives of the error function with respect to weights for each neuron by propagating the error through layers in the backward direction. It can also be applied to the evaluation of other derivatives such as Hessian and Jacobian matrices.

Back-propagation algorithm can be briefly stated as:

Step 1: Weights are initialized to small random values.

Step 2: An input-output pair is presented to network and network calculates its output according to its current synaptic weights.

Step 3: Local errors are determined for all layers.

Step 4: Weights are updated.

Step 5: Another training pair is presented and the algorithm goes back to step 2.

All the training pairs are presented to the network recurrently until the network converges to an acceptably low level of error. After a successful training, the network gains the ability of generalization for a specific problem and get ready to give responses for unseen data.

Consider the network presented Figure 3.3. Assuming that it has n_0 inputs, n_1 hidden neurons and n_2 output neurons, the algorithm is outline of Back-propagation can mathematically be formulated as follows [10]:

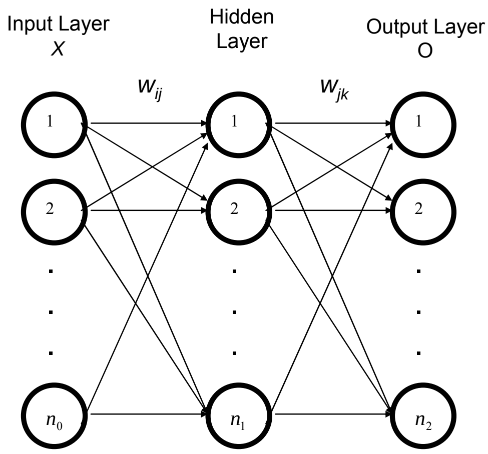


Figure 3.3 Typical MLP Network with Single Hidden Layer

1. Initialize the weights to small random values $\left[W_{ji}\right]$

$$\left[W_{ji}\right]=\begin{bmatrix} w_{11} & w_{12} & \cdots & w_{1n_0} \\ w_{21} & w_{22} & \cdots & w_{2n_0} \\ \vdots & \vdots & \vdots & \vdots \\ w_{n_1 1} & w_{n_1 2} & \cdots & w_{n_1 n_0} \end{bmatrix} \tag{3.3}$$

2. Present the first training pair $\{X_i\}$

$$\{X_i\}=\begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_{n_0} \end{bmatrix} \tag{3.4}$$

3. Calculate the inputs to hidden layer $\{u_j\}$ using Eq. (3.5)

$$\{u_j\} = \begin{Bmatrix} u_1 \\ u_2 \\ \vdots \\ u_{n_1} \end{Bmatrix} = [W_{ji}]\{X_i\} \tag{3.5}$$

4. Inputs $\{u_j\}$ to hidden neurons are subjected to activation function (Ψ) to produce their outputs $\{y_j\}$ using Eq. (3.6)

$$\{y_j\} = \begin{Bmatrix} y_1 \\ y_2 \\ \vdots \\ y_{n_1} \end{Bmatrix} = \begin{Bmatrix} \Psi_1 \\ \Psi_2 \\ \vdots \\ \Psi_{n_1} \end{Bmatrix} \left(\begin{Bmatrix} u_1 \\ u_2 \\ \vdots \\ u_{n_1} \end{Bmatrix} \right) = \begin{Bmatrix} \Psi_1(u_1) \\ \Psi_2(u_2) \\ \vdots \\ \Psi_{n_1}(u_{n_1}) \end{Bmatrix} = \begin{Bmatrix} 1/(1+e^{(-\gamma_1 u_1)}) \\ 1/(1+e^{(-\gamma_2 u_2)}) \\ \vdots \\ 1/(1+e^{(-\gamma_{n_1} u_{n_1})}) \end{Bmatrix} \tag{3.6}$$

5. Using weights between the hidden and output layers $[W_{kj}]$

$$[W_{kj}] = \begin{bmatrix} w_{11} & w_{12} & \cdots & w_{1n_1} \\ w_{21} & w_{22} & \cdots & w_{2n_1} \\ \vdots & \vdots & \vdots & \vdots \\ w_{n_2 1} & w_{n_2 2} & \cdots & w_{n_2 n_1} \end{bmatrix} \tag{3.7}$$

6. Calculate the inputs to output layer using Eq. (3.8)

$$\{u_k\} = \begin{Bmatrix} u_1 \\ u_2 \\ \vdots \\ u_{n_2} \end{Bmatrix} = [W_{kj}]\{y_j\} \tag{3.8}$$

7. Inputs $\{u_k\}$ to output neurons are subjected to activation function (Ψ) to produce their outputs $\{y_k\}$ using Eq. (3.9)

$$\{y_k\} = \begin{Bmatrix} y_1 \\ y_2 \\ \vdots \\ y_{n_2} \end{Bmatrix} = \begin{Bmatrix} \Psi_1 \\ \Psi_2 \\ \vdots \\ \Psi_{n_2} \end{Bmatrix} \left(\begin{Bmatrix} u_1 \\ u_2 \\ \vdots \\ u_{n_2} \end{Bmatrix} \right) = \begin{Bmatrix} \Psi_1(u_1) \\ \Psi_2(u_2) \\ \vdots \\ \Psi_{n_2}(u_{n_2}) \end{Bmatrix} = \begin{Bmatrix} 1/(1+e^{(-\gamma_1 u_1)}) \\ 1/(1+e^{(-\gamma_2 u_2)}) \\ \vdots \\ 1/(1+e^{(-\gamma_{n_2} u_{n_2})}) \end{Bmatrix} \tag{3.9}$$

8. Calculate the weight changes between output and hidden layers using Eq. (3.10)

$$\left[\Delta W_{kj}\right] = \eta \,\{d_k - y_k\}\{y_k\}\{y_j\}^{\mathrm{T}} \tag{3.10}$$

where η is learning rate selected between 0 and 1.

9. Update the weights using Eq. (3.11)

$$\lfloor W_{kj} \rfloor = \lfloor W_{kj} \rfloor + \lfloor \Delta W_{kj} \rfloor \tag{3.11}$$

10. Calculate the weight change between hidden and input layers using Eq. (3.12)

$$\left[\Delta W_{ji}\right] = \eta \,\{y_j\}\{d_k - y_k\}\left[W_{kj}\right]^{\mathrm{T}} \{X_i\}^{\mathrm{T}} \tag{3.12}$$

11. Update the weigths using Eq. (3.13)

$$\lfloor W_{ji} \rfloor = \lfloor W_{ji} \rfloor + \lfloor \Delta W_{ji} \rfloor \tag{3.13}$$

The algorithm continues for all training sets until the mean squared error (MSE) between the desired and calculated output is close enough to tolerance.

3.3.1.1 Derivation of Back-Propagation Algorithm

Let us assume that network is composed of an input layer with n_0 inputs, first hidden layer with n_1 neurons, second hidden layer with n_2 neurons and finally an output layer with n_3 neurons as it is shown in Figure 3.4.

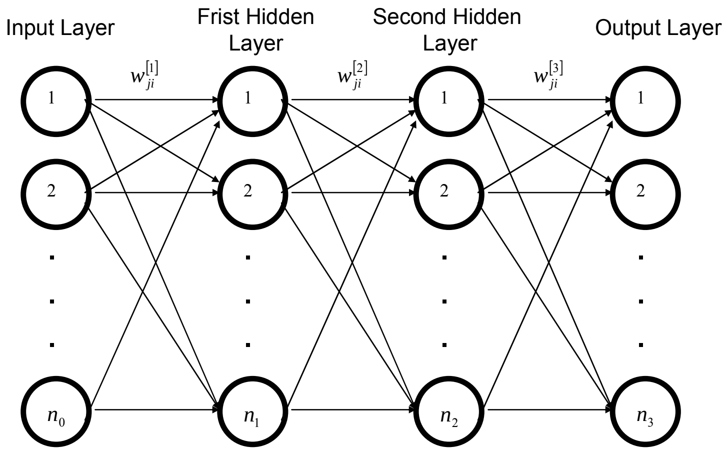


Figure 3.4 Typical MLP Network with Two Hidden Layers

Each training pair consists of n_0 inputs x_i $(i = 1,2,...,n_0)$ and n_3 outputs d_j $(j = 1,2,...,n_3)$. Learning of MLP network is the process of determining the optimum values of synaptic weights such that the difference between network's output y_{jp} and desired output d_{jp} averaged over all instances p is to be minimized. Back-propagation algorithm utilizes the steepest descent algorithm for minimization of the error function. Mean squared error function for the p-th training example can be stated as:

$$E_p = \frac{1}{2}\sum_{j=1}^{n_3}(d_{jp} - y_{jp})^2 = \frac{1}{2}\sum_{j=1}^{n_3}e_{jp}^2 \tag{3.14}$$

and the total error function is the sum-squared error as:

$$E = \sum_p E_p = \frac{1}{2}\sum_p\sum_j(d_{jp} - y_{jp})^2 \tag{3.15}$$

where d_{jp} and y_{jp} are the desired and network's outputs of the j-th output neuron for the p-th training example, respectively.

For each training example the weights $w_{ji}^{[s]}$ (s = 1, 2, 3 representing the layer number) are moved by an amount $\Delta w_{ji}^{[s]}$ which can be written as:

$$\Delta w_{ji}^{[s]} = -\eta \frac{\partial E_p}{\partial w_{ji}^{[s]}}, \quad \eta > 0 \tag{3.16}$$

where η is called as step size or learning rate which specifies the amount of weight change proportional to the respective negative gradient of the local error function E_p. Using chain rule for Eq. 3.16, one can write:

$$\Delta w_{ji}^{[3]} = -\eta \frac{\partial E_p}{\partial w_{ji}^{[3]}} = -\eta \frac{\partial E_p}{\partial u_j^{[3]}} \frac{\partial u_j^{[3]}}{\partial w_{ji}^{[3]}} \tag{3.17}$$

Considering that

$$u_j^{[3]} = \sum_{i=1}^{n_2} w_{ji}^{[3]} x_i^{[3]} = \sum_{i=1}^{n_2} w_{ji}^{[3]} o_i^{[2]} \tag{3.18}$$

and defining local error , called delta δ_j :

$$\delta_j^{[3]} = -\frac{\partial E_p}{\partial u_j^{[3]}} = -\frac{\partial E_p}{\partial e_{jp}^{[3]}} \frac{\partial e_{jp}^{[3]}}{\partial u_j^{[3]}} = e_{jp} \frac{\partial \Psi_j^{[3]}}{\partial u_j^{[3]}} \tag{3.19}$$

a general formula is obtained for changing the weights in the output layer as:

$$\Delta w_{ji}^{[3]} = \eta \delta_j^{[3]} x_i^{[3]} = \eta \delta_j^{[3]} o_i^{[2]} \tag{3.20}$$

where

$$\delta_j^{[3]} o_j = e_{jp} (\Psi_j^{[3]})' = (d_{jp} - y_{jp}) \frac{\partial \Psi_j^{[3]}}{\partial u_j^{[3]}} \tag{3.21}$$

Updating the weights for the second hidden layer, it can be written that:

$$\Delta w_{ji}^{[2]} = -\eta \frac{\partial E_p}{\partial w_{ji}^{[2]}} = -\eta \frac{\partial E_p}{\partial u_j^{[2]}} \frac{\partial u_j^{[2]}}{\partial w_{ji}^{[2]}} = \eta \delta_j^{[2]} x_i^{[2]} = \eta \delta_j^{[2]} o_i^{[1]} \tag{3.22}$$

where the local error is stated as:

$$\delta_j^{[2]} = -\frac{\partial E_p}{\partial u_j^{[2]}} \quad (j = 1,2,....,n_2) \tag{3.23}$$

using chain rule

$$\delta_j^{[2]} = -\frac{\partial E_p}{\partial u_j^{[2]}} = -\frac{\partial E_p}{\partial o_j^{[2]}} \frac{\partial o_j^{[2]}}{\partial u_j^{[2]}} \tag{3.24}$$

Considering that

$$o_j^{[2]} = \Psi_j^{[2]}(u_j^{[2]}) \tag{3.25}$$

then

$$\delta_j^{[2]} = -\frac{\partial E_p}{\partial o_j^{[2]}} \frac{\partial \Psi_j^{[2]}}{\partial u_j^{[2]}} \tag{3.26}$$

where $-\frac{\partial E_p}{\partial o_j^{[2]}}$ can be evaluated as

$$-\frac{\partial E_p}{\partial o_j^{[2]}} = -\sum_{i=1}^{n_3} \frac{\partial E_p}{\partial u_i^{[3]}} \frac{\partial u_i^{[3]}}{\partial o_j^{[2]}} = \sum_{i=1}^{n_3} \left(-\frac{\partial E_p}{\partial u_i^{[3]}} \right) \frac{\partial}{\partial o_j^{[2]}} \left(\sum_{k=1}^{n_3} w_{ik}^{[3]} x_k^{[3]} \right) = \sum_{i=1}^{n_3} \delta_i^{[3]} \frac{\partial}{\partial o_j^{[2]}} \left(\sum_{k=1}^{n_3} w_{ik}^{[3]} o_k^{[2]} \right)$$
$$= \sum_{i=1}^{n_3} \delta_i^{[3]} w_{ij}^{[3]} \tag{3.27}$$

Consequently for the second hidden layer the local error can be determined by:

$$\delta_j^{[2]} = \frac{\partial \Psi_j^{[2]}}{\partial u_j^{[2]}} \sum_{i=1}^{n_3} \delta_i^{[3]} w_{ij}^{[3]} \tag{3.28}$$

Weight updating formula for the first hidden layer can be derived in the same fashion

$$\Delta w_{ji}^{[1]} = \eta \delta_j^{[1]} x_i^{[1]} = \eta \delta_j^{[1]} o_i^{[0]} \tag{3.29}$$

where the local errors are evaluated as

$$\delta_j^{[1]} = \frac{\partial \Psi_j^{[1]}}{\partial u_j^{[1]}} \sum_{i=1}^{n_2} \delta_i^{[2]} w_{ij}^{[2]} \tag{3.30}$$

The local errors of the hidden layers are evaluated on the basis of the local errors in following layer. Precisely, local errors of the neurons in output layer are determined using the Eq. 3.21. Then, local errors in the output layer are back-propagated through preceding layer. In the output layer error is a function of network's output and desired output and the derivative of the activation function. On the other hand, for hidden layers local errors are determined based on the local errors in the upper layer.

3.3.1.2 Batch Learning Mode

In the above algorithm on-line mode of learning is described. In on-line learning mode a training example *p* is presented to network, and then weight changes are carried out before the next training pair is presented. In batch (or off-line) mode, weights are updated after presenting all training data. In fact, local errors are calculated when each training pattern is presented, however weights are changed according to local errors averaged over entire training set. This yields such a weight change:

$$\Delta w_{ji}^{[s]} = \sum_p \Delta_p w_{ji}^{[s]} = -\eta \frac{\partial E_p}{\partial w_{ji}^{[s]}(k)} = \eta \sum_p \delta_{jp}^{[s]} o_{ip}^{[s-1]} \tag{3.31}$$

Presenting the entire training data set to the network once during training process is called an epoch. Hence, in batch mode, weights are updated at the end of each epoch.

Both on-line and batch modes of training have some advantages as well as disadvantages. In online mode, updating the weights after presentation of each training data leads to some noise which helps the network to get out of the local minimum. However, global performance of the network is deteriorated. On the other hand, network's outputs will be more approximate in the batch mode. However, network is more prone to being trapped in local minimum when batch mode of learning is preferred. Furthermore, memory storage requirements and computational works are increased due to averaging the weight corrections, and consequently learning speed slows down.

3.3.1.3 Back-Propagation Algorithm with Momentum Term

Learning rate η should be selected small enough to provide a proper learning. If learning rate is chosen too small, then learning will be slow. Besides network might get trapped in local minima. On the other hand, if learning rate is assigned to a large value, then rapid training takes place, in which case network may not converge to minimum.

In order to overcome these difficulties, momentum term is added to weight change equation such that:

$$\Delta w_{ji}^{[s]}(k) = \eta \delta_j^{[s]} o_i^{[s-1]} + \alpha \Delta w_{ji}^{[s]}(k-1) \tag{3.32}$$

where

$\eta > 0 \qquad 0 \le \alpha < 1$

3.3.1.4 Quickprop

Quickprop is a modified gradient search procedure in order to improve the convergence speed. The performance improvement gained with Quickprop has been shown in most of the problems. Its fast convergence basically depends on utilization the information about the second order derivative of the performance surface. Quickprop is a heuristic learning algorithm for a multilayer perceptron, developed by Fahlman [82].

The slope of the activation function is almost zero, when a neuron with a sigmoid function is close to its extreme boundaries. Therefore, the corresponding local error of neuron δ_i, and consequently its weight change Δw_{ji} are almost zero. In order to overcome this difficulty a modified activation function is proposed by Fahlman in his Quickprop algorithm.

$$\Psi(u_j) = (1 + e^{-\gamma u_j})^{-1} + 0.1u_j \tag{3.33}$$

The Quickprop learning algorithm can be formulated as

$$\Delta w_{ji}(k) = -\eta^{(k)} S_{ji}(k) + \alpha_{ji}^{(k)} \Delta w_{ji}(k-1) \tag{3.34}$$

$$S_{ji}(k) := \frac{\partial E(\mathbf{w}^{(k)})}{\partial w_{ji}} + \gamma w_{ji}(k) \tag{3.35}$$

with the learning rate

$$\eta^{(k)} = \begin{cases} \eta_0\,, & \textit{if } \Delta w_{ji}(k-1) = 0.0 \textit{ or } S_{ji}(k)\Delta w_{ji}(k-1) > 0.0 \\ 0\,, & \textit{otherwise} \end{cases} \tag{3.36}$$

and the momentum rate

$$\alpha_{ji}^{(k)} = \begin{cases} \alpha_{\max}\,, & \textit{if } \tilde{\alpha}_{ji}^{(k)} > \alpha_{\max} \textit{ or } S_{ji}(k)\Delta w_{ji}(k-1)\tilde{\alpha}_{ji}^{(k)} < 0.0 \\ \tilde{\alpha}_{ji}^{(k)} = \dfrac{S_{ji}(k)}{S_{ji}(k-1) - S_{ji}(k)}\,, & \textit{otherwise} \end{cases} \tag{3.37}$$

Note that if $\Delta w_{ji} = 0$, the learning rate $\eta^{(k)} \neq 0$ is only necessary to start the training or restart it. γ is the small decay factor which prevents the weights from having large values. Typical values of the parameters are: $0.01 \leq \eta_0 \leq 0.6$, $\alpha_{\max} = 1.75$, $\gamma = 10^{-4}$.

Usually, the Quickprop algorithm is simplified as

$$\Delta w_{ji}(k) = \begin{cases} \alpha_{ji}^{(k)} \Delta w_{ji}(k-1), & if \ \Delta w_{ji}(k-1) \neq 0 \\ \eta_0 \dfrac{\partial E}{\partial w_{ji}}, & if \ \Delta w_{ji}(k-1) = 0 \end{cases} \tag{3.38}$$

where

$$\alpha_{ji}^{(k)} = \min \left\{ \frac{\dfrac{\partial E\left(\boldsymbol{w}^{(k)}\right)}{\partial w_{ji}}}{\dfrac{\partial E\left(\boldsymbol{w}^{(k-1)}\right)}{\partial w_{ji}} - \dfrac{\partial E\left(\boldsymbol{w}^{(k)}\right)}{\partial w_{ji}}}, \quad \alpha_{\max} \right\} \tag{3.39}$$

3.3.1.5 Delta-Bar-Delta algorithm

Delta-Bar-Delta is an adaptive step-size procedure developed by Jacobs [83]. The learning rate and momentum coefficient are adjusted considering the neuron's local error at a previous iteration. The learning rate is linearly increased, if both former and current weight changes have the same sign. If weight updates have different signs, this indicates that weight has been changed too much. When this takes place, the learning rate will be reduced by the algorithm to avoid divergence.

Delta-Bar-Delta algorithm, can be written in the form

$$\Delta w_{ji}(k) = -\eta_{ji}^{(k)} \frac{\partial E}{\partial w_{ji}} \tag{3.40}$$

with a change in the learning rate η_{ji} in each epoch given by

$$\eta_{ji}^{(k)} = \begin{cases} \eta_{ji}^{(k-1)} + a, & if \ \bar{\delta}_{ji}(k-1)\hat{\delta}_{ji}(k) > 0, \\ b\eta_{ji}^{(k-1)}, & if \ \bar{\delta}_{ji}(k-1)\hat{\delta}_{ji}(k) < 0, \\ 0, & otherwise \end{cases} \tag{3.41}$$

where a is a parameter for an additive increase and b is a parameter for a multi-plicative (exponential) decrease in the learning rates η_{ji} and

$$\hat{\delta}_{ji}(k) = \frac{\partial E}{\partial w_{ji}} \tag{3.42}$$

$$\overline{\delta}_{ji}(k) = (1-\vartheta)\hat{\delta}_{ji}(k) + \vartheta\overline{\delta}_{ji}(k-1) \tag{3.43}$$

where ϑ is the momentum parameter ($0 \leq \vartheta < 1$). The parameters a, b and ϑ are specified by the user. Typical values of these parameters are: $10^{-4} \leq a \leq 0.1$, $0.5 \leq b \leq 0.9$ and $0.1 \leq \vartheta \leq 0.7$.

3.3.1.6 Conjugate Gradient Algorithm (CG)

Another back-propagation algorithm with an adaptable learning rate and momentum rate is the conjugate gradient algorithm. There are different versions of the conjugate gradient algorithm. In general, the algorithm can be formulated as

$$\Delta \boldsymbol{w}^{\boldsymbol{k}} = \alpha_k \boldsymbol{d}_k \tag{3.44}$$

$$\boldsymbol{d}_0 = -\nabla E\left(w^{(0)}\right) \tag{3.45}$$

$$\boldsymbol{d}_{k+1} = -\nabla E\left(w^{(k+1)}\right) + \beta_k \boldsymbol{d}_k \tag{3.46}$$

$$\beta_k = \frac{\nabla E\left(\boldsymbol{w}^{(k+1)}\right)^{\mathrm{T}} \nabla E\left(\boldsymbol{w}^{(k)}\right)}{\nabla E\left(\boldsymbol{w}^{(k)}\right)^{\mathrm{T}} \nabla E\left(\boldsymbol{w}^{(k)}\right)} \tag{3.47}$$

$$\alpha_k = \arg\min(E\left(w^{(k)}\right) + \eta^{(k)} d_k) \tag{3.48}$$

where $\boldsymbol{w}^{\boldsymbol{k}}$ is the weight matrix at the kth iteration, $\boldsymbol{d}_k$ is the current direction of weight movement, ∇E is the gradient, β_k is a parameter which specifies how much of the past direction is considered to determine the new conjugate direction, α_k is the step size.

Gradient descent algorithms utilize the local approximation of the slope of the performance surface to find out the best direction to change the weights in order to achieve lower the error. However, second order methods such as conjugate gradient algorithm make use of information acquired by the second order derivatives of the performance surface to update the weights.

Main drawback associated with second order methods is that they involve much more computational work for each weight update. This leads to a slower convergence as compared with the first order algorithms.

3.3.1.7 The Levenberg-Marquardt (L-M) algorithm

The Levenberg-Marquardt (L-M) algorithm [84] is one of the most convenient higher-order adaptive algorithms for error minimization procedure of a neural network. It is an instance of a pseudo second order methods. In order to update the weights, unlike standard gradient descent algorithms, the second order methods utilizes the Hessian or the matrix of second derivatives of the performance surface to move the weights, while pseudo-second order methods approximate the Hessian. In other words, the second order algorithms take the advantage of the curvature of performance surface instead of the information only acquired by the slope. Especially, the L-M algorithm junks second order derivatives of the error instead, and uses the Gauss-Newton approximation which keeps the Jacobian matrix. Using a second order method, exact minimum can be found in one step, if the performance surface is a second order polynomial. In neural networks, since variation of error may be non-convex, quadratic approximations involve multiple steps for convergence besides, network may diverge. In general, the algorithm can be formulated as:

Consider the sum-of-squares error function in the form

$$E_p = \frac{1}{2}\sum_{j=1}^{n_3}(d_{jp} - y_{jp})^2 = \frac{1}{2}\sum_{j=1}^{n_3} e_{jp}^2 = \frac{1}{2}\|\boldsymbol{e}\|^2 \tag{3.49}$$

where e_p is the error for the p-th pattern, and $\boldsymbol{e}$ is a vector with elements e_p. Suppose we are currently at a point $\mathbf{w}_{\text{old}}$ in weight space and we move to a point $\mathbf{w}_{\text{new}}$. If the displacement $\mathbf{w}_{\text{new}} - \mathbf{w}_{\text{old}}$ is small then error vector can be expanded to first order in a Taylor series

$$\boldsymbol{e}(\mathbf{w}_{\text{new}}) = \boldsymbol{e}(\mathbf{w}_{\text{old}}) + \mathbf{Z}(\mathbf{w}_{\text{new}} - \mathbf{w}_{\text{old}}) \tag{3.50}$$

where **Z** is defined as a matrix with elements

$$(\mathbf{Z})_{pi} \equiv \frac{\partial e_p}{\partial w_i} \tag{3.51}$$

The error function (3.50) can then be written as

$$E = \frac{1}{2}\left\|\boldsymbol{e}(\mathbf{w}_{\text{old}}) + \mathbf{Z}(\mathbf{w}_{\text{new}} - \mathbf{w}_{\text{old}})\right\|^2 \tag{3.52}$$

If error is to be minimized with respect to the new weights $\mathbf{w}_{\text{new}}$ it is obtained that

$$\mathbf{w}_{\text{new}} = \mathbf{w}_{\text{old}} - (\mathbf{Z}^{\mathrm{T}}\mathbf{Z})^{-1}\mathbf{Z}^{\mathrm{T}}\boldsymbol{e}(\mathbf{w}_{\text{old}}) \tag{3.53}$$

For the sum-of-squares error function, the elements of the Hessian matrix (**H**) take the form

$$(\mathbf{H}) = \frac{\partial^2 E}{\partial w_i \partial w_k} = \sum_p \frac{\partial e_p}{\partial w_i}\frac{\partial e_p}{\partial w_k} + \frac{\partial^2 e_p}{\partial w_i \partial w_k} \tag{3.54}$$

If the second term is neglected, then the Hessian can be written in the form

$$\mathbf{H} = \mathbf{Z}^{\mathrm{T}}\mathbf{Z} \tag{3.55}$$

In principle, in order to minimize the error, the weight update equation (3.53) can be applied iteratively. However, this approach has a shortcoming such that step size could jump to relatively large values in which case linear approximation is no longer valid. Levenberg-Marquardt algorithm, minimizes the error while trying to keep the step size small enough so that linear approximation remains valid. This is acquired by a modified error function of the form

$$E = \frac{1}{2}\left\| e(\mathbf{w}_{\text{old}}) + \mathbf{Z}(\mathbf{w}_{\text{new}} - \mathbf{w}_{\text{old}}) \right\|^2 + \lambda \left\| \mathbf{w}_{\text{new}} - \mathbf{w}_{\text{old}} \right\|^2 \tag{3.56}$$

where the parameter λ governs the step size. For large values of λ the value of $\left\| \mathbf{w}_{\text{new}} - \mathbf{w}_{\text{old}} \right\|^2$ tend to be small. If we minimize the modified error (3.56) with respect to $\mathbf{w}_{\text{new}}$, we obtain

$$\mathbf{w}_{\text{new}} = \mathbf{w}_{\text{old}} - (\mathbf{Z}^{\text{T}}\mathbf{Z} + \lambda \mathbf{I})^{-1} \mathbf{Z}^{\text{T}} e(\mathbf{w}_{\text{old}}) \tag{3.57}$$

where I is the unit matrix and the step length is determined by λ^{-1}. The error will decrease for sufficiently large values of λ.

In practice a value must be selected initially for λ and this value should vary throughout the error minimization process. According to one common approach, λ is initialized with 0.1, and at each step the change in error E is observed. After taking the step predicted by (3.57), if the error increases, the new weights are retained, λ is reduced by 10, and the process is repeated. If the error increases, then λ is multiplied by 10, the former weights are reconstituted, and a new weight update is computed. This process is repeated until a decrease in *E* is obtained.

3.3.2 Cross-Validation

One of the problems associated with the training of neural networks is to determine how many epochs are required to achieve a successful training. If network is kept training too much i.e. too many epochs are processed, then the network starts to memorize the training data and consequently loses its generalization ability. This phenomenon is known as overtraining. On the other hand, if training is stopped prematurely, then the network may not converge enough to minima i.e. it may not learn the actual input-output relationship. In order to overcome this difficulty an independent data set referred to as cross-validation set is utilized. While training proceeds, a pair of data which is not used in training i.e. cross-validation data, is presented to network at the end of each epoch to measure the network's performance for unseen data. This action is called as cross-validation.

In order to prevent overtraining, global performance of the network for both training and cross-validation data set should be observed. While training proceeds, error for training data keeps reducing, however for cross-validation data error starts to increase at a specific epoch i.e. overtraining takes place. This means that network starts to lose its generalization ability at which time training must be terminated as shown in Figure 3.5.

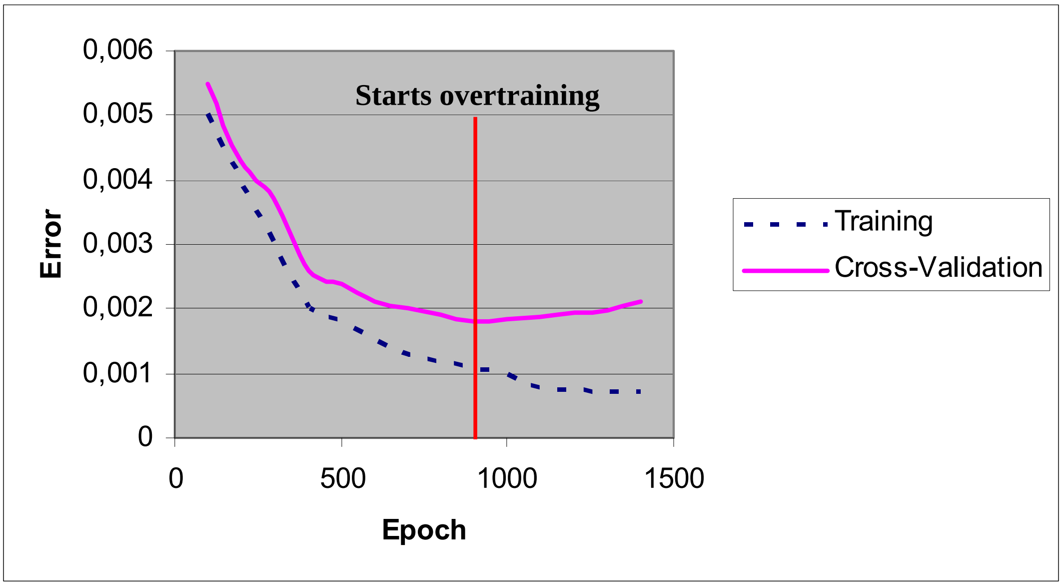


Figure 3.5 Overtraining

3.3.3 Testing

Testing phenomenon can be defined as estimation of the network's post-training performance. In order to accomplish this, a set of unseen examples should be reserved for testing.

Another objective of testing is to determine the optimum number of hidden neurons. Although there are some heuristics proposed to find out how many neurons should be used in hidden layer, the best way to determine the required number is by trial-error approach.

Selection of number of neurons for hidden layer is non-trivial such that if too many neurons are used in hidden layer, a problem known as over-fitting occurs. Conversely, if the hidden neurons are less than the optimum value, under-fitting takes place. Over-fitting means network over-fits the training data and loses its generalization ability. Excessive number of hidden neurons means that the network tends to seek a more complex relationship than what actual I/O has. However if number of hidden neurons is assigned a value less than required, the network fails to represent the actual I/O relationship i.e. less complex function is represented by the network. In both cases, i.e. in over-fitting and under-fitting, the network loses its generalization ability and fails to represent the actual relationship. In order to overcome this difficulty, starting from a small number of neurons, networks with various numbers of hidden neurons should be compared in terms of testing and training performances. At a specific number of neurons, testing performance of the network starts being deteriorated which indicates that the network starts to lose its generalization ability for unseen data. It should be noticed that the training performance keeps improving with the increasing number of neurons, implying that the network over-fits the training data as it is shown in Figure 3.6.

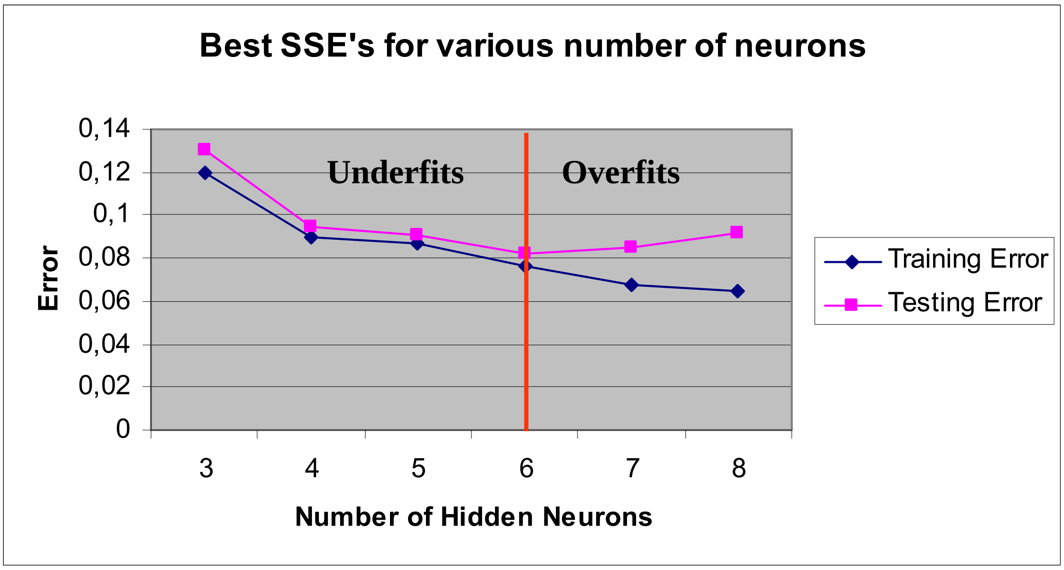


Figure 3.6 Underfitting and overfitting

In Figures 3.7(a) and (b) dashed line represents the actual I/O relationship; continuous line represents what network learns and circles represent the training points. The network is expected to learn the actual relationship using those training points. In the first graph, the network can handle the relationship well and achieves a good generalization. However in the second case, network is fed up with excessive number of hidden neurons, than captures training points more successfully, however represents more complex function than desired and consequently loses its generalization ability for unseen data. That is to say, overfitting takes place.

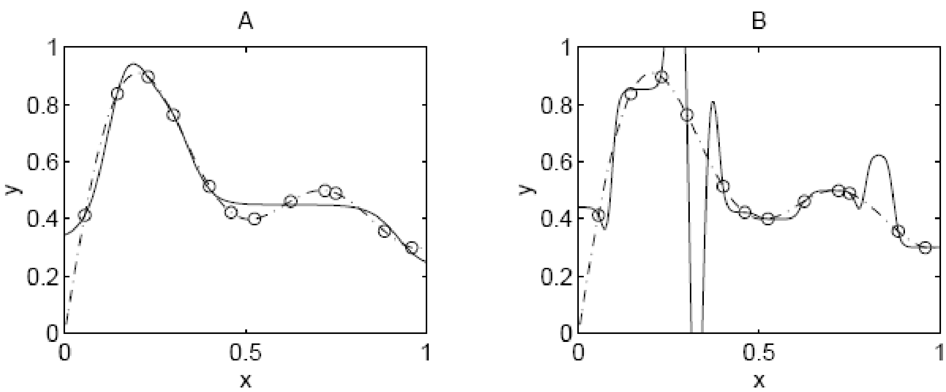


Figure 3.7 a) Desired b) Overfitting

CHAPTER 4

COMMODORE BARRY BRIDGE : A LONG CANTILEVER THROUGH TRUSS BRIDGE

4.1 General

The Commodore Barry Bridge (CBB) spans the Delaware River between Chester, Pennsylvania and Bridgeport, New Jersey. The bridge has five traffic lanes and currently serves more than six million vehicles annually, a significant percentage of which is heavy truck traffic. It was opened to traffic in 1974. The bridge is the longest cantilever steel truss bridge in the U.S. with a main span length of 1,644 (501.09 meters) feet and a total length of 13,912 feet (4,240.38 meters). In addition to a single three span cantilever through truss, The Commodore Barry Bridge consists of 63 simply supported steel stringer approach spans and 11 simply supported deck truss approach spans as it is shown in Figure 4.1.

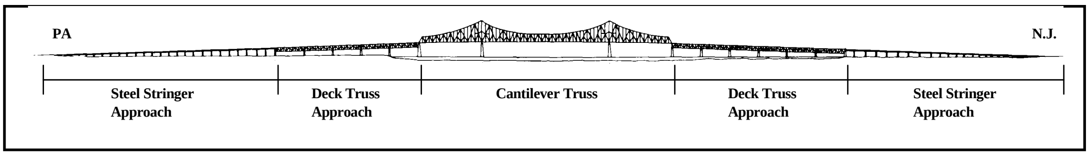


Figure 4.1 Components of CBB

Figure 4.1 Components of CBB (cont'd)

In the following subsections, the main structural components of the bridge will be introduced in detail.

4.2 Structural System Properties of CBB

The Commodore Barry Bridge is a three span cantilever through truss structure with a total length of 3,288 ft (1 002.18 m). A schematic showing the elevation view of the bridge is shown in Figure 4.2. It consists of two (2) anchor spans with lengths of 822 ft (250.54 m) each, two (2) cantilever arms with lengths of 411 ft (125.27 m) each, and one (1) suspended span with a length of 822 ft (250.54 m).

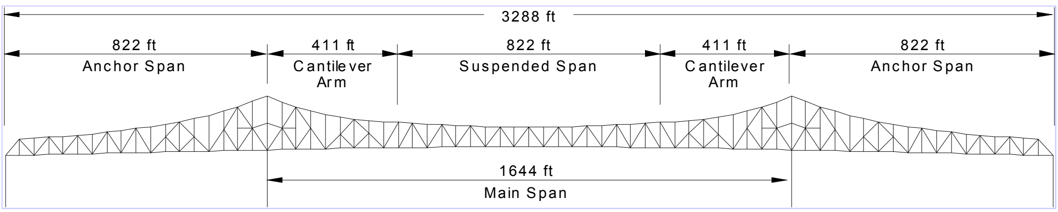


Figure 4.2 Cantilever Through Truss Spans

4.2.1 The Principal Structural System

The principal structural system of the bridge consists of a pair of trusses (North Truss and South Truss) spaced 72.5 ft (22.1 m) between their centerlines. The primary truss members consist of welded box sections at the upper and lower chords, a mix of welded box sections and wide flange sections at the diagonals, and a mix of welded box sections and wide flange sections at the verticals.

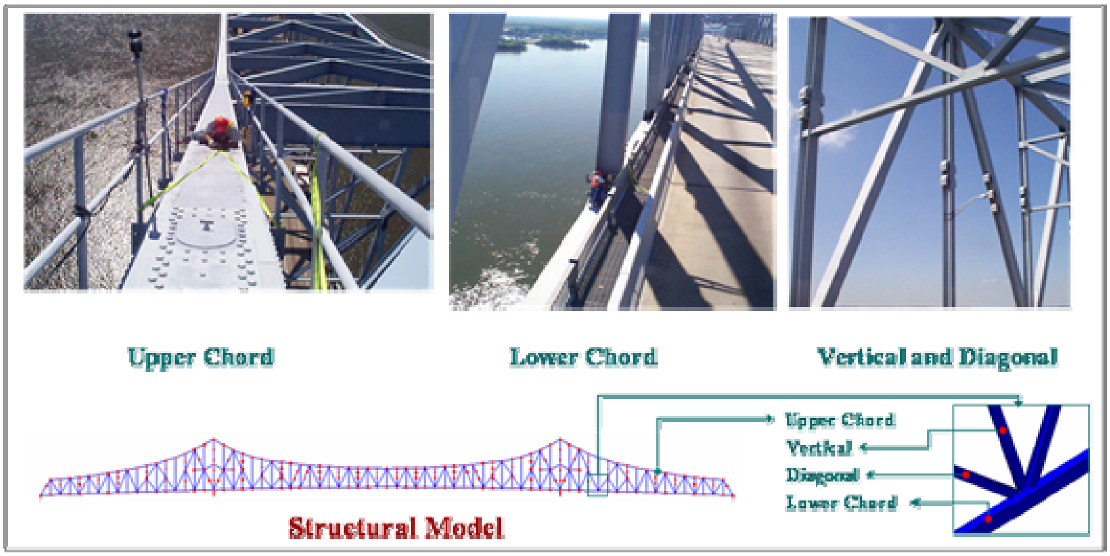


Figure 4.3 Primary Truss Members

4.2.2 The Secondary Members

The secondary members are used to provide lateral bracing by K-bracing at the upper and lower chord levels, and by portal and sway frames located at various panel points throughout the spans as it is shown in Figure 4.4.

Figure 4.4 Secondary Members

4.2.3 Deck

The deck is composed of an 8-inch (20.32 cm) reinforced concrete roadway, which mainly supports the live (traffic) loads and transfers them to the floor system. The width of the roadway is 60 ft (18.288 m) between curb faces. The floor system is composed of wide flange roadway stringers, which are composite with the deck, tapered floor beams and wind bracing. The roadway stringers are continuous for 4 and 5 span over the tapered wide flange floor beams.

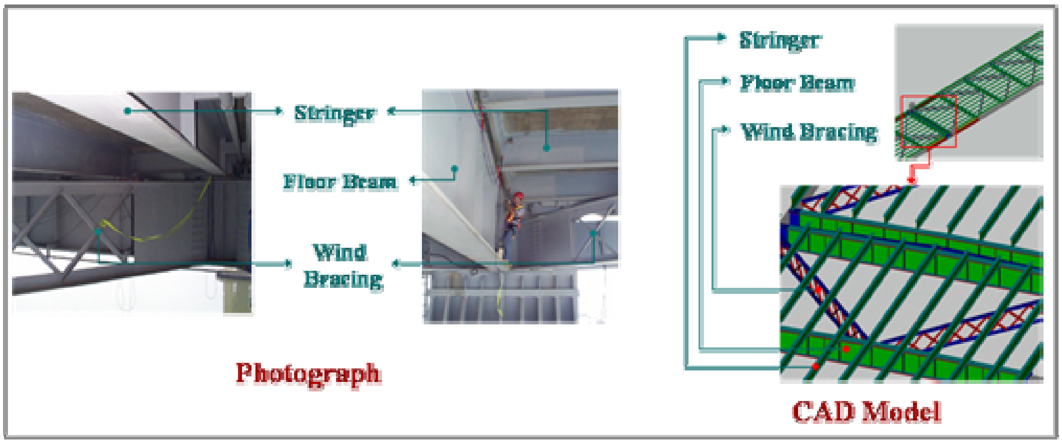


Figure 4.5 Stringers, Floor Beams and Wind Bracings

4.2.4 Piers

There are four reinforced concrete piers supporting the bridge as it is shown in Figure. Piers are classified into two groups (1 and 2) in terms of their geometry as Pier E1, W1 and Pier E2, W2 where E (East) and W (West) represents the location of piers.

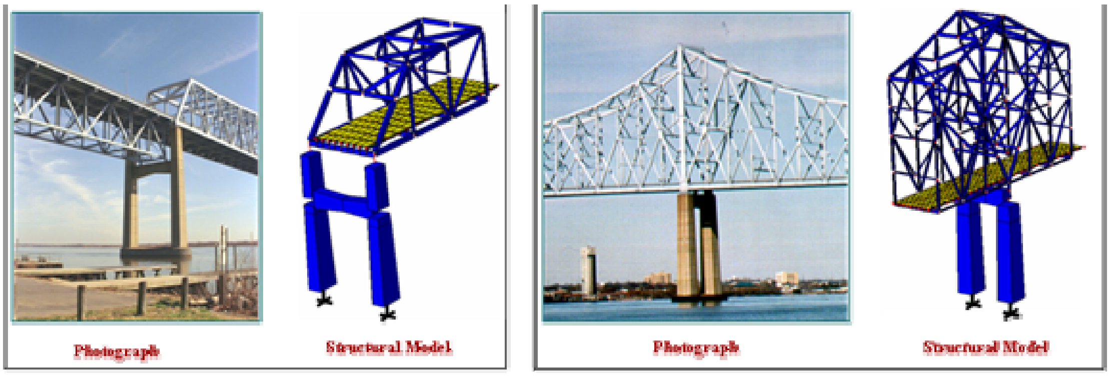


Figure 4.6 a) Piers E2, W2 b) Piers E1, W1

4.2.5 Critical Structural Systems and Mechanisms

The bridge has some structural features in connection to design and functionality of its movement systems at the boundary and continuity locations, as well as the floor system. The comprehension of these structural features is of particular importance to calibration work implemented for the bridge.

4.2.5.1 Movement systems at boundary and continuity locations

CBB has two major movement systems, which in turn enable the bridge to release some of its internal forces at the boundary and continuity locations. The first movement system is triggered through the bearings at piers, such that the bearings are designed to allow for the movement of the superstructure in certain directions while transmitting the loads. Two types of bearings are used in the bridge. Expansion bearings that permit both rotation and longitudinal translation are used at Piers W2 and E2. These bearings also incorporate uplift prevention devices. On the other hand, the bearings used at Piers W1 and E1 are of fixed type, enabling a rotational movement only. Bearings are shown in Figure 4.7.

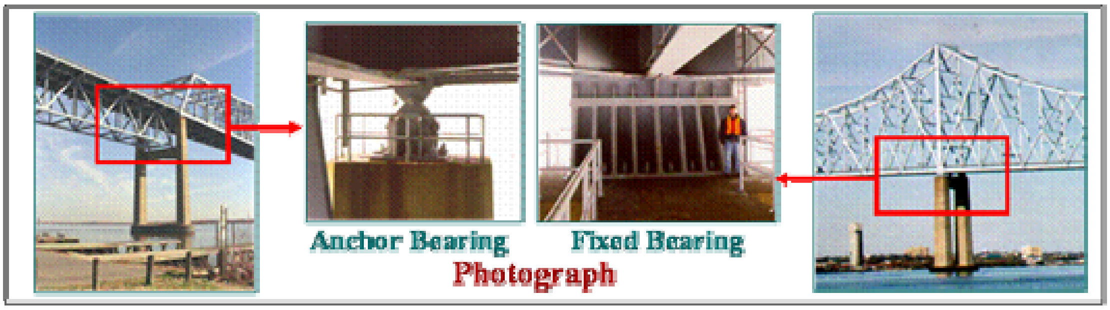


Figure 4.7 Bearings

The second movement system is owing to the design of the suspended span at Panel Points (PP) 27 and 45, as is shown in Figure 4.8. Here, the detailing of the three-hinged linkage element enables longitudinal expansion of the suspended span at PP27. The detailing of the wind linkage, which is the other end of the suspended span, prevents longitudinal movement of the suspended span at PP45. Figure 4.8 also shows the suspended truss hangers at these panel points. The truss hangers are pinned at their upper and lower extremities thereby releasing moments for the member in the longitudinal direction. In addition, the upper and lower chords at the hanger locations contain pins that provide axial force releases in these members.

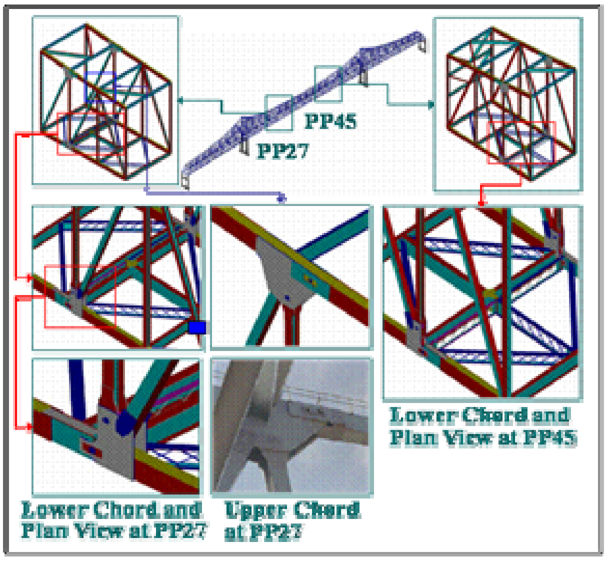


Figure 4.8 Elements of Suspended Span

4.2.5.2 Floor System

Apart from the two movement systems discussed in the previous section, another important structural feature of the through truss lies in its deck and floor system. As is shown in Figure 4.9, the floor system is designed in such a way that the deck rests upon the longitudinal stringers across the roadway, and the stringers are supported by transverse floor beams with expansion and/or fixed shoes in between. Analogous to bearings, these shoes are also designed to release of some of the internal forces between these two components.

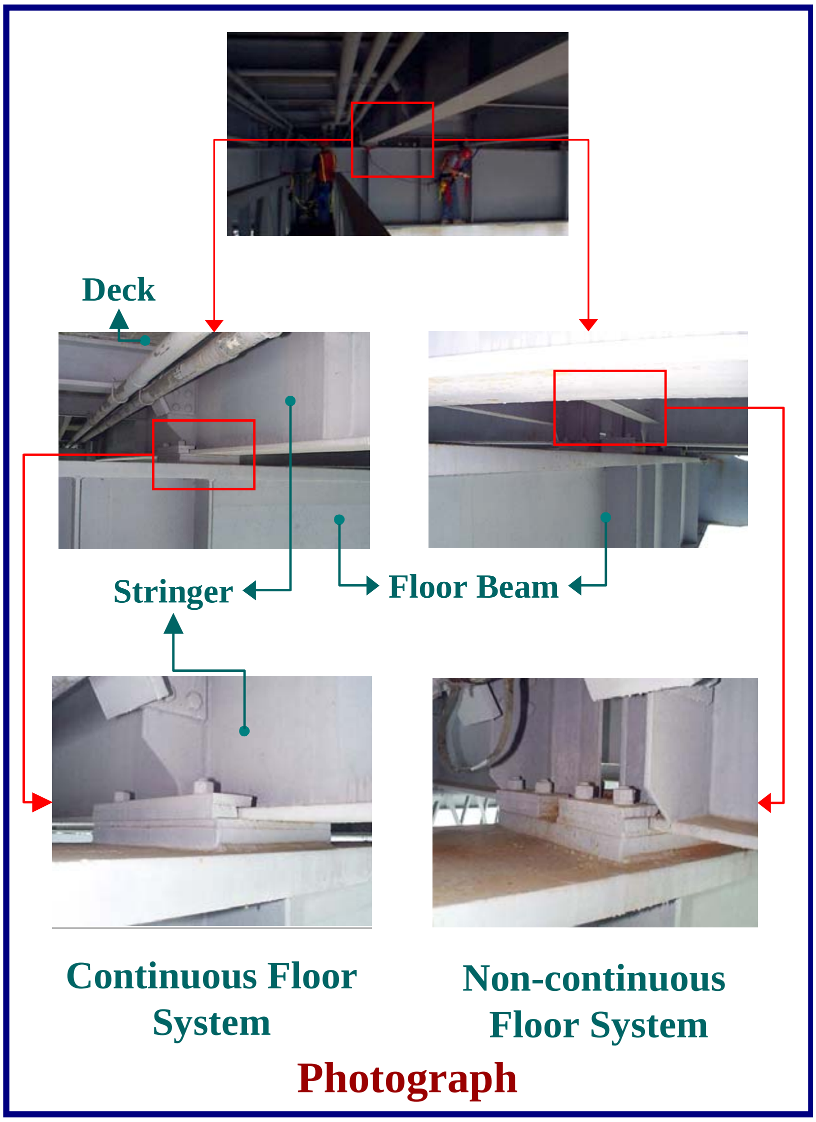


Figure 4.9 Shoes Between Stringers and Floor Beams

4.3 FE Model of CBB

The primary truss members and out-of-plane elements of the bridge (bottom chords, top chords, verticals, diagonals, floor beams, stringers, K-bracing, sway and portal frames) were modeled in SAP 2000 [85] using 3D frame elements with six degrees of freedom at each node. Each truss element was represented by at least one 3D frame element. The piers supporting the through truss were also modeled using 3D frame elements. The total number of frame elements in the FE model is 6,047.

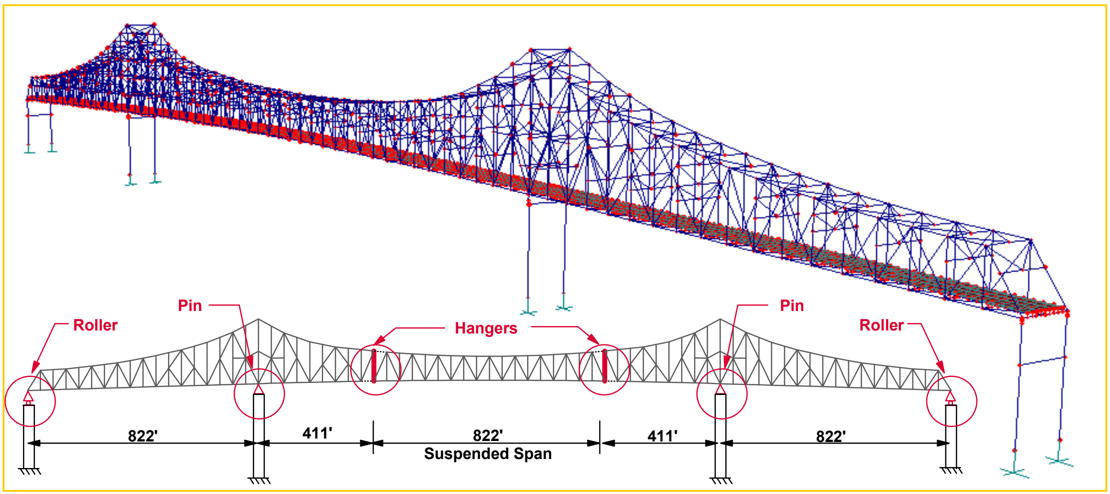


Figure 4.10 FE Model of Cantilever Truss of CBB

The bearings were represented by rigid links in the FE model of the through truss, and member end releases were introduced to accurately simulate the type of movement that the bearings exhibit. Accordingly, the rigid links simulating the expansion bearings at Piers W2 and E2 have both the shear and moment end releases, while the rigid links representing the fixed bearings at Piers W1 and E1 have only moment end releases as it is shown in Figure 4.11.

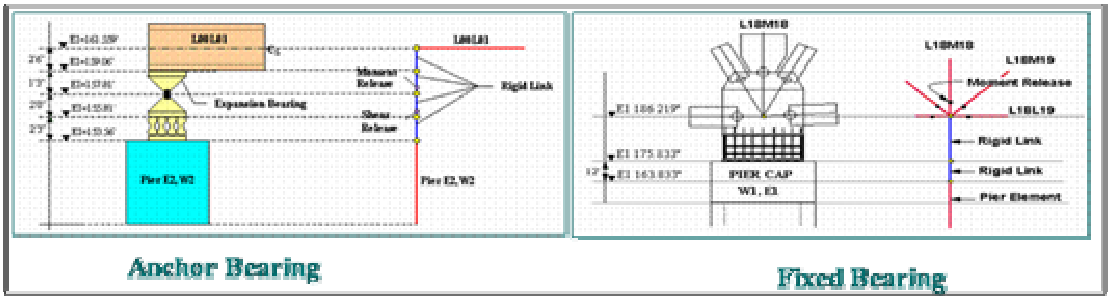


Figure 4.11 Representation of Bearings in FE Model

The movement system at hanger locations was simulated in the FE model by using various member end releases in SAP2000 as illustrated in Figure 4.12.

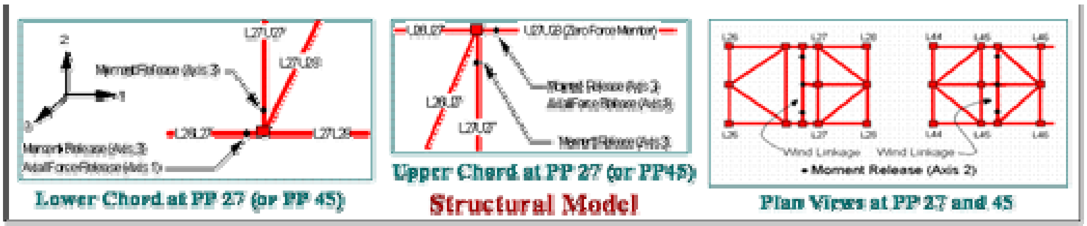


Figure 4.12 Elements of Suspended Span (Structural Model)

The reinforced concrete deck slab was represented by rectangular shell elements (4 nodes) with six degrees of freedom at each node. A shell element in SAP2000 is a numerical combination of a membrane element and a bending element. This element therefore permits simulation of in-plane and out-of-plane deformations. In general, a 7 ft (2.13 m) by 10 ft (3.048 m) rectangular mesh size was used for the shell elements, and their thickness was taken as 8 inches (20.32 cm). The total number of shell elements used in the 3D FE model is 2,966. Altogether, the model incorporates a total number of 25,218 degrees of freedom.

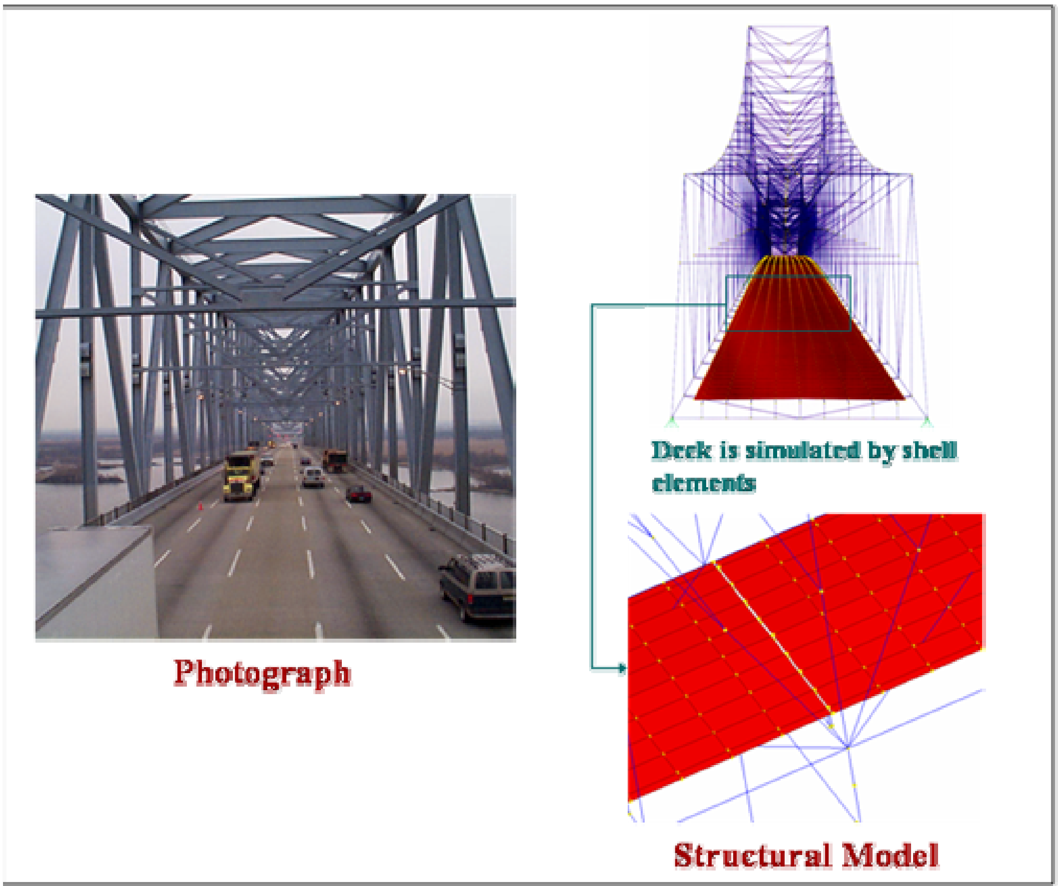


Figure 4.13 Deck

A number of different simulations of deck and floor system were employed in the model depending on the type of shoes used (i.e., fixed or expansion) and the continuity of the deck over the floor beam. Figure 4.14 illustrates the modeling of the deck and floor system for the following four cases: (i) continuous deck, expansion shoe; (ii) continuous deck, fixed shoe; (iii) non-continuous deck, expansion shoes; and finally (iv) non-continuous deck, fixed shoes. In all these models, it was assumed that a fully composite action takes place between the deck and stringers based on the assumption that the deck works with stringers in a perfectly composite manner for resisting loads placed on the bridge. This assumption is enforced in the models by defining body constraints at the corresponding nodes (points A and B, or points C and D in Figure 4.14) of deck and stringers.

At the connection between stringers and floor beams, an expansion or fixed shoe leads to a release of both the bending moment and shear force in the former, and only the bending moment in the latter. Hence, as is shown in Figure 4.14, at those parts of floor system where the deck is continuous over the floor beam (the cases i and ii), rigid links with appropriate member end releases were used (i) to permit a relative movement between the nodes B and E in the DOFs where the releases take place, and (ii) to enable a rigid body behavior in the other DOFs. For modeling the floor system where the deck is discontinuous (i.e., stress relief joints), the discussion slightly differs in the sense that the nodes of deck (A, C), stringer (B, D) and floor beam (E) do not fall in the same vertical plane. An accurate simulation of this behavior entails the node E to be associated to the composite deck-stringer system on both sides. Thus, after defining two hypothetical nodes F and G, they were connected to nodes B and D using additional rigid links to account for different behaviors observed on both sides. Here again, releases were incorporated into the rigid links (BF and DG) to simulate the relative displacements in certain DOFs. Finally, an overall integration of these components was accomplished by defining two more rigid links between nodes E, G and nodes E, F.

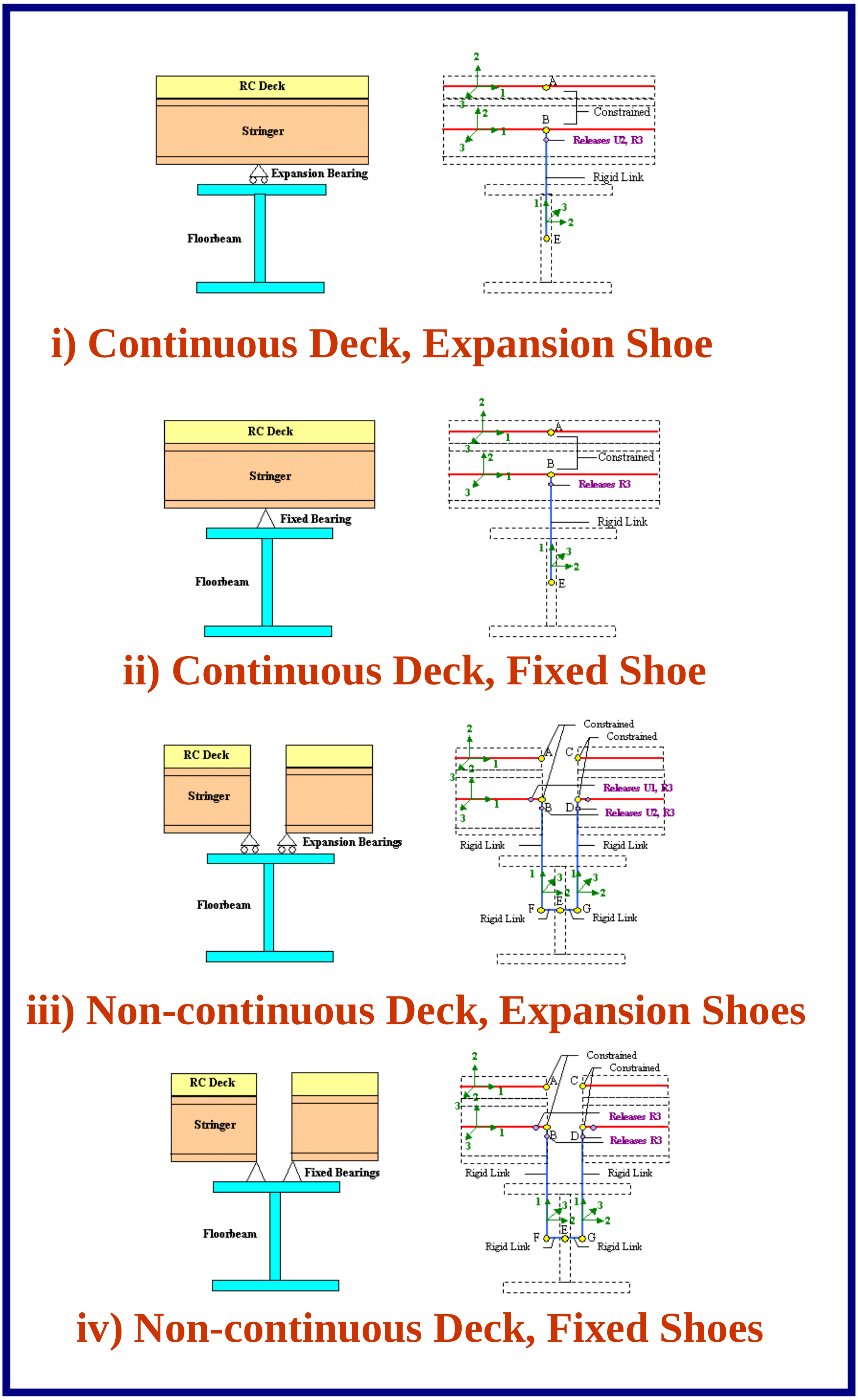


Figure 4.14 Structural Model of Shoes Between Stringers and Floor Beams

The FE model of the through truss spans required material property definitions for steel and concrete. In SAP2000, the shell elements are defined as concrete and the frame elements are defined as steel. The material properties assigned to the steel frame and concrete shell elements were based on information provided in the design drawings. The Modulus of Elasticity for concrete was defined as 3,600 ksi (24821.126 N/mm^2) based on a 28-day compressive strength of 4 ksi (27.579 N/mm^2). Poisson's Ratio for concrete was defined as 0.2. The Modulus of Elasticity for steel was defined as 29,000 ksi (199947.96 N/mm^2). Poisson's Ratio for steel was defined as 0.3.

Section properties for the steel frame elements were calculated from the geometric dimensions for the various cross sections given in the design drawings. The parameters calculated included:

- Cross Sectional Area, A
- Moment of Inertia, I_x & I_y
- Radius of Gyration, r_x & r_y
- Section Modulus, S_x & S_y
- Torsion Constant, J

These properties are automatically calculated by SAP2000 for standard open and rectangular shapes. If a truss member had an irregular section that SAP2000 did not contain, it was assigned a general section and modification factors were assigned to the properties to obtain the correct values.

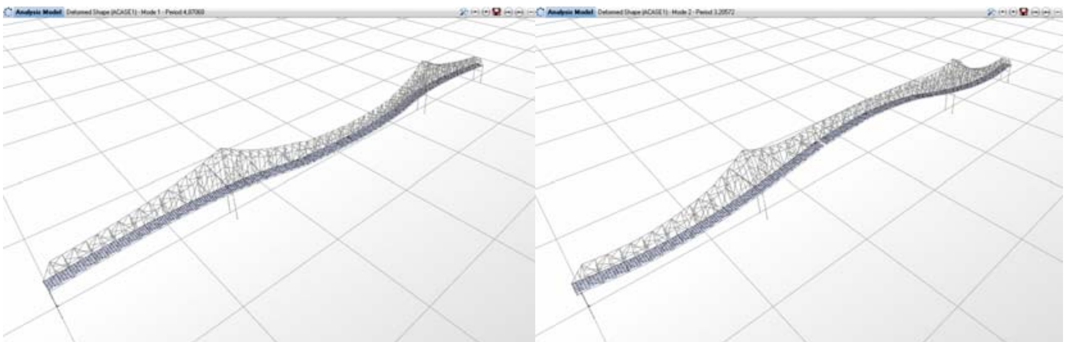
4.4 Modal Properties

4.4.1 Nominal Modes

The FE model of CBB is constructed using nominal structural parameters and material properties, as well as ideal boundary and continuity conditions. This model will be referred to as nominal model of the bridge from this point forward. Modal analysis of the nominal model has been carried out by virtue of SAP2000 for the first 20 modes, and the following frequencies and mode shapes are obtained.

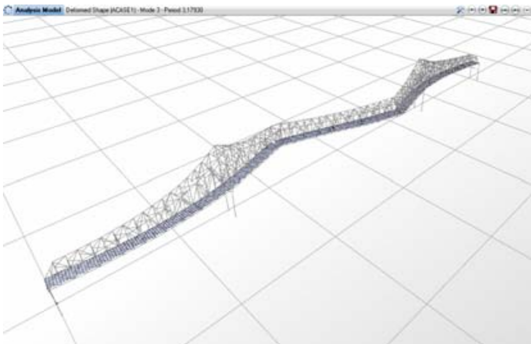
Table 4.1 Modal Periods And Frequencies of Nominal Model

Modal Periods And Frequencies				
Mode	Period	Frequency	CircFreq	Eigenvalue
	Sec	Cyc/sec	rad/sec	rad2/sec2
1	4,871	0,205	1,290	1,664
2	3,206	0,312	1,960	3,842
3	3,179	0,315	1,976	3,906
4	2,407	0,415	2,610	6,814
5	2,110	0,474	2,977	8,864
6	1,862	0,537	3,375	11,387
7	1,787	0,560	3,516	12,362
8	1,551	0,645	4,051	16,414
9	1,498	0,668	4,194	17,592
10	1,335	0,749	4,706	22,151
11	1,260	0,794	4,989	24,886
12	1,099	0,910	5,719	32,702
13	1,062	0,942	5,918	35,025
14	1,023	0,977	6,141	37,715
15	0,999	1,001	6,287	39,531
16	0,900	1,111	6,978	48,690
17	0,867	1,153	7,244	52,474
18	0,801	1,249	7,845	61,540
19	0,783	1,277	8,024	64,376
20	0,694	1,442	9,060	82,085

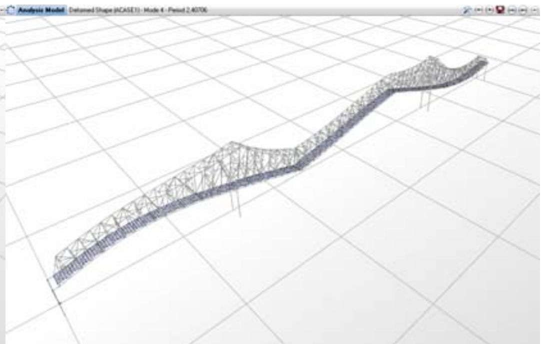


1st mode 2nd mode

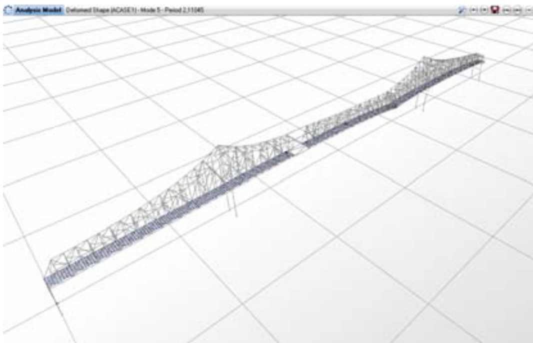
Figure 4.15 Shapes of the First Twenty Modes of Nominal Model



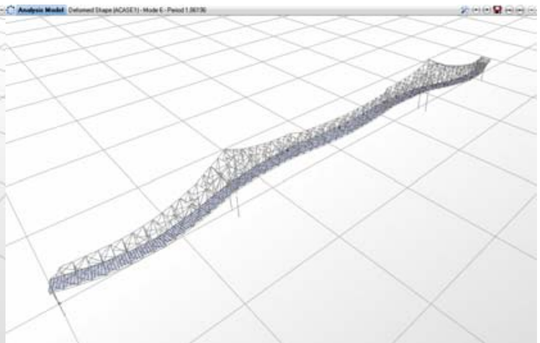
3rd mode



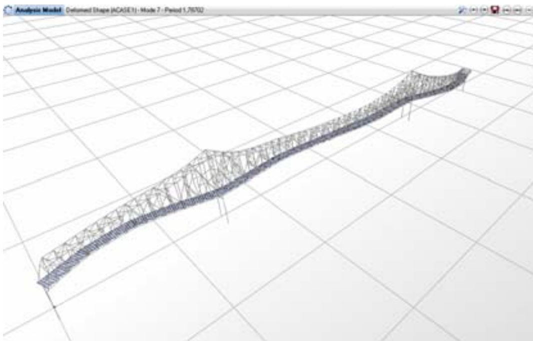
4th mode



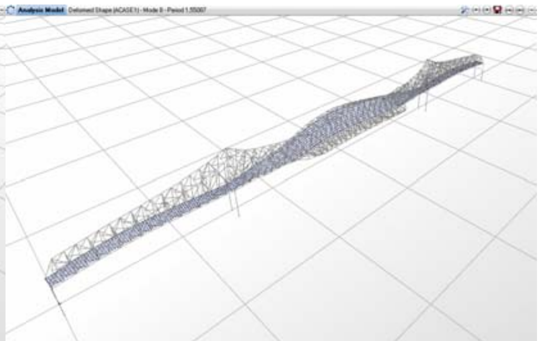
5th mode



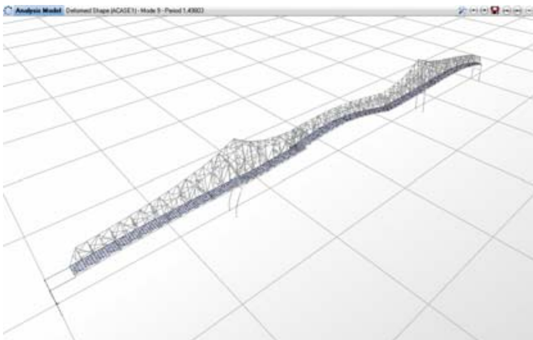
6th mode



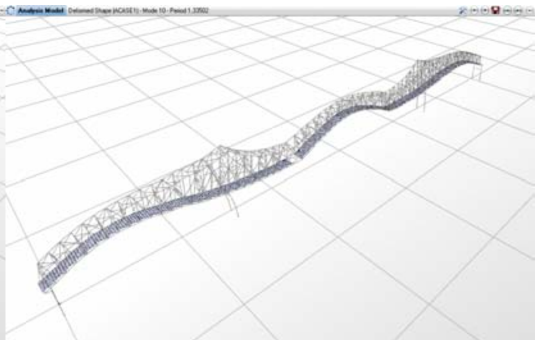
7th mode



8th mode

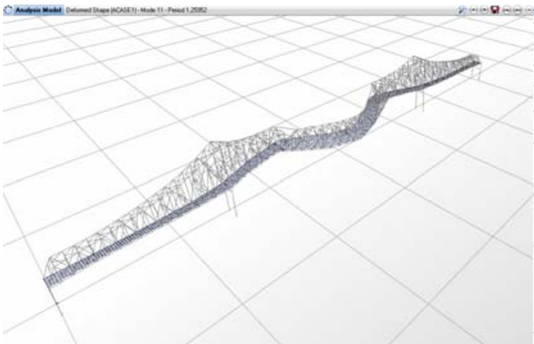


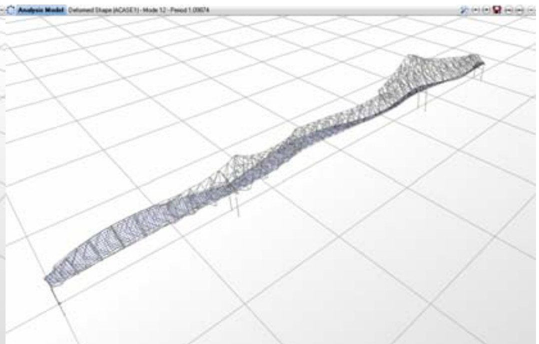
9th mode



10th mode

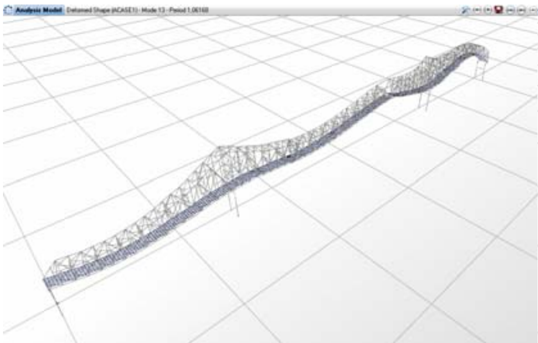
Figure 4.15 (cont'd)

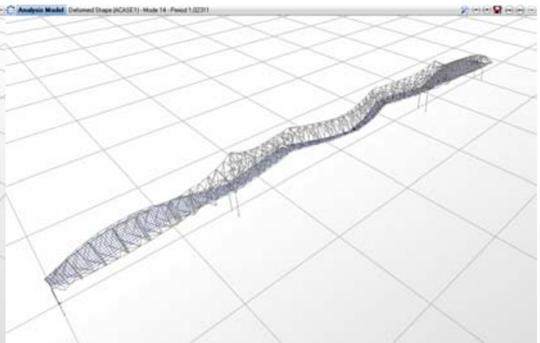




11th mode

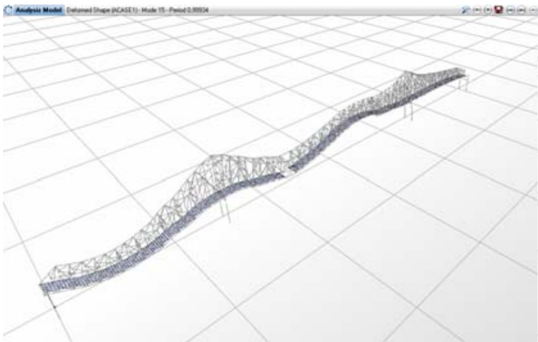
12th mode

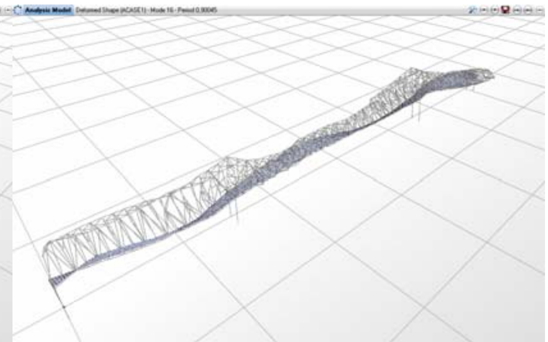




13th mode

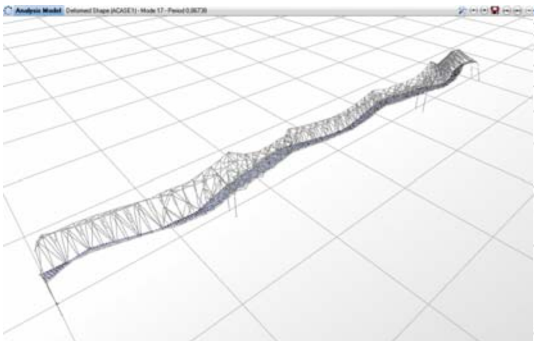
14th mode

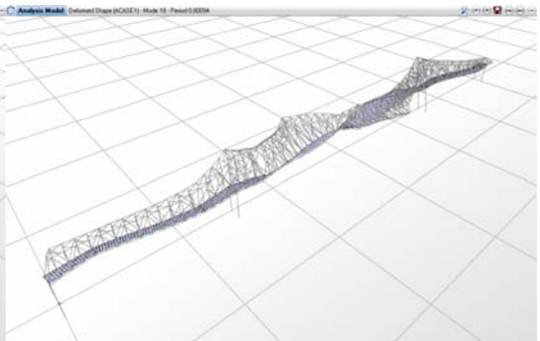




15th mode

16th mode

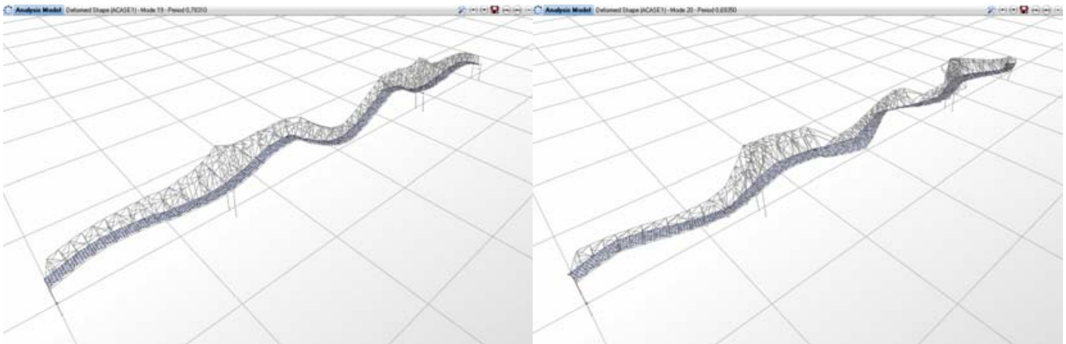




17th mode

18th mode

Figure 4.15 (cont'd)



19th mode 20th mode

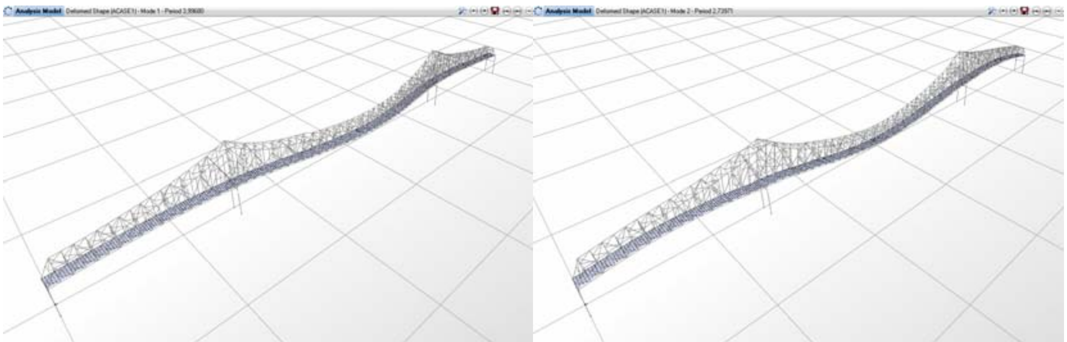
Figure 4.15 (cont'd)

4.4.2 Experimental Modes

Field tests were formerly implemented by DI3 researchers to collect vibration data from various locations on the bridge [86]. The details of the instrumentation can be found in Appendix-A. They carried out spectral analyses with the collected data to identify the global frequencies. Mode shapes corresponding to each frequency were then identified for the first twenty modes as listed in Table 4.2 and illustrated in Figure 4.16.

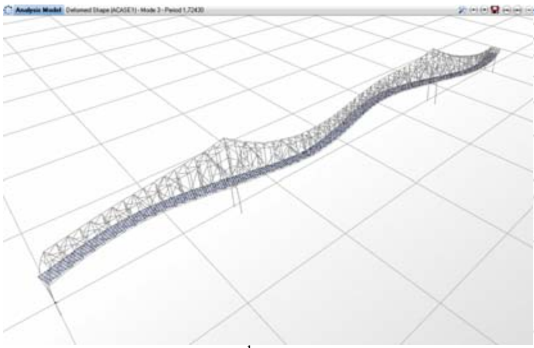
Table 4.2 Experimental Periods and Frequencies

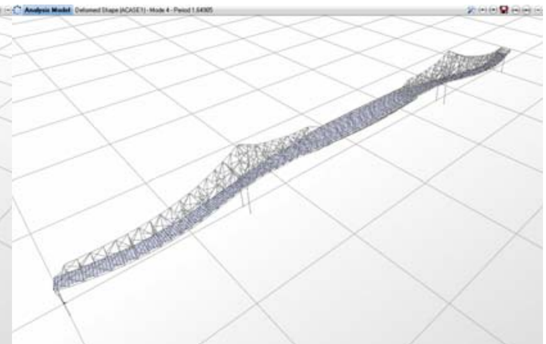
Modal Periods And Frequencies				
Mode	Period	Frequency	CircFreq	Eigenvalue
	Sec	Cyc/sec	rad/sec	rad2/sec2
1	3,997	0,250	1,572	2,471
2	2,740	0,365	2,293	5,260
3	1,724	0,580	3,644	13,278
4	1,650	0,606	3,808	14,503
5	1,501	0,666	4,185	17,516
6	1,470	0,680	4,274	18,265
7	1,442	0,693	4,357	18,983
8	1,152	0,868	5,453	29,731
9	1,079	0,927	5,822	33,897
10	1,035	0,966	6,068	36,820
11	1,017	0,983	6,178	38,163
12	0,963	1,039	6,528	42,615
13	0,873	1,146	7,200	51,841
14	0,869	1,151	7,230	52,275
15	0,752	1,329	8,350	69,722
16	0,726	1,377	8,651	74,840
17	0,704	1,421	8,928	79,707
18	0,643	1,555	9,768	95,413
19	0,636	1,572	9,875	97,508
20	0,597	1,676	10,533	110,950

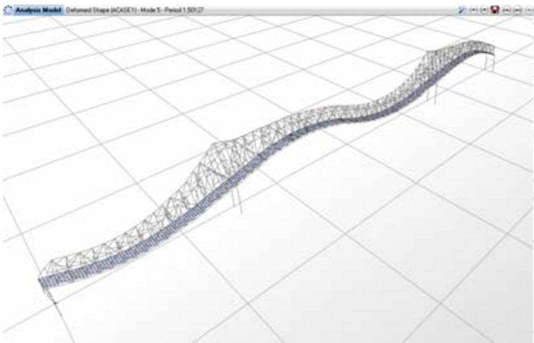


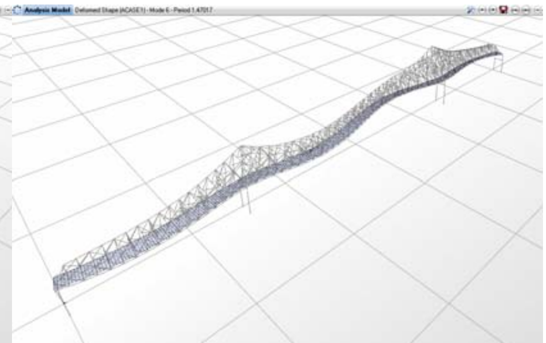
1st mode 2nd mode

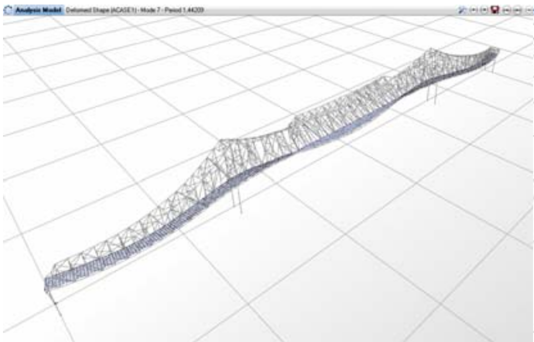
Figure 4.16 Modal Shapes Obtained Experimentally

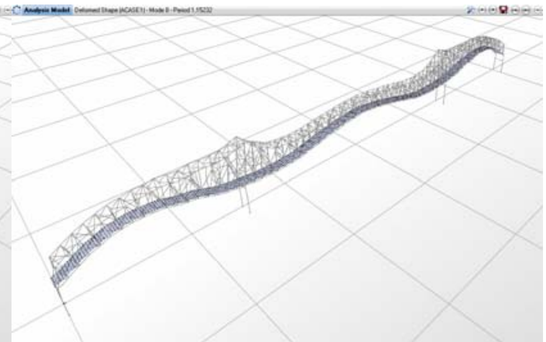

3rd mode

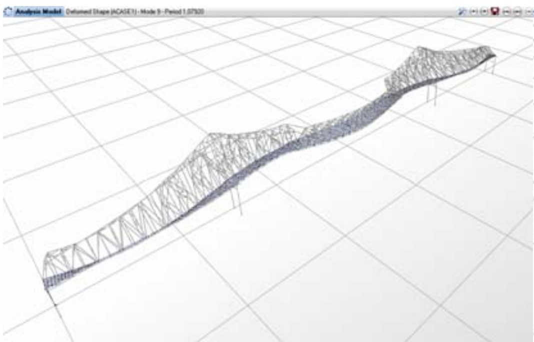

4th mode


5th mode


6th mode


7th mode


8th mode


9th mode

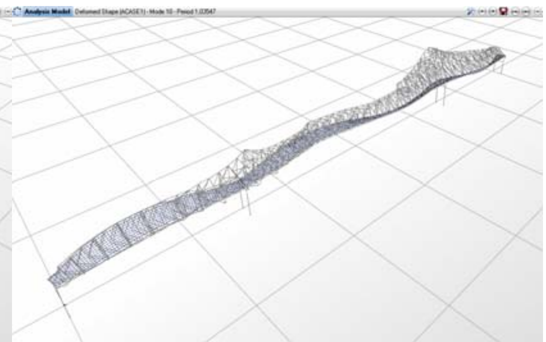
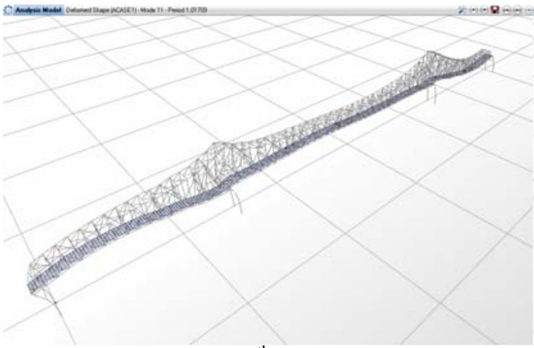
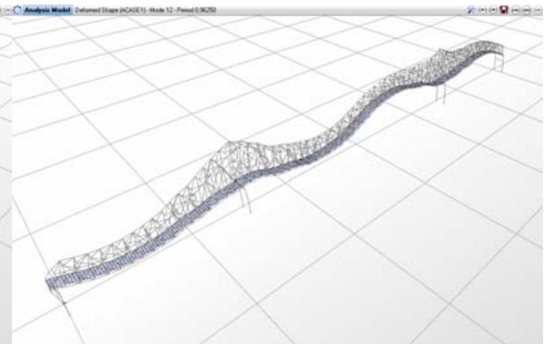

10th mode

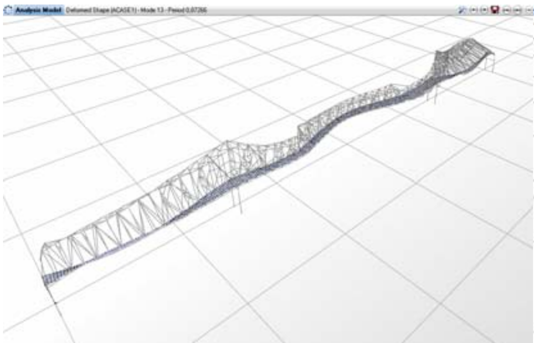
Figure 4.16 (cont'd)



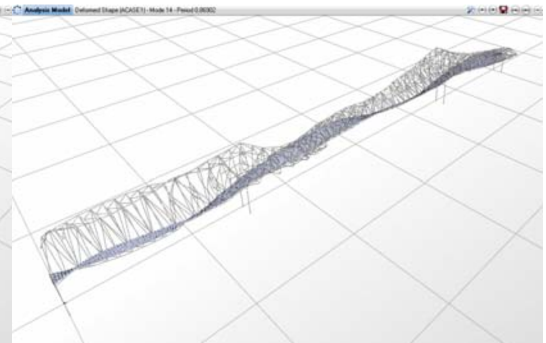
11^{th} mode



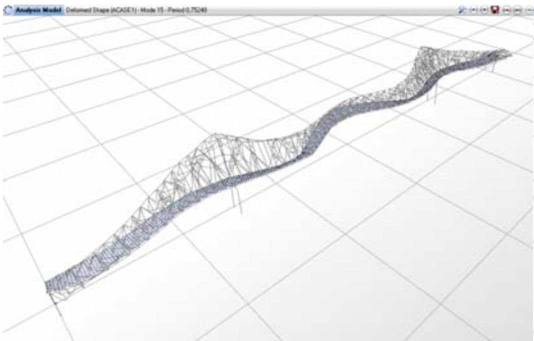
12^{th} mode



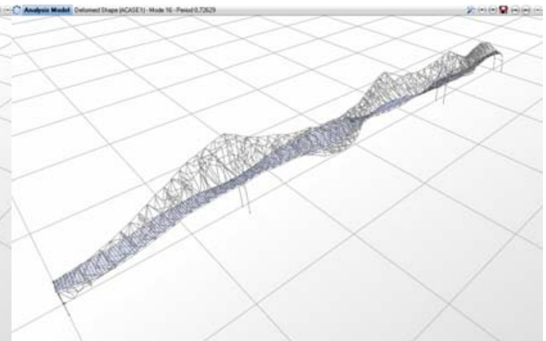
13^{th} mode



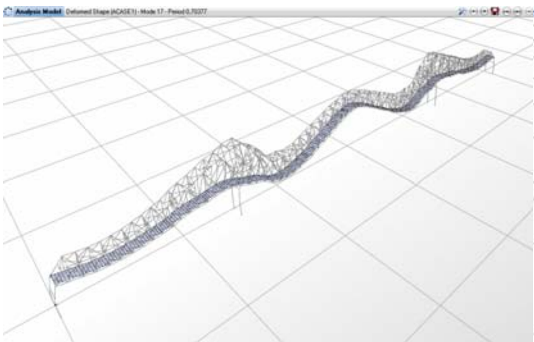
14^{th} mode



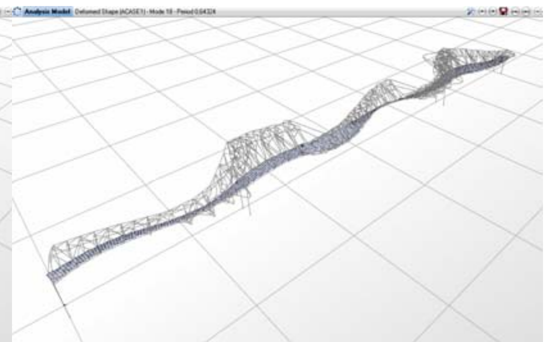
15^{th} mode



16^{th} mode

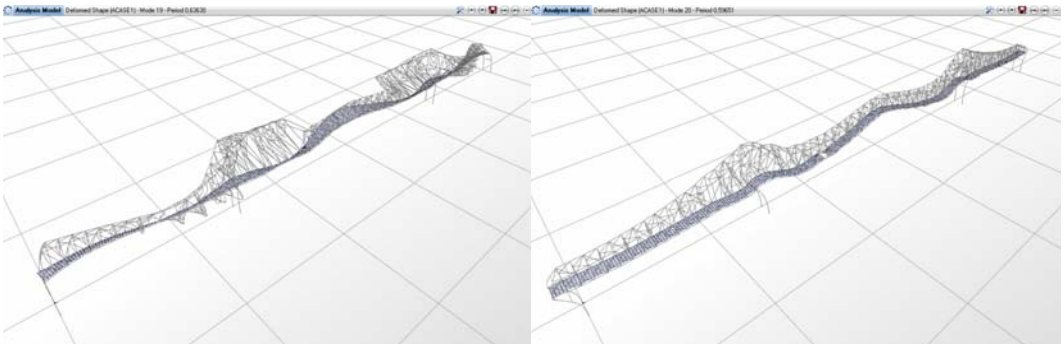


17^{th} mode



18^{th} mode

Figure 4.16 (cont'd)



19th mode 20th mode

Figure 4.16 (cont'd)

4.4.3 Comparison

MAC (Modal Assurance Criterion) matrix is utilized in order to assess the correlation between the measured (by experiments) and simulated (by nominal FE model) model properties of the bridge. MAC matrix shows the correlation between modes of two different models and is defined as [87]:

$$\mathrm{MAC}(\{\varphi_{iN}\},\{\varphi_{iE}\}) = \frac{\left|\{\varphi_{iN}\}^{\mathrm{T}}\{\varphi_{iE}\}\right|}{\{\varphi_{iN}\}^{\mathrm{T}}\{\varphi_{iN}\}\{\varphi_{iE}\}^{\mathrm{T}}\{\varphi_{iE}\}} \tag{4.1}$$

where $\{\varphi_{iN}\}$ is the i-th mode shape identified from the nominal FE model and $\{\varphi_{iE}\}$ is the corresponding mode shape obtained experimentally. MAC value is between zero and one. A value close to one represents a strong correlation between the modes compared ,and it is zero if the two mode shapes are orthogonal and therefore uncorrelated with each other.

Table 4.3 MAC Matrix Calculated For Experimental and Nominal Modes

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0,988	0,000	0,393	0,055	0,000	0,172	0,117	0,000	0,020	0,031	0,001	0,000	0,000	0,063	0,006	0,038	0,000	0,007	0,004	0,001
2	0,000	0,994	0,000	0,000	0,609	0,000	0,000	0,022	0,000	0,000	0,006	0,273	0,000	0,000	0,000	0,000	0,000	0,001	0,000	0,003
3	0,387	0,000	0,780	0,082	0,000	0,262	0,006	0,000	0,208	0,026	0,002	0,000	0,156	0,074	0,209	0,075	0,000	0,002	0,310	0,002
4	0,000	0,569	0,000	0,000	0,957	0,000	0,000	0,089	0,000	0,000	0,000	0,175	0,000	0,000	0,000	0,000	0,186	0,002	0,000	0,066
5	0,000	0,815	0,000	0,000	0,191	0,000	0,000	0,129	0,000	0,000	0,006	0,121	0,000	0,000	0,000	0,000	0,134	0,000	0,000	0,116
6	0,000	0,000	0,444	0,712	0,000	0,366	0,053	0,000	0,021	0,003	0,001	0,000	0,046	0,303	0,063	0,000	0,000	0,000	0,037	0,001
7	0,008	0,000	0,166	0,446	0,000	0,680	0,183	0,000	0,012	0,035	0,000	0,000	0,274	0,192	0,000	0,059	0,000	0,037	0,002	0,000
8	0,148	0,000	0,001	0,362	0,000	0,002	0,872	0,000	0,005	0,257	0,000	0,000	0,009	0,131	0,025	0,208	0,000	0,123	0,067	0,000
9	0,001	0,226	0,005	0,001	0,002	0,000	0,001	0,234	0,001	0,000	0,107	0,243	0,002	0,000	0,003	0,000	0,138	0,025	0,004	0,103
10	0,000	0,026	0,000	0,000	0,256	0,000	0,000	0,863	0,000	0,000	0,313	0,147	0,000	0,000	0,000	0,000	0,149	0,000	0,000	0,146
11	0,005	0,000	0,182	0,006	0,000	0,329	0,016	0,000	0,534	0,000	0,001	0,000	0,508	0,002	0,262	0,273	0,000	0,183	0,329	0,001
12	0,004	0,000	0,008	0,090	0,000	0,061	0,190	0,000	0,524	0,954	0,000	0,000	0,082	0,014	0,173	0,011	0,000	0,001	0,038	0,000
13	0,000	0,138	0,000	0,000	0,000	0,000	0,000	0,675	0,000	0,000	0,427	0,908	0,000	0,000	0,000	0,000	0,118	0,000	0,000	0,124
14	0,053	0,000	0,008	0,003	0,000	0,001	0,001	0,000	0,317	0,648	0,000	0,000	0,336	0,049	0,423	0,036	0,000	0,003	0,280	0,000
15	0,000	0,103	0,000	0,000	0,013	0,000	0,000	0,437	0,000	0,000	0,394	0,915	0,000	0,000	0,000	0,000	0,316	0,000	0,000	0,271
16	0,047	0,000	0,192	0,350	0,000	0,044	0,039	0,000	0,018	0,022	0,000	0,000	0,126	0,953	0,211	0,005	0,000	0,220	0,010	0,000
17	0,010	0,000	0,068	0,068	0,000	0,074	0,038	0,000	0,036	0,075	0,000	0,000	0,054	0,448	0,604	0,289	0,000	0,073	0,006	0,000
18	0,057	0,000	0,123	0,134	0,000	0,120	0,275	0,000	0,286	0,020	0,000	0,000	0,297	0,028	0,001	0,910	0,000	0,160	0,189	0,000
19	0,000	0,021	0,000	0,000	0,038	0,000	0,000	0,002	0,000	0,000	0,115	0,230	0,000	0,000	0,000	0,000	0,906	0,000	0,000	0,562
20	0,008	0,000	0,007	0,006	0,001	0,060	0,051	0,000	0,113	0,012	0,011	0,000	0,200	0,013	0,207	0,087	0,002	0,778	0,011	0,008
Max	0,988	0,994	0,780	0,712	0,957	0,680	0,872	0,863	0,534	0,954	0,427	0,915	0,508	0,953	0,604	0,910	0,906	0,778	0,329	0,562

The MAC matrix (Table 4.3) shows that the first and the second modes are consistent between the experimental and analytical results. However, 3rd, 4th, 6th, 9th, 11th, 13th, 15th, 18th, 19th and 20th modes in the nominal model are not matched with any of those obtained experimentally with a MAC value greater than 0.8, implying that these modes do not exist in reality (i.e. lost). A mode switch is observed for other modes (5th, 7th, 8th, 10th, 12th, 14th, 16th, and 17th), that is to say they exist in reality, yet they do not appear in the same rank as obtained experimentally.

Table 4.4 Frequency Variation between Experimental and Nominal Modes

Mode no.	1	2	5	7	8	10	12	14	16	17
Freq. (Exp.) Cyc/sec	0,250	0,365	0,666	0,693	0,868	0,966	1,039	1,151	1,377	1,421
Freq.(Nom.) Cyc/sec	0,205	0,312	0,415	0,645	0,749	0,91	0,942	1,111	1,249	1,277
Discrepancy	18,0%	14,5%	37,7%	6,9%	13,7%	5,8%	9,3%	3,5%	9,3%	10,1%

Considerable discrepancies are observed in frequencies of common modes as it is shown in Table 4.4. The discrepancy is highest for the 5th mode (37.7%) and is lowest for the 14th mode (3.5%). It lies between these two values for the other modes.

According to comparison results, it is clear that there is a significant variation between nominal and experimental modal properties. Since frequencies and mode shapes are a function of parameters such as the mass, stiffness, damping and boundary conditions of a structure, discrepancies in the identified frequencies and mode shapes from the experiment and the model can be attributed to differences in these parameters between the two. For example, a frozen roller bearing or loss of composite action will affect the boundary conditions and stiffness of the bridge, respectively. If the effects are not purely local, they will influence global structural response. As a result, the global dynamic properties obtained from the experiments performed on the structure will differ to some degree from those obtained from a model that does not recognize such changes. When analyses are conducted with different parameter values, the sensitivity of the model to these parameters can be investigated. Therefore, the next step will be parametric studies of CBB where sensitivity analysis are carried out which will be discussed in following chapter.

CHAPTER 5

PARAMETRIC STUDIES

5.1 General

Parameter sensitivity studies are carried out to examine the impact of the variation of parameters upon the dynamic properties of CBB, and thus to determine the most critical parameters for calibration of the FE model of the bridge. The procedure followed is that each time a single parameter is changed in the nominal FE model of the bridge (referred to as modified model) and the changes in the modal properties (frequency, order, and existence of the modes) are observed. The first twenty modes are considered for this purpose, and Modal Assurance Criterion (MAC) is used to determine the modal consistency between two modes as defined by Eq. (5.1):

$$\mathrm{MAC}(\{\varphi_{iM}\},\{\varphi_{iN}\}) = \frac{\left|\{\varphi_{iM}\}^{\mathrm{T}}\{\varphi_{iN}\}\right|}{\{\varphi_{iM}\}^{\mathrm{T}}\{\varphi_{iM}\}\{\varphi_{iN}\}^{\mathrm{T}}\{\varphi_{iN}\}} \tag{5.1}$$

where $\{\varphi_{iM}\}$ is the i-th mode shape identified from the modified model and $\{\varphi_{iN}\}$ is the corresponding mode shape in the nominal model. As discussed in previous chapters MAC value lies between zero and one. The higher the value of MAC is, the stronger correlation exists between two modes. Modal consistency is identified such that two modes are identical if MAC value between them is more than 0.8. If a mode cannot be coupled with any others with a MAC value above 0.8, it is considered as lost.

It may be anticipated that most sensitive parameters to the dynamic properties of the bridge are mass, material properties, boundary, and continuity conditions. Hence, the parameters for sensitivity analyses are chosen as follows:

- Mass of the deck concrete
- Rigidity of the piers
- Variations in boundary conditions
- Force releases and kinematics of the movement systems

In conducting the sensitivity studies, these parameters are varied and the changes in the modal order and frequencies are investigated for the first 20 modes. It is assumed that I_x, I_y, J and E values of piers vary between 50% and 200% of the nominal values, whereas area of piers is changed between 80% and 120%; the mass of deck is varied between 80% and %120 of its nominal value. Finally, releases representing the movement systems and boundary conditions are fully hinged or fully restrained.

5.2 Sensitivity Analyses

5.2.1 Inner Piers (W1,E1)

5.2.1.1 Area

Firstly, area of inner piers (W1,E1) is reduced and increased by 20% of the nominal value. Modal order and corresponding frequencies are compared with those of nominal model. Based on the observations, it can be said that there is no mode switch for both two extreme cases. Furthermore, frequency variations for all modes are less than 1% as it is shown in Table 5.1.

Table 5.1 Changes in Modal Freq. for Extreme Cases of Possible Variations of Area of Inner Piers

Nominal		Areax0,8				Areax1,2			
Modes	Freq	Modes	Freq	Variation in freq.	MAC	Modes	Freq	Variation in freq.	MAC
1	0,205	1	0,205	-0,03%	1,000	1	0,205	0,02%	1,000
2	0,312	2	0,312	-0,01%	1,000	2	0,312	0,01%	1,000
3	0,315	3	0,314	-0,03%	1,000	3	0,315	0,02%	1,000
4	0,415	4	0,415	0,00%	1,000	4	0,415	0,00%	1,000
5	0,474	5	0,474	0,00%	1,000	5	0,474	0,00%	1,000
6	0,537	6	0,536	-0,22%	1,000	6	0,538	0,14%	1,000
7	0,560	7	0,558	-0,25%	1,000	7	0,561	0,17%	1,000
8	0,645	8	0,644	-0,07%	1,000	8	0,645	0,04%	1,000
9	0,668	9	0,668	0,00%	1,000	9	0,668	0,00%	1,000
10	0,749	10	0,749	-0,01%	1,000	10	0,749	0,01%	1,000
11	0,794	11	0,793	-0,17%	1,000	11	0,795	0,12%	1,000
12	0,910	12	0,907	-0,35%	1,000	12	0,912	0,24%	1,000
13	0,942	13	0,942	-0,03%	1,000	13	0,942	0,02%	1,000
14	0,977	14	0,976	-0,15%	1,000	14	0,978	0,11%	1,000
15	1,001	15	1,000	-0,04%	1,000	15	1,001	0,02%	1,000
16	1,111	16	1,110	-0,06%	1,000	16	1,111	0,04%	1,000
17	1,153	17	1,151	-0,15%	1,000	17	1,154	0,10%	1,000
18	1,249	18	1,248	-0,06%	1,000	18	1,249	0,05%	1,000
19	1,277	19	1,277	-0,04%	1,000	19	1,277	0,02%	1,000
20	1,442	20	1,442	-0,01%	1,000	20	1,442	0,00%	1,000

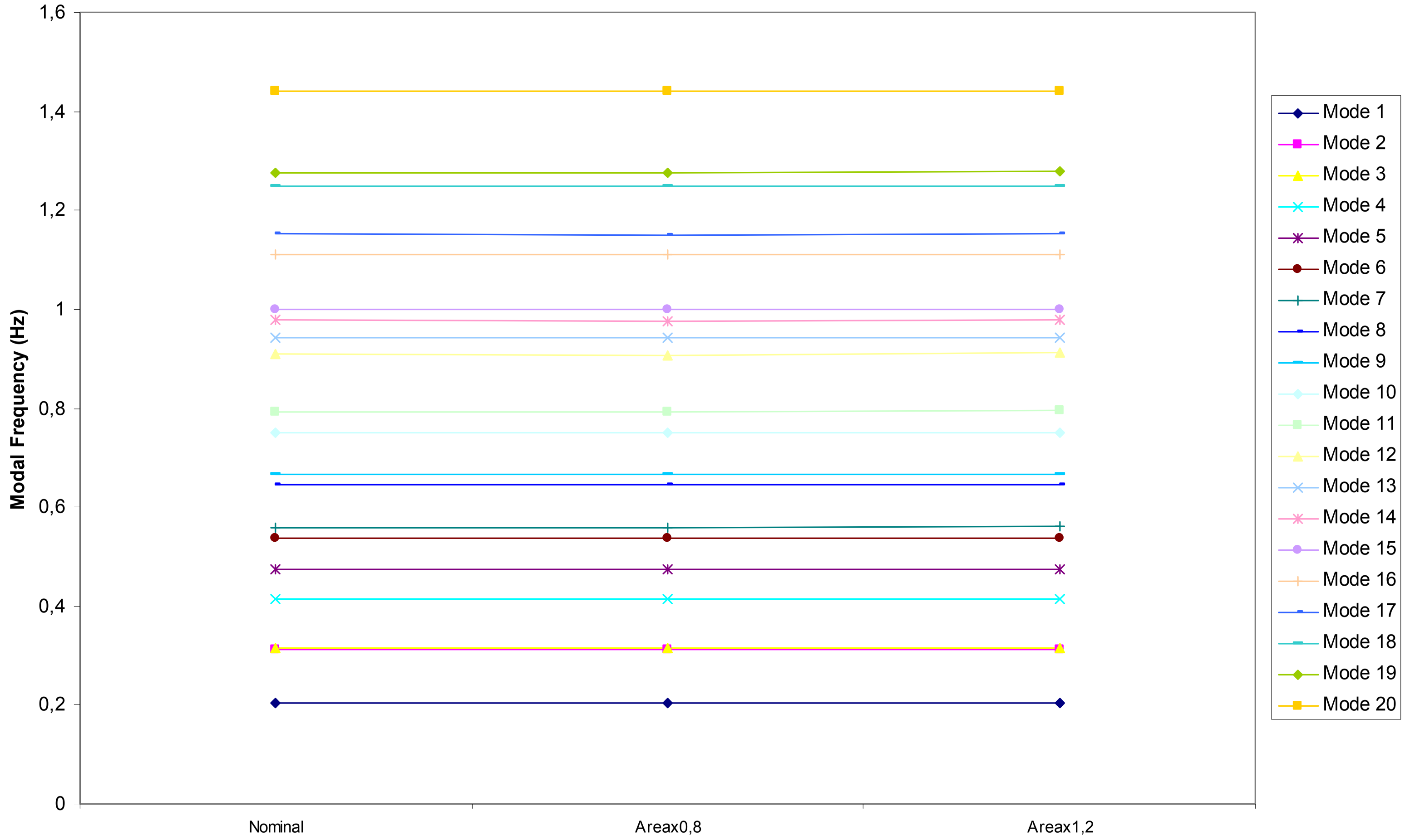


Figure 5.1 Changes in Modal Order for Extreme Cases of Possible Variations of Area of Inner piers

5.2.1.2 I_x

Two modified models of the bridge are created changing I_x by 50% and 200%. It is observed from table 5.2 that when I_x is reduced by 50%, 5th and 9th modes are lost, and for 10th 13th and 15th modes frequencies vary more than 1%. When I_x is increased by 200%, 5th and 9th modes are lost as well, and for 1st, 3rd, 10th, 13th, 15th, 19th modes, changes in the frequencies are more than 1%.

Table 5.2 Changes in Modal Frequencies for Extreme Cases of Possible Variations of I_x of Inner Piers

Nominal		I_xx0,5				I_xx2,0			
Modes	Freq	Modes	Freq	Variation in freq.	MAC	Modes	Freq	Variation in freq.	MAC
1	0,205	1	0,204	-0,70%	1,000	1	0,208	1,14%	1,000
2	0,312	2	0,310	-0,62%	1,000	2	0,312	0,16%	1,000
3	0,315	3	0,312	-0,75%	1,000	3	0,318	1,24%	1,000
4	0,415		0,374			4	0,417	0,38%	1,000
5	0,474	4	0,414	-0,29%	0,987	6	0,538	0,23%	1,000
6	0,537		0,511				0,555		
7	0,560	6	0,536	-0,14%	1,000	7	0,560	0,08%	1,000
8	0,645	7	0,559	-0,05%	1,000	8	0,645	0,01%	1,000
9	0,668	8	0,645	-0,01%	1,000	10	0,737	-1,67%	0,884
10	0,749	10	0,737	-1,58%	0,979	11	0,795	0,11%	1,000
11	0,794	11	0,793	-0,07%	1,000		0,874		
12	0,910	12	0,910	0,00%	1,000	12	0,910	0,00%	1,000
13	0,942	13	0,917	-2,65%	0,986	13	0,959	1,80%	0,994
14	0,977	14	0,977	0,00%	1,000	14	0,977	0,00%	1,000
15	1,001	15	0,985	-1,58%	0,994	15	1,051	5,02%	0,954
16	1,111	16	1,111	-0,01%	1,000	16	1,111	0,01%	1,000
17	1,153	17	1,153	-0,02%	1,000	17	1,153	0,03%	1,000
18	1,249	18	1,249	0,00%	1,000	18	1,249	0,00%	1,000
19	1,277	19	1,267	-0,81%	1,000	19	1,300	1,81%	0,999
20	1,442	20	1,442	-0,03%	1,000	20	1,443	0,05%	1,000

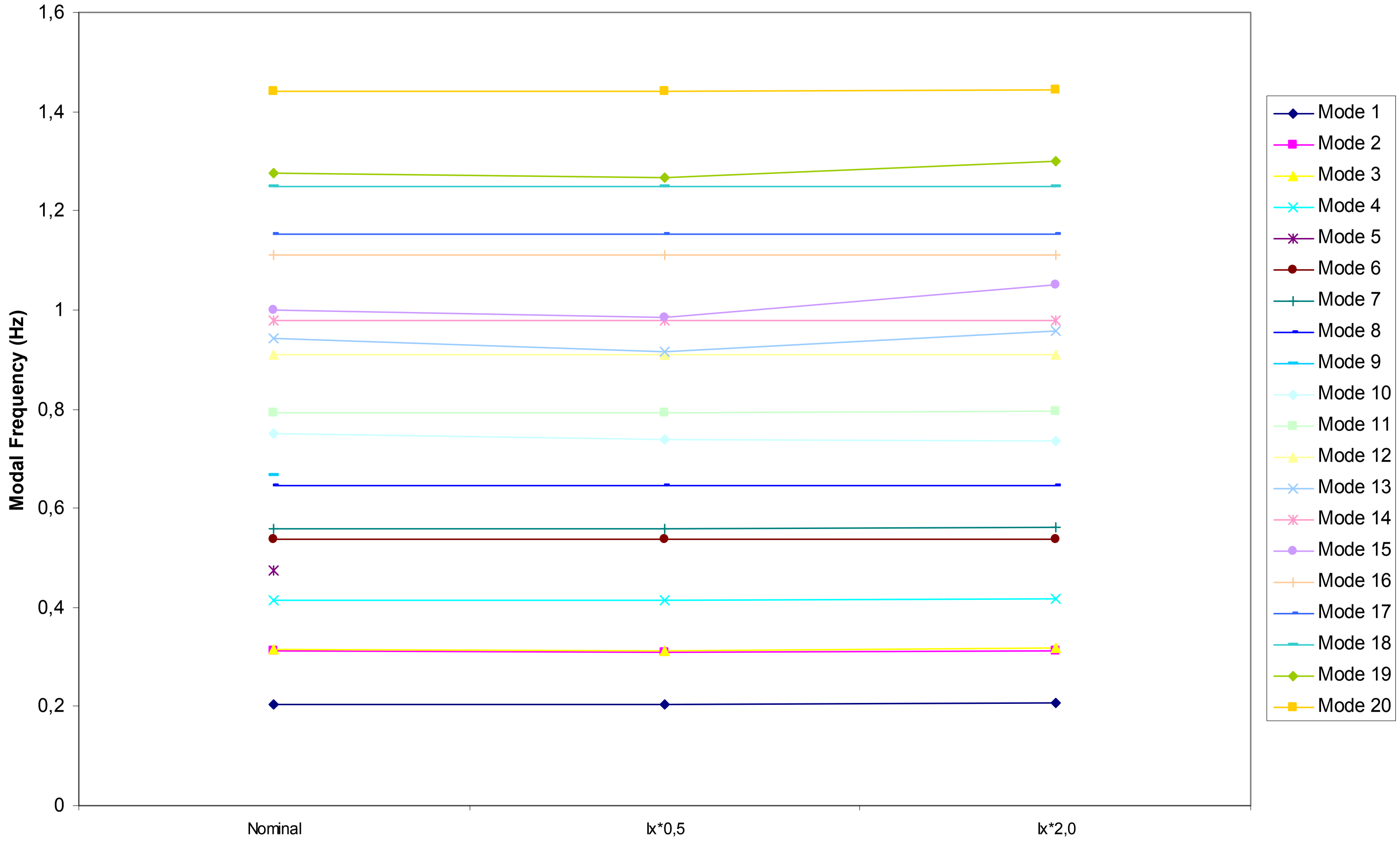


Figure 5.2 Changes in Modal Order for Extreme Cases of Possible Variations of I_x of Inner piers

5.2.1.3 I_y

Sensitivity of I_y of inner piers is examined considering the extreme cases. No mode switch has been observed in the two extreme cases. However, when reducing I_y by 50%, frequency variations are more than 1% for the 6^{th}, 7^{th}, 11^{th}, 17^{th} and18^{th} modes. When I_y is increased by 200%, only 7^{th} and 18^{th} modes' frequencies vary more than 1%.

Table 5.3 Changes in Modal Frequencies for Extreme Cases of Possible Variations of I_y of Inner Piers

Nominal		I_yx0,5				I_yx2,0			
Modes	Freq	Modes	Freq	Variation in freq.	MAC	Modes	Freq	Variation in freq.	MAC
1	0,205	1	0,204	-0,59%	1,000	1	0,206	0,34%	1,000
2	0,312	2	0,312	0,00%	1,000	2	0,312	0,00%	1,000
3	0,315	3	0,313	-0,55%	1,000	3	0,315	0,30%	1,000
4	0,415	4	0,415	0,00%	1,000	4	0,415	0,00%	1,000
5	0,474	5	0,474	0,00%	0,995	5	0,474	0,00%	1,000
6	0,537	6	0,528	-1,64%	0,996	6	0,542	0,97%	0,998
7	0,560	7	0,546	-2,47%	0,997	7	0,568	1,51%	0,999
8	0,645	8	0,645	-0,02%	1,000	8	0,645	0,02%	1,000
9	0,668	9	0,668	0,00%	1,000	9	0,668	0,00%	1,000
10	0,749	10	0,749	0,00%	1,000	10	0,749	0,00%	1,000
11	0,794	11	0,782	-1,54%	0,998	11	0,802	0,97%	0,999
12	0,910	12	0,907	-0,31%	0,999	12	0,913	0,26%	1,000
13	0,942	13	0,942	0,00%	1,000	13	0,942	0,00%	1,000
14	0,977	14	0,977	-0,03%	0,995	14	0,978	0,05%	1,000
15	1,001	15	1,001	0,00%	1,000	15	1,001	0,00%	1,000
16	1,111	16	1,102	-0,75%	0,982	16	1,115	0,38%	0,995
17	1,153	17	1,137	-1,39%	0,995	17	1,163	0,90%	0,998
18	1,249	18	1,227	-1,74%	0,998	18	1,263	1,17%	0,996
19	1,277	19	1,277	0,00%	1,000	19	1,277	0,00%	1,000
20	1,442	20	1,442	-0,01%	1,000	20	1,442	0,00%	1,000

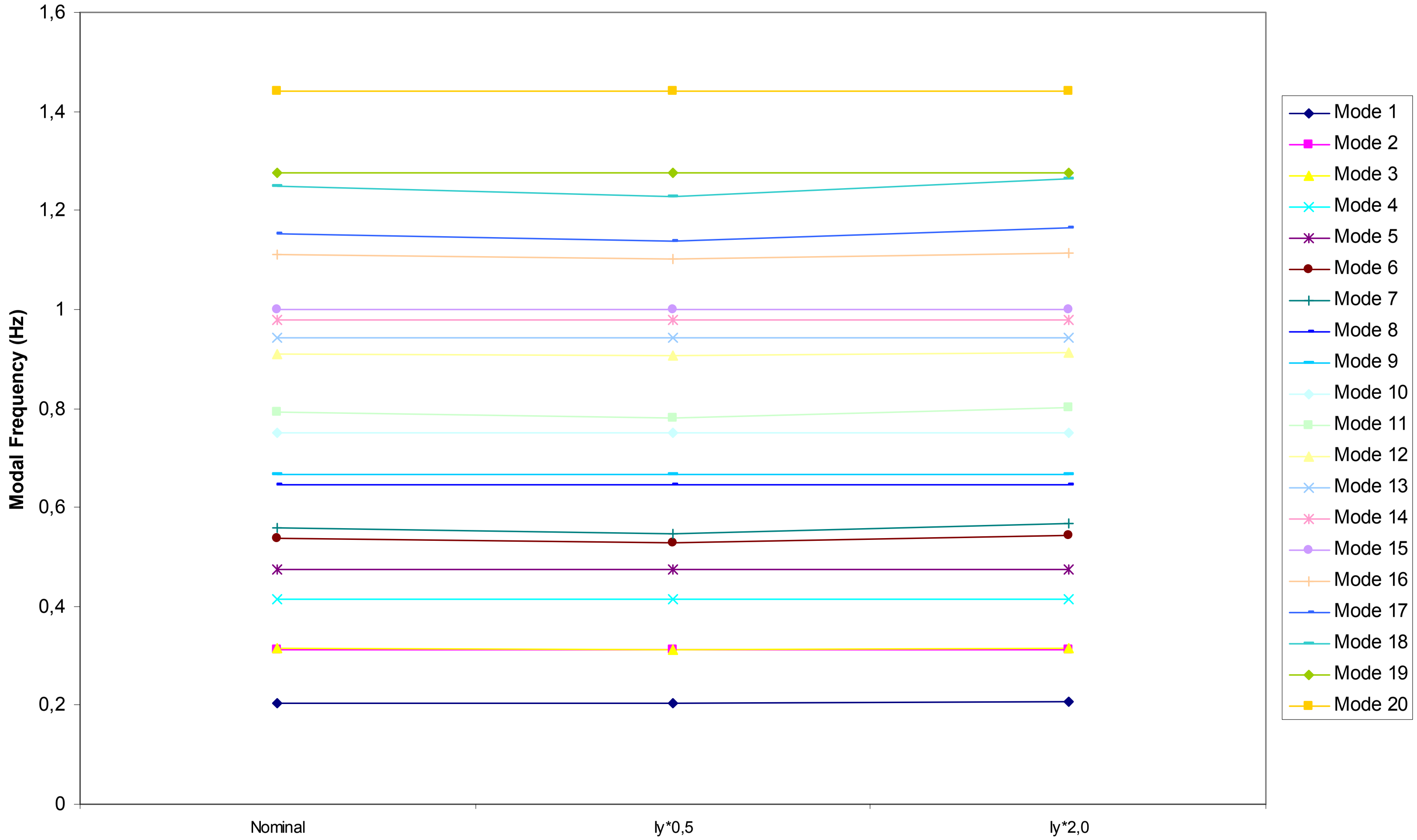


Figure 5.3 Changes in Modal Order for Extreme Cases of Possible Variations of I_y of Inner Piers

5.2.1.4 J

Variations in dynamic properties are also investigated for the extreme cases of torsion constant of the inner piers. According to the results obtained it is observed that there is a shift between 2nd and 3rd modes when reducing J by 50%, and frequencies of 1st and 3rd modes change more than 1%. When J is increased by 200%, then there is no mode shifts, yet 1st and 3rd modes' frequencies vary more than 1% as well.

Table 5.4 Changes in Modal Frequencies for Extreme Cases of Possible Variations of J of Inner Piers

Nominal		Jx0,5				Jx2,0			
Modes	Freq	Modes	Freq	Variation in freq.	MAC	Modes	Freq	Variation in freq.	MAC
1	0,205	1	0,202	-1,54%	1,000	1	0,209	1,65%	1,000
2	0,312	3	0,309	-1,66%	1,000	2	0,312	0,00%	1,000
3	0,315	2	0,312	0,00%	1,000	3	0,320	1,79%	1,000
4	0,415	4	0,415	0,00%	1,000	4	0,415	0,00%	1,000
5	0,474	5	0,474	0,00%	1,000	5	0,474	0,01%	1,000
6	0,537	6	0,535	-0,31%	1,000	6	0,539	0,34%	1,000
7	0,560	7	0,559	-0,10%	1,000	7	0,560	0,12%	1,000
8	0,645	8	0,645	-0,01%	1,000	8	0,645	0,02%	1,000
9	0,668	9	0,668	-0,01%	1,000	9	0,668	0,01%	1,000
10	0,749	10	0,749	0,00%	1,000	10	0,749	0,00%	1,000
11	0,794	11	0,793	-0,14%	1,000	11	0,795	0,16%	1,000
12	0,910	12	0,910	0,00%	1,000	12	0,910	0,00%	1,000
13	0,942	13	0,942	0,00%	1,000	13	0,942	0,00%	1,000
14	0,977	14	0,977	0,00%	1,000	14	0,977	0,01%	1,000
15	1,001	15	1,001	0,00%	1,000	15	1,001	0,00%	1,000
16	1,111	16	1,110	-0,02%	1,000	16	1,111	0,02%	1,000
17	1,153	17	1,153	-0,03%	1,000	17	1,153	0,03%	1,000
18	1,249	18	1,249	0,00%	1,000	18	1,249	0,01%	1,000
19	1,277	19	1,277	0,00%	1,000	19	1,277	0,00%	1,000
20	1,442	20	1,441	-0,08%	1,000	20	1,443	0,08%	1,000

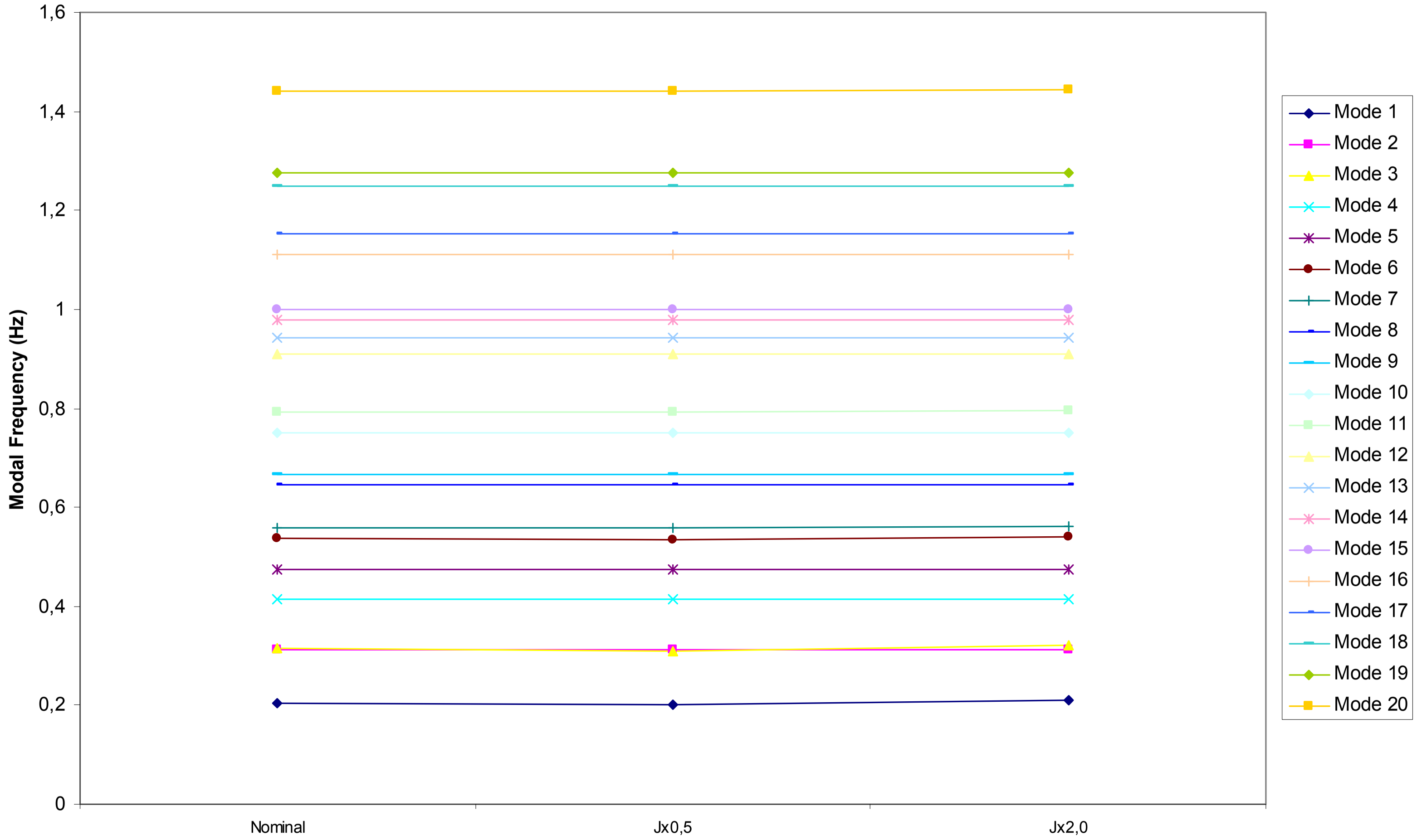


Figure 5.4 Changes in Modal Order for Extreme Cases of Possible Variations of J of Inner Piers

5.2.1.5 E

Variations in modal response of the structure based on the changes in elastic modulus of piers are also examined. Elastic modulus of inner piers is changed by 50% and 200%. It is observed that a great variation occurs in modal properties for both cases. Only 14th and 20th modes remain consistent. 5th and 9th modes in the nominal model are lost and more than 1% variation is observed for the other modes. Shifting in some modes are also present.

Table 5.5 Changes in Modal Frequencies for Extreme Cases of Possible Variations of E of Inner Piers

Nominal		Ex0,5				Ex2,0			
Modes	Freq	Modes	Freq	Variation in freq.	MAC	Modes	Freq	Variation in freq.	MAC
1	0,205	1	0,199	-3,24%	1,000	1	0,211	2,98%	1,000
2	0,312	3	0,304	-3,32%	1,000	2	0,313	0,18%	1,000
3	0,315	2	0,310	-0,67%	0,999	3	0,324	3,17%	1,000
4	0,415		0,373			4	0,417	0,39%	1,000
5	0,474	4	0,414	-0,36%	0,986	6	0,548	1,94%	0,998
6	0,537		0,509				0,556		
7	0,560	6	0,520	-3,19%	0,994	7	0,572	2,24%	0,998
8	0,645	7	0,538	-3,93%	0,991	8	0,646	0,17%	1,000
9	0,668	8	0,643	-0,32%	1,000	10	0,737	-1,59%	1,000
10	0,749	10	0,737	-1,63%	0,978	11	0,807	1,61%	0,886
11	0,794	11	0,774	-2,54%	0,995		0,879		
12	0,910	12	0,894	-1,74%	0,997	12	0,919	0,97%	0,999
13	0,942	13	0,916	-2,75%	0,988	13	0,960	1,93%	0,994
14	0,977	14	0,971	-0,64%	0,998	14	0,981	0,36%	0,999
15	1,001	15	0,983	-1,77%	0,995	15	1,053	5,25%	0,949
16	1,111	16	1,099	-1,05%	0,970	16	1,117	0,55%	0,992
17	1,153	17	1,130	-2,00%	0,991	17	1,168	1,34%	0,997
18	1,249	18	1,223	-2,03%	0,928	18	1,266	1,43%	0,993
19	1,277	19	1,265	-0,97%	1,000	19	1,302	1,95%	0,999
20	1,442	20	1,440	-0,12%	1,000	20	1,444	0,12%	1,000

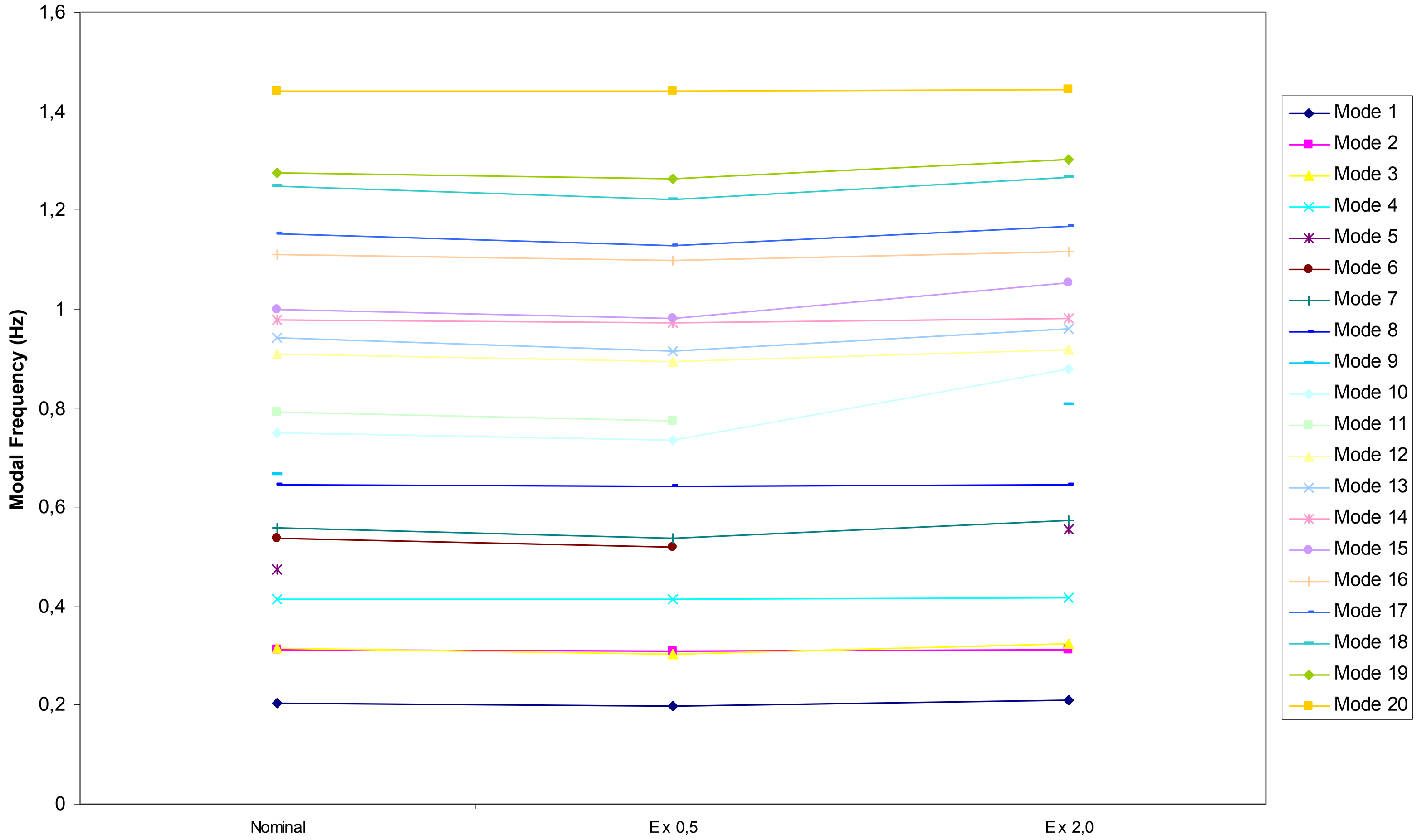


Figure 5.5 Changes in Modal Order for Extreme Cases of Possible Variations of E of Inner Piers

5.2.2 Outer Piers (W2,E2)

5.2.2.1 Area

The effects of changing same parameters of outer piers on modal response are investigated as well. Firstly, area of outer piers is modified by 80% and 120% of nominal value to represent the two extreme cases. Neither there is a change in modal order nor a non-trivial variation is observed for mode frequencies. The highest variation is observed for 17th mode, which is as low as 0.09%.

Table 5.6 Changes in Modal Frequencies for Extreme Cases of Possible Variations of A of Outer Piers

Nominal		Areax0,5				Areax2			
Modes	Freq	Modes	Freq	Variation in freq.	MAC	Modes	Freq	Variation in freq.	MAC
1	0,205	1	0,205	0,00%	1,000	1	0,205	0,00%	1,000
2	0,312	2	0,312	0,00%	1,000	2	0,312	0,00%	1,000
3	0,315	3	0,315	-0,01%	1,000	3	0,315	0,01%	1,000
4	0,415	4	0,415	-0,01%	1,000	4	0,415	0,01%	1,000
5	0,474	5	0,474	0,00%	1,000	5	0,474	0,00%	1,000
6	0,537	6	0,537	-0,04%	1,000	6	0,537	0,03%	1,000
7	0,560	7	0,559	-0,04%	1,000	7	0,560	0,03%	1,000
8	0,645	8	0,645	0,00%	1,000	8	0,645	0,00%	1,000
9	0,668	9	0,668	0,00%	1,000	9	0,668	0,00%	1,000
10	0,749	10	0,749	-0,01%	1,000	10	0,749	0,01%	1,000
11	0,794	11	0,794	0,00%	1,000	11	0,794	0,00%	1,000
12	0,910	12	0,910	0,00%	1,000	12	0,910	0,00%	1,000
13	0,942	13	0,942	-0,01%	1,000	13	0,942	0,01%	1,000
14	0,977	14	0,977	-0,01%	1,000	14	0,977	0,01%	1,000
15	1,001	15	1,001	-0,01%	1,000	15	1,001	0,00%	1,000
16	1,111	16	1,110	-0,07%	1,000	16	1,111	0,05%	1,000
17	1,153	17	1,152	-0,09%	1,000	17	1,154	0,06%	1,000
18	1,249	18	1,248	-0,02%	1,000	18	1,249	0,02%	1,000
19	1,277	19	1,277	0,00%	1,000	19	1,277	0,00%	1,000
20	1,442	20	1,442	-0,03%	1,000	20	1,442	0,01%	1,000

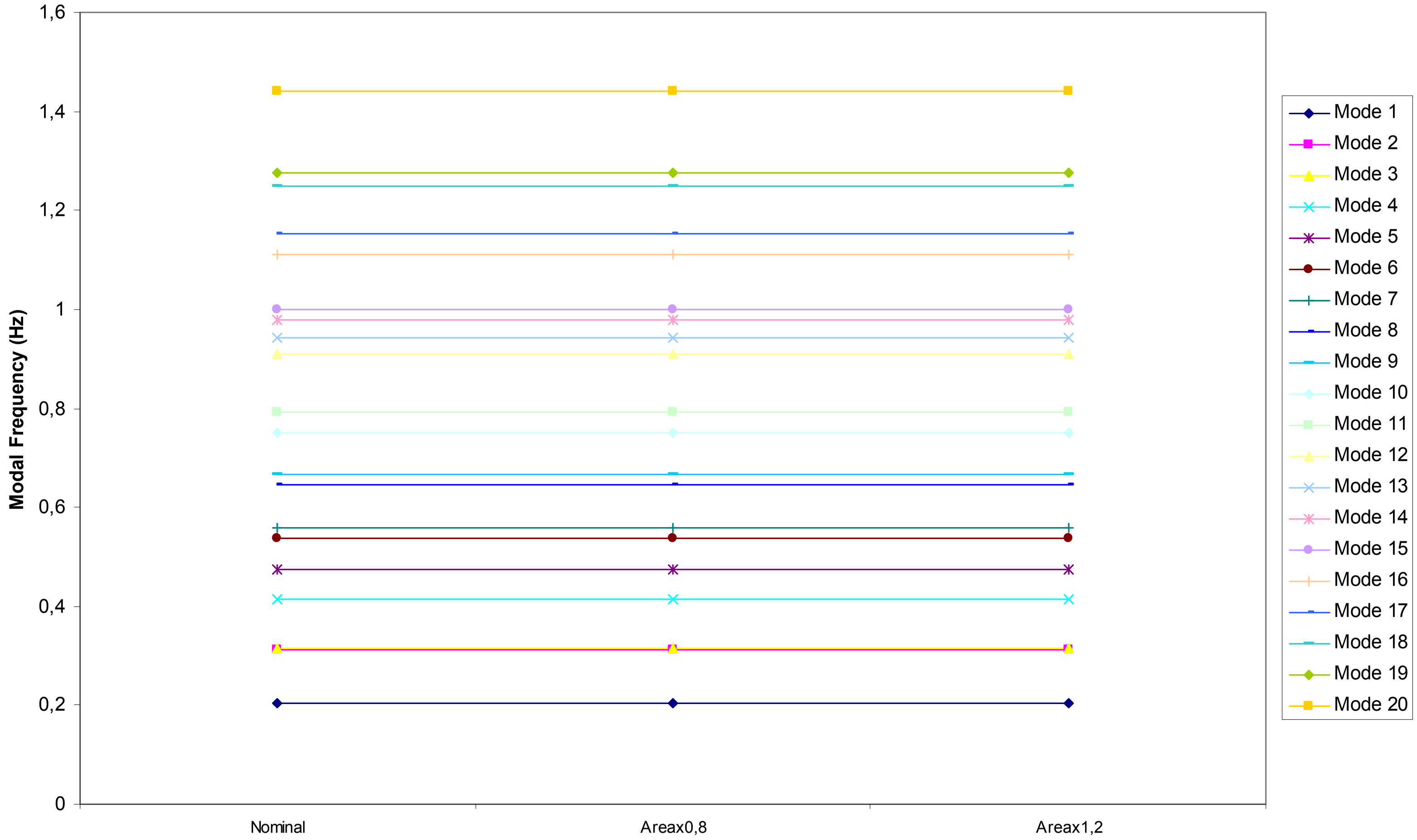


Figure 5.6 Changes in Modal Order for Extreme Cases of Possible Variations of A of Outer Piers

5.2.2.2 I_x

I_x of the outer piers is assigned to 50% and 200% of its nominal value. No change in the modal order is observed with respect to nominal modes. Furthermore, variations in mode frequencies are all trivial.

Table 5.7 Changes in Modal Frequencies for Extreme Cases of Possible Variations of I_x of Outer Piers

Nominal		I_xx0,5				I_xx2,0			
Modes	Freq	Modes	Freq	Variation in freq.	MAC	Modes	Freq	Variation in freq.	MAC
1	0,205	1	0,205	0,00%	1,000	1	0,205	0,00%	1,000
2	0,312	2	0,312	0,00%	1,000	2	0,312	0,00%	1,000
3	0,315	3	0,315	0,00%	1,000	3	0,315	0,00%	1,000
4	0,415	4	0,415	0,00%	1,000	4	0,415	0,00%	1,000
5	0,474	5	0,474	0,00%	1,000	5	0,474	0,00%	1,000
6	0,537	6	0,537	-0,01%	1,000	6	0,537	0,00%	1,000
7	0,560	7	0,560	-0,01%	1,000	7	0,560	0,01%	1,000
8	0,645	8	0,645	0,00%	1,000	8	0,645	0,00%	1,000
9	0,668	9	0,668	0,00%	1,000	9	0,668	0,00%	1,000
10	0,749	10	0,749	0,00%	1,000	10	0,749	0,00%	1,000
11	0,794	11	0,794	0,00%	1,000	11	0,794	0,00%	1,000
12	0,910	12	0,910	0,00%	1,000	12	0,910	0,00%	1,000
13	0,942	13	0,942	0,00%	1,000	13	0,942	0,00%	1,000
14	0,977	14	0,977	0,00%	1,000	14	0,977	0,00%	1,000
15	1,001	15	1,001	0,00%	1,000	15	1,001	0,00%	1,000
16	1,111	16	1,111	-0,01%	1,000	16	1,111	0,00%	1,000
17	1,153	17	1,153	-0,01%	1,000	17	1,153	0,01%	1,000
18	1,249	18	1,249	0,00%	1,000	18	1,249	0,00%	1,000
19	1,277	19	1,277	0,00%	1,000	19	1,277	0,00%	1,000
20	1,442	20	1,442	0,00%	1,000	20	1,442	0,00%	1,000

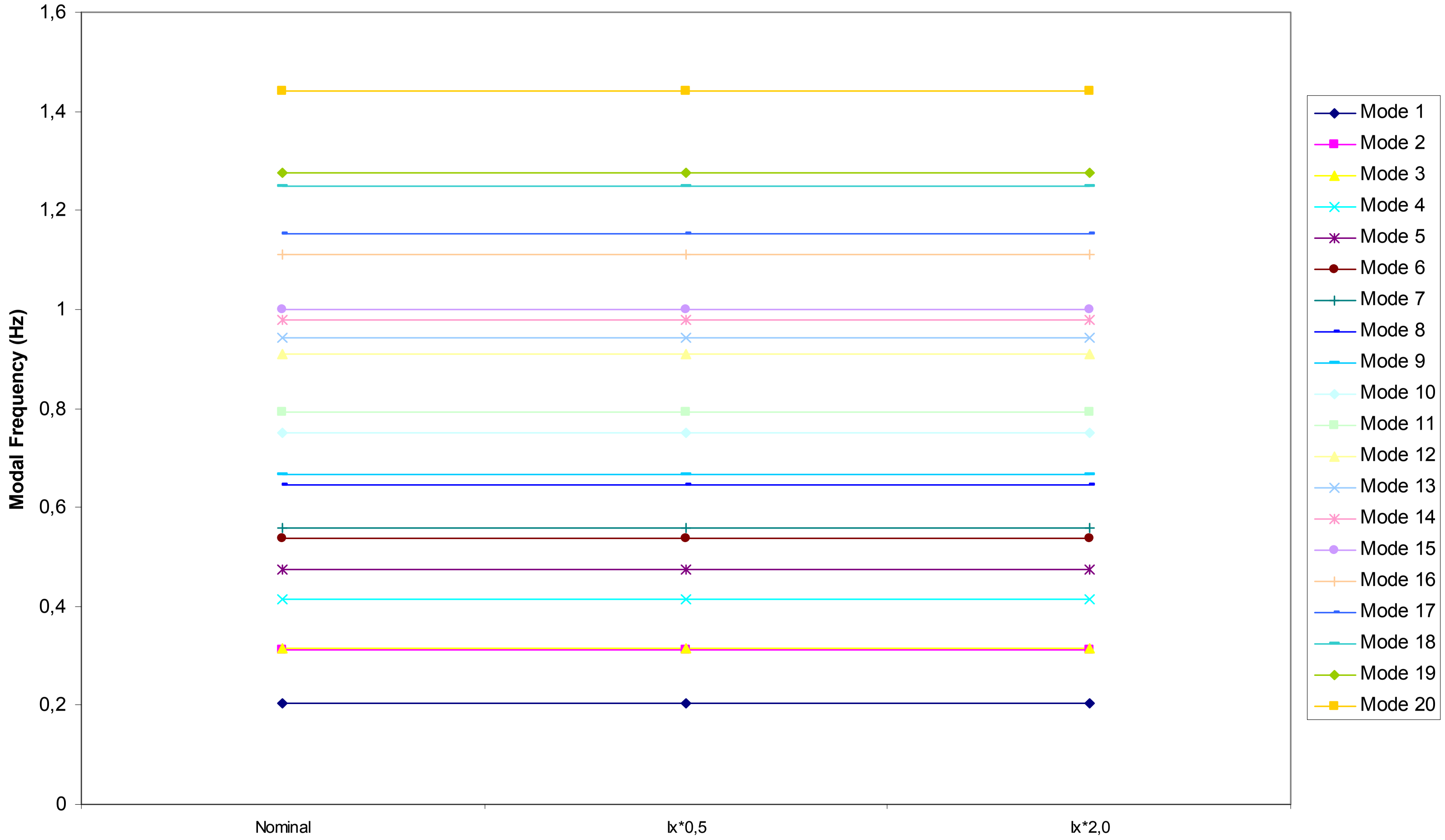


Figure 5.7 Changes in Modal Order for Extreme Cases of Possible Variations of I_x of Outer Piers

5.2.2.3 I_y

I_y of the outer piers is modified within the same range. It is observed that the change in frequencies for the 6th, 7th, 16th, 17th, 20th modes remains in the range between 2.19% and 1%. However modal order is completely consistent with that of the nominal model.

Table 5.8 Changes in Modal Frequencies for Extreme Cases of Possible Variations of I_y of Outer Piers

Nominal		I_yx0,5				I_yx2,0			
Modes	Freq	Modes	Freq	Variation in freq.	MAC	Modes	Freq	Variation in freq.	MAC
1	0,205	1	0,205	-0,24%	1,000	1	0,206	0,14%	1,000
2	0,312	2	0,312	0,00%	1,000	2	0,312	0,00%	1,000
3	0,315	3	0,313	-0,42%	1,000	3	0,315	0,24%	1,000
4	0,415	4	0,415	0,00%	1,000	4	0,415	0,00%	1,000
5	0,474	5	0,474	0,00%	1,000	5	0,474	0,00%	1,000
6	0,537	6	0,528	-1,70%	0,998	6	0,542	1,00%	0,999
7	0,560	7	0,551	-1,61%	0,999	7	0,565	0,96%	1,000
8	0,645	8	0,644	-0,16%	0,999	8	0,645	0,11%	1,000
9	0,668	9	0,668	0,00%	1,000	9	0,668	0,00%	1,000
10	0,749	10	0,749	0,00%	1,000	10	0,749	0,00%	1,000
11	0,794	11	0,794	0,00%	1,000	11	0,794	0,00%	1,000
12	0,910	12	0,908	-0,22%	1,000	12	0,911	0,11%	1,000
13	0,942	13	0,942	0,00%	1,000	13	0,942	0,00%	1,000
14	0,977	14	0,977	-0,07%	1,000	14	0,978	0,03%	1,000
15	1,001	15	1,001	0,00%	1,000	15	1,001	0,00%	1,000
16	1,111	16	1,096	-1,28%	0,989	16	1,118	0,68%	0,996
17	1,153	17	1,128	-2,19%	0,994	17	1,168	1,28%	0,998
18	1,249	18	1,238	-0,82%	0,992	18	1,255	0,50%	0,997
19	1,277	19	1,277	0,00%	1,000	19	1,277	0,00%	1,000
20	1,442	20	1,421	-1,48%	0,972	20	1,456	0,98%	0,988

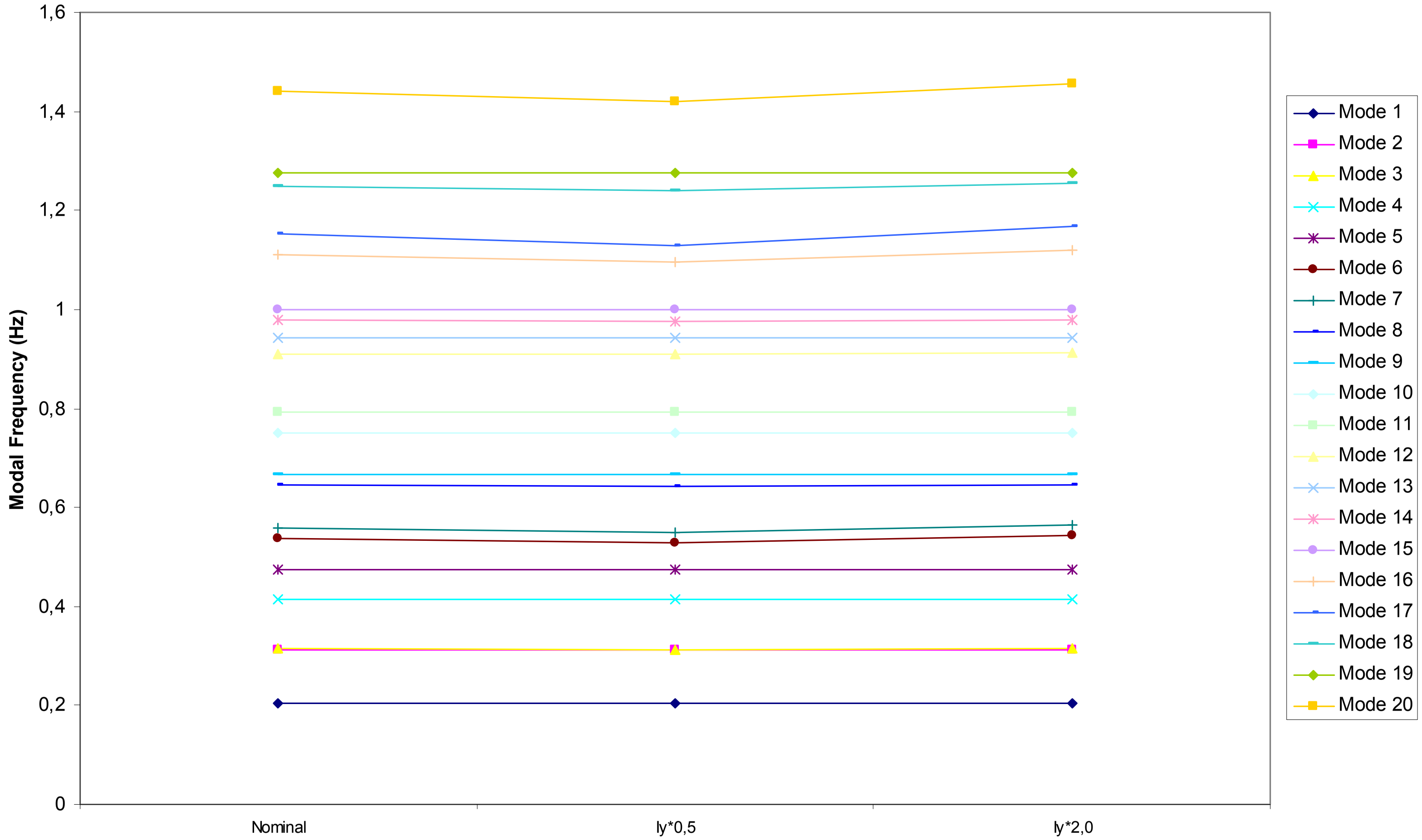


Figure 5.8 Changes in Modal Order for Extreme Cases of Possible Variations of I_y of Outer Piers

5.2.2.4 J

Identical observations are carried out for the torsion constant of the outer piers. All the frequency variations are quite less than 1%. Evidently, no shift in modal order is observed.

Table 5.9 Changes in Modal Frequencies for Extreme Cases of Possible Variations of J of Outer Piers

Nominal		Jx0,5				Jx2,0			
Modes	Freq	Modes	Freq	Variation in freq.	MAC	Modes	Freq	Variation in freq.	MAC
1	0,205	1	0,205	0,00%	1,000	1	0,205	0,00%	1,000
2	0,312	2	0,312	0,00%	1,000	2	0,312	0,00%	1,000
3	0,315	3	0,315	-0,01%	1,000	3	0,315	0,01%	1,000
4	0,415	4	0,415	0,00%	1,000	4	0,415	0,00%	1,000
5	0,474	5	0,474	0,00%	1,000	5	0,474	0,00%	1,000
6	0,537	6	0,537	-0,03%	1,000	6	0,537	0,02%	1,000
7	0,560	7	0,559	-0,03%	1,000	7	0,560	0,02%	1,000
8	0,645	8	0,645	0,00%	1,000	8	0,645	0,00%	1,000
9	0,668	9	0,668	0,00%	1,000	9	0,668	0,00%	1,000
10	0,749	10	0,749	0,00%	1,000	10	0,749	0,00%	1,000
11	0,794	11	0,794	0,00%	1,000	11	0,794	0,00%	1,000
12	0,910	12	0,910	0,00%	1,000	12	0,910	0,00%	1,000
13	0,942	13	0,942	0,00%	1,000	13	0,942	0,00%	1,000
14	0,977	14	0,977	-0,01%	1,000	14	0,977	0,01%	1,000
15	1,001	15	1,001	0,00%	1,000	15	1,001	0,00%	1,000
16	1,111	16	1,110	-0,04%	1,000	16	1,111	0,02%	1,000
17	1,153	17	1,153	-0,03%	1,000	17	1,153	0,03%	1,000
18	1,249	18	1,249	0,00%	1,000	18	1,249	0,01%	1,000
19	1,277	19	1,277	0,00%	1,000	19	1,277	0,00%	1,000
20	1,442	20	1,442	0,00%	1,000	20	1,442	0,00%	1,000

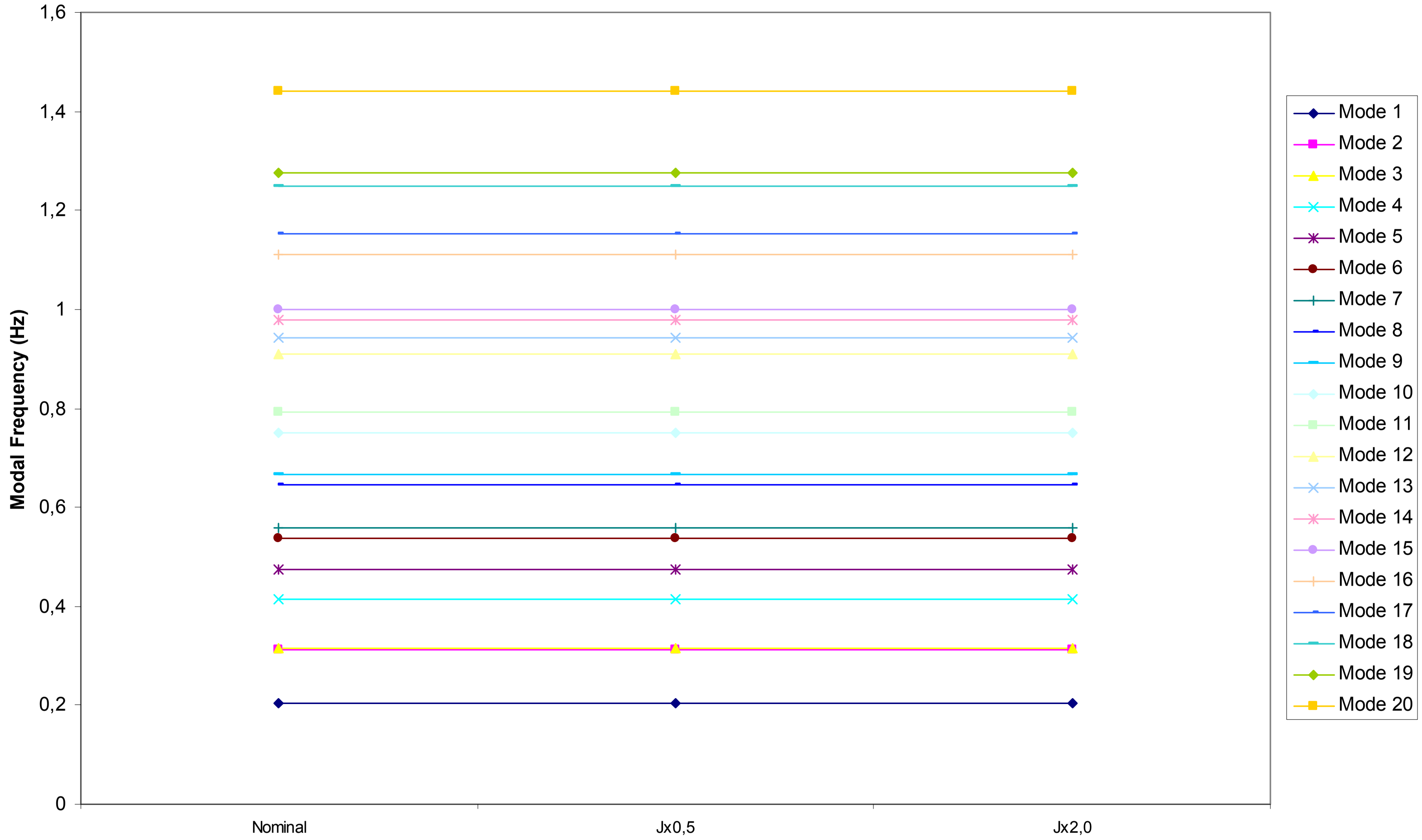


Figure 5.9 Changes in Modal Order for Extreme Cases of Possible Variations of J of Outer Piers

5.2.2.5 E

Elastic modulus of the outer piers is also changed by previously defined values. It is obtained that frequencies for 6th, 7th, 16th, 17th, and 20th modes vary between %1.09 and %2.71. There is no shift in modal order.

Table 5.10 Changes in Modal Frequencies for Extreme Cases of Possible Variations of E of Outer Piers

Nominal		Ex0,5				Ex2,0			
Modes	Freq	Modes	Freq	Variation in freq.	MAC	Modes	Freq	Variation in freq.	MAC
1	0,205	1	0,205	-0,29%	1,000	1	0,206	0,17%	1,000
2	0,312	2	0,312	-0,02%	1,000	2	0,312	0,01%	1,000
3	0,315	3	0,313	-0,50%	1,000	3	0,315	0,28%	1,000
4	0,415	4	0,415	-0,03%	1,000	4	0,416	0,02%	1,000
5	0,474	5	0,474	0,00%	1,000	5	0,474	0,00%	1,000
6	0,537	6	0,526	-2,01%	0,998	6	0,543	1,16%	0,999
7	0,560	7	0,549	-1,90%	0,999	7	0,566	1,11%	1,000
8	0,645	8	0,644	-0,18%	0,999	8	0,646	0,12%	1,000
9	0,668	9	0,668	0,00%	1,000	9	0,668	0,00%	1,000
10	0,749	10	0,749	-0,03%	1,000	10	0,749	0,02%	1,000
11	0,794	11	0,794	-0,01%	1,000	11	0,794	0,01%	1,000
12	0,910	12	0,908	-0,25%	1,000	12	0,911	0,13%	1,000
13	0,942	13	0,942	-0,03%	1,000	13	0,942	0,02%	1,000
14	0,977	14	0,976	-0,11%	1,000	14	0,978	0,06%	1,000
15	1,001	15	1,001	-0,02%	1,000	15	1,001	0,00%	1,000
16	1,111	16	1,092	-1,71%	0,985	16	1,120	0,87%	0,995
17	1,153	17	1,122	-2,71%	0,994	17	1,171	1,53%	0,998
18	1,249	18	1,237	-0,94%	0,989	18	1,256	0,58%	0,997
19	1,277	19	1,277	-0,01%	1,000	19	1,277	0,00%	1,000
20	1,442	20	1,418	-1,64%	0,964	20	1,458	1,09%	0,986

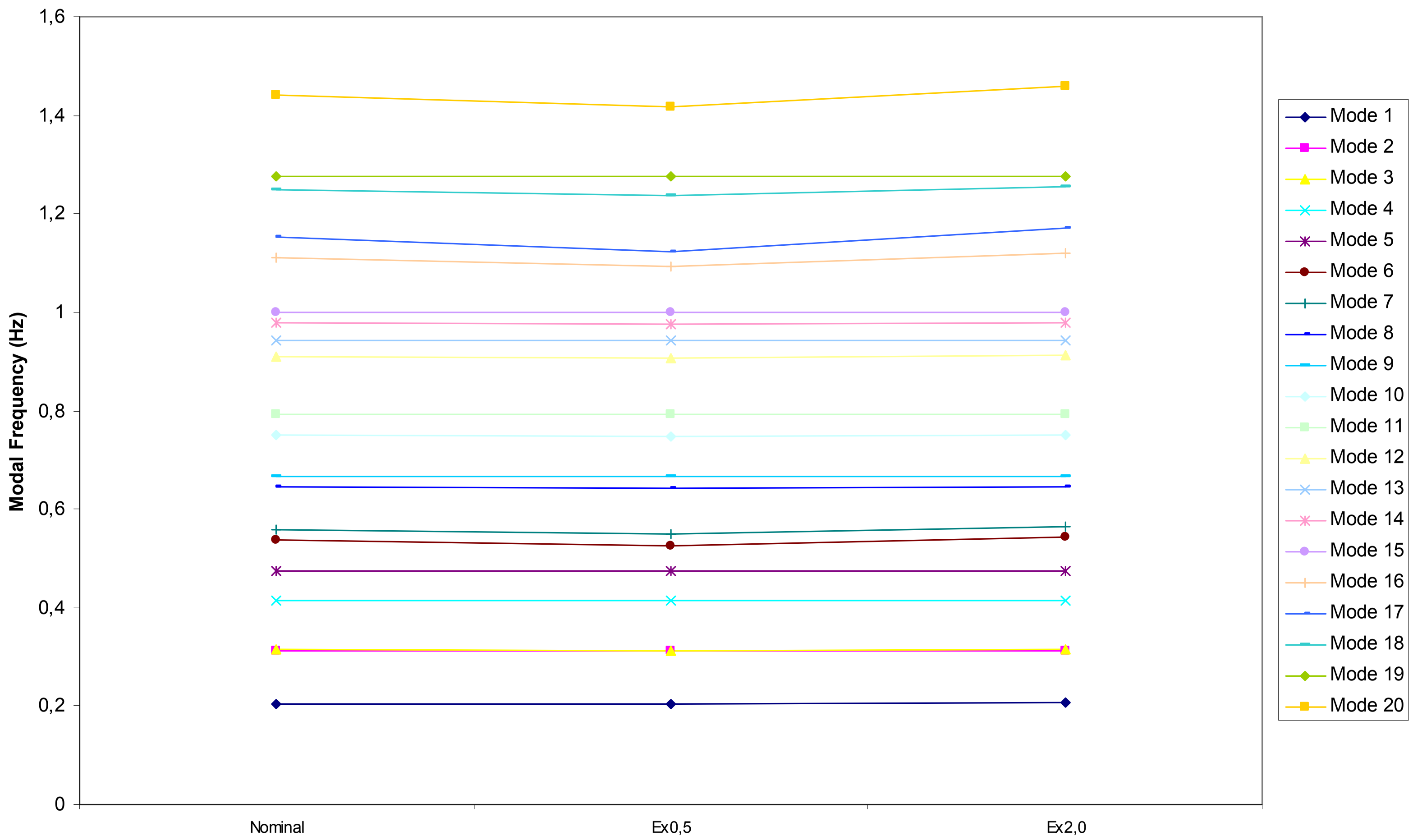


Figure 5.10 Changes in Modal Order for Extreme Cases of Possible Variations of E of Outer Piers

5.2.3 Mass of the Deck

Variation in mass of the deck is expected to have some influence on modal response of the bridge. For deck, pre-defined extreme cases are created by considering 80% and 120% of the nominal mass. When the mass of the deck is changed by these amounts, it is observed that all the modal frequencies vary in the range between 1.6% and 3.5% without any mode shifts.

Table 5.11 Changes in Modal Frequencies for Extreme Cases of Possible Variations of Deck Mass

Nominal		Deck massx0,8				Deck massx1,2			
Modes	Freq	Modes	Freq	Variation in freq.	MAC	Modes	Freq	Variation in freq.	MAC
1	0,205	1	0,212	3,26%	1,000	1	0,199	-2,99%	1,000
2	0,312	2	0,322	3,32%	1,000	2	0,303	-3,02%	1,000
3	0,315	3	0,324	2,99%	1,000	3	0,306	-2,75%	1,000
4	0,415	4	0,428	2,94%	1,000	4	0,404	-2,70%	1,000
5	0,474	5	0,489	3,30%	0,995	5	0,460	-3,00%	0,993
6	0,537	6	0,553	2,91%	0,997	6	0,522	-2,77%	0,997
7	0,560	7	0,576	2,92%	0,999	7	0,544	-2,76%	0,999
8	0,645	8	0,662	2,60%	0,998	8	0,630	-2,27%	0,998
9	0,668	9	0,688	3,10%	1,000	9	0,649	-2,84%	1,000
10	0,749	10	0,775	3,49%	1,000	10	0,725	-3,16%	1,000
11	0,794	11	0,814	2,49%	0,998	11	0,775	-2,41%	0,999
12	0,910	12	0,927	1,82%	0,998	12	0,896	-1,57%	0,999
13	0,942	13	0,974	3,38%	1,000	13	0,913	-3,07%	1,000
14	0,977	14	1,001	2,38%	0,995	14	0,958	-2,01%	0,996
15	1,001	15	1,034	3,32%	1,000	15	0,970	-3,02%	1,000
16	1,111	16	1,130	1,71%	0,997	16	1,093	-1,62%	0,998
17	1,153	17	1,173	1,72%	0,997	17	1,134	-1,67%	0,998
18	1,249	18	1,273	1,95%	0,999	18	1,225	-1,85%	1,000
19	1,277	19	1,320	3,34%	1,000	19	1,238	-3,04%	0,999
20	1,442	20	1,475	2,25%	0,993	20	1,408	-2,33%	0,993

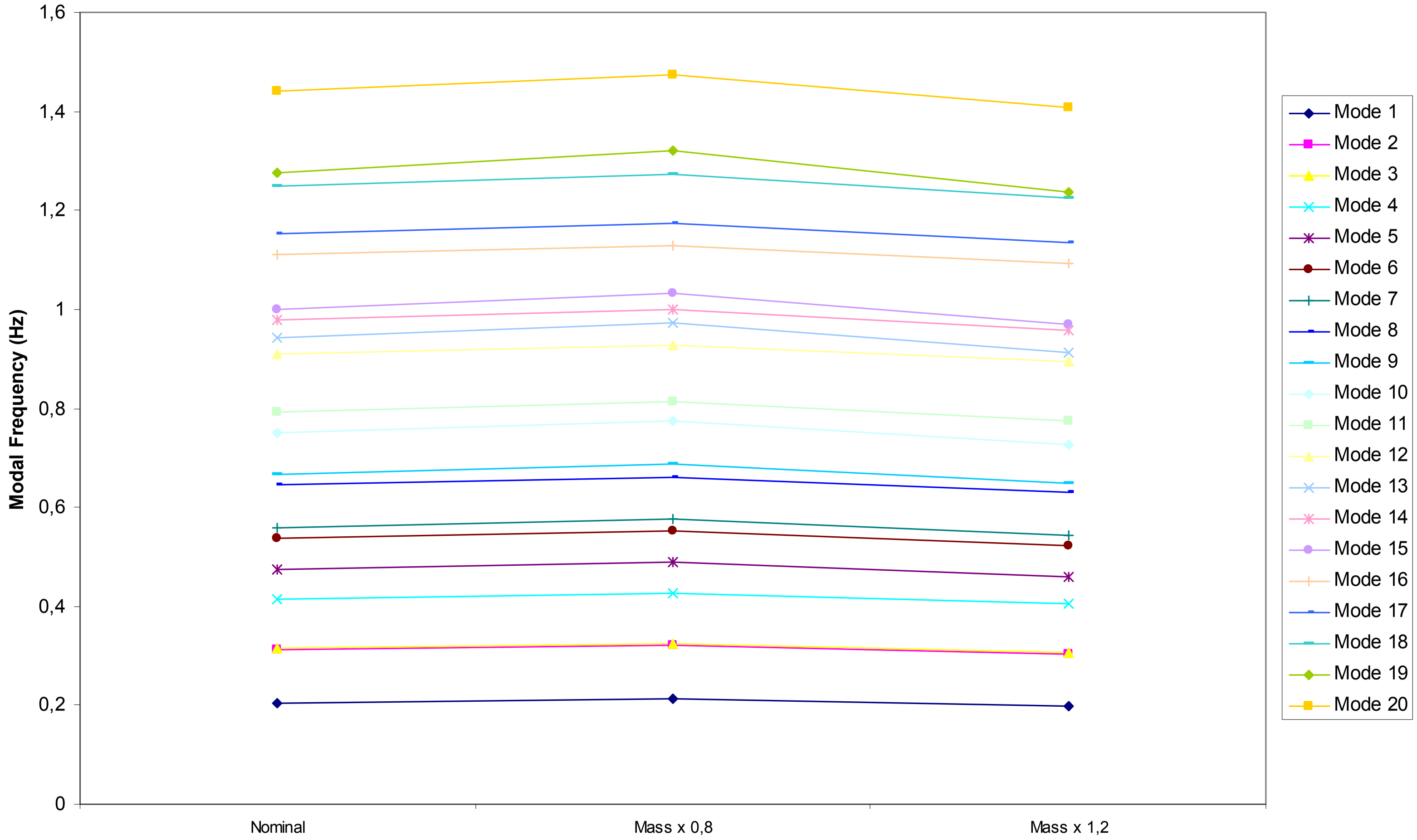


Figure 5.11 Changes in Modal Order for Extreme Cases of Possible Variations of Deck Mass

5.2.4 Suspended Span

5.2.4.1 Chord Members Around Hangers

As discussed in chapter 4, some releases are defined on upper and lower chord members around hangers in order to achieve suspension behavior in the mid-part of the bridge. To identify the influence of these movement mechanisms on bridge's modal response, they are switched to fully restrained case and then modal variations are observed. Firstly, bending moment releases are removed. No significant variation is observed in frequencies except for the 4th mode whose frequency changes about 1.1% as it is shown in Table 5.12. Figure 5.13 shows that no mode shift has been observed. Secondly, axial force releases are cancelled out. A significant variation in both modal order and frequencies has been observed. Specifically, 3rd, 5th, 7th, 9th, 11th, 14th and 15th modes are lost. Besides, except for 6th, 16th and 20th modes, frequency variations for existing modes lie between 2.2% and 33% as it is shown in Table 5.13.

Table 5.12 Changes in Modal Frequencies for Rotationally Fixed Case of Chord Members

Nominal		Rotationally fixed Chord Members			
Modes	Freq	Modes	Freq	Variation in freq.	MAC
1	0,205	1	0,205	0,00%	1,000
2	0,312	2	0,312	0,10%	1,000
3	0,315	3	0,315	0,01%	1,000
4	0,415	4	0,420	1,11%	1,000
5	0,474	5	0,474	0,11%	0,968
6	0,537	6	0,537	0,01%	1,000
7	0,560	7	0,560	0,00%	1,000
8	0,645	8	0,645	0,09%	1,000
9	0,668	9	0,668	0,05%	1,000
10	0,749	10	0,751	0,30%	1,000
11	0,794	11	0,794	0,03%	1,000
12	0,910	12	0,910	0,00%	1,000
13	0,942	13	0,943	0,08%	1,000
14	0,977	14	0,978	0,01%	1,000
15	1,001	15	1,002	0,10%	1,000
16	1,111	16	1,111	0,00%	1,000
17	1,153	17	1,153	0,01%	1,000
18	1,249	18	1,249	0,03%	1,000
19	1,277	19	1,279	0,16%	1,000
20	1,442	20	1,442	0,01%	1,000

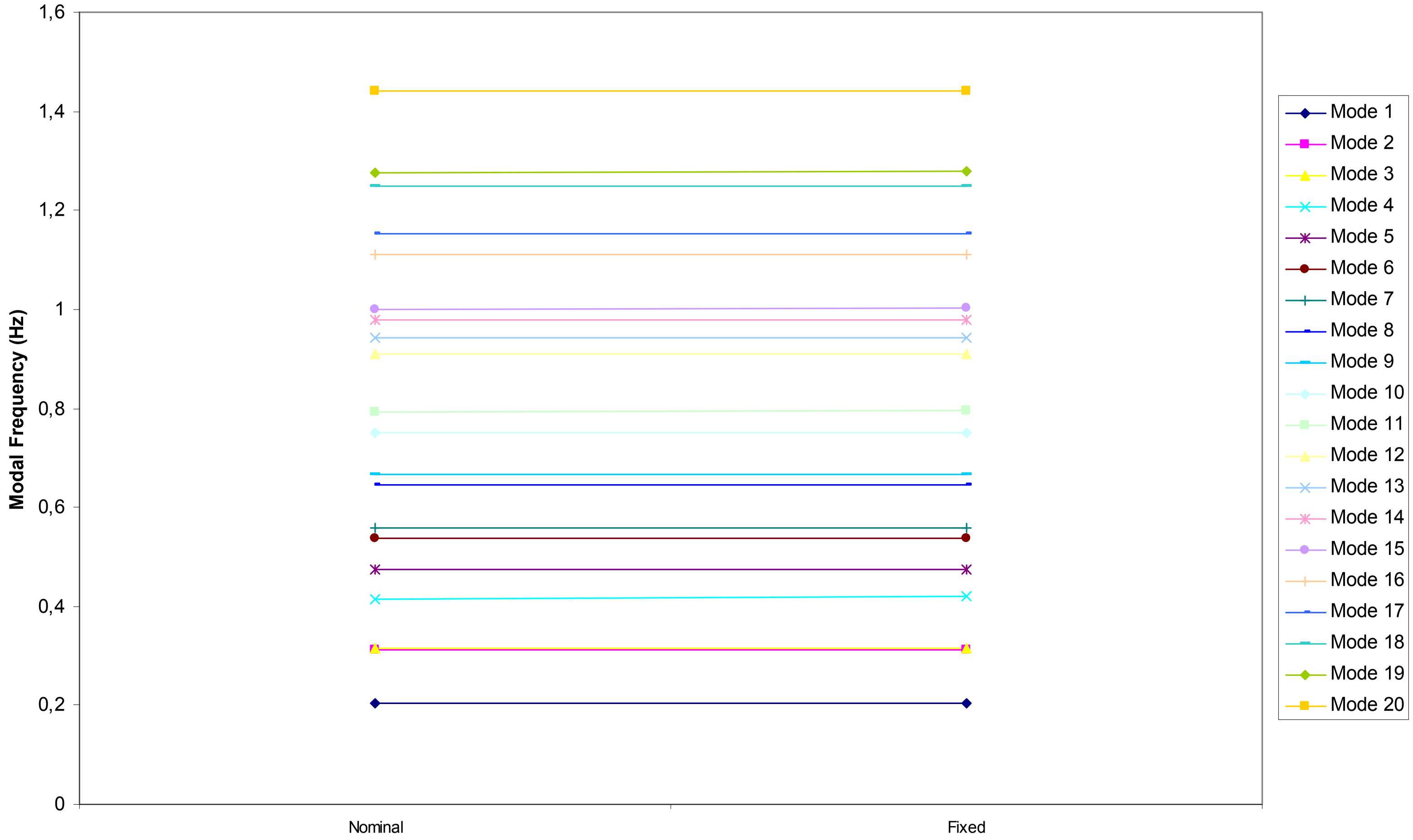


Figure 5.12 Changes in Modal Order for Rotationally Fixed Case of Chord Members

Table 5.13 Changes in Modal Frequencies for Axially Fixed Case of Chord Members

Nominal		Axially Fixed Chord Members			
Modes	Freq	Modes	Freq	Variation in freq.	MAC
1	0,205	1	0,223	8,72%	0,986
2	0,312	2	0,328	5,12%	0,995
3	0,315		0,518		
4	0,415	6	0,541	0,75%	0,985
5	0,474	4	0,554	33,28%	0,827
6	0,537		0,595		
7	0,560	8	0,659	2,21%	0,982
8	0,645		0,665		
9	0,668	10	0,829	10,69%	0,870
10	0,749		0,878		
11	0,794	12	0,921	3,57%	0,980
12	0,910	13	1,002	6,40%	0,941
13	0,942		1,056		
14	0,977	16	1,111	0,05%	1,000
15	1,001		1,145		
16	1,111	17	1,210	4,94%	0,774
17	1,153	18	1,302	4,26%	0,980
18	1,249	20	1,451	0,63%	0,982
19	1,277		1,473		
20	1,442	19	1,481	15,95%	0,946

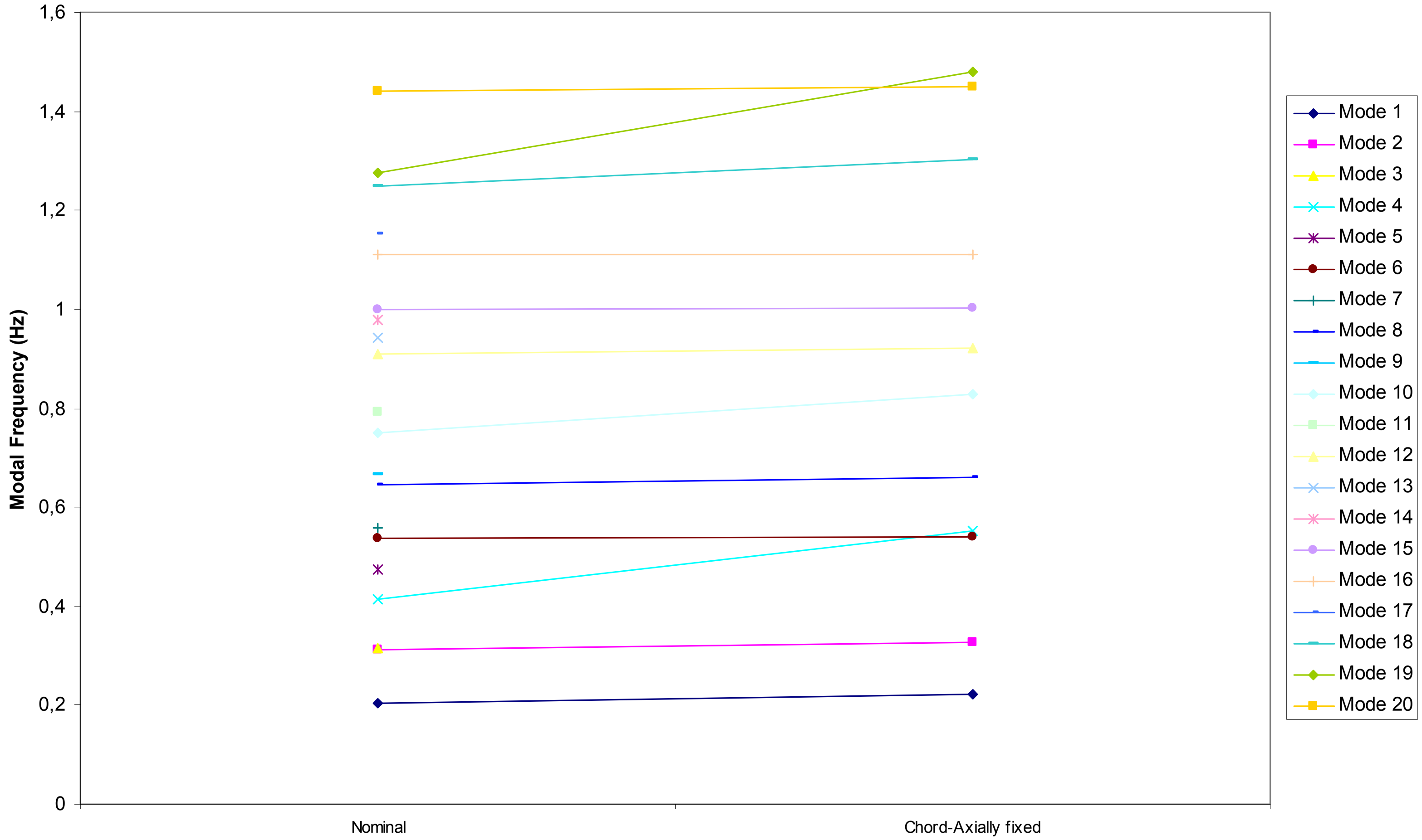


Figure 5.13 Changes in Modal Order for Axially Fixed Case of Chord Members

5.2.4.2 Wind Linkages and Hangers

Other movement mechanisms for achieving suspension behavior are wind linkages and hangers which are modeled by frame elements with moment releases of both ends in the corresponding directions. When these releases are fixed separately, no considerable change in modal properties has been observed with respect to nominal case as it is shown in Table 5.14.

Table 5.14 Changes in Modal Frequencies for Fixed Case of Wind Linkages

Nominal		Rotationally fixed Wind linkages			
Modes	Freq	Modes	Freq	Variation in freq.	MAC
1	0,205	1	0,205	0,00%	1,000
2	0,312	2	0,312	0,03%	1,000
3	0,315	3	0,315	0,02%	1,000
4	0,415	4	0,415	0,00%	1,000
5	0,474	5	0,476	0,47%	0,985
6	0,537	6	0,537	0,00%	1,000
7	0,560	7	0,560	0,00%	1,000
8	0,645	8	0,645	0,00%	1,000
9	0,668	9	0,668	0,12%	1,000
10	0,749	10	0,750	0,08%	1,000
11	0,794	11	0,794	0,02%	1,000
12	0,910	12	0,910	0,00%	1,000
13	0,942	13	0,942	0,02%	1,000
14	0,977	14	0,977	0,00%	1,000
15	1,001	15	1,001	0,07%	1,000
16	1,111	16	1,111	0,00%	1,000
17	1,153	17	1,153	0,00%	1,000
18	1,249	18	1,249	0,00%	1,000
19	1,277	19	1,277	0,01%	1,000
20	1,442	20	1,442	0,01%	1,000

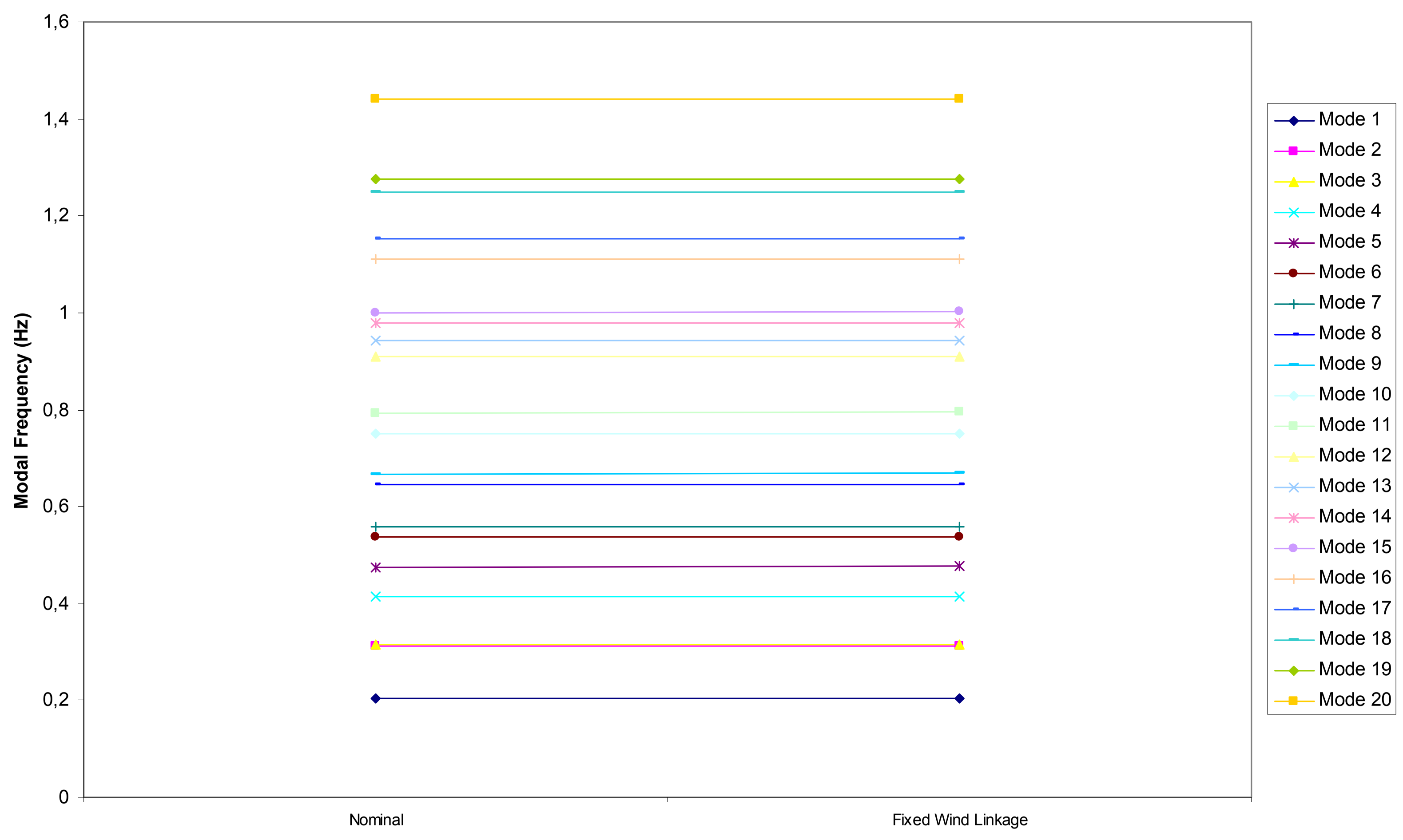


Figure 5.14 Changes in Modal Order for Fixed Case of Wind Linkages

Table 5.15 Changes in Modal Frequencies for Fixed Case of Hangers

Nominal		Rotationally fixed Hangers			
Modes	**Freq**	**Modes**	**Freq**	**Variation in freq.**	**MAC**
1	0,205	1	0,205	0,00%	1,000
2	0,312	2	0,312	0,02%	1,000
3	0,315	3	0,315	0,04%	1,000
4	0,415	4	0,416	0,04%	1,000
5	0,474	5	0,475	0,23%	0,976
6	0,537	6	0,537	0,00%	1,000
7	0,560	7	0,560	0,00%	1,000
8	0,645	8	0,645	0,00%	1,000
9	0,668	9	0,668	0,06%	1,000
10	0,749	10	0,749	0,03%	1,000
11	0,794	11	0,794	0,01%	1,000
12	0,910	12	0,910	0,00%	1,000
13	0,942	13	0,942	0,03%	1,000
14	0,977	14	0,977	0,00%	1,000
15	1,001	15	1,001	0,04%	1,000
16	1,111	16	1,111	0,00%	1,000
17	1,153	17	1,153	0,00%	1,000
18	1,249	18	1,249	0,01%	1,000
19	1,277	19	1,277	0,01%	1,000
20	1,442	20	1,442	0,00%	1,000

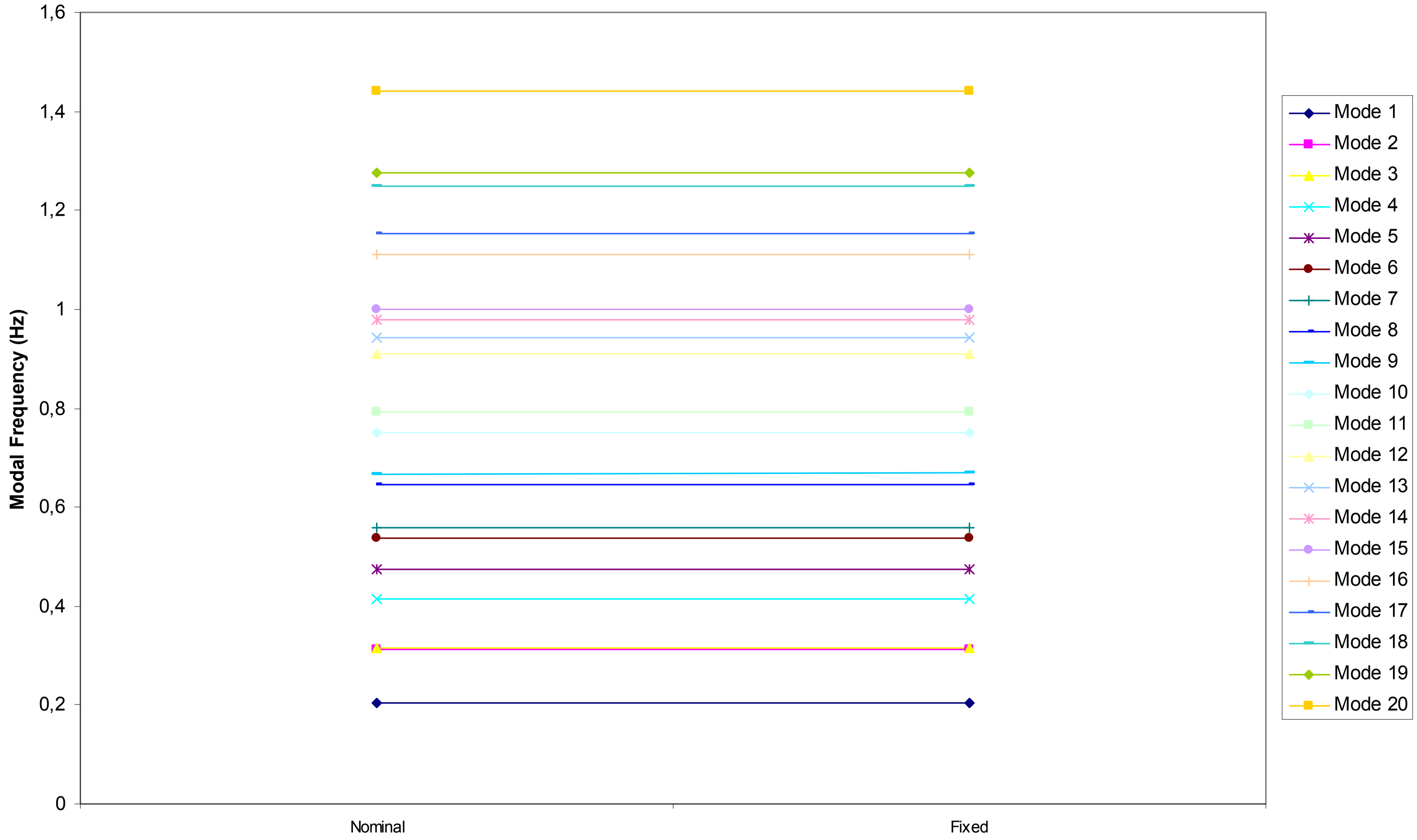


Figure 5.15 Changes in Modal Order for Fixed Case of Hangers

5.2.5 Bearings

Bearings are located between superstructure and substructure to create relative displacements between these two components of the bridge. As explained in detail in Chapter 4, they are represented by frame elements in the FE model where the relative displacements they create are modeled by defining only moment releases at inner piers, and both shear and moment releases at outer piers. When shear force releases are removed at outer piers, 5th and 9th modes are lost. Besides, the frequency of the 10th mode varies by 2%, whereas variations in frequencies for other modes are less than 1%. When moment releases at outer piers are removed, however, modal properties do not undergo a considerable change. When it comes to the moment releases at inner piers, their removal leads to some significant changes in modal properties such that 5th mode is lost. Frequency variations in 1st and 3rd modes are almost 1%, and are 3.6% and 2% for 9th and 10th modes, respectively.

Table 5.16 Changes in Modal Frequencies for Rotationally Fixed Case of Bearings at W1,E1

Nominal		Rotationally Fixed bearings at W1,E1			
Modes	Freq	Modes	Freq	Variation in freq.	MAC
1	0,205	1	0,207	0,92%	1,000
2	0,312	2	0,313	0,41%	1,000
3	0,315	3	0,318	0,97%	1,000
4	0,415	4	0,417	0,32%	1,000
5	0,474	5	0,494	4,32%	0,609
6	0,537	6	0,538	0,17%	1,000
7	0,560	7	0,560	0,07%	1,000
8	0,645	8	0,645	0,04%	1,000
9	0,668	9	0,691	3,58%	0,925
10	0,749	10	0,764	2,05%	0,954
11	0,794	11	0,794	0,07%	1,000
12	0,910	12	0,911	0,04%	1,000
13	0,942	13	0,948	0,62%	0,999
14	0,977	14	0,978	0,03%	1,000
15	1,001	15	1,006	0,54%	0,999
16	1,111	16	1,111	0,00%	1,000
17	1,153	17	1,153	0,01%	1,000
18	1,249	18	1,249	0,01%	1,000
19	1,277	19	1,283	0,49%	0,999
20	1,442	20	1,442	0,00%	1,000

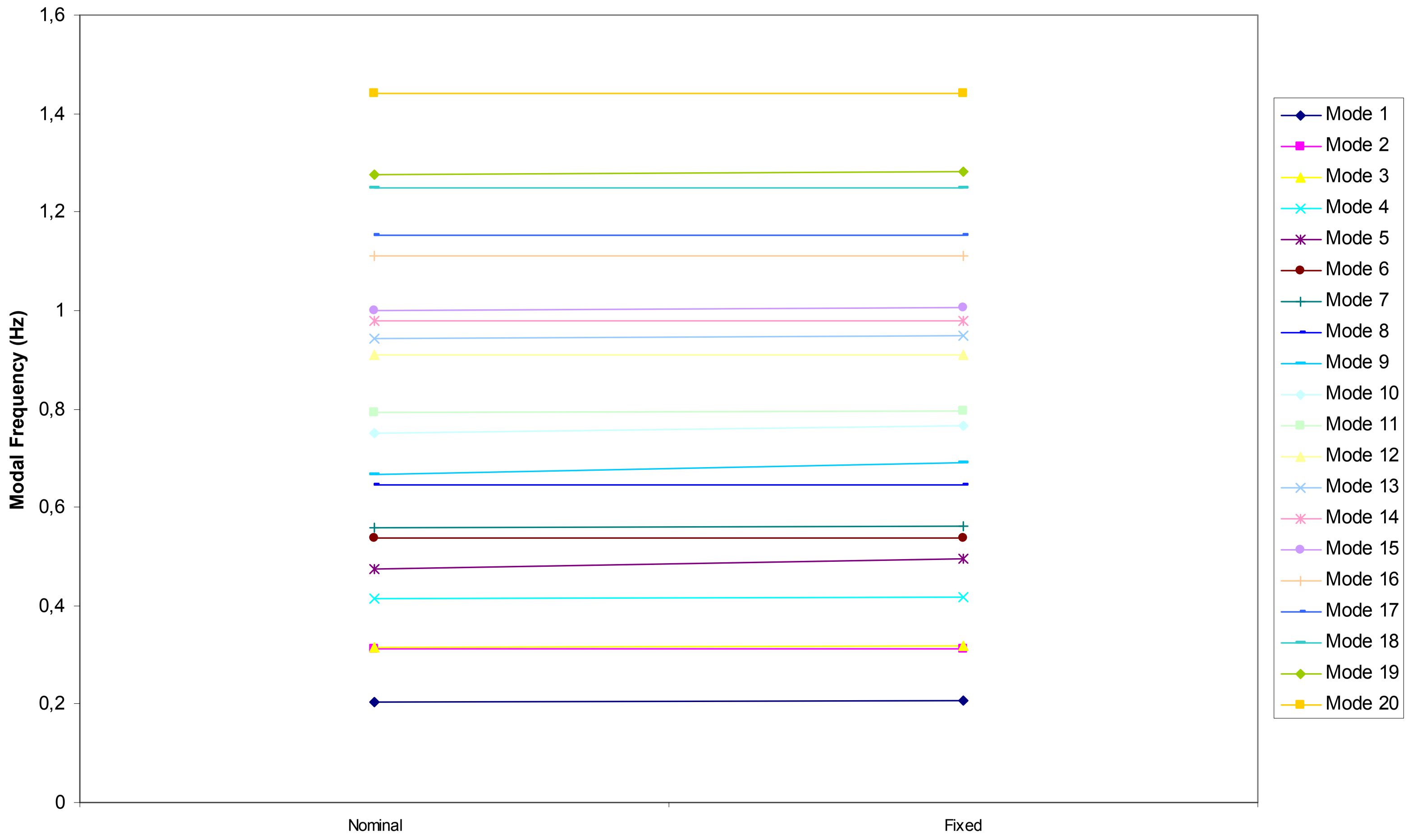


Figure 5.16 Changes in Modal Order for Rotationally Fixed Case of Bearings at W1,E1

Table 5.17 Changes in Modal Frequencies for Shear Fixed Case of Bearings at W2,E2

Nominal		V2 fixed Bearings at W2,E2			
Modes	Freq	Modes	Freq	Variation in freq.	MAC
1	0,205	1	0,207	0,92%	1,000
2	0,312	2	0,313	0,41%	1,000
3	0,315	3	0,318	0,97%	1,000
4	0,415	4	0,417	0,32%	1,000
5	0,474		0,494		
6	0,537	6	0,538	0,17%	1,000
7	0,560	7	0,560	0,07%	1,000
8	0,645	8	0,645	0,04%	1,000
9	0,668		0,691		
10	0,749	10	0,764	2,05%	0,834
11	0,794	11	0,794	0,07%	1,000
12	0,910	12	0,911	0,04%	1,000
13	0,942	13	0,948	0,62%	0,999
14	0,977	14	0,978	0,03%	1,000
15	1,001	15	1,006	0,54%	0,987
16	1,111	16	1,111	0,00%	1,000
17	1,153	17	1,153	0,01%	1,000
18	1,249	18	1,249	0,01%	1,000
19	1,277	19	1,283	0,49%	1,000
20	1,442	20	1,442	0,00%	1,000

Table 5.18 Changes in Modal Frequencies for Rotationally Fixed Case of Bearings at W2,E2

Nominal		Rotationally fixed Bearings at W2,E2			
Modes	Freq	Modes	Freq	Variation in freq.	MAC
1	0,205	1	0,205	0,00%	1,000
2	0,312	2	0,313	0,20%	1,000
3	0,315	3	0,315	0,00%	1,000
4	0,415	4	0,417	0,30%	1,000
5	0,474	5	0,474	0,00%	0,999
6	0,537	6	0,537	0,02%	1,000
7	0,560	7	0,560	0,02%	1,000
8	0,645	8	0,645	0,00%	1,000
9	0,668	9	0,668	0,02%	1,000
10	0,749	10	0,751	0,21%	1,000
11	0,794	11	0,794	0,01%	1,000
12	0,910	12	0,910	0,03%	1,000
13	0,942	13	0,944	0,17%	1,000
14	0,977	14	0,978	0,06%	1,000
15	1,001	15	1,002	0,10%	1,000
16	1,111	16	1,112	0,12%	1,000
17	1,153	17	1,154	0,10%	1,000
18	1,249	18	1,249	0,02%	1,000
19	1,277	19	1,278	0,04%	1,000
20	1,442	20	1,442	0,00%	1,000

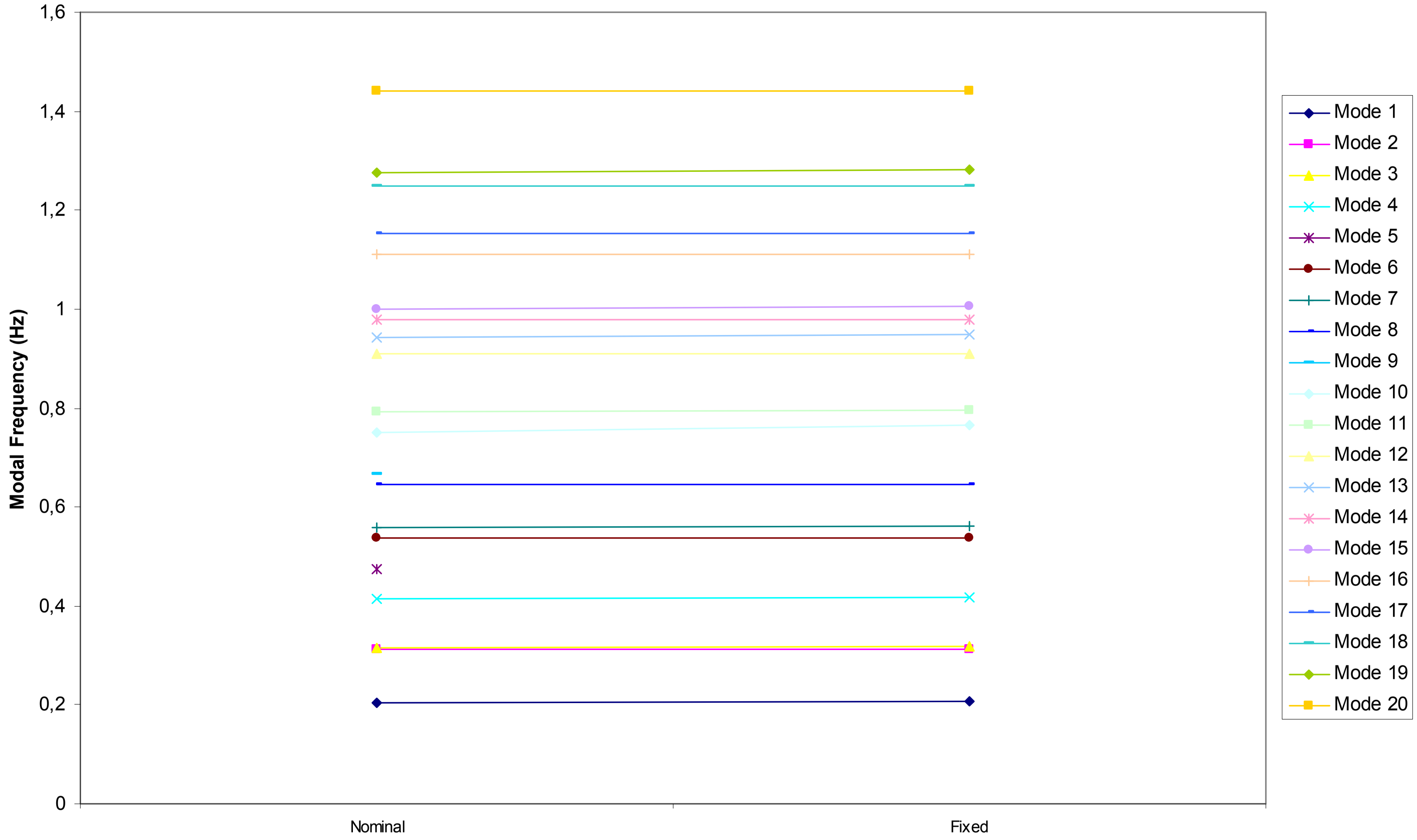


Figure 5.17 Changes in Modal Order for Shear Fixed Case of Bearings at W2,E2

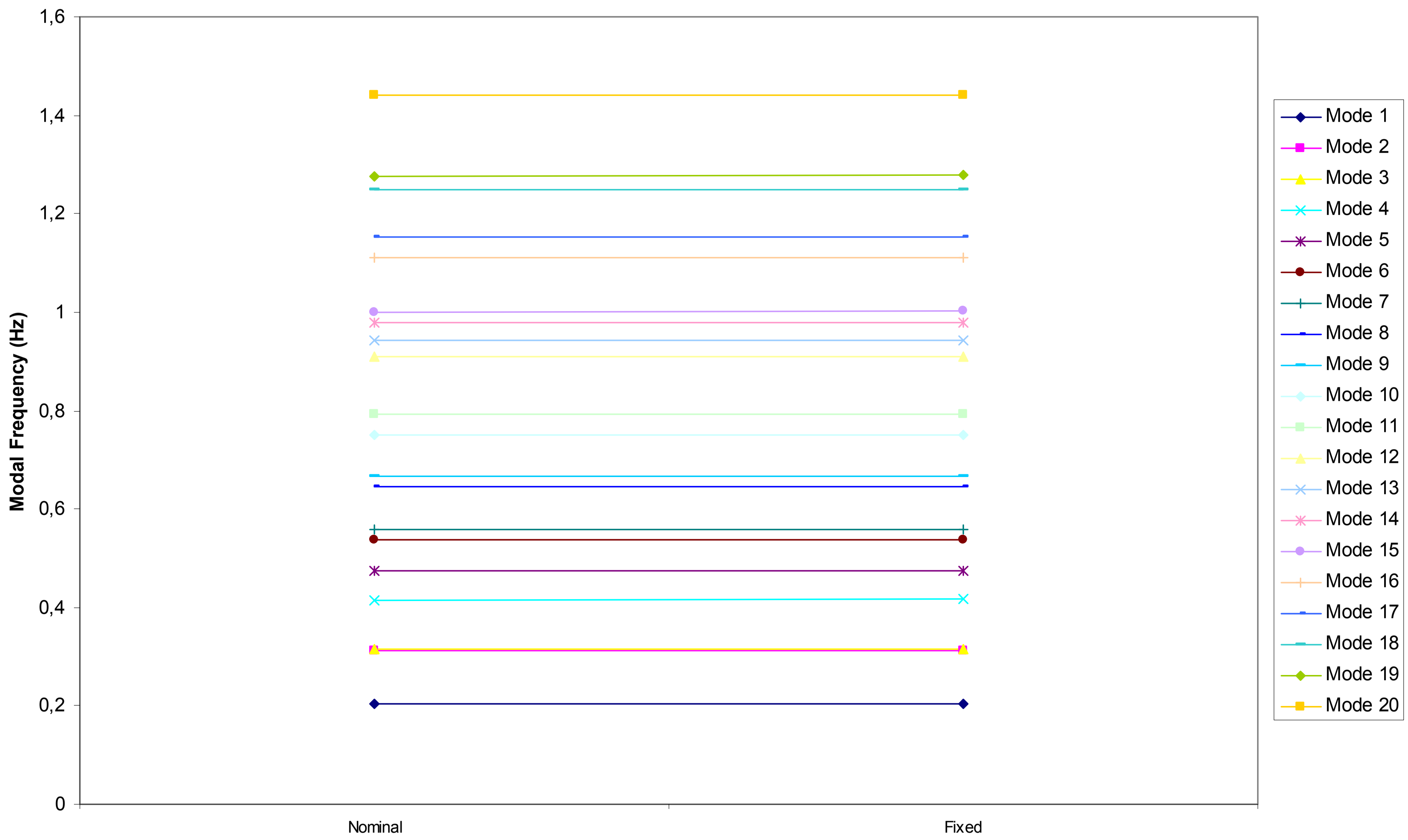


Figure 5.18 Changes in Modal Order for Rotationally Fixed Case of Bearings at W2,E2

5.2.6 Shoes

At a connection between stringers and floor beams, either an expansion or a fixed shoe is present. In expansion shoes both bending moment and shear force are released, whereas in fixed shoes only bending moment is released. Firstly, only shear force releases are removed from expansion bearings, and the following changes are observed in the modal properties of the structure: 5^{th} mode is lost and frequencies of 3^{rd}, 6^{th}, 7^{th}, 11^{th}, 13^{th}, 15^{th}, 19^{th}, 20^{th} modes vary in the range of 1.1% and 4.6%n as it is shown in Table 5.19. When bending moment releases are removed from the model, a significant variation in modal properties is observed such that all the modal frequencies change more than %1 except the missing two modes that are 5^{th} and 15^{th} modes as it is shown in Table 5.20.

Table 5.19 Changes in Modal Properties for Shear Fixed Case of Shoes

Nominal		V2 Fixed Shoes			
Modes	Freq	Modes	Freq	Variation in freq.	MAC
1	0,205	1	0,216	5,43%	0,998
2	0,312	2	0,333	6,76%	1,000
3	0,315	3	0,364	15,81%	0,986
4	0,415	4	0,443	6,52%	1,000
5	0,474		0,527		
6	0,537	6	0,566	5,43%	0,938
7	0,560	7	0,595	6,40%	0,986
8	0,645	8	0,658	2,05%	0,976
9	0,668	9	0,679	1,72%	0,941
10	0,749	10	0,790	5,45%	0,979
11	0,794	11	0,859	8,14%	0,946
12	0,910	12	0,928	1,97%	0,996
13	0,942	13	0,982	4,21%	0,991
14	0,977	14	1,031	5,50%	0,894
15	1,001	16	1,129	1,62%	0,981
16	1,111	17	1,196	3,75%	0,962
17	1,153	19	1,233	-3,45%	0,965
18	1,249	18	1,274	2,07%	0,982
19	1,277	20	1,509	4,65%	0,918
20	1,442		1,518		

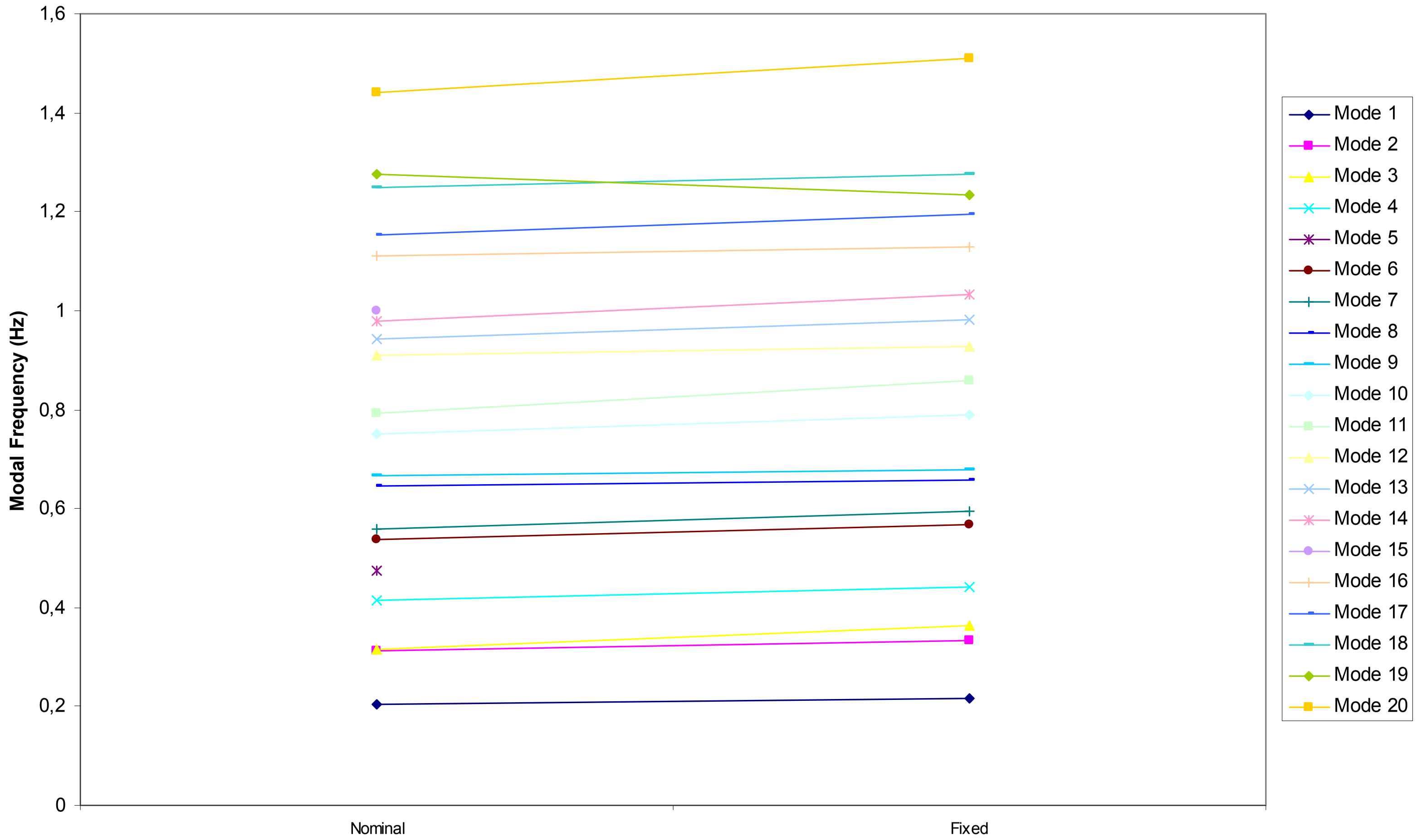


Figure 5.19 Changes in Modal Order for Shear Fixed Case of Shoes

Table 5.20 Changes in Modal Properties for Rotationally Fixed Case of Shoes

Nominal		Rotationally Fixed shoes			
Modes	Freq	Modes	Freq	Variation in freq.	MAC
1	0,205	1	0,207	0,69%	1,000
2	0,312	2	0,315	0,87%	1,000
3	0,315	3	0,320	1,68%	1,000
4	0,415	4	0,419	0,96%	1,000
5	0,474		0,490		
6	0,537	6	0,543	1,09%	0,998
7	0,560	7	0,566	1,22%	1,000
8	0,645	8	0,649	0,59%	0,999
9	0,668	9	0,670	0,31%	0,998
10	0,749	10	0,756	0,87%	0,999
11	0,794	11	0,803	1,08%	0,999
12	0,910	12	0,915	0,48%	1,000
13	0,942	13	0,957	1,63%	0,997
14	0,977	14	0,985	0,77%	0,999
15	1,001	15	1,047	4,58%	0,965
16	1,111	16	1,116	0,49%	1,000
17	1,153	17	1,161	0,66%	0,999
18	1,249	18	1,257	0,66%	1,000
19	1,277	19	1,323	3,60%	0,995
20	1,442	20	1,459	1,19%	0,996

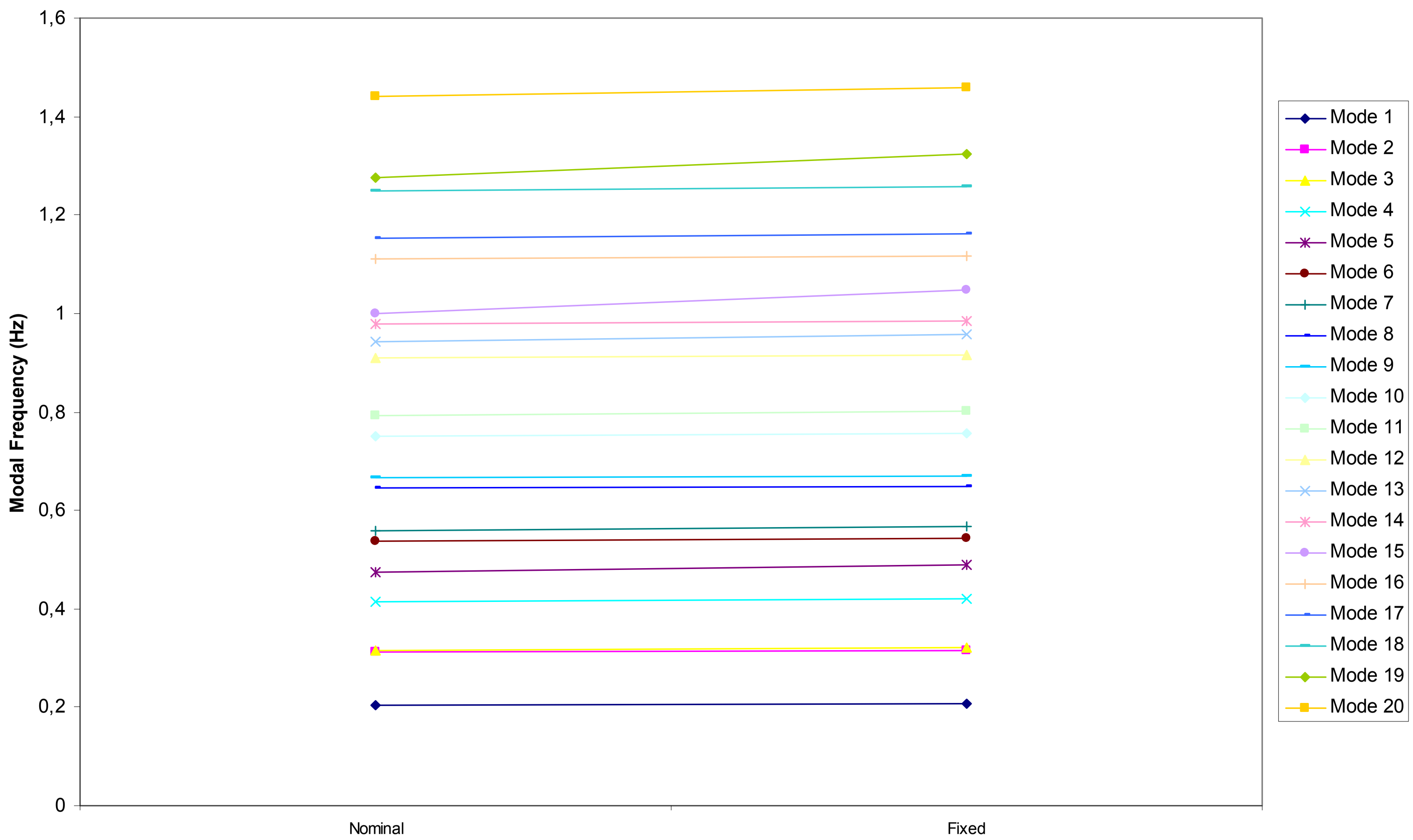


Figure 5.20 Changes in Modal Order for Rotationally Fixed Case of Shoes

5.3 Evaluation of the Results

The analyses show explicitly that the modal properties are very sensitive to a change in elastic modulus of the inner pier concrete, and thus the stiffness of the inner piers. For instance, the variation in the elastic modulus causes the order of some modes to switch. The variation of modal properties with respect to boundary conditions and movement systems indicates that the rotational degrees of freedom have only a slight impact on the modal properties. On the other hand, as far as the translational degrees of freedom are concerned, the variations in the modal properties are very obvious. Similar to the effect of inner pier stiffness, they also result in remarkable changes in modal shapes, frequencies, and modal order. However it is noticed that parameters related with outer piers do not have a significant effect on modal properties. A change in the mass of the deck also leads to a great frequency variations without resulting to any mode switch. The results obtained are summarized in Table 5.21

Table 5.21 Overall Outlook

	STRUCTURAL PARAMETERS																			
	Pier E1,W1					Pier E2,W2					Suspended Span				B.C.s					Deck
Mode	A	E	Ix	Iy	J	A	E	Ix	Iy	J	Cθ	Cδ	HG	WL	Bθ2	Bv2	Bθ1	Sθ	Sv	Mass
1	x	√	√	x	√	x	x	x	x	x	x	√	x	x	x	x	√	√	x	√
2	x	√	x	x	x	x	x	x	x	x	x	√	x	x	x	x	x	√	x	√
3	x	√	√	x	√	x	x	x	x	x	x	-	x	x	x	x	√	√	√	√
4	x	√	x	x	x	x	x	x	x	x	√	√	x	x	x	x	x	v	x	√
5	x	-	-	x	x	x	x	x	x	x	x	-	x	x	x	-	-	-	-	√
6	x	√	x	√	x	x	√	x	√	x	x	x	x	x	x	x	x	√	√	√
7	x	√	x	√	x	x	√	x	√	x	x	-	x	x	x	x	x	√	√	√
8	x	√	x	x	x	x	x	x	x	x	x	√	x	x	x	x	x	√	x	√
9	x	-	-	x	x	x	x	x	x	x	x	-	x	x	x	-	√	√	x	√
10	x	√	√	x	x	x	x	x	x	x	x	√	x	x	x	√	√	√	x	√
11	x	√	x	√	x	x	x	x	x	x	x	-	x	x	x	x	x	√	√	√
12	x	√	x	x	x	x	x	x	x	x	x	√	x	x	x	x	x	√	x	√
13	x	√	√	x	x	x	x	x	x	x	x	√	x	x	x	x	x	√	√	√
14	x	√	x	x	x	x	x	x	x	x	x	-	x	x	x	x	x	√	x	√
15	x	√	√	x	x	x	x	x	x	x	x	-	x	x	x	x	x	-	√	√
16	x	√	x	x	x	x	√	x	√	x	x	x	x	x	x	x	x	√	x	√
17	x	√	x	√	x	x	√	x	√	x	x	√	x	x	x	x	x	√	x	√
18	x	√	x	√	x	x	x	x	x	x	x	√	x	x	x	x	x	√	x	√
19	x	√	√	x	x	x	x	x	x	x	x	√	x	x	x	x	x	√	√	√
20	x	√	x	x	x	x	√	x	√	x	x	x	x	x	x	x	x	√	x	√
Mode Switch	N	Y	Y	N	Y	N	N	N	N	N	N	Y	N	N	N	Y	Y	Y	Y	N

x : frequency variation is less than 1%
√ : frequency variation is more than 1%
N : no
Y: yes
Cθ : Rotational releases on chord members
HG: Releases on hangers
WL : Releases on Wind Linkages
Bθ2 : Rotational releases in bearings at Piers W2, E2
Bv2 : Shear releases in bearings at Piers W2, E2
Bθ1 : Rotational releases in bearings at Piers W1, E1
Sθ : Rotational releases in shoes between deck and stringers
Sv : Shear releases in shoes between deck and stringers

Based on the results of sensitivity analyses, structural parameters can be classified into three significance groups in terms of their influence on dynamic response of the structure.

Elastic modulus of the inner pier, axial fixity of chord members around hangers, shear fixity of shoes between stringers and floor beams and mass of the deck are determined as the most significant properties. They are designated as the first parameter group, whose variations lead to a considerable change in either frequencies or order of modes.

I_x, J of the inner piers, rotational fixity of bearings at inner piers and rotational fixity of shoes between stringers and floor beams are determined as second parameter group due to their secondary level impact on the modal parameters of the bridge. Their variations do not completely change the first ten modes, and level of frequency changes occurs around 1 percent.

Remaining parameters cause only trivial change in the first ten modes, and hence are recognized as the third parameter group. They will be disregarded during calibration studies. In other words they will not be included as output variables in neural network models.

5.4 Static Sensitivity Analysis

As to be discussed in the following chapter, the movement systems of the bridge are modeled and represented with partial fixity springs during calibration studies to account for cases between the two extreme conditions, that is fully released and fully restrained static sensitivity analyses are conducted to determine the sensitive ranges of the springs defined for rotational fixity of shoes between stringers and floor beams, shear fixity of shoes between stringers and floor beams, axial fixity of chord members around hangers and bearings at inner piers.

Upper limits of partial fixity spring constants are set such that when the force or moment on a considered member reaches 99% of the force or moment of the fully restrained case, then that spring constant value is assigned as the upper limit of partial fixity. Lower limit is identified such that when the force or moment on considered member reduces to 1% of the force or moment of the fully fixed case, then that spring constant value is assigned as lower limit of partial fixity. The sensitive ranges of each parameter represented by partial fixity springs are shown in the Table 5.22 and Figures 5.21 to 5.24.

Table 5.22 Sensitive Ranges of Spring Parameters

Parameters	k_1	k_2	k_3	k_4
Units	kip/in	kip-in/rad	kip/in	kip-in/rad
Lower Limit	10^1	10^6	10^3	10^6
Upper Limit	10^5	10^{10}	10^6	10^8

Where k_1 represents axial fixity of chord members around hangers, k_2 represents bearings (rotational fixity) at interior piers, k_3 represents shear fixity of shoes between stringers and floor beams and k_4 represents Rotational fixity of shoes between stringers and floor beams.

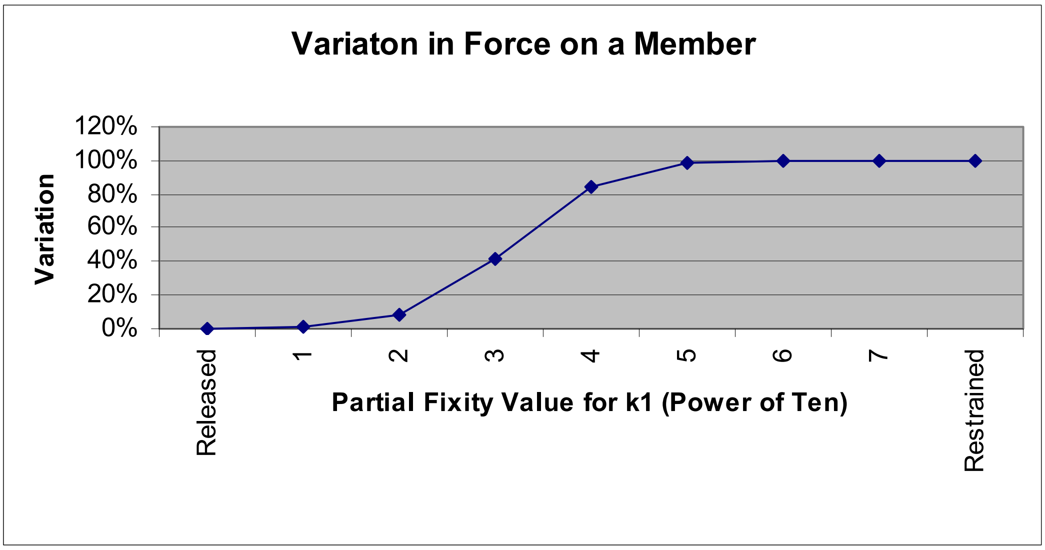


Figure 5.21 Sensitive Range for k_1 Parameter

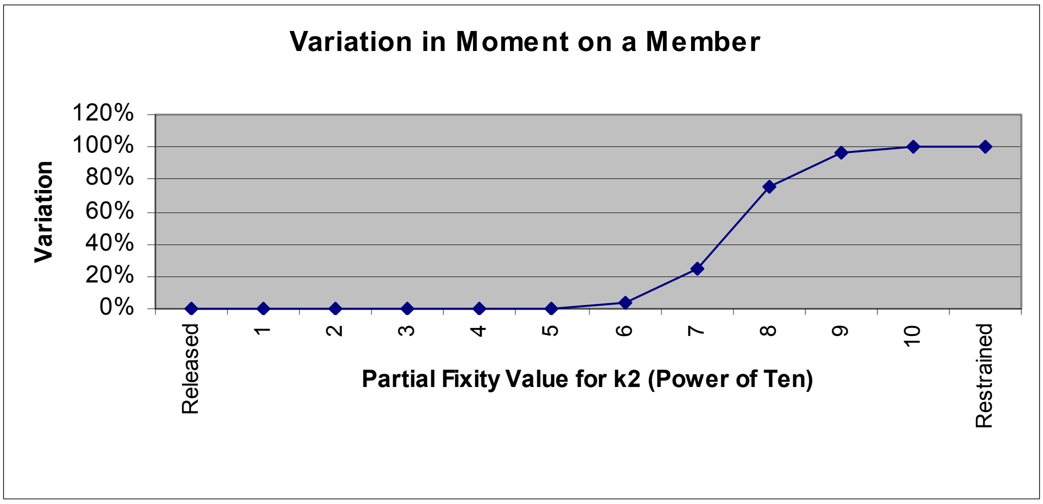


Figure 5.22 Sensitive Range for k_2 Parameter

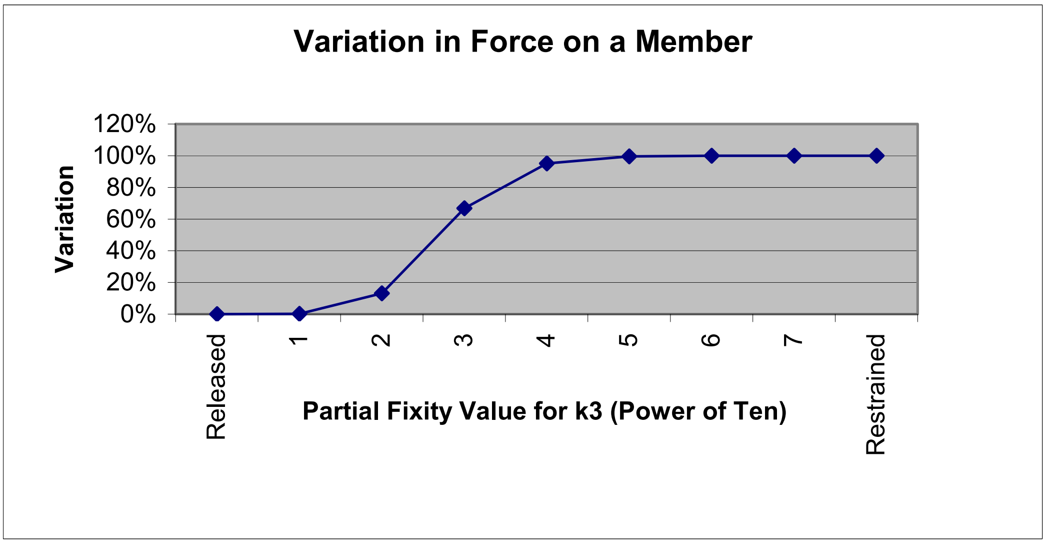


Figure 5.23 Sensitive Range for k_3 Parameter

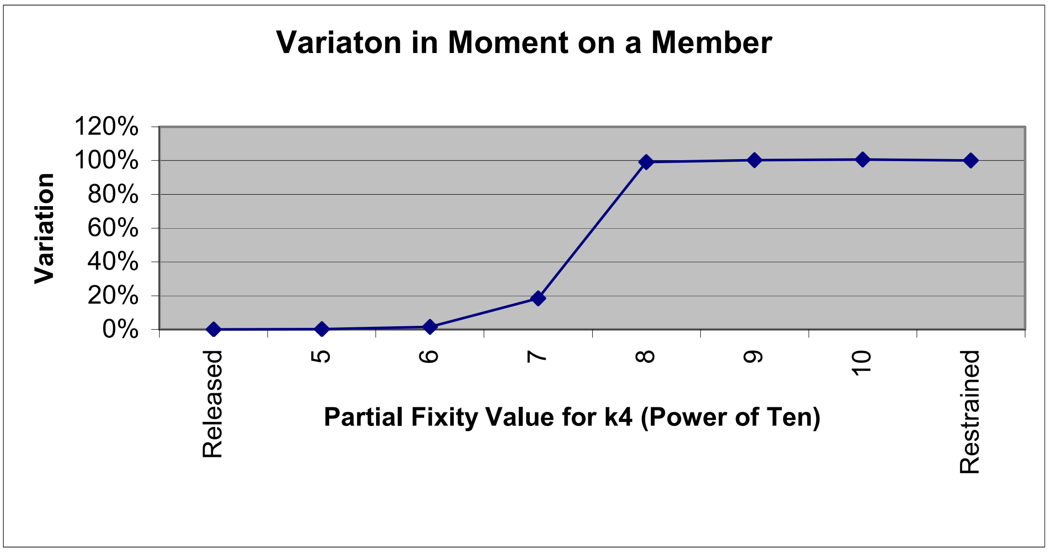


Figure 5.24 Sensitive Range for k_4 Parameter

CHAPTER 6

CALIBRATION STUDY USING ANN

6.1 General

The major objective of this study is to determine the inverse relationship between structural parameters and dynamic properties of CBB using ANNs and to calibrate the FE model of CBB via a trained ANN. Since the bridge is a large and quite complicated structure, this study is a challenging task. Particularly, there are many issues concerning with the composition of network parameters in order to achieve the best performance of the network. In this chapter, some topics will be discussed in order to get the best performance from neural network, and calibration study will be carried out using neural network.

6.2 Calibration

The essence of calibration lies in the phenomena of comparing and correlating the structural response of the analytical model with experimental results. The discrepancies observed between the analytical model and experimental measurements may be due to a number of geometrical and structural parameters, as well as behavioral parameters, that differ between the model and the structure. The calibration process aims at identifying these parameters and updating them in the analytical model to improve its performance in simulating the actual behavior of the existing structure as closely as possible.

Structural identification requires the formulation of mathematical model representing the dynamics of a structure. Formulation of these mathematical expressions is somewhat difficult since civil engineering structures have uncertain nature and complex behavior. Furthermore, environment loadings and the uncertainties caused by the structural model errors are other elements which contribute to the complexity and difficulty of the problem. Nevertheless, it is possible to overcome these shortcomings using ANNs which have the capability of learning with noisy data and have ability to approximate functions.

In the following, calibration of finite element model of CBB will be studied via a successfully trained ANN. Firstly, neural network will be trained to learn the inverse relationship between structural parameters and dynamic properties of CBB. This learning procedure requires a number of known structural parameters which constitute output patterns and corresponding models' modal frequencies which constitute the input patterns. Specification of these input and output patterns will be discussed next.

6.3 Selecting Outputs

In parametric studies (Section 5.3), three parameter groups have been identified depending on the level of their significance for dynamic properties of the bridge. Structural parameters in the first and second groups will be used for training of neural network since they have a considerable impact on the dynamic response of the structure. These parameters are listed below for convenience.

- Moment of inertia about x axis (I_x) value of the interior piers
- Torsion constant (J) value of the interior piers
- Modulus of elasticity (E) value of the interior piers
- Axial fixity of chord members around hangers (k_1)
- Rotational fixity of bearings at interior piers (k_2)
- Shear fixity of shoes between stringers and floor beams (k_3)
- Rotational fixity of shoes between stringers and floor beams (k_4)
- Mass of the deck (m)

The above parameters constitute the output variables of the neural network. For the sake of simplicity, modification factors are used as outputs for I_x, J and mass parameters.

Elimination of some parameters is also important since reducing number of output variables provides selecting fewer input variables; consequently hidden neuron requirement is reduced. In other words, network architecture will be less complicated, and therefore required number of training data will be reduced. A network with fewer unknowns (i.e. weights) and with fewer equations (i.e. training data) will be trained faster.

A total of 1400 different FE models of the bridge are generated in SAP2000 by assigning random values to selected structural parameters within their previously specified ranges. Modal analysis of all models are performed again with SAP2000 and the first twenty modes are identified for each model with the mode shapes and corresponding frequencies. This way a “model pool” is constituted. Selecting the input pairs and forming the training data are implemented after investigating the model pool.

6.4 Selecting Inputs

Since ANN is expected to learn the inverse relationship between modal frequencies and structural parameters, modal frequencies are selected as inputs to neural network. As mentioned above, the model pool consists of the first twenty modes of 1400 different FE models of the bridge generated with different values of selected parameters. It should be noted that the change of structural parameters in these models lead to switch of some modes or to loss of some others. Accordingly, some modes obtained experimentally may not appear in the same rank, or may completely disappear in a particular FE model of the bridge. As far as mode switch is concerned, the problem is not at much significance since a MAC analysis can be held to match the analytical and experimental modes. On the other hand, the loss of mode poses a significant problem for training neural network such that when a mode is lost, it is impossible to represent its absence numerically as an input to neural network.

Therefore modes, which exist in most of the models out of 1400, are filtered out and specified as inputs of neural network whereas modes which tend to lose in most of the models are ignored as it is shown in Figure 6.1.

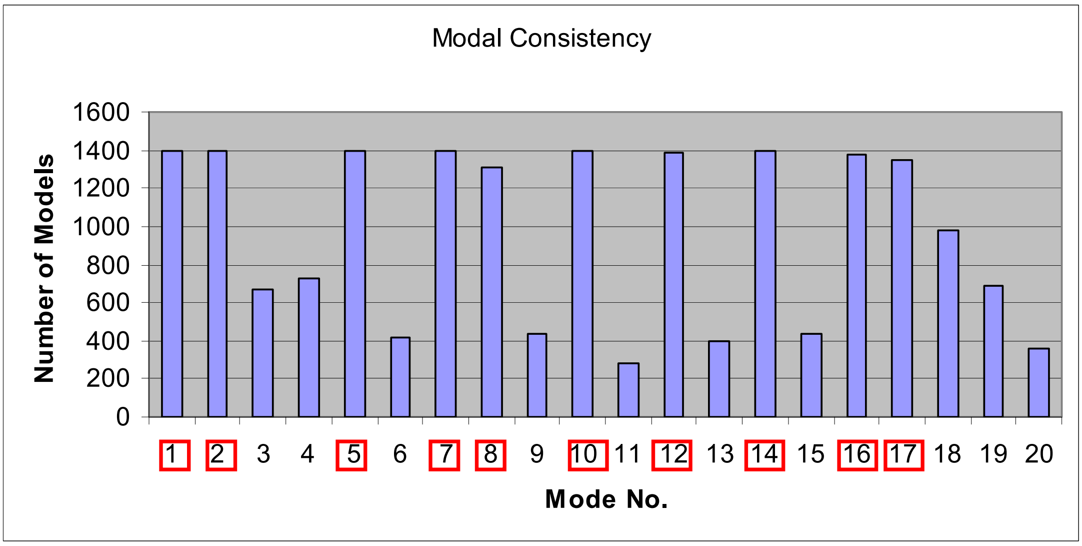


Figure 6.1 Modal Consistency of 1400 Models with respect to Experimental Modes

The modes, 1^{st}, 2^{nd}, 5^{th}, 7^{th}, 8^{th}, 10^{th}, 12^{th}, 14^{th}, 16^{th}, 17^{th} (marked in Figure 6.1) appear in more than 1300 FE models of the bridge. They are considered as the consistent modes, and therefore are assigned as inputs to neural network.

Since neural network is expected to make a function approximation, number of inputs must be more than or at least equal to number of outputs. Since there are eight outputs, input variables must be more than that. Besides, network will become more complex if number of input nodes is increased. More complex network takes much more time for convergence and requires more training data as well. Therefore, by selecting ten inputs, network complexity is minimized as much as possible; while satisfying the network constraint that the number of input variables must be more than number of output variables.

6.5 Training Data

Initially, the model pool consists of 1400 FE models of CBB. When selecting inputs, consistent modes are searched. Notice that the consistent modes exist in most of the models, not in all of the models. Therefore the FE models which contain all the consistent modes (i.e. inputs to network) have been filtered out and specified as data for neural network. Out of 1400 models in all, 1200 of them include the consistent modes and consequently those models constitute network data. 65%, 15% and 20% of 1200 data are reserved for training, cross validation and testing, respectively.

According to Carpenter and Hoffman [88] , it is suggested that the minimum number (*NT*) of training data pairs based on the network architecture should be between

$$NT=H*I + O*H \tag{7.1}$$

and

$$NT=H(I+ 1) + O(H+ 1) \tag{7.2}$$

where I is the number of input nodes, H is the number of hidden layer nodes, and O is the number of output nodes. Considering that the network is likely to have one hidden layer with 15 neurons Eq.(7.2) yields NT = 325. It is clear that % 65 of 1200 extremely exceeds this required limit. Another criteria for determination of the minimum required training data depending on the network architecture is suggested by Zang and Imregun [3] as;

$$NT = 1+ H\,(I+O+1)\,/\,O \tag{7.3}$$

Eq.(7.3) yields S=37 based on the previous assumption that 15 hidden neuron will be used. This minimum limit is also exceeded with 65% of 1200 data. List of the training data can be found in Appendix B.

6.6 Network Parameters and Architecture

Since inverse relation between modal frequencies and structural parameters can be defined as a function approximation problem, multi layer perceptron type of network is selected due to its suitability for this type of problems [33]. A software called Neurosolutions (version 5.06) [89] is utilized for this study as neural network tool. Out of many error minimization algorithms available in Neurosolutions software, Levenberg-Marquardt algorithm is selected as error minimization algorithm owing to its superiority over others. One single hidden layer is preferred since provided that a sufficient number of neurons is used a single hidden layer is adequate [33, 46]. Architecture of the network is shown in Figure 6.2.

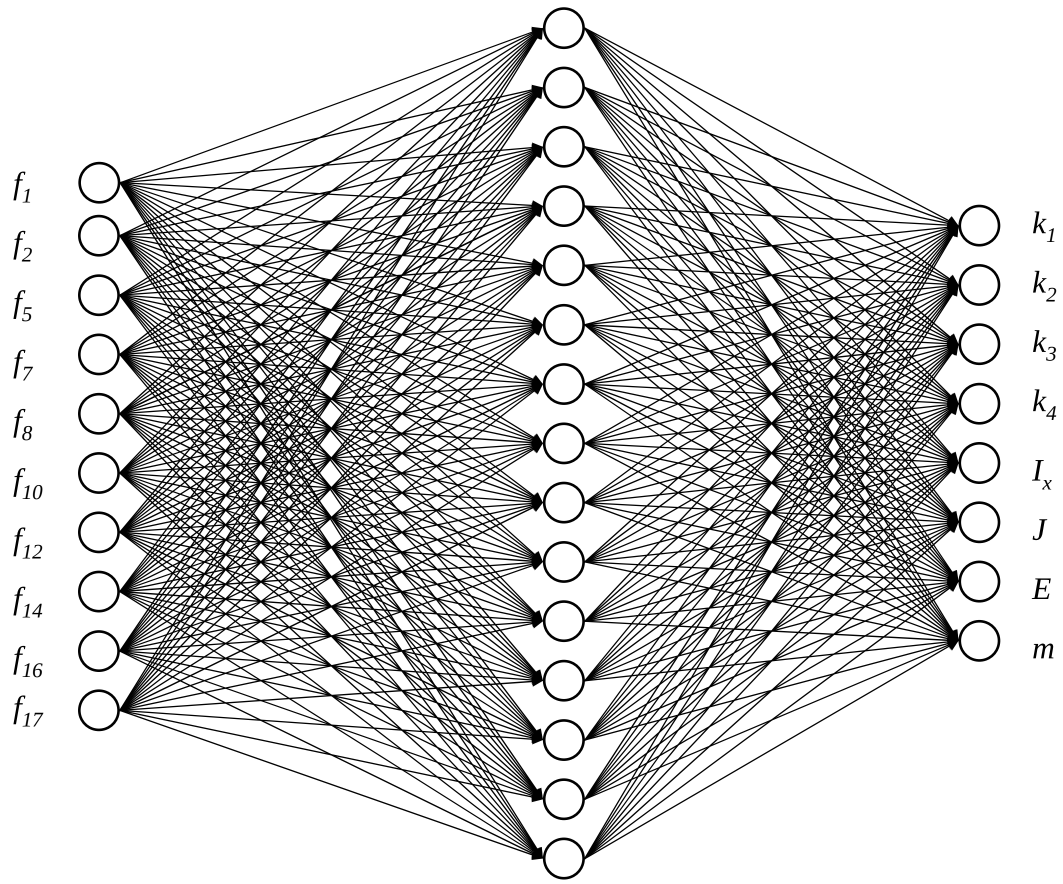


Figure 6.2 Network Architecture for Inverse Relation

Sigmoid transfer function is assigned to both hidden and output neurons. The normalization range of both input and output neurons is narrowed to 0.2-0.8 from 0.05-0.95 default normalization range of Neurosolutions. If normalized values are too close to either zero or one, it causes numerical difficulties and results in slow learning [6, 33, 37]. Since narrower normalization range improves the network performance, input and output pairs are normalized within the range between 0.2 and 0.8. It is also suggested that weights should be initialized with small random weights. By default settings of Neurosolutions weights are initialized between -0.5 and 0.5 which also overlaps with the recommendations [10, 56]. Maximum epoch number is limited to 1000.

Number of hidden neurons to use in NN is another issue to resolve. There are different rules and heuristics established for determining the required quantity. According to one of them the upper limit of hidden neuron number is calculated as follows [33] :

$$H = 2 * I + 1 \tag{7.4}$$

According to another one for required hidden neuron number is calculated as [37] :

$$H = \frac{I + O}{2} + I \tag{7.5}$$

Kermanshahi [89] suggests the use of Eq. (7.6) for this purpose.

$$H = \frac{I + O}{2} + \alpha \tag{7.6}$$

where α can be selected as 1 or 2 and H, I, O represent the number of hidden, input and output neurons respectively. These equations yield the number of required hidden neurons as 21, 19 and 10, respectively.

The best way to determine the number of neurons used in the hidden layer is by trial and error [33]. However the limits of hidden neuron numbers might be imposed in the line with above mentioned heuristics. To achieve this, performances of networks with numbers of hidden neurons changing from 10 to 21 are compared (Figure 6.3). Each network is executed 2 times.

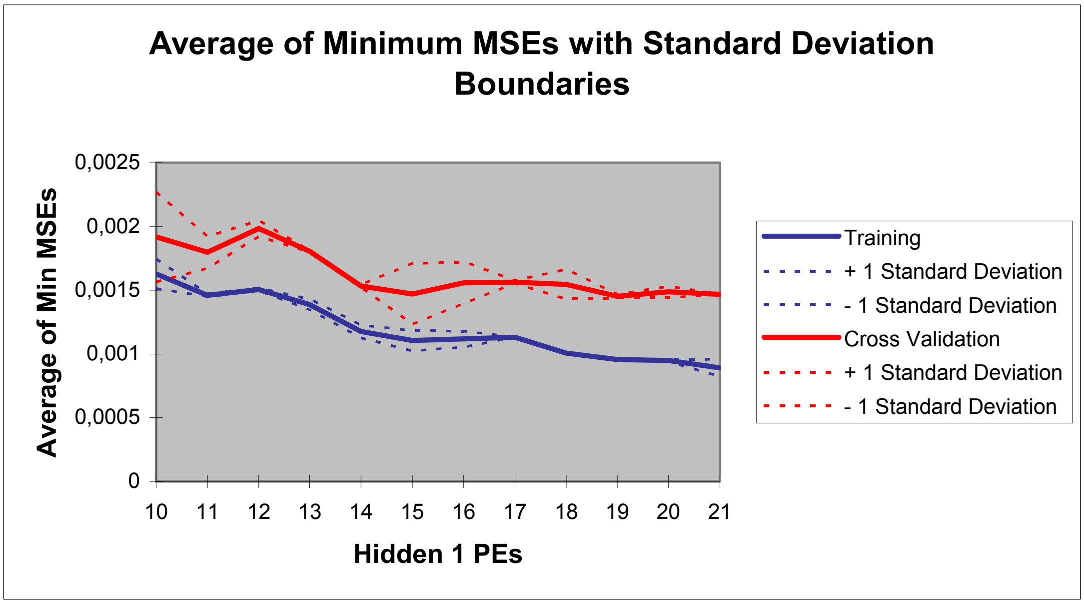


Figure 6.3 Average of Minimum MSEs with for Networks with Various Hidden Neurons

Table 6.1 Performance of the Best Network

Best Networks	*Training*	*Cross Validation*
Run #	2	2
Epoch #	998	546
Minimum MSE	0,00117358	0,001380672
Final MSE	0,00117369	0,001470557

Figure 6.1 shows that the minimum mean squared error (MSE) is acquired using 15 hidden neurons when cross validation performance is considered. However considering the training performance, the network which yields the minimum error contains 21 hidden neurons. Surely it is expected that increasing number of hidden neurons improves training performance, whereas, at a specific number of neurons cross validation performance starts being deteriorated. This phenomenon is called overfitting. In other words, neural network loses its generalization ability for unseen data. Table 6.1 shows the performance of the best network (i.e. network with 15 hidden neurons). Minimum mean squared error (MSE) is reached in the second run

and at the 998th epoch for training data, whereas considering the cross-validation performance, minimum MSE is acquired at 546th epoch as 0.00138.

Since we are searching for the best network to generalize the input-output relationship for unseen data, selection of the number of hidden neurons must be based on the cross validation error which is also estimation of network's performance for unseen data. Consequently, optimum number of hidden neuron is determined as 15.

6.6.1 Comparison of Error Minimization Algorithms

Among many error minimization algorithms, Levenberg-Marquardt (L-M) is the most prolific one owing to its faster convergence and lesser level of error [91, 92]. It must be noted that in most of the papers published after 2002, L-M algorithm has been selected concerning with the applications of neural networks in structural engineering. In the study, error minimization algorithms available in Neurosolutions are compared. Apart from L-M algorithm, gradient descent, Quickprop, Delta-bar-Delta and Conjugate Gradient algorithms are also available. For the sake of completeness, performances of these error minimization algorithms are obtained (Figures 6.4 to 6.8) and compared as it is shown in Table 6.2.

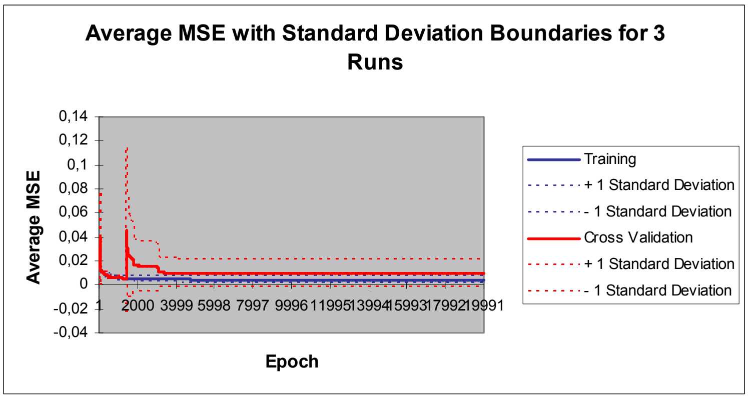


Figure 6.4 Training Performance of CG

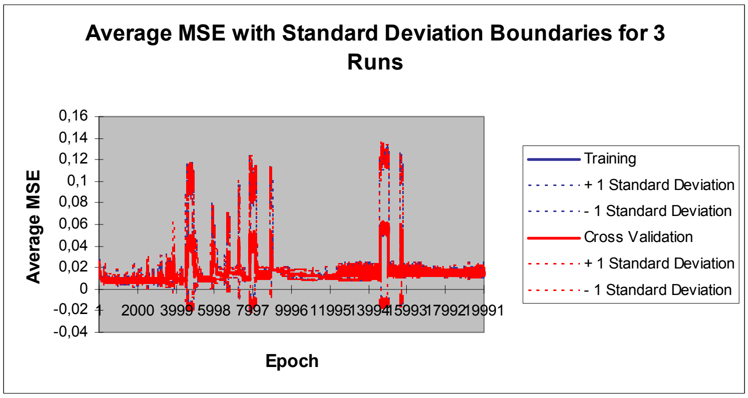


Figure 6.5 Training Performance of D-B-D

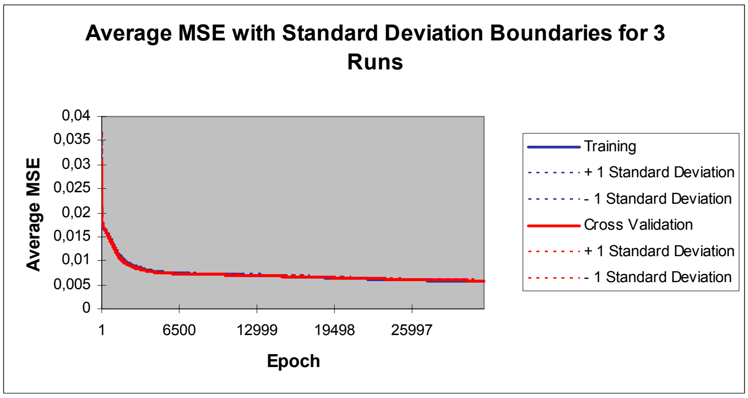


Figure 6.6 Training Performance of Quickprop

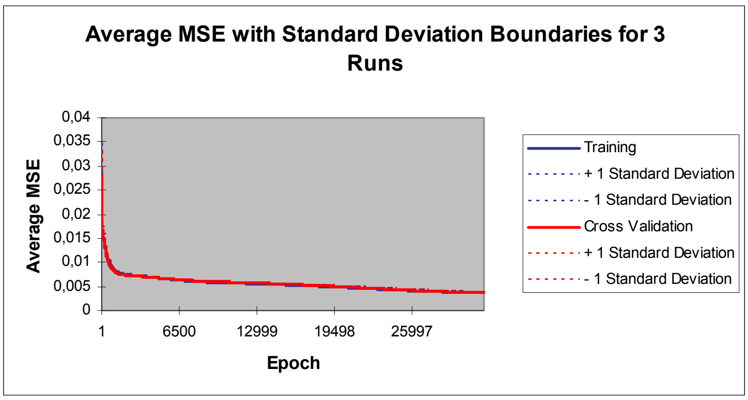


Figure 6.7 Training Performance of Momentum

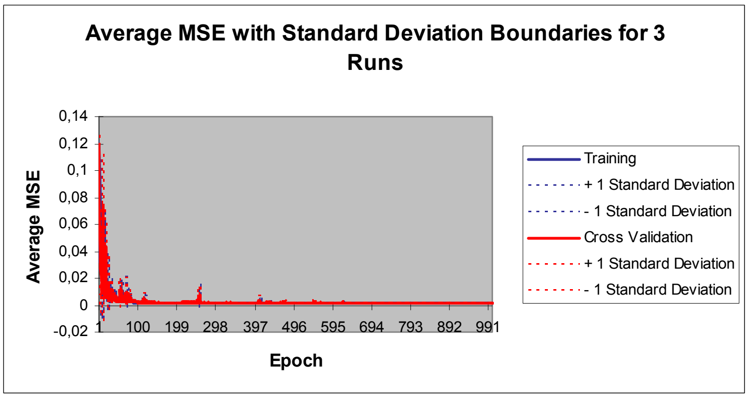


Figure 6.8 Training Performance of Levenberg-Marquardt

Table 6.2 Performances of Various Error Minimization Algorithms in Tabular Form

	C-G		DBD		Quickprop		Momentum		L-M	
Best Networks	*Training*	*Cross*	*Training*	*Cross*	*Training*	*Cross*	*Training*	*Cross*	*Training*	*Cross*
Run #	2	2	3	3	3	1	1	1	2	2
Epoch #	20000	19345	1214	1924	65000	65000	65000	65000	1000	671
Minimum MSE	0,0022	0,0024	0,0049	0,0050	0,0046	0,0047	0,0030	0,0029	0,0011	0,0014
Final MSE	0,0022	0,0024	0,0135	0,0137	0,0046	0,0047	0,0030	0,0029	0,0011	0,0014

According to training and cross validation performances which are shown in Table 6.2, it is obvious that L-M algorithm outperforms the others since it reaches the lowest MSE much earlier with a lesser level of error. To compare, considering the cross validation performances; 0.47% and 0.29% MSEs at 65000th epoch are obtained for Quickprop and Momentum respectively, i.e. they need further iterations. Delta Bar Delta (DBD) reaches 0.49% MSE at 1926th epoch, C-G 0.24% MSE at 19345th epoch, and L-M 0.13% MSE at 733rd epoch.

6.7 Testing

After several trainings, network which provides the best performance is selected. In order to measure the selected network's post training performance, testing phase is implemented. Network is provided with both known input and output pairs, and comparison takes place between network's output and actual output. As mentioned above, 20% of data is reserved for testing, which yields 244 out of 1200. In this study, correlation coefficient (r) is utilized for measuring how well network learns the relationship for unseen data. Correlation coefficient is defined as:

$$r = \frac{\dfrac{\sum_i (x_i - \bar{x})(d_i - \bar{d})}{N}}{\sqrt{\dfrac{\sum_i (d_i - \bar{d})^2}{N}}\sqrt{\dfrac{\sum_i (x_i - \bar{x})^2}{N}}} \tag{7.7}$$

where x and d represent network's output and desired output respectively.

Table 6.3 Testing Performance

Performance	k1	k2	k3	k4	Ix (mod)	J (mod)	E	m (mod)
MSE	0,0985	0,1012	0,1674	0,2324	0,0465	0,0240	69618	0,0001
NMSE	0,0401	0,0959	0,0417	0,1456	0,2492	0,1339	0,0315	0,0054
MAE	0,2517	0,2541	0,3103	0,3886	0,1492	0,1157	201	0,0068
r	0,9805	0,9509	0,9796	0,9266	0,8718	0,9333	0,9842	0,9974

It is clear that network has acquired the generalization ability for unseen data. Correlation coefficients are very close to 1 which means that network responds well for all the parameters. Comparison of desired and calculated outputs for each parameter can be found in Appendix C.

6.8 Simulated Case

After several trainings, network which provides the best performance is selected. Network is fed up with the experimental modal frequencies to give the desired outputs. Since output pattern of network consists of structural parameters, response of network will be the actual properties of the bridge. Then, structural properties are fed up into FE model for the calculation of modal parameters. In the following, MAC matrix is formed in order to determine the modal assurance between experimental mode shapes and mode shapes of updated FE model. All the modes are perfectly overlaps since orthogonal members of the MAC matrix have a value of more than 0.9 as it is shown in Table 6.4.

Besides, for the first twenty modes, discrepancies between experimental modal frequencies and updated model's frequencies are less than 5% as it is shown in Table 6.5. The highest discrepancy is calculated for 6th mode with a value of 3.03%. For the 3rd and 4th modes, inconsistencies are more than 2%; for 1st, 5th, 11th, 16th and 20th modes, discrepancies are more than 1% and for remaining modes less than 1%. discrepancies are obtained. Based on this comparison, it can be concluded that experimental modal properties and modal properties of updated model completely coincide.

Table 6.4 MAC Matrix of Updated Model's Modes with respect to Experimental Modes

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1,000	0,000	0,327	0,048	0,000	0,146	0,127	0,000	0,011	0,024	0,001	0,000	0,005	0,058	0,023	0,032	0,000	0,010	0,000	0,001
2	0,000	1,000	0,000	0,000	0,550	0,000	0,000	0,039	0,000	0,000	0,005	0,286	0,000	0,000	0,000	0,000	0,004	0,000	0,000	0,003
3	0,297	0,000	0,998	0,337	0,000	0,007	0,016	0,000	0,180	0,000	0,004	0,000	0,007	0,204	0,120	0,039	0,000	0,001	0,208	0,003
4	0,029	0,000	0,350	0,979	0,000	0,327	0,031	0,000	0,003	0,036	0,001	0,000	0,023	0,390	0,026	0,032	0,000	0,015	0,005	0,001
5	0,000	0,539	0,000	0,000	0,999	0,000	0,000	0,183	0,000	0,000	0,016	0,070	0,000	0,000	0,000	0,000	0,111	0,002	0,000	0,030
6	0,164	0,000	0,025	0,210	0,000	0,995	0,086	0,000	0,259	0,000	0,000	0,000	0,301	0,057	0,008	0,155	0,000	0,034	0,069	0,000
7	0,136	0,000	0,001	0,181	0,000	0,033	0,986	0,000	0,000	0,273	0,000	0,000	0,066	0,067	0,011	0,272	0,000	0,174	0,039	0,000
8	0,000	0,043	0,000	0,000	0,177	0,000	0,000	1,000	0,000	0,000	0,339	0,423	0,000	0,000	0,000	0,000	0,024	0,001	0,000	0,002
9	0,007	0,000	0,197	0,003	0,000	0,270	0,000	0,000	0,997	0,342	0,001	0,000	0,060	0,015	0,000	0,314	0,000	0,125	0,038	0,001
10	0,024	0,000	0,000	0,072	0,000	0,004	0,260	0,000	0,370	1,000	0,000	0,000	0,181	0,009	0,210	0,000	0,000	0,008	0,083	0,000
11	0,001	0,008	0,004	0,001	0,088	0,000	0,000	0,316	0,001	0,000	0,961	0,114	0,001	0,000	0,002	0,000	0,117	0,017	0,002	0,081
12	0,000	0,294	0,000	0,000	0,079	0,000	0,000	0,418	0,000	0,000	0,258	0,999	0,000	0,000	0,000	0,000	0,185	0,000	0,000	0,233
13	0,015	0,000	0,000	0,041	0,000	0,244	0,047	0,000	0,010	0,174	0,001	0,000	0,965	0,334	0,084	0,230	0,000	0,013	0,393	0,001
14	0,057	0,000	0,235	0,405	0,000	0,049	0,040	0,000	0,031	0,016	0,000	0,000	0,123	0,991	0,186	0,000	0,000	0,177	0,001	0,000
15	0,027	0,000	0,121	0,021	0,000	0,004	0,018	0,000	0,000	0,196	0,002	0,000	0,146	0,127	0,999	0,034	0,000	0,127	0,328	0,002
16	0,035	0,000	0,055	0,078	0,000	0,124	0,268	0,000	0,292	0,003	0,000	0,000	0,294	0,000	0,022	0,995	0,000	0,124	0,118	0,000
17	0,000	0,005	0,001	0,000	0,101	0,000	0,000	0,018	0,000	0,000	0,181	0,182	0,000	0,000	0,000	0,000	1,000	0,002	0,000	0,374
18	0,008	0,000	0,000	0,036	0,002	0,036	0,173	0,000	0,158	0,005	0,015	0,001	0,077	0,118	0,099	0,180	0,002	0,992	0,010	0,011
19	0,001	0,000	0,213	0,003	0,000	0,049	0,046	0,000	0,019	0,095	0,002	0,000	0,399	0,002	0,399	0,078	0,000	0,012	0,993	0,001
20	0,001	0,002	0,004	0,001	0,040	0,000	0,000	0,004	0,001	0,000	0,055	0,231	0,001	0,000	0,002	0,000	0,328	0,013	0,001	0,995

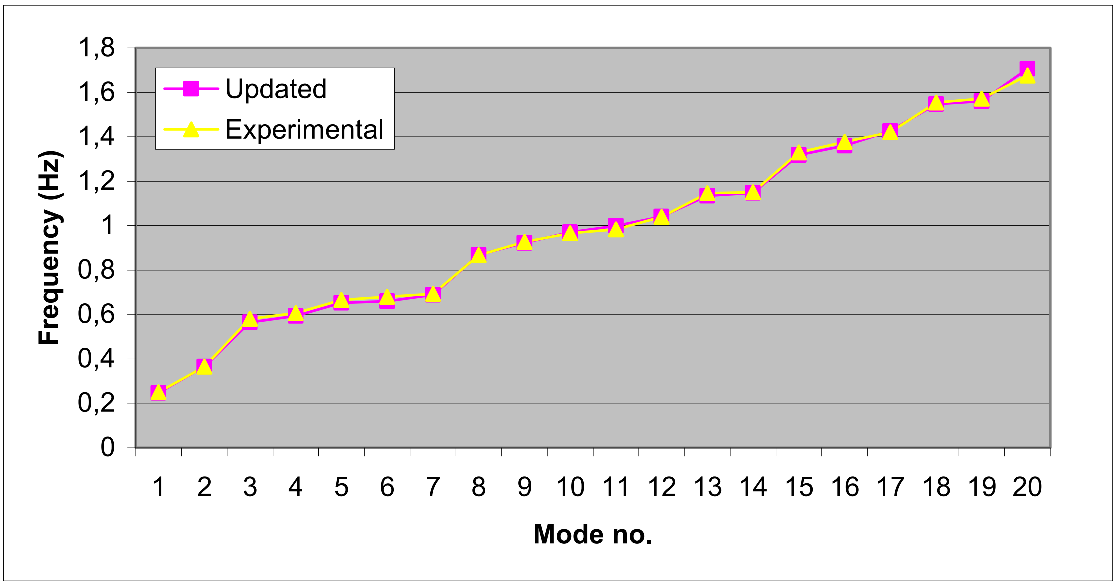


Figure 6.9 Comparison of Frequencies for the First 20 Modes

Table 6.5 Discrepancies in Frequencies

Mode no.	Frequencies (Cyc/sec)		Relative error
	Updated	Experimental	
1	0,247	0,250	1,41%
2	0,366	0,365	0,15%
3	0,564	0,580	2,67%
4	0,593	0,606	2,17%
5	0,653	0,666	1,98%
6	0,660	0,680	3,03%
7	0,688	0,693	0,80%
8	0,869	0,868	0,12%
9	0,923	0,927	0,43%
10	0,970	0,966	0,39%
11	0,999	0,983	1,58%
12	1,041	1,039	0,22%
13	1,135	1,146	0,94%
14	1,148	1,151	0,23%
15	1,318	1,329	0,81%
16	1,360	1,377	1,23%
17	1,427	1,421	0,41%
18	1,547	1,555	0,46%
19	1,561	1,572	0,67%
20	1,706	1,676	1,75%

6.9 Model Updating

Table 6.6 Updated Structural Parameters

Parameter	k_1	k_2	k_3	K_4	I_x (mod)	J (mod)	E	M (mod)
Units	kip/in	kip-in/rad	kip/in	kip-in/rad	-	-	ksi	-
Nominal Value	0	0	0	0	1	1	3600	1
Updated Value	28614	8,54E+08	325822	4,91E+08	2,352	0,092	5649	0,978

Since it is confirmed that modal properties of updated model successfully coincides with experimental ones, then updated parameters can be examined.

According to outputs of the network, at inner piers elastic modulus is increased to 5650 ksi from 3600 ksi whereas torsional rigidity is reduced by more than 90%. The results also show that in the actual condition of the bridge the bending rigidity of piers about x axis is 2.35 times as stiff as its simulation by nominal FE model. Since it is practically meaningless to update I_x rigidity of inner piers by 235%, this implies that deformed length of inner piers for bending about x axis should be reduced. This significant increment may be due to also another effect such that, the effects of the approach spans at both ends of the cantilever truss may lead to increase in the bending stiffness of the outer piers. Movement mechanisms of the anchor bearings and the rigidity of the outer piers are not selected as variables for the neural network. Even if these parameters are not determined as sensitive, variations in the conditions of these parameters can somehow be represented by updating of the rigidity of the inner piers. Furthermore, reinforcements of the piers are not modeled. Consideration of the reinforcement stiffness in the piers may also leads to increment in the stiffness of the piers.

Another significant observation is associated with spring constants used to simulate the partial fixity behavior in the movement systems of the bridge. The results show that all spring constants k_1, k_2, k_3 and k_4 are just below the upper limit of their sensitive ranges, indicating that the movement systems are almost frozen.

The mass of the deck does not much change. It only differs by 2.2% with respect to the nominal model.

Significant reduction in the torsion rigidity of the inner piers is further examined. Torsion constant of the inner piers is modified in the updated model, then variation in the modal properties with respect to updated model is observed as it is shown in Table 6.7. When nominal value of the torsion constant is assigned to the inner piers, there is no considerable change in the modal properties. This observation is also valid for modifying J by 200% of its nominal value. Based on the results, torsion constants of the inner piers are no longer sensitive, therefore it is in vain to try to make a comment about J parameter.

Table 6.7 Variation in Frequencies for modification in J

Mode no.	J*0.09 Frequency Cyc/sec	J*1 Frequency Cyc/sec	J*1 Variation	J*2 Frequency Cyc/sec	J*2 Variation
1	0,247	0,252	2,0%	0,253	2,7%
2	0,366	0,366	0,0%	0,366	0,0%
3	0,564	0,573	1,5%	0,576	2,0%
4	0,593	0,596	0,4%	0,597	0,6%
5	0,653	0,653	0,0%	0,653	0,0%
6	0,660	0,660	0,0%	0,660	0,0%
7	0,688	0,688	0,1%	0,689	0,1%
8	0,869	0,869	0,0%	0,869	0,0%
9	0,923	0,924	0,1%	0,925	0,2%
10	0,970	0,970	0,0%	0,970	0,0%
11	0,999	0,999	0,1%	0,999	0,1%
12	1,041	1,041	0,0%	1,041	0,0%
13	1,135	1,135	0,0%	1,135	0,0%
14	1,148	1,148	0,0%	1,149	0,1%
15	1,318	1,321	0,2%	1,322	0,3%
16	1,360	1,360	0,0%	1,360	0,0%
17	1,427	1,427	0,0%	1,427	0,0%
18	1,547	1,548	0,1%	1,548	0,1%
19	1,561	1,561	0,0%	1,561	0,0%
20	1,706	1,706	0,0%	1,706	0,0%

It can be roughly concluded that the global stiffness of the bridge is increased in calibrated model. The updated FE model can be used in future simulations, since it represents as-is condition of the structure.

CHAPTER 7

CONCLUSION

Neural networks are artificial intelligence tools which have the learning and generalization ability from examples and experience to bring out solutions to problems. Neural networks have become popular tools for various civil engineering problems due to their outstanding features. In structural engineering discipline, artificial neural networks have been utilized in the field of structural optimization, model updating, damage detection, structural analysis and strength prediction.

The essence of calibration lies in the phenomena of comparing and correlating the structural response of an analytical model with experimental results. The discrepancies observed between the analytical model and experimental measurements may be due to a number of geometrical and structural parameters, as well as behavioral parameters, that differ between the model and the actual structure. The calibration process aims at identifying these parameters and updating them in the analytical model to improve its performance in simulating the actual behavior of the existing structure as closely as possible. Commodore Barry Bridge (CBB) is one of the unique structures since the bridge is the longest cantilever through truss bridge in the United States and serves more than six million vehicles annually, a significant percentage of which is heavy truck traffic. Therefore, calibration of FE model of this bridge becomes vital. Calibration studies are generally complicated for such a structure of this size and complexity. Since artificial neural networks are powerful tools for such advanced analysis and works, they are utilized here for calibration of CBB.

The Commodore Barry Bridge spans the Delaware River between Chester, Pennsylvania and Bridgeport, New Jersey. It opened to traffic in 1974. The bridge is the longest cantilever steel truss bridge in the U.S. with a main span length of 1,644 (501.09 meters) feet and a total length of 13,912 feet (4,240.38 meters). Modal properties of nominal model and experimental modal properties are compared. Significant variation is observed between them. Therefore, considerable variation between structural parameters of the nominal model and as-is parameters of the bridge is expected.

In parametric studies, structural parameters that most affect the dynamic behavior of the entire structure are identified. The procedure followed is that each time a single parameter is changed in the nominal FE model of the bridge and the changes in the modal properties (frequency, order, and existence of the modes) are observed. Investigating the sensitivity analysis results, structural parameters are classified into three significance groups in terms of their influence on dynamic response of structure.

Structural parameters in the first and second groups are determined as sensitive parameters which are used in calibration study, since their variations have a considerable impact on dynamic response of the structure. These parameters are listed as:

- Moment of inertia about x axis (I_x) value of the interior piers
- Torsion constant (J) value of the interior piers
- Modulus of elasticity (E) value of the interior piers
- Axial fixity of chord members around hangers(k_1)
- Bearings (rotational fixity) at interior piers (k_2)
- Shear fixity of shoes between stringers and floor beams (k_3)
- Rotational fixity of shoes between stringers and floor beams (k_4)
- Mass of the deck (m)

Since ANN is expected to learn the inverse relationship between modal frequencies and structural parameters, modal frequencies are selected as inputs and these sensitive parameters are selected as outputs to network. Modal frequencies used for neural network are the consistent modes which are 1^{st}, 2^{nd}, 5^{th}, 7^{th}, 8^{th}, 10^{th}, 12^{th}, 14^{th}, 16^{th}, 17^{th} modes.

Various networks with different architectures and different error minimization algorithms are trained and tested. Among them, network with 15 hidden neurons and L-M minimization algorithm performs best. Neural network successfully learns the inverse relationship between dynamic properties and structural parameters.

Trained network is fed up with experimental frequencies to give the outputs i.e. actual structural parameters. Then, structural properties are fed up into FE model for the calculation of modal parameters. It is obtained that the experimental modal properties and updated model's are perfectly overlaps. In other words, mode shapes of first twenty modes of updated model completely coincide for the experimental modes and difference in the frequencies are in acceptable range.

Finally, model updating is conducted. According to the parameters obtained by feeding up the trained network with experimental frequencies, following results are obtained:

- All spring constants k_1, k_2, k_3 and k_4 are just below the upper limit of their sensitive ranges, indicating that the movement systems are almost frozen.
- Rigidity of the inner piers (EI_x) should be increased by 3.69%.
- Mass of the deck should be slightly reduced.
- Modification in torsion constant of the inner piers should be ignored.

It can be concluded that the global stiffness of the bridge is increased in calibrated model. The updated FE model can be used in future simulations, since it represents as-is condition of the structure.

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APPENDIX A

INSTRUMENTATION

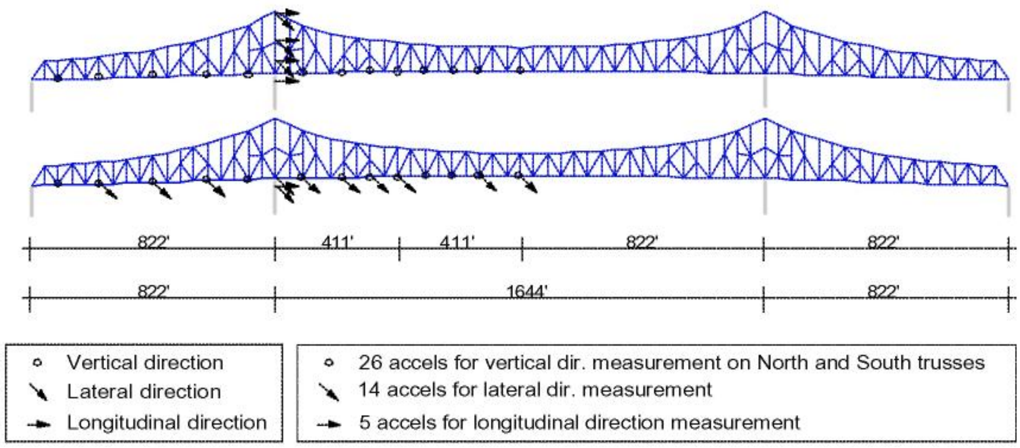

Figure A.1 Instrumentation

APPENDIX B

LIST OF DATA FOR NEURAL NETWORK

Table B.1 Training - Cross validation – Testing Input Data (Frequencies of the Selected Modes) for Neural Network

f1	f2	f5	f7	f8	f10	f12	f14	f16	f17
0,209	0,313	0,421	0,628	0,735	0,902	0,926	1,098	1,249	1,162
0,213	0,334	0,449	0,668	0,804	0,925	1,007	1,131	1,268	1,433
0,210	0,321	0,428	0,655	0,772	0,919	0,973	1,121	1,263	1,320
0,247	0,367	0,574	0,696	0,874	0,974	1,047	1,158	1,346	1,458
0,264	0,386	0,686	0,722	0,923	1,014	1,101	1,180	1,391	1,498
0,209	0,309	0,431	0,634	0,736	0,905	0,938	1,100	1,245	1,340
0,200	0,306	0,410	0,632	0,734	0,901	0,925	1,096	1,236	1,251
0,220	0,332	0,456	0,671	0,783	0,939	1,012	1,142	1,292	1,413
0,246	0,357	0,637	0,675	0,848	0,954	1,015	1,136	1,346	1,390
0,220	0,337	0,609	0,669	0,834	0,927	1,017	1,126	1,288	1,388
0,255	0,369	0,659	0,695	0,878	0,978	1,051	1,155	1,371	1,438
0,255	0,370	0,721	0,701	0,888	0,985	1,061	1,161	1,373	1,408
0,224	0,347	0,471	0,687	0,842	0,955	1,045	1,158	1,313	1,487
0,214	0,330	0,438	0,671	0,792	0,935	1,000	1,139	1,283	1,357
0,226	0,338	0,543	0,670	0,830	0,940	1,015	1,137	1,314	1,402
0,250	0,365	0,653	0,688	0,872	0,969	1,043	1,148	1,357	1,421
0,224	0,339	0,658	0,648	0,808	0,914	0,968	1,099	1,277	1,300
0,215	0,322	0,509	0,642	0,782	0,907	0,958	1,103	1,262	1,300
0,215	0,323	0,442	0,656	0,753	0,923	0,981	1,125	1,271	1,341
0,222	0,331	0,444	0,674	0,777	0,946	1,016	1,148	1,303	1,380
0,226	0,338	0,660	0,649	0,808	0,919	0,968	1,105	1,296	1,299
0,205	0,309	0,473	0,625	0,747	0,891	0,920	1,082	1,233	1,227
0,196	0,314	0,462	0,626	0,742	0,884	0,924	1,085	1,208	1,152
0,258	0,377	0,667	0,709	0,902	0,997	1,077	1,169	1,385	1,460
0,259	0,375	0,632	0,708	0,898	0,995	1,074	1,168	1,383	1,437
0,214	0,313	0,419	0,646	0,740	0,919	0,963	1,117	1,266	1,317
0,212	0,314	0,468	0,637	0,756	0,904	0,945	1,098	1,249	1,430
0,203	0,318	0,439	0,630	0,740	0,896	0,930	1,095	1,232	1,176
0,201	0,304	0,407	0,630	0,726	0,896	0,915	1,092	1,226	1,240
0,209	0,319	0,559	0,636	0,780	0,892	0,951	1,088	1,240	1,294
0,240	0,364	0,552	0,699	0,877	0,973	1,069	1,170	1,347	1,423
0,215	0,331	0,440	0,675	0,798	0,943	1,006	1,146	1,296	1,365
0,244	0,355	0,616	0,675	0,847	0,954	1,015	1,136	1,350	1,368
0,252	0,380	0,633	0,712	0,911	0,998	1,086	1,168	1,358	1,436
0,229	0,345	0,668	0,658	0,824	0,927	0,986	1,111	1,293	1,322
0,199	0,301	0,404	0,627	0,723	0,892	0,910	1,088	1,220	1,233
0,203	0,318	0,425	0,633	0,754	0,901	0,935	1,101	1,238	1,176
0,218	0,335	0,448	0,659	0,779	0,931	0,986	1,131	1,282	1,237
0,244	0,366	0,684	0,691	0,878	0,969	1,048	1,146	1,330	1,359
0,204	0,319	0,427	0,646	0,773	0,897	0,965	1,101	1,230	1,318
0,228	0,349	0,521	0,671	0,828	0,944	1,014	1,142	1,310	1,334
0,267	0,388	0,681	0,728	0,931	1,022	1,110	1,187	1,399	1,498
0,227	0,335	0,447	0,680	0,794	0,953	1,033	1,156	1,315	1,427
0,224	0,338	0,450	0,686	0,792	0,950	1,037	1,155	1,303	1,425
0,234	0,347	0,652	0,664	0,832	0,937	0,997	1,120	1,311	1,302

Table B.1 (cont'd)

f1	f2	f5	f7	f8	f10	f12	f14	f16	f17
0,262	0,384	0,678	0,719	0,919	1,009	1,096	1,177	1,384	1,486
0,259	0,379	0,662	0,712	0,908	1,000	1,084	1,172	1,383	1,458
0,207	0,308	0,414	0,636	0,730	0,908	0,943	1,104	1,247	1,311
0,235	0,340	0,606	0,651	0,808	0,925	0,969	1,112	1,320	1,324
0,201	0,308	0,413	0,628	0,736	0,893	0,927	1,091	1,223	1,333
0,232	0,341	0,639	0,656	0,817	0,928	0,980	1,114	1,310	1,276
0,205	0,315	0,428	0,645	0,768	0,915	0,955	1,113	1,258	1,293
0,207	0,316	0,427	0,632	0,733	0,900	0,937	1,099	1,238	1,156
0,228	0,342	0,464	0,686	0,835	0,957	1,039	1,159	1,319	1,421
0,207	0,326	0,521	0,657	0,801	0,914	0,988	1,117	1,259	1,392
0,230	0,364	0,505	0,696	0,858	0,958	1,064	1,159	1,307	1,369
0,202	0,310	0,415	0,629	0,724	0,901	0,930	1,097	1,240	1,388
0,230	0,345	0,553	0,675	0,844	0,941	1,028	1,139	1,311	1,415
0,200	0,316	0,435	0,626	0,751	0,890	0,924	1,090	1,221	1,171
0,202	0,300	0,405	0,621	0,708	0,892	0,911	1,085	1,224	1,306
0,262	0,381	0,671	0,717	0,915	1,007	1,092	1,176	1,388	1,475
0,200	0,313	0,420	0,623	0,738	0,881	0,917	1,083	1,200	1,154
0,203	0,299	0,414	0,622	0,714	0,894	0,911	1,086	1,228	1,308
0,254	0,368	0,658	0,696	0,880	0,980	1,053	1,156	1,371	1,436
0,209	0,313	0,436	0,641	0,739	0,913	0,949	1,109	1,259	1,319
0,226	0,339	0,643	0,650	0,809	0,918	0,970	1,104	1,289	1,287
0,223	0,330	0,529	0,657	0,809	0,924	0,989	1,120	1,291	1,359
0,253	0,367	0,656	0,693	0,876	0,976	1,050	1,154	1,367	1,436
0,200	0,308	0,414	0,637	0,721	0,899	0,941	1,099	1,230	1,280
0,226	0,337	0,653	0,647	0,804	0,915	0,964	1,101	1,288	1,292
0,231	0,342	0,644	0,657	0,821	0,928	0,983	1,112	1,303	1,289
0,222	0,329	0,455	0,666	0,784	0,938	1,004	1,139	1,294	1,419
0,248	0,365	0,643	0,688	0,870	0,969	1,041	1,148	1,353	1,410
0,207	0,311	0,473	0,631	0,751	0,893	0,932	1,088	1,233	1,230
0,239	0,357	0,695	0,677	0,854	0,953	1,021	1,133	1,327	1,364
0,199	0,302	0,395	0,630	0,718	0,894	0,964	1,091	1,223	1,237
0,224	0,343	0,482	0,667	0,806	0,937	1,006	1,138	1,289	1,278
0,257	0,379	0,659	0,713	0,909	1,003	1,086	1,172	1,380	1,463
0,231	0,348	0,562	0,674	0,845	0,941	1,027	1,139	1,312	1,424
0,210	0,327	0,425	0,659	0,782	0,920	0,988	1,125	1,262	1,376
0,205	0,312	0,419	0,633	0,746	0,898	0,936	1,097	1,232	1,381
0,215	0,324	0,433	0,663	0,761	0,927	0,993	1,131	1,274	1,353
0,245	0,359	0,640	0,680	0,856	0,960	1,025	1,141	1,352	1,397
0,201	0,298	0,407	0,618	0,707	0,890	0,905	1,081	1,219	1,309
0,205	0,318	0,411	0,630	0,750	0,899	0,930	1,097	1,239	1,177
0,212	0,325	0,466	0,648	0,772	0,909	0,970	1,111	1,251	1,210
0,239	0,344	0,618	0,656	0,817	0,931	0,981	1,117	1,328	1,348
0,235	0,364	0,545	0,694	0,869	0,961	1,057	1,159	1,318	1,398
0,254	0,375	0,649	0,705	0,893	0,988	1,067	1,165	1,369	1,435
0,207	0,310	0,456	0,628	0,741	0,896	0,927	1,089	1,235	1,413
0,250	0,379	0,620	0,710	0,905	0,994	1,080	1,167	1,357	1,412
0,204	0,306	0,412	0,629	0,725	0,901	0,928	1,096	1,239	1,376
0,210	0,324	0,440	0,647	0,783	0,909	0,967	1,112	1,247	1,462
0,227	0,351	0,443	0,689	0,839	0,958	1,047	1,160	1,309	1,288
0,208	0,317	0,427	0,639	0,771	0,907	0,950	1,106	1,246	1,418
0,261	0,381	0,728	0,718	0,917	1,008	1,095	1,177	1,386	1,442
0,201	0,305	0,412	0,629	0,715	0,898	0,927	1,093	1,231	1,296
0,252	0,365	0,713	0,693	0,874	0,975	1,046	1,153	1,367	1,394
0,197	0,307	0,415	0,631	0,739	0,895	0,927	1,092	1,226	1,272
0,228	0,337	0,639	0,650	0,807	0,921	0,968	1,108	1,307	1,280
0,209	0,309	0,416	0,639	0,729	0,907	0,946	1,105	1,246	1,309
0,230	0,345	0,553	0,670	0,836	0,939	1,018	1,137	1,311	1,399
0,213	0,324	0,431	0,663	0,779	0,932	0,985	1,134	1,282	1,344
0,207	0,313	0,444	0,624	0,736	0,895	0,919	1,090	1,237	1,167
0,205	0,307	0,438	0,629	0,730	0,897	0,927	1,091	1,233	1,315
0,207	0,316	0,455	0,634	0,750	0,900	0,941	1,097	1,239	1,181
0,226	0,347	0,466	0,686	0,839	0,952	1,045	1,157	1,306	1,530
0,203	0,314	0,423	0,626	0,726	0,893	0,922	1,092	1,226	1,157
0,215	0,320	0,434	0,655	0,759	0,923	0,982	1,124	1,270	1,353

Table B.1 (cont'd)

f1	f2	f5	f7	f8	f10	f12	f14	f16	f17
0,208	0,320	0,418	0,656	0,764	0,911	0,966	1,117	1,248	1,319
0,208	0,310	0,465	0,629	0,746	0,898	0,926	1,090	1,244	1,209
0,218	0,334	0,459	0,673	0,826	0,944	1,016	1,145	1,304	1,383
0,197	0,295	0,400	0,618	0,695	0,885	0,901	1,077	1,208	1,241
0,240	0,346	0,623	0,660	0,822	0,935	0,988	1,121	1,334	1,357
0,205	0,305	0,417	0,632	0,726	0,904	0,934	1,099	1,243	1,312
0,218	0,331	0,448	0,651	0,778	0,926	0,968	1,124	1,284	1,230
0,217	0,321	0,520	0,641	0,781	0,908	0,956	1,102	1,269	1,139
0,195	0,296	0,398	0,618	0,709	0,883	0,893	1,075	1,203	1,210
0,217	0,340	0,488	0,670	0,810	0,934	1,014	1,139	1,280	1,230
0,208	0,321	0,427	0,657	0,772	0,915	0,974	1,120	1,254	1,328
0,215	0,329	0,458	0,661	0,786	0,927	0,994	1,130	1,273	1,394
0,255	0,369	0,659	0,695	0,879	0,979	1,051	1,155	1,371	1,438
0,200	0,311	0,448	0,632	0,748	0,895	0,936	1,090	1,235	1,426
0,259	0,379	0,662	0,712	0,908	1,000	1,084	1,170	1,376	1,462
0,258	0,372	0,666	0,700	0,887	0,984	1,061	1,160	1,373	1,454
0,233	0,353	0,549	0,683	0,854	0,951	1,044	1,151	1,320	1,405
0,218	0,329	0,527	0,656	0,805	0,922	0,986	1,118	1,287	1,359
0,236	0,349	0,615	0,666	0,834	0,941	1,000	1,125	1,322	1,354
0,231	0,337	0,574	0,648	0,803	0,920	0,963	1,107	1,311	1,297
0,206	0,308	0,413	0,638	0,728	0,907	0,946	1,105	1,246	1,290
0,212	0,330	0,440	0,663	0,793	0,925	0,997	1,130	1,269	1,390
0,205	0,321	0,424	0,658	0,767	0,916	1,030	1,121	1,256	1,318
0,206	0,318	0,435	0,647	0,777	0,911	0,964	1,111	1,254	1,316
0,218	0,323	0,442	0,659	0,772	0,931	0,991	1,131	1,285	1,400
0,229	0,337	0,579	0,648	0,804	0,917	0,964	1,103	1,292	1,300
0,218	0,325	0,493	0,652	0,788	0,921	0,977	1,118	1,279	1,292
0,208	0,323	0,422	0,656	0,772	0,917	0,979	1,121	1,257	1,349
0,207	0,317	0,521	0,633	0,756	0,895	0,941	1,093	1,235	1,215
0,216	0,330	0,463	0,657	0,780	0,926	0,988	1,127	1,277	1,484
0,220	0,330	0,441	0,653	0,772	0,927	0,977	1,127	1,282	1,215
0,201	0,305	0,411	0,631	0,735	0,891	0,925	1,090	1,217	1,266
0,261	0,387	0,731	0,728	0,931	1,022	1,112	1,186	1,393	1,456
0,207	0,315	0,426	0,629	0,734	0,897	0,928	1,096	1,235	1,161
0,242	0,355	0,682	0,676	0,848	0,954	1,015	1,138	1,347	1,339
0,239	0,350	0,655	0,669	0,836	0,944	1,001	1,131	1,330	1,291
0,201	0,302	0,428	0,622	0,712	0,888	0,911	1,080	1,219	1,297
0,223	0,334	0,445	0,678	0,785	0,944	1,025	1,148	1,298	1,395
0,203	0,298	0,402	0,622	0,703	0,893	0,910	1,084	1,223	1,256
0,200	0,302	0,417	0,623	0,739	0,892	0,913	1,084	1,223	1,251
0,230	0,359	0,535	0,691	0,859	0,960	1,054	1,160	1,324	1,381
0,227	0,345	0,556	0,670	0,840	0,933	1,020	1,131	1,297	1,404
0,218	0,325	0,524	0,651	0,796	0,919	0,975	1,114	1,285	1,352
0,200	0,309	0,440	0,631	0,732	0,891	0,932	1,087	1,221	1,305
0,223	0,332	0,529	0,659	0,811	0,925	0,995	1,122	1,289	1,372
0,209	0,313	0,419	0,632	0,734	0,903	0,937	1,100	1,242	1,423
0,264	0,382	0,674	0,719	0,917	1,011	1,094	1,179	1,395	1,481
0,232	0,339	0,608	0,649	0,806	0,922	0,966	1,109	1,314	1,325
0,215	0,323	0,492	0,633	0,764	0,903	0,938	1,099	1,258	1,252
0,222	0,335	0,456	0,671	0,836	0,938	1,016	1,139	1,297	1,437
0,211	0,318	0,426	0,652	0,746	0,919	0,972	1,120	1,264	1,343
0,222	0,343	0,528	0,666	0,825	0,929	1,008	1,130	1,286	1,344
0,212	0,318	0,427	0,635	0,747	0,909	0,940	1,106	1,258	1,180
0,248	0,363	0,691	0,689	0,869	0,969	1,040	1,148	1,351	1,368
0,213	0,323	0,460	0,652	0,768	0,923	0,977	1,121	1,277	1,389
0,215	0,322	0,484	0,647	0,784	0,913	0,969	1,109	1,268	1,284
0,232	0,340	0,584	0,653	0,811	0,925	0,973	1,111	1,313	1,313
0,228	0,342	0,456	0,686	0,810	0,959	1,048	1,161	1,320	1,516
0,221	0,337	0,451	0,663	0,787	0,936	0,994	1,136	1,291	1,248
0,208	0,323	0,441	0,654	0,787	0,912	0,978	1,116	1,252	1,346
0,215	0,321	0,460	0,650	0,767	0,916	0,972	1,116	1,263	1,378
0,216	0,321	0,471	0,650	0,770	0,920	0,972	1,117	1,274	1,434
0,242	0,352	0,624	0,670	0,840	0,946	1,006	1,128	1,332	1,367
0,229	0,336	0,574	0,647	0,802	0,916	0,962	1,103	1,296	1,297

Table B.1 (cont'd)

f1	f2	f5	f7	f8	f10	f12	f14	f16	f17
0,224	0,339	0,500	0,660	0,806	0,933	0,994	1,132	1,298	1,291
0,228	0,340	0,583	0,650	0,811	0,918	0,971	1,104	1,288	1,311
0,238	0,352	0,624	0,668	0,838	0,943	1,004	1,126	1,325	1,366
0,244	0,354	0,634	0,671	0,842	0,949	1,010	1,132	1,345	1,385
0,205	0,304	0,417	0,630	0,720	0,899	0,930	1,093	1,233	1,285
0,245	0,359	0,676	0,683	0,860	0,962	1,029	1,142	1,346	1,349
0,209	0,319	0,422	0,651	0,763	0,917	0,967	1,118	1,259	1,329
0,222	0,343	0,458	0,672	0,817	0,938	1,013	1,141	1,284	1,261
0,209	0,314	0,468	0,636	0,755	0,901	0,944	1,097	1,244	1,435
0,208	0,327	0,429	0,659	0,781	0,926	0,988	1,128	1,273	1,379
0,211	0,317	0,479	0,629	0,754	0,899	0,932	1,093	1,247	1,235
0,201	0,301	0,408	0,625	0,710	0,893	0,919	1,087	1,222	1,267
0,213	0,327	0,454	0,647	0,769	0,917	0,965	1,117	1,268	1,214
0,205	0,305	0,410	0,632	0,720	0,902	0,934	1,098	1,238	1,284
0,265	0,388	0,677	0,726	0,929	1,018	1,107	1,186	1,392	1,491
0,254	0,373	0,708	0,704	0,897	0,990	1,072	1,163	1,371	1,408
0,220	0,331	0,445	0,653	0,774	0,926	0,975	1,126	1,280	1,225
0,227	0,337	0,475	0,678	0,804	0,949	1,027	1,151	1,310	1,434
0,232	0,355	0,467	0,695	0,848	0,967	1,054	1,167	1,321	1,310
0,254	0,372	0,648	0,701	0,891	0,986	1,064	1,160	1,369	1,434
0,194	0,305	0,405	0,623	0,727	0,875	0,916	1,075	1,191	1,305
0,248	0,370	0,628	0,696	0,885	0,976	1,058	1,156	1,357	1,395
0,234	0,349	0,526	0,690	0,849	0,962	1,052	1,161	1,334	1,387
0,214	0,324	0,439	0,657	0,760	0,922	0,985	1,124	1,267	1,366
0,196	0,299	0,403	0,621	0,717	0,883	0,904	1,078	1,204	1,246
0,225	0,340	0,529	0,674	0,837	0,935	1,023	1,134	1,298	1,389
0,224	0,354	0,468	0,693	0,850	0,957	1,055	1,161	1,303	1,296
0,200	0,311	0,417	0,634	0,758	0,898	0,939	1,097	1,229	1,324
0,212	0,312	0,421	0,644	0,737	0,913	0,957	1,112	1,255	1,310
0,223	0,340	0,469	0,681	0,798	0,952	1,032	1,154	1,312	1,448
0,219	0,323	0,510	0,646	0,785	0,914	0,966	1,109	1,273	1,149
0,238	0,352	0,618	0,669	0,841	0,944	1,007	1,128	1,331	1,358
0,219	0,330	0,464	0,666	0,781	0,937	1,004	1,138	1,296	1,395
0,201	0,314	0,426	0,626	0,748	0,889	0,923	1,090	1,217	1,161
0,221	0,332	0,490	0,665	0,798	0,934	1,003	1,134	1,294	1,491
0,235	0,341	0,606	0,655	0,813	0,930	0,976	1,116	1,327	1,328
0,205	0,316	0,449	0,631	0,745	0,896	0,934	1,094	1,235	1,180
0,223	0,335	0,454	0,668	0,787	0,941	1,010	1,142	1,298	1,495
0,244	0,354	0,681	0,675	0,846	0,953	1,013	1,135	1,345	1,349
0,233	0,354	0,509	0,683	0,837	0,956	1,036	1,156	1,320	1,332
0,254	0,372	0,653	0,702	0,891	0,988	1,065	1,161	1,372	1,439
0,225	0,328	0,438	0,669	0,778	0,941	1,015	1,143	1,298	1,390
0,225	0,342	0,465	0,669	0,817	0,941	1,008	1,142	1,297	1,264
0,233	0,347	0,652	0,664	0,833	0,935	0,997	1,118	1,305	1,302
0,205	0,316	0,445	0,640	0,741	0,904	0,952	1,102	1,243	1,357
0,208	0,316	0,460	0,641	0,757	0,905	0,955	1,103	1,248	1,372
0,198	0,308	0,432	0,627	0,741	0,892	0,926	1,084	1,229	1,195
0,201	0,307	0,410	0,634	0,733	0,892	0,925	1,093	1,219	1,255
0,216	0,319	0,449	0,644	0,754	0,916	0,962	1,114	1,266	1,447
0,212	0,317	0,425	0,651	0,746	0,919	0,972	1,120	1,264	1,327
0,223	0,347	0,474	0,673	0,833	0,936	1,018	1,140	1,280	1,280
0,211	0,317	0,425	0,637	0,745	0,909	0,948	1,108	1,254	1,158
0,239	0,350	0,625	0,664	0,832	0,939	0,997	1,124	1,330	1,363
0,206	0,320	0,424	0,636	0,760	0,899	0,946	1,100	1,233	1,175
0,222	0,345	0,480	0,671	0,818	0,939	1,017	1,140	1,297	1,308
0,255	0,374	0,651	0,705	0,895	0,990	1,069	1,164	1,372	1,438
0,211	0,320	0,467	0,640	0,763	0,905	0,954	1,103	1,249	1,210
0,204	0,310	0,447	0,634	0,739	0,904	0,937	1,097	1,247	1,335
0,197	0,300	0,415	0,622	0,706	0,884	0,912	1,079	1,206	1,243
0,227	0,337	0,448	0,684	0,787	0,955	1,034	1,158	1,314	1,409
0,211	0,318	0,483	0,628	0,756	0,897	0,928	1,092	1,248	1,229
0,250	0,367	0,709	0,695	0,879	0,980	1,052	1,155	1,370	1,401
0,233	0,340	0,654	0,654	0,813	0,927	0,975	1,114	1,320	1,301
0,248	0,364	0,613	0,692	0,872	0,974	1,044	1,152	1,367	1,395

Table B.1 (cont'd)

f1	f2	f5	f7	f8	f10	f12	f14	f16	f17
0,202	0,309	0,411	0,639	0,737	0,900	0,990	1,101	1,232	1,264
0,229	0,347	0,666	0,660	0,829	0,931	0,992	1,114	1,299	1,324
0,238	0,358	0,679	0,679	0,860	0,953	1,029	1,132	1,317	1,356
0,213	0,320	0,429	0,657	0,757	0,927	0,984	1,128	1,278	1,355
0,202	0,304	0,430	0,622	0,719	0,890	0,912	1,083	1,221	1,354
0,201	0,317	0,425	0,628	0,748	0,889	0,925	1,091	1,214	1,170
0,204	0,309	0,538	0,625	0,752	0,884	0,923	1,076	1,221	1,236
0,212	0,316	0,463	0,640	0,757	0,910	0,950	1,105	1,260	1,408
0,222	0,335	0,449	0,676	0,785	0,946	1,023	1,149	1,302	1,409
0,223	0,338	0,451	0,666	0,793	0,939	1,001	1,139	1,295	1,249
0,242	0,365	0,691	0,689	0,876	0,967	1,046	1,143	1,330	1,378
0,219	0,338	0,446	0,665	0,803	0,933	1,001	1,136	1,280	1,243
0,222	0,332	0,443	0,675	0,781	0,946	1,019	1,149	1,303	1,406
0,213	0,316	0,442	0,639	0,749	0,911	0,951	1,108	1,257	1,404
0,213	0,317	0,423	0,652	0,740	0,924	0,970	1,124	1,274	1,313
0,239	0,352	0,605	0,670	0,837	0,944	1,002	1,130	1,325	1,341
0,221	0,338	0,551	0,647	0,802	0,913	0,961	1,104	1,273	1,239
0,266	0,384	0,684	0,721	0,918	1,011	1,096	1,181	1,396	1,495
0,240	0,361	0,702	0,681	0,865	0,958	1,033	1,136	1,326	1,379
0,198	0,298	0,409	0,624	0,708	0,889	0,949	1,084	1,214	1,218
0,228	0,345	0,460	0,723	0,860	1,042	1,047	1,162	1,320	1,240
0,221	0,322	0,436	0,658	0,768	0,930	0,989	1,131	1,283	1,400
0,245	0,353	0,633	0,669	0,838	0,946	1,006	1,131	1,344	1,380
0,207	0,308	0,417	0,634	0,725	0,905	0,936	1,101	1,244	1,325
0,196	0,308	0,409	0,627	0,734	0,892	0,925	1,090	1,221	1,350
0,205	0,319	0,426	0,643	0,765	0,912	0,957	1,112	1,255	1,456
0,220	0,339	0,451	0,669	0,824	0,938	1,009	1,141	1,290	1,238
0,210	0,309	0,414	0,636	0,733	0,907	0,942	1,104	1,248	1,352
0,218	0,336	0,510	0,664	0,820	0,926	1,008	1,126	1,284	1,344
0,235	0,342	0,606	0,655	0,815	0,929	0,977	1,115	1,320	1,328
0,215	0,336	0,444	0,679	0,806	0,935	1,015	1,142	1,282	1,376
0,213	0,322	0,513	0,632	0,773	0,900	0,939	1,095	1,262	1,284
0,227	0,344	0,484	0,684	0,836	0,951	1,043	1,151	1,315	1,352
0,211	0,326	0,500	0,642	0,785	0,902	0,960	1,101	1,250	1,283
0,260	0,378	0,661	0,712	0,904	0,999	1,080	1,172	1,382	1,455
0,218	0,336	0,454	0,658	0,801	0,928	0,985	1,129	1,278	1,241
0,225	0,340	0,508	0,677	0,826	0,944	1,029	1,144	1,307	1,336
0,229	0,348	0,536	0,684	0,848	0,947	1,043	1,148	1,311	1,398
0,229	0,342	0,491	0,684	0,820	0,952	1,038	1,155	1,314	1,504
0,208	0,315	0,487	0,637	0,769	0,896	0,944	1,092	1,241	1,271
0,230	0,349	0,586	0,665	0,834	0,936	0,998	1,121	1,302	1,322
0,248	0,367	0,647	0,692	0,878	0,974	1,049	1,149	1,349	1,422
0,221	0,334	0,473	0,670	0,797	0,937	1,015	1,139	1,291	1,423
0,217	0,338	0,471	0,666	0,805	0,932	1,004	1,136	1,279	1,237
0,216	0,323	0,434	0,653	0,759	0,923	0,978	1,124	1,271	1,403
0,219	0,343	0,568	0,674	0,839	0,932	1,026	1,133	1,289	1,364
0,235	0,355	0,675	0,674	0,852	0,948	1,020	1,129	1,320	1,340
0,260	0,379	0,660	0,712	0,904	0,998	1,079	1,173	1,383	1,455
0,268	0,388	0,690	0,726	0,928	1,020	1,107	1,186	1,401	1,508
0,220	0,339	0,472	0,673	0,796	0,937	1,020	1,141	1,289	1,491
0,201	0,317	0,431	0,649	0,758	0,906	0,961	1,110	1,240	1,313
0,214	0,321	0,430	0,649	0,759	0,922	0,972	1,121	1,271	1,449
0,214	0,324	0,433	0,649	0,760	0,917	0,972	1,118	1,261	1,471
0,204	0,313	0,439	0,638	0,747	0,904	0,946	1,103	1,239	1,322
0,237	0,350	0,604	0,666	0,838	0,939	1,004	1,125	1,323	1,338
0,213	0,332	0,436	0,658	0,792	0,927	0,989	1,128	1,277	1,499
0,217	0,325	0,514	0,635	0,774	0,905	0,945	1,101	1,267	1,162
0,214	0,319	0,431	0,637	0,751	0,911	0,945	1,108	1,261	1,186
0,259	0,381	0,677	0,715	0,912	1,005	1,089	1,174	1,387	1,480
0,212	0,314	0,431	0,642	0,744	0,911	0,957	1,110	1,254	1,346
0,216	0,322	0,443	0,654	0,763	0,923	0,980	1,123	1,271	1,390
0,212	0,315	0,517	0,635	0,773	0,901	0,943	1,093	1,259	1,312
0,253	0,370	0,652	0,698	0,887	0,982	1,060	1,159	1,371	1,430
0,218	0,328	0,483	0,655	0,801	0,923	0,987	1,120	1,285	1,310

Table B.1 (cont'd)

f1	f2	f5	f7	f8	f10	f12	f14	f16	f17
0,234	0,352	0,685	0,669	0,841	0,944	1,007	1,126	1,321	1,348
0,204	0,315	0,423	0,630	0,729	0,898	0,931	1,097	1,235	1,158
0,207	0,308	0,424	0,634	0,723	0,905	0,935	1,100	1,244	1,281
0,219	0,345	0,457	0,675	0,830	0,939	1,025	1,143	1,291	1,281
0,236	0,356	0,476	0,695	0,840	0,971	1,054	1,170	1,333	1,320
0,192	0,300	0,402	0,623	0,723	0,876	0,908	1,075	1,193	1,234
0,245	0,357	0,627	0,677	0,853	0,956	1,021	1,136	1,342	1,382
0,215	0,335	0,450	0,662	0,798	0,926	0,994	1,129	1,264	1,242
0,216	0,335	0,490	0,668	0,806	0,930	1,011	1,132	1,283	1,490
0,205	0,323	0,424	0,659	0,770	0,916	1,037	1,122	1,256	1,324
0,206	0,313	0,420	0,644	0,731	0,908	0,954	1,109	1,245	1,310
0,263	0,385	0,683	0,721	0,921	1,013	1,099	1,180	1,390	1,493
0,243	0,369	0,697	0,696	0,886	0,978	1,059	1,151	1,343	1,392
0,197	0,309	0,413	0,634	0,750	0,891	0,936	1,092	1,216	1,290
0,226	0,337	0,448	0,684	0,798	0,954	1,040	1,158	1,312	1,422
0,246	0,358	0,638	0,677	0,852	0,956	1,019	1,137	1,346	1,393
0,232	0,361	0,505	0,694	0,845	0,963	1,052	1,162	1,313	1,344
0,219	0,320	0,434	0,654	0,760	0,926	0,979	1,126	1,277	1,384
0,195	0,299	0,403	0,620	0,697	0,882	0,907	1,077	1,201	1,259
0,228	0,353	0,473	0,690	0,860	0,956	1,051	1,160	1,306	1,287
0,212	0,331	0,497	0,644	0,793	0,897	0,961	1,099	1,238	1,289
0,246	0,361	0,639	0,682	0,860	0,961	1,029	1,141	1,345	1,399
0,244	0,368	0,615	0,693	0,881	0,974	1,052	1,149	1,343	1,406
0,256	0,378	0,661	0,709	0,905	0,995	1,081	1,168	1,370	1,453
0,210	0,322	0,429	0,645	0,771	0,911	0,962	1,113	1,251	1,458
0,208	0,317	0,421	0,630	0,747	0,901	0,929	1,099	1,245	1,170
0,212	0,329	0,438	0,660	0,791	0,927	0,992	1,130	1,274	1,445
0,244	0,356	0,630	0,675	0,848	0,953	1,015	1,135	1,344	1,380
0,213	0,332	0,509	0,667	0,804	0,932	1,006	1,134	1,284	1,397
0,256	0,378	0,671	0,709	0,903	0,997	1,078	1,168	1,378	1,467
0,207	0,310	0,460	0,630	0,746	0,900	0,931	1,093	1,246	1,202
0,215	0,330	0,446	0,651	0,771	0,920	0,972	1,121	1,268	1,219
0,211	0,309	0,414	0,639	0,726	0,912	0,946	1,108	1,255	1,286
0,249	0,359	0,643	0,678	0,852	0,957	1,022	1,139	1,354	1,403
0,200	0,300	0,422	0,621	0,714	0,891	0,909	1,082	1,221	1,294
0,198	0,301	0,421	0,621	0,706	0,884	0,910	1,077	1,208	1,257
0,243	0,352	0,618	0,670	0,840	0,947	1,007	1,131	1,342	1,360
0,232	0,340	0,577	0,654	0,814	0,925	0,976	1,111	1,308	1,313
0,216	0,328	0,523	0,638	0,781	0,907	0,949	1,103	1,271	1,302
0,212	0,325	0,438	0,653	0,783	0,915	0,978	1,118	1,256	1,412
0,208	0,311	0,419	0,641	0,748	0,911	0,942	1,108	1,253	1,273
0,266	0,386	0,742	0,727	0,929	1,022	1,110	1,187	1,400	1,468
0,213	0,329	0,553	0,659	0,805	0,921	0,995	1,120	1,276	1,315
0,212	0,323	0,439	0,658	0,762	0,927	0,987	1,128	1,276	1,370
0,210	0,311	0,486	0,630	0,753	0,897	0,930	1,088	1,244	1,087
0,213	0,325	0,434	0,657	0,786	0,930	0,983	1,130	1,285	1,424
0,241	0,350	0,612	0,668	0,836	0,945	1,001	1,129	1,340	1,352
0,240	0,350	0,625	0,666	0,834	0,941	0,999	1,125	1,331	1,363
0,221	0,332	0,449	0,674	0,786	0,945	1,019	1,147	1,302	1,403
0,225	0,338	0,538	0,669	0,828	0,937	1,014	1,135	1,307	1,394
0,238	0,355	0,685	0,674	0,851	0,950	1,018	1,130	1,320	1,360
0,232	0,338	0,602	0,648	0,804	0,920	0,964	1,107	1,310	1,316
0,247	0,359	0,639	0,678	0,852	0,957	1,021	1,140	1,353	1,398
0,255	0,372	0,665	0,700	0,887	0,986	1,061	1,161	1,377	1,450
0,234	0,347	0,661	0,665	0,832	0,941	0,997	1,125	1,333	1,320
0,207	0,320	0,435	0,648	0,781	0,901	0,968	1,105	1,237	1,336
0,263	0,386	0,656	0,725	0,924	1,014	1,103	1,186	1,389	1,458
0,246	0,357	0,632	0,678	0,852	0,956	1,019	1,138	1,348	1,385
0,249	0,361	0,644	0,682	0,859	0,962	1,029	1,143	1,355	1,408
0,215	0,327	0,437	0,661	0,785	0,925	0,990	1,129	1,271	1,364
0,264	0,384	0,666	0,722	0,922	1,015	1,101	1,182	1,397	1,479
0,217	0,337	0,455	0,662	0,790	0,933	0,994	1,134	1,285	1,244
0,202	0,312	0,425	0,629	0,734	0,898	0,930	1,095	1,234	1,145
0,218	0,325	0,437	0,661	0,767	0,930	0,994	1,132	1,280	1,377

Table B.1 (cont'd)

f1	f2	f5	f7	f8	f10	f12	f14	f16	f17
0,260	0,379	0,651	0,714	0,909	1,003	1,085	1,174	1,387	1,456
0,212	0,320	0,434	0,652	0,773	0,918	0,971	1,120	1,263	1,340
0,204	0,307	0,469	0,627	0,746	0,890	0,926	1,081	1,229	1,225
0,207	0,313	0,413	0,646	0,746	0,913	0,944	1,113	1,255	1,287
0,207	0,330	0,455	0,657	0,787	0,917	0,989	1,123	1,256	1,465
0,231	0,351	0,660	0,668	0,841	0,941	1,007	1,123	1,310	1,321
0,214	0,324	0,430	0,654	0,776	0,922	0,979	1,124	1,268	1,394
0,207	0,305	0,456	0,625	0,733	0,893	0,919	1,084	1,231	1,398
0,230	0,354	0,472	0,693	0,847	0,968	1,055	1,169	1,331	1,296
0,235	0,345	0,615	0,657	0,820	0,931	0,983	1,117	1,321	1,343
0,226	0,341	0,540	0,657	0,815	0,925	0,988	1,123	1,290	1,340
0,243	0,355	0,680	0,676	0,850	0,955	1,018	1,137	1,346	1,350
0,201	0,317	0,423	0,637	0,756	0,897	0,946	1,099	1,226	1,146
0,216	0,318	0,428	0,653	0,750	0,925	0,975	1,124	1,276	1,335
0,231	0,348	0,569	0,662	0,824	0,930	0,987	1,120	1,290	1,392
0,202	0,304	0,423	0,624	0,718	0,896	0,917	1,088	1,232	1,325
0,253	0,378	0,649	0,710	0,903	0,996	1,078	1,170	1,372	1,438
0,212	0,325	0,435	0,661	0,758	0,927	0,991	1,130	1,274	1,371
0,195	0,303	0,405	0,628	0,729	0,888	0,917	1,086	1,211	1,251
0,240	0,362	0,615	0,683	0,866	0,961	1,036	1,139	1,330	1,389
0,250	0,367	0,626	0,695	0,879	0,979	1,051	1,156	1,367	1,407
0,204	0,306	0,470	0,626	0,744	0,894	0,915	1,084	1,240	1,226
0,203	0,311	0,411	0,643	0,742	0,899	0,996	1,102	1,230	1,276
0,204	0,313	0,415	0,643	0,747	0,898	0,945	1,102	1,228	1,288
0,263	0,381	0,635	0,718	0,915	1,009	1,093	1,178	1,394	1,458
0,250	0,368	0,651	0,693	0,880	0,976	1,052	1,152	1,359	1,426
0,240	0,350	0,624	0,666	0,833	0,942	0,998	1,127	1,335	1,363
0,258	0,381	0,678	0,714	0,910	1,004	1,086	1,173	1,386	1,480
0,248	0,373	0,709	0,702	0,896	0,984	1,070	1,158	1,349	1,402
0,209	0,322	0,467	0,636	0,761	0,908	0,946	1,104	1,260	1,212
0,202	0,299	0,404	0,623	0,702	0,896	0,911	1,088	1,229	1,254
0,235	0,341	0,602	0,653	0,811	0,926	0,973	1,112	1,315	1,321
0,207	0,313	0,418	0,633	0,754	0,904	0,938	1,102	1,244	1,393
0,188	0,300	0,425	0,621	0,713	0,874	0,901	1,071	1,190	1,224
0,210	0,328	0,460	0,654	0,768	0,917	0,983	1,119	1,261	1,437
0,222	0,336	0,451	0,660	0,787	0,933	0,988	1,133	1,290	1,243
0,203	0,311	0,408	0,625	0,737	0,890	0,921	1,090	1,220	1,143
0,199	0,297	0,406	0,619	0,702	0,888	0,903	1,079	1,215	1,267
0,216	0,326	0,458	0,658	0,772	0,923	0,986	1,125	1,272	1,398
0,199	0,309	0,455	0,632	0,737	0,887	0,930	1,087	1,213	1,269
0,237	0,353	0,682	0,672	0,843	0,949	1,009	1,132	1,334	1,336
0,239	0,358	0,576	0,682	0,857	0,955	1,038	1,151	1,332	1,309
0,230	0,339	0,605	0,649	0,811	0,921	0,974	1,111	1,318	1,306
0,215	0,330	0,469	0,663	0,785	0,928	0,998	1,129	1,279	1,407
0,219	0,340	0,442	0,685	0,816	0,951	1,033	1,155	1,306	1,421
0,239	0,348	0,622	0,663	0,828	0,938	0,992	1,123	1,330	1,357
0,199	0,301	0,433	0,621	0,718	0,890	0,909	1,079	1,224	1,293
0,237	0,343	0,589	0,657	0,817	0,932	0,980	1,118	1,325	1,319
0,225	0,344	0,458	0,675	0,800	0,947	1,021	1,149	1,304	1,262
0,196	0,303	0,405	0,621	0,725	0,886	0,910	1,080	1,213	1,277
0,213	0,325	0,438	0,658	0,783	0,925	0,984	1,127	1,273	1,360
0,248	0,371	0,711	0,699	0,893	0,983	1,066	1,156	1,351	1,409
0,257	0,376	0,664	0,708	0,900	0,996	1,075	1,168	1,382	1,457
0,200	0,304	0,409	0,631	0,735	0,900	0,924	1,096	1,234	1,260
0,213	0,311	0,417	0,641	0,738	0,914	0,954	1,111	1,259	1,337
0,220	0,326	0,476	0,655	0,778	0,923	0,983	1,122	1,276	1,445
0,206	0,317	0,430	0,645	0,771	0,905	0,959	1,107	1,240	1,318
0,231	0,341	0,605	0,653	0,813	0,925	0,975	1,112	1,312	1,326
0,208	0,310	0,539	0,632	0,760	0,895	0,935	1,087	1,240	1,252
0,235	0,345	0,588	0,661	0,824	0,936	0,988	1,121	1,329	1,330
0,244	0,355	0,617	0,674	0,844	0,951	1,011	1,136	1,344	1,359
0,236	0,355	0,606	0,672	0,848	0,946	1,015	1,127	1,317	1,364
0,227	0,348	0,536	0,685	0,847	0,949	1,043	1,149	1,314	1,399
0,195	0,298	0,401	0,617	0,695	0,878	0,903	1,073	1,196	1,259

Table B.1 (cont'd)

f1	f2	f5	f7	f8	f10	f12	f14	f16	f17
0,251	0,373	0,725	0,702	0,896	0,987	1,071	1,159	1,358	1,422
0,206	0,316	0,466	0,641	0,761	0,904	0,955	1,101	1,246	1,418
0,246	0,359	0,636	0,679	0,856	0,957	1,024	1,138	1,342	1,392
0,220	0,339	0,431	0,675	0,813	0,943	1,022	1,146	1,294	1,506
0,221	0,325	0,443	0,660	0,774	0,932	0,994	1,133	1,286	1,419
0,233	0,341	0,604	0,654	0,813	0,929	0,974	1,115	1,327	1,325
0,224	0,333	0,459	0,673	0,788	0,946	1,016	1,147	1,306	1,400
0,230	0,352	0,507	0,687	0,839	0,957	1,049	1,158	1,320	1,325
0,227	0,340	0,466	0,685	0,812	0,957	1,042	1,159	1,318	1,465
0,212	0,329	0,440	0,650	0,781	0,920	0,972	1,121	1,267	1,211
0,202	0,301	0,406	0,625	0,711	0,893	0,919	1,087	1,222	1,282
0,222	0,337	0,526	0,659	0,812	0,926	0,994	1,125	1,289	1,339
0,204	0,320	0,420	0,641	0,762	0,904	0,956	1,106	1,239	1,428
0,226	0,344	0,531	0,679	0,842	0,945	1,034	1,144	1,311	1,387
0,245	0,356	0,634	0,675	0,847	0,953	1,015	1,136	1,347	1,388
0,235	0,342	0,613	0,652	0,811	0,926	0,975	1,113	1,324	1,338
0,220	0,348	0,461	0,681	0,835	0,947	1,034	1,151	1,294	1,271
0,242	0,353	0,626	0,670	0,843	0,946	1,009	1,130	1,335	1,367
0,214	0,320	0,428	0,637	0,769	0,912	0,944	1,109	1,264	1,179
0,220	0,329	0,439	0,670	0,771	0,936	1,008	1,140	1,287	1,366
0,234	0,341	0,609	0,653	0,813	0,927	0,975	1,115	1,325	1,328
0,243	0,355	0,630	0,673	0,846	0,950	1,012	1,132	1,336	1,378
0,204	0,306	0,429	0,629	0,722	0,900	0,926	1,093	1,238	1,281
0,199	0,300	0,390	0,627	0,714	0,894	0,904	1,090	1,224	1,235
0,205	0,321	0,423	0,651	0,774	0,910	0,971	1,112	1,249	1,330
0,245	0,376	0,660	0,707	0,893	0,985	1,069	1,166	1,337	1,465
0,256	0,371	0,658	0,700	0,885	0,983	1,059	1,161	1,374	1,443
0,212	0,315	0,423	0,642	0,745	0,916	0,963	1,113	1,263	1,391
0,244	0,358	0,606	0,680	0,857	0,960	1,026	1,140	1,348	1,377
0,207	0,312	0,434	0,624	0,733	0,896	0,920	1,091	1,238	1,161
0,211	0,335	0,441	0,655	0,797	0,916	0,985	1,120	1,257	1,238
0,223	0,333	0,461	0,667	0,794	0,939	1,008	1,140	1,297	1,500
0,211	0,315	0,476	0,636	0,760	0,903	0,945	1,098	1,249	1,238
0,201	0,313	0,411	0,640	0,748	0,903	0,947	1,103	1,237	1,292
0,218	0,326	0,440	0,661	0,766	0,932	0,994	1,134	1,285	1,375
0,203	0,323	0,423	0,642	0,769	0,902	0,958	1,104	1,236	1,177
0,234	0,355	0,548	0,681	0,848	0,953	1,038	1,152	1,325	1,396
0,228	0,336	0,655	0,649	0,805	0,918	0,966	1,105	1,296	1,301
0,210	0,325	0,434	0,647	0,757	0,919	0,968	1,119	1,268	1,185
0,227	0,340	0,533	0,661	0,817	0,932	0,999	1,130	1,303	1,360
0,216	0,340	0,504	0,680	0,820	0,934	1,030	1,141	1,282	1,394
0,218	0,337	0,457	0,681	0,789	0,944	1,029	1,149	1,296	1,403
0,235	0,359	0,562	0,685	0,859	0,954	1,041	1,151	1,318	1,407
0,256	0,379	0,720	0,713	0,911	1,003	1,088	1,171	1,377	1,434
0,203	0,309	0,414	0,637	0,719	0,899	0,942	1,099	1,230	1,283
0,214	0,322	0,435	0,655	0,759	0,924	0,983	1,125	1,272	1,366
0,204	0,316	0,418	0,640	0,766	0,897	0,952	1,097	1,230	1,324
0,213	0,322	0,464	0,651	0,770	0,918	0,976	1,117	1,268	1,387
0,221	0,336	0,450	0,678	0,788	0,944	1,026	1,148	1,296	1,423
0,216	0,320	0,428	0,648	0,758	0,921	0,970	1,120	1,270	1,434
0,202	0,303	0,406	0,629	0,708	0,893	0,924	1,090	1,220	1,258
0,231	0,341	0,644	0,657	0,819	0,930	0,984	1,115	1,312	1,303
0,221	0,326	0,433	0,666	0,787	0,938	0,990	1,139	1,294	1,344
0,196	0,312	0,457	0,636	0,745	0,891	0,942	1,093	1,219	1,296
0,258	0,385	0,733	0,724	0,928	1,018	1,108	1,182	1,388	1,457
0,206	0,315	0,420	0,639	0,757	0,907	0,948	1,106	1,246	1,381
0,204	0,302	0,406	0,620	0,711	0,892	0,912	1,085	1,225	1,366
0,221	0,329	0,450	0,664	0,778	0,935	1,000	1,136	1,289	1,422
0,204	0,311	0,438	0,633	0,733	0,895	0,937	1,093	1,227	1,332
0,212	0,326	0,432	0,666	0,780	0,924	0,986	1,130	1,267	1,342
0,208	0,313	0,438	0,635	0,732	0,906	0,942	1,102	1,250	1,333
0,217	0,330	0,441	0,655	0,777	0,929	0,984	1,129	1,284	1,217
0,260	0,381	0,729	0,719	0,917	1,009	1,096	1,177	1,383	1,445
0,210	0,315	0,421	0,649	0,761	0,917	0,956	1,117	1,260	1,295

Table B.1 (cont'd)

f1	f2	f5	f7	f8	f10	f12	f14	f16	f17
0,235	0,346	0,612	0,660	0,823	0,936	0,986	1,121	1,331	1,341
0,248	0,364	0,621	0,688	0,869	0,968	1,039	1,148	1,351	1,390
0,222	0,337	0,457	0,676	0,819	0,941	1,022	1,145	1,294	1,400
0,223	0,337	0,448	0,667	0,807	0,941	1,007	1,142	1,298	1,224
0,231	0,345	0,548	0,680	0,846	0,946	1,036	1,145	1,315	1,424
0,205	0,314	0,501	0,635	0,768	0,895	0,944	1,092	1,233	1,437
0,228	0,347	0,520	0,667	0,821	0,937	1,002	1,135	1,295	1,322
0,247	0,360	0,689	0,685	0,865	0,966	1,035	1,145	1,358	1,369
0,231	0,339	0,602	0,649	0,806	0,921	0,966	1,108	1,308	1,317
0,262	0,385	0,731	0,724	0,926	1,016	1,105	1,182	1,388	1,453
0,215	0,333	0,495	0,648	0,789	0,914	0,967	1,114	1,266	1,268
0,212	0,327	0,480	0,654	0,788	0,914	0,984	1,115	1,262	1,265
0,210	0,323	0,432	0,644	0,753	0,917	0,960	1,116	1,268	1,184
0,207	0,309	0,427	0,628	0,728	0,898	0,928	1,093	1,233	1,369
0,210	0,321	0,437	0,660	0,766	0,921	1,023	1,125	1,263	1,314
0,227	0,339	0,489	0,678	0,813	0,947	1,029	1,148	1,309	1,468
0,205	0,319	0,428	0,645	0,769	0,897	0,961	1,101	1,229	1,336
0,220	0,338	0,446	0,683	0,812	0,943	1,029	1,149	1,292	1,409
0,205	0,310	0,415	0,626	0,738	0,898	0,922	1,094	1,239	1,133
0,212	0,315	0,428	0,638	0,745	0,911	0,950	1,108	1,255	1,431
0,228	0,350	0,486	0,679	0,821	0,953	1,025	1,152	1,316	1,300
0,222	0,336	0,512	0,668	0,824	0,933	1,013	1,131	1,297	1,357
0,206	0,313	0,433	0,624	0,733	0,894	0,919	1,091	1,233	1,158
0,210	0,316	0,424	0,632	0,757	0,904	0,933	1,102	1,250	1,165
0,213	0,320	0,461	0,644	0,762	0,912	0,960	1,110	1,259	1,432
0,211	0,327	0,485	0,653	0,790	0,909	0,982	1,111	1,254	1,272
0,234	0,343	0,674	0,657	0,819	0,931	0,982	1,117	1,321	1,318
0,245	0,355	0,608	0,676	0,850	0,955	1,018	1,137	1,350	1,367
0,231	0,336	0,656	0,648	0,804	0,920	0,964	1,107	1,305	1,293
0,209	0,313	0,424	0,640	0,737	0,908	0,952	1,107	1,247	1,332
0,206	0,317	0,449	0,629	0,744	0,894	0,931	1,093	1,231	1,184
0,234	0,360	0,486	0,699	0,845	0,971	1,064	1,172	1,328	1,329
0,233	0,342	0,487	0,685	0,828	0,957	1,040	1,159	1,323	1,508
0,210	0,309	0,414	0,637	0,731	0,909	0,946	1,106	1,252	1,341
0,203	0,324	0,421	0,648	0,774	0,904	0,971	1,110	1,236	1,470
0,210	0,322	0,435	0,641	0,778	0,910	0,956	1,110	1,253	1,178
0,203	0,313	0,415	0,641	0,748	0,900	0,948	1,102	1,232	1,302
0,228	0,349	0,515	0,679	0,834	0,945	1,033	1,147	1,305	1,336
0,201	0,316	0,447	0,627	0,740	0,884	0,926	1,084	1,210	1,173
0,226	0,340	0,643	0,653	0,815	0,923	0,976	1,108	1,298	1,288
0,235	0,345	0,598	0,660	0,822	0,934	0,985	1,121	1,325	1,326
0,233	0,351	0,467	0,688	0,825	0,961	1,044	1,163	1,320	1,293
0,220	0,339	0,462	0,670	0,796	0,943	1,014	1,145	1,302	1,235
0,202	0,303	0,406	0,631	0,734	0,900	0,922	1,096	1,235	1,264
0,201	0,315	0,492	0,632	0,761	0,889	0,939	1,088	1,222	1,198
0,198	0,305	0,410	0,623	0,730	0,892	0,916	1,087	1,222	1,360
0,207	0,314	0,419	0,646	0,762	0,913	0,954	1,113	1,255	1,309
0,251	0,367	0,636	0,694	0,879	0,976	1,050	1,152	1,360	1,414
0,255	0,382	0,725	0,717	0,920	1,007	1,098	1,172	1,365	1,445
0,217	0,323	0,455	0,650	0,767	0,922	0,972	1,120	1,274	1,447
0,215	0,322	0,526	0,647	0,794	0,912	0,970	1,106	1,274	1,344
0,230	0,350	0,520	0,675	0,832	0,948	1,023	1,147	1,315	1,336
0,261	0,383	0,655	0,718	0,913	1,004	1,089	1,179	1,379	1,454
0,230	0,352	0,508	0,685	0,838	0,957	1,044	1,158	1,322	1,329
0,199	0,306	0,416	0,636	0,729	0,895	0,980	1,095	1,223	1,257
0,239	0,354	0,584	0,672	0,845	0,947	1,012	1,132	1,327	1,336
0,255	0,373	0,709	0,705	0,900	0,991	1,076	1,165	1,374	1,401
0,199	0,303	0,442	0,633	0,743	0,888	0,937	1,091	1,212	1,367
0,229	0,337	0,650	0,649	0,806	0,920	0,966	1,107	1,303	1,290
0,260	0,381	0,679	0,714	0,912	1,003	1,088	1,172	1,381	1,482
0,204	0,307	0,472	0,624	0,741	0,887	0,917	1,078	1,224	1,222
0,259	0,385	0,669	0,722	0,924	1,015	1,103	1,180	1,387	1,484
0,228	0,349	0,466	0,685	0,819	0,960	1,041	1,161	1,322	1,278
0,258	0,376	0,647	0,708	0,901	0,996	1,076	1,168	1,379	1,446

Table B.1 (cont'd)

f1	f2	f5	f7	f8	f10	f12	f14	f16	f17
0,206	0,310	0,417	0,640	0,727	0,912	0,946	1,109	1,255	1,301
0,192	0,298	0,397	0,620	0,710	0,877	0,900	1,073	1,194	1,231
0,204	0,309	0,539	0,629	0,759	0,890	0,931	1,082	1,233	1,253
0,209	0,319	0,411	0,643	0,761	0,910	0,957	1,109	1,251	1,358
0,218	0,333	0,448	0,657	0,781	0,927	0,986	1,129	1,276	1,229
0,208	0,320	0,426	0,655	0,768	0,909	0,971	1,115	1,245	1,328
0,230	0,352	0,522	0,692	0,859	0,962	1,058	1,160	1,333	1,402
0,223	0,330	0,478	0,663	0,793	0,932	0,999	1,132	1,289	1,440
0,247	0,360	0,637	0,682	0,861	0,961	1,030	1,141	1,347	1,396
0,224	0,332	0,447	0,674	0,785	0,943	1,019	1,146	1,297	1,396
0,207	0,311	0,418	0,629	0,730	0,900	0,931	1,097	1,238	1,431
0,257	0,376	0,662	0,706	0,899	0,993	1,074	1,165	1,373	1,453
0,259	0,382	0,667	0,717	0,915	1,008	1,092	1,176	1,388	1,473
0,216	0,330	0,442	0,656	0,802	0,924	0,984	1,126	1,271	1,205
0,212	0,319	0,442	0,650	0,752	0,914	0,970	1,115	1,256	1,326
0,231	0,339	0,552	0,669	0,832	0,938	1,015	1,135	1,313	1,196
0,209	0,327	0,437	0,658	0,800	0,913	0,990	1,117	1,255	1,365
0,254	0,369	0,641	0,698	0,883	0,982	1,056	1,158	1,372	1,421
0,252	0,364	0,633	0,691	0,872	0,973	1,043	1,152	1,367	1,405
0,210	0,311	0,425	0,640	0,737	0,909	0,952	1,107	1,250	1,327
0,245	0,361	0,636	0,681	0,865	0,958	1,035	1,141	1,341	1,389
0,225	0,337	0,468	0,678	0,799	0,945	1,028	1,149	1,302	1,425
0,212	0,327	0,436	0,650	0,780	0,913	0,974	1,117	1,251	1,194
0,239	0,357	0,678	0,677	0,857	0,952	1,025	1,130	1,315	1,356
0,215	0,325	0,446	0,658	0,759	0,926	0,987	1,128	1,275	1,369
0,191	0,298	0,429	0,619	0,710	0,878	0,900	1,073	1,196	1,238
0,238	0,343	0,616	0,655	0,814	0,929	0,977	1,115	1,323	1,341
0,221	0,331	0,455	0,652	0,777	0,926	0,977	1,125	1,283	1,229
0,238	0,343	0,615	0,655	0,814	0,929	0,977	1,116	1,328	1,340
0,233	0,350	0,534	0,687	0,851	0,957	1,048	1,157	1,329	1,391
0,222	0,333	0,441	0,678	0,799	0,946	1,009	1,149	1,300	1,371
0,254	0,374	0,652	0,705	0,895	0,991	1,070	1,164	1,376	1,442
0,257	0,378	0,670	0,709	0,903	0,997	1,078	1,168	1,376	1,466
0,193	0,309	0,483	0,628	0,745	0,882	0,929	1,080	1,206	1,298
0,242	0,355	0,681	0,675	0,850	0,952	1,018	1,133	1,332	1,355
0,200	0,302	0,402	0,624	0,721	0,889	0,913	1,085	1,214	1,255
0,263	0,381	0,658	0,717	0,912	1,006	1,090	1,177	1,391	1,461
0,210	0,320	0,461	0,631	0,753	0,899	0,934	1,097	1,242	1,201
0,261	0,384	0,659	0,721	0,921	1,012	1,099	1,181	1,392	1,469
0,228	0,352	0,466	0,693	0,845	0,966	1,055	1,168	1,327	1,277
0,235	0,340	0,602	0,654	0,812	0,929	0,975	1,116	1,327	1,324
0,209	0,313	0,419	0,641	0,750	0,912	0,948	1,110	1,255	1,322
0,200	0,301	0,437	0,621	0,720	0,890	0,910	1,079	1,222	1,297
0,204	0,321	0,431	0,649	0,782	0,907	0,971	1,112	1,243	1,358
0,199	0,298	0,399	0,621	0,712	0,892	0,902	1,084	1,221	1,241
0,259	0,378	0,671	0,710	0,904	0,998	1,079	1,170	1,385	1,467
0,255	0,377	0,742	0,710	0,907	0,998	1,083	1,167	1,370	1,444
0,236	0,348	0,606	0,664	0,831	0,941	0,995	1,125	1,338	1,344
0,201	0,303	0,415	0,627	0,708	0,896	0,920	1,090	1,227	1,254
0,206	0,313	0,417	0,645	0,755	0,908	0,950	1,109	1,244	1,295
0,223	0,336	0,461	0,674	0,830	0,941	1,020	1,143	1,297	1,405
0,200	0,297	0,398	0,621	0,693	0,887	0,904	1,080	1,210	1,232
0,209	0,311	0,433	0,638	0,735	0,905	0,945	1,102	1,243	1,299
0,200	0,300	0,404	0,624	0,702	0,892	0,914	1,086	1,220	1,252
0,244	0,356	0,625	0,677	0,851	0,954	1,019	1,135	1,339	1,380
0,225	0,348	0,469	0,687	0,845	0,952	1,046	1,155	1,309	1,536
0,226	0,352	0,488	0,689	0,840	0,955	1,046	1,158	1,300	1,298
0,207	0,312	0,416	0,641	0,749	0,914	0,947	1,111	1,258	1,296
0,226	0,344	0,642	0,659	0,825	0,928	0,988	1,112	1,292	1,277
0,208	0,309	0,416	0,631	0,726	0,902	0,934	1,098	1,240	1,352
0,229	0,344	0,548	0,657	0,810	0,927	0,974	1,119	1,288	1,341
0,213	0,313	0,444	0,641	0,749	0,911	0,953	1,108	1,257	1,342
0,204	0,312	0,427	0,639	0,728	0,902	0,946	1,102	1,236	1,312
0,227	0,339	0,543	0,662	0,823	0,930	1,002	1,127	1,298	1,383

Table B.1 (cont'd)

f1	f2	f5	f7	f8	f10	f12	f14	f16	f17
0,238	0,365	0,551	0,696	0,873	0,967	1,062	1,164	1,328	1,409
0,245	0,371	0,682	0,701	0,894	0,982	1,067	1,157	1,345	1,532
0,206	0,314	0,458	0,633	0,751	0,900	0,938	1,095	1,244	1,196
0,254	0,376	0,640	0,707	0,903	0,993	1,078	1,165	1,367	1,440
0,190	0,303	0,486	0,621	0,740	0,872	0,913	1,066	1,192	1,312
0,206	0,310	0,422	0,638	0,732	0,906	0,946	1,104	1,244	1,304
0,196	0,302	0,403	0,622	0,720	0,888	0,911	1,083	1,214	1,287
0,258	0,382	0,670	0,716	0,916	1,006	1,093	1,176	1,387	1,473
0,217	0,323	0,438	0,659	0,764	0,927	0,989	1,129	1,276	1,357
0,198	0,296	0,398	0,620	0,700	0,892	0,907	1,083	1,221	1,257
0,213	0,322	0,431	0,642	0,756	0,916	0,954	1,115	1,268	1,190
0,217	0,326	0,518	0,639	0,781	0,909	0,954	1,104	1,271	1,312
0,240	0,352	0,600	0,670	0,841	0,947	1,007	1,129	1,334	1,354
0,205	0,314	0,425	0,627	0,747	0,893	0,926	1,092	1,225	1,156
0,233	0,344	0,655	0,658	0,823	0,930	0,986	1,114	1,306	1,311
0,214	0,322	0,437	0,639	0,755	0,910	0,953	1,109	1,255	1,189
0,217	0,324	0,451	0,652	0,767	0,922	0,977	1,122	1,273	1,453
0,220	0,342	0,483	0,670	0,808	0,933	1,017	1,136	1,284	1,282
0,220	0,331	0,441	0,673	0,783	0,944	1,019	1,146	1,299	1,397
0,220	0,335	0,527	0,643	0,790	0,908	0,949	1,102	1,258	1,304
0,208	0,309	0,504	0,628	0,758	0,889	0,927	1,080	1,234	1,285
0,246	0,355	0,636	0,673	0,845	0,951	1,012	1,134	1,345	1,385
0,253	0,376	0,658	0,707	0,900	0,993	1,075	1,165	1,371	1,449
0,197	0,295	0,397	0,617	0,710	0,884	0,893	1,076	1,205	1,212
0,255	0,376	0,708	0,710	0,906	0,998	1,082	1,168	1,372	1,412
0,229	0,344	0,628	0,659	0,821	0,929	0,983	1,117	1,299	1,403
0,197	0,299	0,401	0,623	0,725	0,885	0,907	1,081	1,208	1,243
0,213	0,318	0,431	0,643	0,751	0,915	0,957	1,114	1,261	1,460
0,227	0,342	0,506	0,670	0,836	0,938	1,014	1,136	1,310	1,380
0,208	0,312	0,428	0,641	0,733	0,912	0,951	1,109	1,255	1,299
0,232	0,365	0,527	0,695	0,871	0,960	1,061	1,157	1,307	1,396
0,217	0,320	0,430	0,651	0,759	0,923	0,974	1,123	1,272	1,403
0,208	0,318	0,427	0,650	0,767	0,909	0,963	1,113	1,246	1,303
0,221	0,332	0,443	0,669	0,780	0,936	1,010	1,140	1,287	1,432
0,226	0,338	0,450	0,685	0,797	0,954	1,039	1,158	1,311	1,421
0,249	0,368	0,654	0,694	0,880	0,977	1,052	1,154	1,367	1,428
0,213	0,324	0,490	0,650	0,784	0,915	0,975	1,113	1,266	1,284
0,188	0,298	0,407	0,622	0,708	0,875	0,952	1,073	1,191	1,220
0,226	0,337	0,451	0,680	0,796	0,951	1,032	1,154	1,309	1,447
0,237	0,346	0,665	0,662	0,828	0,936	0,992	1,121	1,320	1,322
0,222	0,339	0,452	0,666	0,787	0,935	1,003	1,137	1,282	1,247
0,212	0,331	0,489	0,645	0,794	0,902	0,972	1,103	1,246	1,288
0,209	0,310	0,420	0,637	0,735	0,908	0,945	1,105	1,249	1,338
0,229	0,341	0,650	0,652	0,815	0,920	0,976	1,105	1,285	1,301
0,252	0,372	0,625	0,702	0,892	0,988	1,066	1,160	1,368	1,428
0,205	0,318	0,443	0,638	0,748	0,905	0,949	1,103	1,245	1,430
0,209	0,318	0,426	0,640	0,746	0,909	0,954	1,109	1,249	1,455
0,202	0,303	0,406	0,629	0,727	0,899	0,919	1,094	1,234	1,254
0,215	0,324	0,437	0,644	0,759	0,917	0,960	1,116	1,269	1,196
0,228	0,339	0,562	0,651	0,802	0,925	0,963	1,115	1,308	1,249
0,221	0,330	0,454	0,664	0,779	0,933	1,002	1,135	1,284	1,401
0,255	0,371	0,645	0,700	0,888	0,985	1,061	1,159	1,370	1,430
0,212	0,324	0,450	0,652	0,766	0,921	0,977	1,121	1,269	1,421
0,254	0,381	0,731	0,714	0,917	1,003	1,094	1,168	1,357	1,452
0,207	0,322	0,473	0,638	0,767	0,899	0,951	1,098	1,239	1,228
0,205	0,322	0,428	0,646	0,768	0,913	0,964	1,114	1,255	1,457
0,210	0,326	0,437	0,651	0,762	0,917	0,975	1,119	1,260	1,183
0,219	0,328	0,440	0,661	0,775	0,933	0,996	1,134	1,286	1,437
0,229	0,359	0,512	0,692	0,862	0,959	1,059	1,159	1,321	1,382
0,202	0,305	0,402	0,634	0,726	0,895	0,980	1,095	1,224	1,254
0,203	0,301	0,437	0,620	0,727	0,888	0,908	1,078	1,217	1,314
0,232	0,339	0,590	0,651	0,810	0,924	0,971	1,112	1,319	1,308
0,204	0,317	0,424	0,632	0,753	0,891	0,936	1,094	1,217	1,161
0,220	0,352	0,475	0,692	0,843	0,956	1,054	1,160	1,303	1,290

Table B.1 (cont'd)

f1	f2	f5	f7	f8	f10	f12	f14	f16	f17
0,211	0,315	0,423	0,636	0,740	0,907	0,945	1,105	1,248	1,440
0,247	0,361	0,632	0,684	0,863	0,963	1,032	1,143	1,350	1,395
0,215	0,329	0,527	0,644	0,795	0,901	0,965	1,100	1,253	1,323
0,223	0,331	0,455	0,670	0,788	0,940	1,012	1,142	1,296	1,419
0,197	0,304	0,417	0,627	0,742	0,896	0,920	1,090	1,229	1,258
0,258	0,384	0,680	0,718	0,920	1,010	1,098	1,176	1,382	1,489
0,240	0,348	0,621	0,664	0,830	0,939	0,994	1,124	1,330	1,356
0,211	0,324	0,434	0,656	0,779	0,920	0,982	1,123	1,264	1,384
0,228	0,338	0,452	0,685	0,797	0,957	1,038	1,160	1,317	1,434
0,222	0,344	0,540	0,664	0,827	0,931	1,005	1,130	1,295	1,358
0,196	0,299	0,402	0,621	0,700	0,888	0,908	1,081	1,212	1,254
0,260	0,387	0,643	0,727	0,931	1,020	1,111	1,185	1,391	1,476
0,220	0,345	0,521	0,670	0,829	0,932	1,016	1,133	1,287	1,341
0,258	0,384	0,675	0,718	0,920	1,010	1,098	1,176	1,381	1,484
0,210	0,320	0,429	0,653	0,752	0,919	0,976	1,120	1,262	1,353
0,201	0,309	0,413	0,625	0,738	0,895	0,921	1,092	1,230	1,422
0,234	0,349	0,468	0,687	0,825	0,962	1,041	1,163	1,326	1,286
0,223	0,332	0,444	0,661	0,782	0,935	0,996	1,135	1,292	1,215
0,257	0,378	0,669	0,710	0,904	0,998	1,080	1,168	1,376	1,465
0,247	0,369	0,725	0,695	0,884	0,978	1,057	1,153	1,353	1,409
0,217	0,320	0,433	0,655	0,753	0,927	0,978	1,127	1,279	1,339
0,233	0,339	0,607	0,647	0,805	0,920	0,967	1,109	1,316	1,323
0,205	0,306	0,411	0,633	0,737	0,902	0,928	1,098	1,237	1,271
0,203	0,311	0,432	0,629	0,734	0,897	0,931	1,093	1,232	1,433
0,206	0,322	0,432	0,639	0,765	0,902	0,950	1,105	1,235	1,186
0,230	0,341	0,534	0,675	0,833	0,945	1,024	1,143	1,316	1,389
0,212	0,326	0,440	0,664	0,794	0,928	0,991	1,131	1,275	1,339
0,255	0,371	0,654	0,699	0,886	0,983	1,059	1,158	1,367	1,434
0,248	0,368	0,627	0,693	0,881	0,973	1,053	1,149	1,345	1,409
0,226	0,347	0,475	0,680	0,818	0,953	1,034	1,154	1,313	1,280
0,220	0,328	0,522	0,654	0,804	0,918	0,984	1,115	1,279	1,346
0,216	0,321	0,466	0,649	0,769	0,918	0,971	1,116	1,270	1,405
0,240	0,347	0,620	0,661	0,824	0,937	0,988	1,122	1,335	1,352
0,245	0,366	0,691	0,692	0,879	0,973	1,051	1,148	1,343	1,380
0,232	0,344	0,657	0,660	0,824	0,933	0,987	1,118	1,318	1,314
0,259	0,383	0,700	0,722	0,919	1,009	1,098	1,181	1,377	1,560
0,213	0,319	0,469	0,642	0,779	0,907	0,958	1,102	1,261	1,281
0,218	0,325	0,500	0,652	0,791	0,920	0,976	1,117	1,279	1,304
0,235	0,349	0,608	0,664	0,834	0,937	0,998	1,122	1,316	1,345
0,225	0,332	0,451	0,673	0,786	0,945	1,018	1,147	1,304	1,400
0,229	0,343	0,554	0,662	0,825	0,932	1,001	1,130	1,306	1,235
0,208	0,306	0,410	0,632	0,722	0,905	0,938	1,099	1,244	1,308
0,225	0,345	0,493	0,685	0,828	0,950	1,044	1,152	1,311	1,321
0,206	0,304	0,456	0,624	0,734	0,894	0,917	1,084	1,234	1,391
0,217	0,324	0,434	0,661	0,764	0,931	0,992	1,133	1,283	1,368
0,227	0,339	0,456	0,683	0,797	0,954	1,037	1,157	1,314	1,439
0,214	0,340	0,454	0,667	0,813	0,932	1,005	1,135	1,274	1,251
0,259	0,377	0,671	0,707	0,903	0,993	1,079	1,169	1,384	1,458
0,220	0,338	0,440	0,678	0,811	0,940	1,023	1,145	1,291	1,423
0,204	0,307	0,425	0,627	0,724	0,900	0,924	1,093	1,239	1,360
0,202	0,311	0,416	0,624	0,741	0,887	0,919	1,087	1,212	1,143
0,250	0,369	0,702	0,700	0,889	0,985	1,064	1,158	1,365	1,403
0,206	0,322	0,492	0,636	0,774	0,898	0,945	1,094	1,245	1,266
0,208	0,318	0,489	0,631	0,761	0,901	0,934	1,095	1,255	1,243
0,249	0,378	0,649	0,708	0,911	0,992	1,087	1,165	1,362	1,443
0,225	0,339	0,457	0,667	0,795	0,940	1,005	1,141	1,299	1,245
0,232	0,339	0,584	0,650	0,807	0,924	0,968	1,110	1,316	1,307
0,210	0,322	0,444	0,654	0,750	0,916	0,978	1,118	1,258	1,341
0,226	0,345	0,529	0,664	0,822	0,931	1,003	1,131	1,290	1,337
0,215	0,324	0,434	0,662	0,757	0,925	0,992	1,129	1,270	1,361
0,222	0,330	0,441	0,672	0,771	0,943	1,011	1,145	1,298	1,372
0,198	0,297	0,400	0,619	0,698	0,892	0,905	1,082	1,221	1,258
0,229	0,343	0,489	0,685	0,820	0,954	1,041	1,156	1,315	1,486
0,209	0,322	0,443	0,643	0,756	0,909	0,960	1,110	1,250	1,176

Table B.1 (cont'd)

f1	f2	f5	f7	f8	f10	f12	f14	f16	f17
0,209	0,328	0,437	0,647	0,779	0,910	0,964	1,114	1,246	1,207
0,216	0,319	0,426	0,654	0,757	0,927	0,980	1,126	1,277	1,362
0,255	0,375	0,664	0,704	0,893	0,989	1,068	1,164	1,374	1,457
0,192	0,298	0,404	0,619	0,716	0,879	0,901	1,074	1,198	1,225
0,224	0,336	0,450	0,678	0,813	0,947	1,020	1,150	1,304	1,387
0,232	0,346	0,665	0,660	0,827	0,931	0,990	1,115	1,301	1,320
0,238	0,347	0,622	0,661	0,825	0,937	0,989	1,123	1,335	1,357
0,246	0,370	0,703	0,698	0,889	0,981	1,062	1,153	1,349	1,402
0,243	0,357	0,664	0,679	0,854	0,956	1,022	1,139	1,338	1,319
0,206	0,306	0,411	0,634	0,717	0,902	0,935	1,099	1,237	1,271
0,223	0,338	0,467	0,671	0,810	0,938	1,018	1,139	1,297	1,301
0,231	0,341	0,600	0,653	0,813	0,924	0,974	1,110	1,307	1,322
0,237	0,349	0,603	0,664	0,832	0,938	0,997	1,121	1,317	1,346
0,242	0,362	0,613	0,685	0,867	0,964	1,037	1,142	1,341	1,392
0,236	0,351	0,683	0,668	0,839	0,940	1,004	1,123	1,311	1,343
0,221	0,327	0,436	0,668	0,772	0,936	1,006	1,140	1,288	1,370
0,201	0,307	0,400	0,628	0,732	0,892	0,924	1,089	1,222	1,295
0,213	0,329	0,461	0,670	0,787	0,928	1,055	1,134	1,272	1,348
0,259	0,384	0,658	0,719	0,919	1,007	1,096	1,177	1,373	1,461
0,204	0,312	0,419	0,639	0,751	0,909	0,945	1,107	1,251	1,326
0,192	0,310	0,407	0,623	0,735	0,877	0,920	1,080	1,194	1,130
0,192	0,303	0,405	0,621	0,727	0,878	0,912	1,076	1,195	1,302
0,208	0,312	0,418	0,643	0,736	0,915	0,956	1,112	1,260	1,313
0,236	0,351	0,674	0,668	0,841	0,941	1,006	1,122	1,310	1,342
0,244	0,353	0,633	0,670	0,839	0,947	1,006	1,131	1,343	1,379
0,238	0,352	0,620	0,668	0,838	0,942	1,003	1,125	1,321	1,363
0,245	0,361	0,604	0,686	0,859	0,963	1,029	1,148	1,342	1,341
0,215	0,323	0,490	0,648	0,793	0,907	0,973	1,104	1,260	1,315
0,241	0,360	0,680	0,682	0,863	0,958	1,032	1,136	1,325	1,358
0,234	0,344	0,601	0,658	0,819	0,933	0,982	1,119	1,329	1,329
0,241	0,349	0,623	0,663	0,829	0,939	0,993	1,124	1,334	1,361
0,194	0,307	0,440	0,623	0,729	0,879	0,918	1,079	1,198	1,335
0,247	0,363	0,700	0,687	0,869	0,968	1,039	1,146	1,350	1,385
0,233	0,339	0,604	0,650	0,806	0,922	0,967	1,109	1,312	1,320
0,258	0,382	0,732	0,719	0,919	1,011	1,097	1,178	1,387	1,452
0,252	0,369	0,728	0,698	0,885	0,981	1,058	1,156	1,361	1,415
0,206	0,323	0,426	0,653	0,773	0,909	0,978	1,115	1,244	1,366
0,219	0,333	0,486	0,666	0,802	0,928	1,006	1,130	1,281	1,494
0,207	0,315	0,424	0,636	0,733	0,908	0,943	1,105	1,252	1,432
0,230	0,337	0,591	0,648	0,805	0,921	0,965	1,109	1,315	1,303
0,213	0,320	0,471	0,645	0,769	0,910	0,964	1,108	1,257	1,433
0,251	0,372	0,702	0,703	0,896	0,988	1,071	1,160	1,358	1,400
0,261	0,381	0,743	0,717	0,915	1,008	1,093	1,176	1,386	1,456
0,246	0,370	0,656	0,694	0,887	0,975	1,060	1,154	1,358	1,424
0,230	0,341	0,606	0,651	0,810	0,923	0,971	1,109	1,308	1,324
0,215	0,329	0,448	0,666	0,778	0,932	1,004	1,135	1,282	1,409
0,228	0,344	0,462	0,685	0,807	0,956	1,042	1,160	1,316	1,508
0,209	0,319	0,497	0,634	0,769	0,902	0,942	1,096	1,255	1,266
0,214	0,318	0,495	0,641	0,772	0,907	0,954	1,101	1,258	1,292
0,227	0,353	0,495	0,688	0,832	0,960	1,049	1,161	1,322	1,310
0,199	0,307	0,440	0,622	0,728	0,883	0,916	1,078	1,209	1,409
0,246	0,366	0,623	0,691	0,877	0,971	1,049	1,147	1,341	1,408
0,247	0,364	0,645	0,687	0,871	0,967	1,042	1,147	1,356	1,408
0,224	0,346	0,482	0,663	0,807	0,932	0,985	1,127	1,277	1,294
0,197	0,305	0,433	0,622	0,727	0,874	0,915	1,069	1,197	1,367
0,217	0,331	0,446	0,669	0,801	0,939	1,004	1,141	1,296	1,368
0,216	0,318	0,466	0,645	0,762	0,915	0,960	1,112	1,267	1,440
0,250	0,367	0,640	0,693	0,874	0,974	1,046	1,154	1,360	1,412
0,254	0,367	0,656	0,692	0,874	0,974	1,045	1,152	1,366	1,432
0,212	0,316	0,434	0,646	0,744	0,913	0,962	1,113	1,256	1,315
0,202	0,300	0,430	0,620	0,714	0,890	0,907	1,080	1,222	1,270
0,218	0,332	0,450	0,652	0,787	0,924	0,973	1,123	1,277	1,230
0,213	0,321	0,447	0,636	0,753	0,906	0,942	1,105	1,252	1,193
0,218	0,338	0,523	0,660	0,816	0,928	0,998	1,126	1,291	1,334

Table B.1 (cont'd)

f1	f2	f5	f7	f8	f10	f12	f14	f16	f17
0,205	0,304	0,411	0,632	0,710	0,903	0,927	1,098	1,240	1,267
0,254	0,372	0,663	0,699	0,887	0,983	1,060	1,159	1,371	1,448
0,205	0,312	0,416	0,641	0,746	0,902	0,944	1,103	1,235	1,282
0,227	0,341	0,455	0,682	0,801	0,951	1,036	1,155	1,308	1,481
0,208	0,312	0,423	0,635	0,736	0,904	0,938	1,102	1,243	1,416
0,212	0,315	0,427	0,646	0,748	0,918	0,965	1,116	1,264	1,350
0,211	0,332	0,456	0,657	0,800	0,918	0,989	1,122	1,261	1,215
0,231	0,341	0,662	0,653	0,814	0,923	0,975	1,109	1,298	1,305
0,212	0,320	0,419	0,648	0,765	0,917	0,967	1,118	1,260	1,364
0,215	0,318	0,456	0,645	0,758	0,916	0,961	1,113	1,267	1,369
0,199	0,311	0,416	0,624	0,741	0,883	0,919	1,085	1,206	1,141
0,224	0,340	0,645	0,651	0,812	0,919	0,973	1,104	1,286	1,292
0,242	0,354	0,632	0,670	0,842	0,947	1,008	1,131	1,342	1,380
0,260	0,388	0,672	0,724	0,930	1,015	1,108	1,182	1,380	1,484
0,213	0,312	0,420	0,643	0,741	0,916	0,956	1,113	1,262	1,358
0,205	0,316	0,447	0,630	0,742	0,898	0,933	1,094	1,238	1,177
0,235	0,340	0,606	0,651	0,808	0,925	0,969	1,112	1,319	1,324
0,202	0,320	0,431	0,640	0,765	0,903	0,954	1,105	1,238	1,158
0,216	0,332	0,441	0,658	0,793	0,928	0,989	1,130	1,277	1,211
0,228	0,340	0,645	0,654	0,814	0,927	0,977	1,113	1,315	1,290
0,201	0,301	0,420	0,624	0,707	0,896	0,914	1,087	1,230	1,249
0,205	0,308	0,433	0,633	0,730	0,903	0,933	1,098	1,244	1,309
0,194	0,298	0,399	0,619	0,712	0,876	0,902	1,073	1,192	1,241
0,208	0,309	0,436	0,630	0,734	0,902	0,930	1,096	1,243	1,377
0,257	0,379	0,719	0,714	0,912	1,003	1,089	1,171	1,376	1,432
0,222	0,347	0,463	0,686	0,836	0,951	1,041	1,154	1,295	1,289
0,223	0,340	0,460	0,685	0,796	0,953	1,039	1,157	1,310	1,415
0,196	0,313	0,427	0,631	0,752	0,886	0,935	1,087	1,211	1,370
0,218	0,321	0,451	0,653	0,766	0,924	0,977	1,123	1,276	1,373
0,252	0,366	0,654	0,690	0,873	0,972	1,044	1,150	1,360	1,426
0,228	0,340	0,595	0,650	0,809	0,920	0,970	1,107	1,298	1,313
0,202	0,317	0,450	0,638	0,748	0,896	0,949	1,096	1,229	1,400
0,236	0,349	0,607	0,664	0,836	0,936	1,001	1,120	1,311	1,347
0,244	0,362	0,685	0,687	0,868	0,966	1,038	1,145	1,346	1,364
0,227	0,354	0,466	0,688	0,846	0,959	1,048	1,161	1,319	1,298
0,199	0,301	0,403	0,627	0,721	0,888	0,911	1,085	1,212	1,240
0,240	0,364	0,558	0,694	0,877	0,966	1,060	1,161	1,338	1,437
0,225	0,338	0,468	0,681	0,803	0,949	1,032	1,152	1,307	1,432
0,211	0,321	0,452	0,649	0,757	0,911	0,971	1,112	1,255	1,356
0,245	0,354	0,633	0,672	0,842	0,949	1,009	1,132	1,342	1,382
0,242	0,358	0,598	0,680	0,856	0,958	1,025	1,139	1,342	1,365
0,211	0,322	0,430	0,657	0,779	0,915	0,979	1,120	1,254	1,338
0,214	0,336	0,487	0,659	0,800	0,926	0,994	1,126	1,280	1,275
0,211	0,335	0,438	0,661	0,797	0,919	0,995	1,125	1,255	1,228
0,205	0,325	0,425	0,664	0,777	0,917	1,045	1,124	1,257	1,338
0,230	0,344	0,645	0,659	0,824	0,930	0,988	1,114	1,304	1,290
0,215	0,333	0,510	0,650	0,799	0,911	0,977	1,112	1,262	1,302
0,212	0,327	0,439	0,663	0,790	0,922	0,992	1,127	1,266	1,344
0,215	0,328	0,439	0,668	0,769	0,935	1,004	1,138	1,286	1,374
0,217	0,340	0,452	0,679	0,826	0,940	1,029	1,145	1,287	1,505
0,227	0,349	0,528	0,687	0,852	0,944	1,050	1,146	1,303	1,396
0,256	0,376	0,658	0,707	0,901	0,994	1,076	1,164	1,368	1,453
0,223	0,344	0,459	0,676	0,808	0,948	1,022	1,150	1,305	1,268
0,214	0,333	0,452	0,656	0,796	0,920	0,987	1,124	1,263	1,219
0,246	0,357	0,641	0,675	0,849	0,954	1,018	1,136	1,349	1,396
0,218	0,334	0,446	0,659	0,785	0,931	0,991	1,131	1,283	1,236
0,214	0,317	0,473	0,641	0,763	0,909	0,952	1,104	1,258	1,456
0,198	0,300	0,409	0,622	0,704	0,890	0,910	1,083	1,218	1,265
0,201	0,301	0,404	0,627	0,699	0,894	0,917	1,089	1,223	1,251
0,213	0,316	0,497	0,639	0,773	0,907	0,951	1,100	1,262	1,286
0,219	0,333	0,439	0,673	0,804	0,938	1,010	1,142	1,291	1,364
0,215	0,333	0,446	0,674	0,805	0,937	1,010	1,142	1,287	1,367
0,262	0,379	0,675	0,710	0,904	0,998	1,080	1,171	1,386	1,476
0,203	0,297	0,399	0,622	0,706	0,893	0,911	1,085	1,223	1,274

Table B.1 (cont'd)

f1	f2	f5	f7	f8	f10	f12	f14	f16	f17
0,203	0,314	0,427	0,625	0,747	0,894	0,920	1,091	1,230	1,157
0,231	0,341	0,591	0,652	0,812	0,923	0,973	1,110	1,304	1,315
0,216	0,327	0,466	0,659	0,779	0,925	0,989	1,126	1,276	1,405
0,208	0,315	0,433	0,642	0,738	0,911	0,953	1,110	1,255	1,363
0,208	0,311	0,471	0,631	0,753	0,897	0,929	1,090	1,241	1,228
0,222	0,332	0,446	0,670	0,785	0,943	1,014	1,144	1,300	1,431
0,236	0,359	0,479	0,699	0,838	0,974	1,062	1,174	1,336	1,323
0,203	0,315	0,451	0,628	0,745	0,889	0,929	1,086	1,221	1,183
0,202	0,316	0,442	0,640	0,742	0,896	0,954	1,098	1,228	1,339
0,243	0,364	0,685	0,690	0,875	0,971	1,047	1,148	1,349	1,362
0,245	0,364	0,638	0,689	0,872	0,970	1,042	1,147	1,352	1,409
0,204	0,312	0,460	0,635	0,752	0,896	0,942	1,093	1,235	1,413
0,221	0,336	0,450	0,666	0,819	0,939	1,004	1,140	1,296	1,216
0,218	0,325	0,436	0,662	0,763	0,927	0,995	1,131	1,274	1,354
0,245	0,354	0,634	0,673	0,843	0,951	1,010	1,134	1,348	1,382
0,204	0,304	0,410	0,623	0,715	0,895	0,917	1,088	1,229	1,345
0,205	0,313	0,412	0,642	0,747	0,906	0,948	1,107	1,243	1,302
0,202	0,308	0,429	0,622	0,749	0,892	0,914	1,085	1,229	1,407
0,201	0,296	0,399	0,620	0,700	0,888	0,908	1,080	1,211	1,240
0,192	0,299	0,388	0,621	0,712	0,885	0,905	1,080	1,207	1,237
0,202	0,302	0,416	0,623	0,740	0,892	0,912	1,083	1,222	1,244
0,259	0,377	0,671	0,708	0,900	0,995	1,075	1,168	1,381	1,467
0,205	0,318	0,496	0,635	0,777	0,885	0,946	1,082	1,227	1,294
0,201	0,298	0,400	0,622	0,700	0,890	0,909	1,084	1,218	1,255
0,212	0,315	0,423	0,638	0,743	0,911	0,948	1,108	1,257	1,434
0,228	0,336	0,452	0,672	0,796	0,946	1,019	1,148	1,306	1,518
0,260	0,377	0,670	0,709	0,901	0,997	1,076	1,169	1,384	1,463
0,203	0,313	0,449	0,635	0,745	0,894	0,942	1,092	1,227	1,360
0,245	0,362	0,644	0,685	0,864	0,966	1,034	1,145	1,357	1,407
0,250	0,366	0,650	0,690	0,873	0,971	1,044	1,148	1,352	1,421
0,227	0,340	0,546	0,667	0,829	0,934	1,011	1,132	1,304	1,395
0,246	0,362	0,695	0,686	0,868	0,965	1,038	1,144	1,340	1,375
0,226	0,348	0,483	0,680	0,839	0,945	1,038	1,146	1,306	1,352
0,265	0,386	0,689	0,722	0,921	1,014	1,100	1,182	1,397	1,504
0,213	0,316	0,429	0,648	0,744	0,920	0,965	1,119	1,267	1,330
0,229	0,351	0,509	0,678	0,830	0,951	1,027	1,150	1,315	1,325
0,196	0,305	0,429	0,627	0,727	0,880	0,920	1,080	1,200	1,285
0,257	0,385	0,675	0,719	0,923	1,010	1,100	1,177	1,380	1,483
0,221	0,335	0,477	0,669	0,800	0,940	1,010	1,141	1,300	1,494
0,225	0,336	0,456	0,678	0,792	0,947	1,025	1,150	1,305	1,438
0,219	0,338	0,515	0,667	0,811	0,931	1,009	1,134	1,282	1,244
0,229	0,344	0,499	0,684	0,826	0,952	1,041	1,153	1,314	1,511
0,198	0,303	0,415	0,623	0,713	0,889	0,916	1,084	1,217	1,305
0,206	0,308	0,411	0,635	0,736	0,902	0,931	1,099	1,237	1,265
0,213	0,314	0,422	0,641	0,742	0,914	0,957	1,112	1,260	1,373
0,210	0,311	0,463	0,633	0,747	0,900	0,938	1,094	1,242	1,408
0,203	0,303	0,406	0,630	0,732	0,901	0,917	1,095	1,237	1,243
0,234	0,354	0,473	0,693	0,856	0,969	1,051	1,168	1,332	1,304
0,259	0,384	0,741	0,722	0,926	1,015	1,105	1,180	1,387	1,464
0,259	0,377	0,738	0,712	0,904	0,999	1,080	1,171	1,382	1,436
0,232	0,347	0,602	0,661	0,829	0,933	0,992	1,118	1,312	1,338
0,220	0,329	0,443	0,669	0,795	0,941	1,000	1,142	1,298	1,354
0,237	0,346	0,617	0,659	0,823	0,934	0,986	1,119	1,324	1,346
0,231	0,342	0,575	0,654	0,814	0,924	0,976	1,111	1,302	1,307
0,242	0,360	0,632	0,681	0,859	0,959	1,028	1,139	1,340	1,390
0,226	0,329	0,440	0,672	0,784	0,944	1,016	1,146	1,301	1,407
0,203	0,316	0,434	0,631	0,758	0,901	0,935	1,097	1,245	1,173
0,254	0,370	0,643	0,700	0,886	0,984	1,059	1,160	1,375	1,426
0,229	0,340	0,453	0,684	0,803	0,957	1,039	1,160	1,319	1,488
0,216	0,325	0,431	0,664	0,779	0,932	0,986	1,134	1,282	1,341
0,202	0,315	0,415	0,630	0,746	0,888	0,931	1,091	1,212	1,160
0,209	0,315	0,419	0,649	0,754	0,920	0,955	1,119	1,266	1,299
0,195	0,296	0,406	0,617	0,690	0,881	0,897	1,073	1,201	1,223
0,238	0,346	0,619	0,658	0,820	0,932	0,984	1,118	1,326	1,349

Table B.1 (cont'd)

f1	f2	f5	f7	f8	f10	f12	f14	f16	f17
0,202	0,300	0,409	0,623	0,704	0,892	0,912	1,085	1,221	1,251
0,220	0,329	0,447	0,669	0,773	0,940	1,006	1,142	1,298	1,378
0,196	0,300	0,434	0,626	0,732	0,880	0,923	1,081	1,200	1,347
0,258	0,375	0,671	0,705	0,895	0,991	1,070	1,165	1,379	1,465
0,241	0,352	0,626	0,670	0,839	0,947	1,006	1,132	1,343	1,373
0,242	0,363	0,682	0,688	0,871	0,968	1,042	1,146	1,345	1,361
0,233	0,351	0,549	0,679	0,852	0,949	1,034	1,147	1,323	1,403
0,256	0,380	0,662	0,712	0,907	0,997	1,083	1,172	1,377	1,458
0,204	0,305	0,415	0,626	0,720	0,899	0,923	1,092	1,235	1,333
0,248	0,360	0,636	0,681	0,858	0,960	1,026	1,142	1,354	1,393
0,214	0,323	0,515	0,635	0,774	0,903	0,944	1,098	1,261	1,148
0,215	0,325	0,437	0,646	0,761	0,918	0,963	1,118	1,268	1,197
0,199	0,302	0,405	0,629	0,707	0,898	0,922	1,092	1,229	1,260
0,220	0,338	0,491	0,657	0,799	0,927	0,985	1,126	1,285	1,279
0,208	0,324	0,448	0,636	0,776	0,897	0,945	1,098	1,234	1,211
0,217	0,332	0,443	0,671	0,807	0,935	1,010	1,140	1,284	1,405
0,256	0,369	0,656	0,697	0,882	0,981	1,054	1,157	1,371	1,435
0,211	0,324	0,437	0,644	0,757	0,917	0,959	1,116	1,267	1,193
0,243	0,353	0,628	0,673	0,843	0,950	1,011	1,133	1,338	1,376
0,214	0,327	0,436	0,661	0,761	0,927	0,994	1,131	1,274	1,395
0,222	0,332	0,530	0,662	0,820	0,926	1,000	1,123	1,293	1,374
0,209	0,310	0,499	0,630	0,760	0,896	0,930	1,086	1,248	1,279
0,252	0,368	0,657	0,694	0,879	0,977	1,051	1,153	1,362	1,432
0,234	0,367	0,550	0,700	0,880	0,969	1,069	1,166	1,332	1,424
0,221	0,342	0,454	0,684	0,823	0,952	1,037	1,156	1,309	1,441
0,207	0,313	0,420	0,633	0,751	0,905	0,936	1,101	1,247	1,396
0,214	0,320	0,428	0,645	0,752	0,914	0,964	1,114	1,258	1,446
0,224	0,337	0,447	0,683	0,818	0,954	1,027	1,157	1,314	1,398
0,219	0,331	0,524	0,651	0,807	0,917	0,980	1,113	1,284	1,347
0,250	0,373	0,640	0,702	0,895	0,986	1,069	1,158	1,354	1,436
0,210	0,325	0,441	0,649	0,780	0,919	0,971	1,118	1,270	1,437
0,191	0,298	0,400	0,620	0,714	0,874	0,901	1,071	1,189	1,226
0,212	0,314	0,457	0,640	0,759	0,911	0,950	1,106	1,259	1,384
0,199	0,315	0,418	0,639	0,751	0,897	0,949	1,099	1,227	1,322
0,205	0,302	0,415	0,626	0,717	0,896	0,920	1,089	1,228	1,294
0,210	0,333	0,450	0,654	0,798	0,918	0,979	1,121	1,257	1,228
0,261	0,378	0,675	0,711	0,903	0,999	1,079	1,171	1,386	1,473
0,205	0,314	0,429	0,628	0,733	0,898	0,927	1,096	1,238	1,158
0,243	0,358	0,606	0,678	0,859	0,956	1,028	1,140	1,351	1,358
0,214	0,321	0,504	0,645	0,783	0,910	0,964	1,105	1,264	1,306
0,244	0,362	0,684	0,687	0,871	0,966	1,042	1,143	1,338	1,365
0,255	0,373	0,660	0,703	0,891	0,988	1,065	1,163	1,378	1,445
0,216	0,332	0,442	0,667	0,802	0,930	1,006	1,135	1,276	1,421
0,202	0,309	0,419	0,629	0,740	0,897	0,929	1,093	1,231	1,327
0,203	0,318	0,424	0,638	0,757	0,901	0,949	1,102	1,235	1,405
0,224	0,334	0,520	0,663	0,813	0,929	1,000	1,127	1,291	1,348
0,217	0,319	0,428	0,652	0,757	0,924	0,974	1,124	1,275	1,398
0,229	0,357	0,484	0,691	0,830	0,962	1,045	1,161	1,313	1,320
0,214	0,338	0,449	0,673	0,811	0,929	1,019	1,136	1,271	1,453
0,200	0,307	0,421	0,622	0,735	0,888	0,914	1,082	1,218	1,370
0,252	0,364	0,652	0,687	0,866	0,968	1,036	1,147	1,362	1,421
0,244	0,358	0,638	0,678	0,853	0,958	1,021	1,139	1,353	1,392
0,202	0,298	0,408	0,621	0,694	0,893	0,905	1,084	1,225	1,230
0,236	0,356	0,498	0,692	0,840	0,967	1,055	1,167	1,331	1,323
0,221	0,334	0,486	0,668	0,805	0,932	1,009	1,133	1,289	1,286
0,233	0,358	0,546	0,684	0,861	0,953	1,043	1,151	1,322	1,407
0,228	0,341	0,639	0,654	0,818	0,921	0,979	1,106	1,284	1,276
0,220	0,324	0,529	0,647	0,792	0,914	0,968	1,108	1,279	1,143
0,213	0,334	0,455	0,661	0,810	0,928	0,997	1,131	1,277	1,211
0,194	0,300	0,408	0,624	0,715	0,875	0,908	1,075	1,193	1,247
0,227	0,342	0,467	0,669	0,805	0,944	1,006	1,143	1,303	1,271
0,212	0,326	0,448	0,667	0,777	0,930	1,036	1,134	1,277	1,331
0,240	0,353	0,596	0,672	0,846	0,948	1,013	1,131	1,335	1,351
0,221	0,346	0,511	0,682	0,851	0,939	1,042	1,139	1,298	1,401

Table B.1 (cont'd)

f1	f2	f5	f7	f8	f10	f12	f14	f16	f17
0,228	0,353	0,468	0,689	0,843	0,958	1,042	1,158	1,306	1,304
0,243	0,365	0,705	0,689	0,874	0,969	1,045	1,144	1,337	1,395
0,217	0,326	0,535	0,638	0,785	0,907	0,951	1,101	1,275	1,328
0,222	0,332	0,482	0,664	0,796	0,931	1,000	1,132	1,287	1,494
0,205	0,312	0,423	0,641	0,746	0,904	0,947	1,105	1,238	1,312
0,254	0,371	0,665	0,698	0,885	0,982	1,060	1,159	1,374	1,452
0,205	0,307	0,422	0,634	0,728	0,904	0,939	1,100	1,242	1,307
0,229	0,339	0,640	0,652	0,811	0,923	0,972	1,111	1,307	1,276
0,214	0,326	0,437	0,664	0,786	0,935	0,990	1,136	1,289	1,348
0,200	0,307	0,424	0,629	0,761	0,891	0,928	1,086	1,223	1,334
0,215	0,320	0,477	0,646	0,772	0,914	0,965	1,111	1,265	1,454
0,230	0,339	0,460	0,684	0,800	0,957	1,038	1,159	1,320	1,427
0,233	0,348	0,663	0,665	0,833	0,939	0,997	1,123	1,322	1,325
0,240	0,362	0,685	0,686	0,872	0,964	1,043	1,140	1,327	1,373
0,199	0,306	0,416	0,632	0,744	0,896	0,929	1,094	1,228	1,271
0,229	0,345	0,460	0,679	0,809	0,953	1,029	1,155	1,313	1,268
0,253	0,367	0,656	0,692	0,875	0,975	1,046	1,153	1,369	1,431
0,210	0,313	0,420	0,644	0,737	0,910	0,957	1,110	1,250	1,317
0,201	0,315	0,425	0,642	0,764	0,899	0,955	1,100	1,232	1,294
0,234	0,352	0,597	0,668	0,840	0,941	1,005	1,123	1,314	1,353
0,230	0,338	0,648	0,650	0,808	0,921	0,969	1,107	1,303	1,290
0,227	0,339	0,451	0,678	0,798	0,950	1,029	1,153	1,309	1,505
0,249	0,366	0,700	0,694	0,879	0,977	1,052	1,152	1,358	1,394
0,206	0,309	0,420	0,637	0,725	0,907	0,942	1,104	1,247	1,291
0,242	0,353	0,622	0,672	0,843	0,950	1,010	1,132	1,342	1,368
0,197	0,297	0,398	0,622	0,721	0,892	0,902	1,085	1,221	1,229
0,219	0,329	0,440	0,669	0,794	0,937	0,998	1,140	1,289	1,352
0,256	0,375	0,663	0,706	0,897	0,993	1,071	1,166	1,381	1,454
0,235	0,359	0,533	0,688	0,854	0,962	1,044	1,159	1,330	1,372
0,231	0,340	0,642	0,654	0,815	0,926	0,977	1,112	1,311	1,288
0,231	0,360	0,468	0,702	0,858	0,976	1,065	1,174	1,332	1,331
0,212	0,318	0,574	0,642	0,782	0,906	0,958	1,100	1,261	1,297
0,223	0,331	0,464	0,669	0,790	0,938	1,009	1,140	1,295	1,412
0,198	0,315	0,432	0,634	0,750	0,889	0,942	1,093	1,213	1,414
0,225	0,347	0,522	0,678	0,836	0,941	1,031	1,143	1,299	1,351
0,226	0,340	0,470	0,682	0,796	0,948	1,033	1,152	1,305	1,427
0,205	0,302	0,411	0,628	0,713	0,898	0,924	1,092	1,231	1,261
0,211	0,323	0,432	0,642	0,749	0,912	0,957	1,112	1,256	1,184
0,199	0,302	0,427	0,623	0,715	0,886	0,914	1,079	1,211	1,272
0,230	0,345	0,489	0,678	0,818	0,951	1,030	1,152	1,315	1,281
0,248	0,363	0,646	0,684	0,865	0,964	1,034	1,144	1,351	1,410
0,251	0,373	0,728	0,701	0,895	0,985	1,068	1,157	1,352	1,425
0,260	0,388	0,653	0,723	0,931	1,016	1,109	1,179	1,370	1,480
0,269	0,391	0,697	0,730	0,933	1,025	1,114	1,190	1,404	1,523
0,239	0,352	0,661	0,672	0,843	0,949	1,010	1,132	1,336	1,322
0,228	0,340	0,453	0,686	0,799	0,956	1,041	1,160	1,315	1,455
0,202	0,308	0,491	0,625	0,752	0,883	0,921	1,073	1,220	1,263
0,214	0,321	0,446	0,653	0,760	0,922	0,977	1,121	1,270	1,343
0,203	0,311	0,419	0,631	0,729	0,904	0,933	1,100	1,245	1,423
0,211	0,323	0,501	0,632	0,770	0,896	0,939	1,094	1,243	1,259
0,205	0,307	0,431	0,629	0,722	0,899	0,926	1,092	1,236	1,301
0,207	0,317	0,424	0,633	0,741	0,907	0,937	1,104	1,256	1,170
0,252	0,370	0,697	0,700	0,890	0,985	1,064	1,158	1,360	1,390
0,212	0,340	0,483	0,665	0,806	0,921	1,005	1,128	1,261	1,238
0,218	0,330	0,445	0,666	0,778	0,933	1,005	1,136	1,283	1,402
0,242	0,351	0,629	0,666	0,832	0,942	0,998	1,126	1,338	1,370
0,246	0,360	0,642	0,681	0,858	0,960	1,027	1,141	1,349	1,402
0,216	0,321	0,513	0,646	0,791	0,907	0,965	1,102	1,264	1,327
0,219	0,335	0,479	0,669	0,808	0,935	1,012	1,136	1,296	1,302
0,239	0,352	0,604	0,670	0,841	0,945	1,006	1,128	1,327	1,354
0,267	0,388	0,691	0,725	0,926	1,018	1,106	1,185	1,398	1,512
0,235	0,345	0,615	0,659	0,821	0,934	0,985	1,120	1,328	1,345
0,247	0,359	0,643	0,679	0,854	0,958	1,023	1,140	1,354	1,403
0,226	0,344	0,465	0,684	0,840	0,950	1,039	1,154	1,304	1,478

Table B.1 (cont'd)

f1	f2	f5	f7	f8	f10	f12	f14	f16	f17
0,260	0,386	0,743	0,724	0,929	1,018	1,109	1,183	1,391	1,464
0,231	0,338	0,579	0,651	0,807	0,925	0,968	1,112	1,323	1,305
0,203	0,306	0,438	0,627	0,728	0,889	0,924	1,084	1,218	1,302
0,241	0,348	0,618	0,663	0,828	0,939	0,992	1,124	1,333	1,353
0,217	0,324	0,513	0,649	0,791	0,917	0,972	1,112	1,278	1,331
0,244	0,355	0,631	0,674	0,847	0,952	1,014	1,135	1,344	1,379
0,218	0,319	0,428	0,655	0,760	0,927	0,982	1,127	1,277	1,372
0,201	0,306	0,420	0,629	0,749	0,889	0,925	1,087	1,217	1,273
0,203	0,304	0,413	0,631	0,715	0,895	0,929	1,092	1,224	1,266
0,261	0,385	0,632	0,724	0,923	1,014	1,102	1,184	1,391	1,446
0,257	0,376	0,657	0,706	0,898	0,991	1,072	1,165	1,367	1,446
0,207	0,314	0,445	0,627	0,738	0,897	0,925	1,092	1,240	1,170
0,244	0,353	0,629	0,672	0,841	0,950	1,008	1,133	1,348	1,373
0,217	0,331	0,447	0,654	0,776	0,923	0,980	1,125	1,270	1,218
0,206	0,315	0,442	0,637	0,740	0,903	0,944	1,101	1,242	1,388
0,235	0,342	0,601	0,655	0,816	0,928	0,978	1,114	1,316	1,325
0,229	0,344	0,534	0,678	0,839	0,943	1,031	1,143	1,308	1,384
0,232	0,348	0,518	0,683	0,842	0,954	1,041	1,154	1,325	1,363
0,218	0,326	0,437	0,666	0,793	0,936	0,995	1,138	1,289	1,359
0,218	0,336	0,468	0,674	0,793	0,936	1,020	1,141	1,288	1,410
0,228	0,336	0,450	0,682	0,800	0,954	1,034	1,157	1,314	1,459
0,209	0,326	0,489	0,639	0,775	0,904	0,952	1,103	1,253	1,252
0,240	0,348	0,606	0,665	0,832	0,941	0,997	1,125	1,331	1,347
0,254	0,371	0,660	0,698	0,887	0,981	1,060	1,159	1,373	1,441
0,213	0,340	0,490	0,667	0,809	0,923	1,009	1,130	1,263	1,235
0,211	0,322	0,427	0,660	0,770	0,921	1,031	1,125	1,263	1,319
0,226	0,341	0,634	0,654	0,813	0,924	0,975	1,113	1,299	1,397
0,223	0,344	0,453	0,672	0,831	0,939	1,019	1,141	1,295	1,284
0,206	0,319	0,464	0,635	0,755	0,901	0,942	1,101	1,238	1,172
0,220	0,337	0,463	0,679	0,798	0,945	1,029	1,149	1,300	1,428
0,224	0,344	0,486	0,687	0,818	0,957	1,046	1,158	1,320	1,457
0,222	0,331	0,457	0,670	0,784	0,943	1,010	1,144	1,302	1,404
0,253	0,373	0,663	0,701	0,891	0,987	1,064	1,161	1,375	1,447
0,250	0,369	0,716	0,698	0,886	0,983	1,059	1,157	1,365	1,412
0,261	0,384	0,666	0,721	0,920	1,013	1,099	1,180	1,391	1,478
0,235	0,344	0,602	0,657	0,819	0,931	0,981	1,119	1,324	1,322
0,231	0,353	0,473	0,687	0,826	0,959	1,038	1,159	1,314	1,304
0,213	0,317	0,503	0,634	0,767	0,903	0,942	1,096	1,257	1,135
0,197	0,308	0,522	0,627	0,743	0,884	0,926	1,078	1,215	1,206
0,197	0,298	0,405	0,621	0,697	0,886	0,907	1,080	1,209	1,236
0,219	0,332	0,445	0,673	0,779	0,939	1,015	1,143	1,290	1,397
0,242	0,356	0,635	0,674	0,849	0,950	1,017	1,135	1,341	1,385
0,244	0,351	0,630	0,667	0,835	0,944	1,001	1,129	1,341	1,374
0,204	0,308	0,494	0,628	0,756	0,887	0,926	1,078	1,229	1,268
0,194	0,295	0,393	0,618	0,702	0,887	0,890	1,078	1,211	1,211
0,222	0,339	0,463	0,678	0,795	0,949	1,027	1,152	1,308	1,470
0,223	0,331	0,444	0,655	0,781	0,929	0,980	1,129	1,285	1,232
0,238	0,346	0,617	0,659	0,821	0,934	0,984	1,121	1,331	1,349
0,235	0,344	0,615	0,656	0,818	0,930	0,980	1,116	1,321	1,340
0,240	0,360	0,565	0,683	0,849	0,960	1,022	1,149	1,335	1,396
0,205	0,309	0,413	0,639	0,745	0,904	0,935	1,103	1,238	1,266
0,233	0,342	0,609	0,654	0,814	0,927	0,976	1,113	1,316	1,331
0,212	0,319	0,429	0,653	0,750	0,918	0,975	1,120	1,261	1,337
0,208	0,322	0,417	0,652	0,777	0,911	0,975	1,114	1,250	1,320
0,198	0,302	0,404	0,627	0,732	0,884	0,917	1,083	1,206	1,249
0,197	0,314	0,446	0,624	0,738	0,875	0,922	1,076	1,196	1,174
0,224	0,342	0,472	0,667	0,802	0,936	1,001	1,137	1,287	1,271
0,208	0,318	0,437	0,631	0,744	0,901	0,932	1,100	1,244	1,180
0,226	0,343	0,458	0,672	0,815	0,944	1,010	1,144	1,299	1,268
0,220	0,328	0,441	0,667	0,776	0,937	1,006	1,139	1,291	1,391
0,224	0,340	0,509	0,676	0,829	0,939	1,027	1,140	1,299	1,352
0,213	0,317	0,455	0,642	0,756	0,909	0,955	1,107	1,253	1,395
0,222	0,343	0,456	0,687	0,833	0,956	1,043	1,159	1,312	1,461
0,216	0,342	0,458	0,676	0,819	0,941	1,020	1,144	1,285	1,270

Table B.1 (cont'd)

f1	f2	f5	f7	f8	f10	f12	f14	f16	f17
0,197	0,299	0,420	0,619	0,704	0,886	0,904	1,077	1,211	1,264
0,210	0,317	0,472	0,629	0,754	0,901	0,930	1,095	1,252	1,212
0,241	0,359	0,618	0,679	0,859	0,955	1,026	1,136	1,327	1,374
0,199	0,298	0,400	0,623	0,699	0,897	0,910	1,088	1,231	1,254
0,220	0,327	0,437	0,668	0,767	0,936	1,003	1,139	1,287	1,359
0,228	0,349	0,483	0,682	0,816	0,953	1,037	1,155	1,312	1,281
0,242	0,361	0,605	0,683	0,865	0,961	1,034	1,138	1,330	1,388
0,214	0,320	0,435	0,653	0,758	0,923	0,980	1,124	1,272	1,370
0,204	0,316	0,456	0,641	0,756	0,904	0,954	1,102	1,246	1,393
0,221	0,328	0,441	0,666	0,771	0,934	1,003	1,137	1,285	1,374
0,209	0,312	0,430	0,639	0,736	0,905	0,948	1,104	1,243	1,318
0,220	0,335	0,452	0,661	0,785	0,931	0,995	1,133	1,282	1,232
0,227	0,338	0,539	0,669	0,831	0,935	1,015	1,132	1,303	1,394
0,213	0,341	0,473	0,661	0,811	0,920	0,999	1,123	1,264	1,297
0,242	0,349	0,625	0,664	0,829	0,940	0,994	1,125	1,337	1,364
0,201	0,302	0,405	0,628	0,702	0,898	0,920	1,092	1,231	1,262
0,238	0,346	0,679	0,663	0,827	0,939	0,992	1,124	1,334	1,325
0,254	0,375	0,717	0,708	0,901	0,996	1,076	1,168	1,380	1,424
0,265	0,386	0,681	0,724	0,926	1,018	1,106	1,183	1,394	1,495
0,212	0,315	0,499	0,637	0,769	0,902	0,946	1,095	1,253	1,289
0,236	0,344	0,611	0,657	0,818	0,933	0,981	1,119	1,331	1,337
0,209	0,325	0,573	0,638	0,784	0,902	0,951	1,098	1,256	1,290
0,233	0,345	0,596	0,659	0,824	0,933	0,987	1,118	1,321	1,331
0,221	0,330	0,545	0,640	0,789	0,910	0,955	1,105	1,282	1,230
0,203	0,316	0,428	0,635	0,752	0,898	0,941	1,100	1,230	1,165
0,212	0,325	0,488	0,651	0,791	0,908	0,979	1,108	1,255	1,294
0,257	0,384	0,622	0,722	0,911	1,004	1,092	1,185	1,372	1,399
0,227	0,348	0,466	0,681	0,818	0,954	1,030	1,154	1,309	1,288
0,207	0,318	0,441	0,647	0,750	0,913	0,965	1,113	1,256	1,337
0,225	0,336	0,529	0,667	0,822	0,934	1,009	1,132	1,300	1,372
0,211	0,326	0,431	0,662	0,780	0,923	0,989	1,128	1,266	1,357
0,203	0,315	0,431	0,642	0,765	0,898	0,953	1,100	1,231	1,311
0,210	0,315	0,420	0,650	0,755	0,920	1,013	1,120	1,267	1,293
0,215	0,333	0,450	0,652	0,788	0,919	0,974	1,121	1,262	1,230
0,220	0,329	0,476	0,658	0,786	0,928	0,989	1,128	1,285	1,474
0,233	0,347	0,600	0,661	0,829	0,933	0,992	1,117	1,306	1,339
0,238	0,348	0,611	0,663	0,829	0,938	0,993	1,122	1,324	1,346
0,219	0,328	0,443	0,647	0,770	0,921	0,962	1,120	1,274	1,218
0,236	0,356	0,555	0,684	0,860	0,956	1,045	1,154	1,333	1,416
0,208	0,325	0,462	0,634	0,768	0,891	0,941	1,092	1,222	1,232
0,203	0,308	0,414	0,625	0,719	0,897	0,920	1,092	1,235	1,406
0,212	0,321	0,514	0,636	0,776	0,905	0,947	1,100	1,266	1,295
0,189	0,294	0,397	0,615	0,712	0,867	0,890	1,062	1,178	1,206
0,223	0,330	0,526	0,658	0,807	0,926	0,990	1,123	1,291	1,363
0,202	0,311	0,457	0,631	0,745	0,895	0,933	1,089	1,233	1,400
0,205	0,306	0,453	0,626	0,736	0,892	0,922	1,084	1,226	1,365
0,206	0,307	0,471	0,625	0,740	0,893	0,919	1,084	1,235	1,067
0,248	0,366	0,651	0,690	0,873	0,972	1,044	1,149	1,357	1,423
0,202	0,317	0,442	0,642	0,753	0,901	0,957	1,100	1,240	1,400
0,199	0,303	0,417	0,627	0,710	0,892	0,921	1,087	1,220	1,261
0,237	0,355	0,475	0,693	0,840	0,968	1,053	1,169	1,330	1,317
0,216	0,330	0,445	0,654	0,792	0,927	0,981	1,127	1,280	1,207
0,240	0,361	0,562	0,688	0,861	0,961	1,046	1,157	1,333	1,413
0,230	0,339	0,594	0,650	0,805	0,923	0,965	1,111	1,317	1,307
0,262	0,383	0,685	0,718	0,916	1,010	1,094	1,178	1,393	1,495
0,245	0,371	0,582	0,699	0,882	0,976	1,056	1,159	1,337	1,467
0,209	0,318	0,472	0,628	0,752	0,896	0,928	1,092	1,241	1,210
0,212	0,323	0,456	0,656	0,771	0,922	0,984	1,123	1,270	1,373
0,231	0,339	0,639	0,653	0,811	0,925	0,973	1,111	1,311	1,283
0,217	0,329	0,454	0,653	0,776	0,924	0,981	1,125	1,277	1,214
0,206	0,306	0,412	0,634	0,712	0,905	0,932	1,100	1,244	1,269
0,203	0,300	0,402	0,626	0,705	0,898	0,917	1,091	1,231	1,247
0,206	0,318	0,428	0,633	0,754	0,904	0,937	1,102	1,247	1,173
0,247	0,368	0,695	0,697	0,885	0,977	1,058	1,154	1,347	1,381

Table B.1 (cont'd)

f1	f2	f5	f7	f8	f10	f12	f14	f16	f17
0,208	0,308	0,413	0,635	0,726	0,906	0,939	1,102	1,245	1,330
0,216	0,326	0,437	0,663	0,767	0,930	0,996	1,133	1,280	1,398
0,240	0,351	0,628	0,668	0,836	0,944	1,002	1,128	1,337	1,369
0,219	0,339	0,450	0,684	0,817	0,950	1,030	1,154	1,306	1,396
0,202	0,304	0,396	0,629	0,727	0,895	0,919	1,091	1,226	1,245
0,219	0,331	0,462	0,664	0,786	0,934	1,002	1,136	1,290	1,448
0,259	0,378	0,653	0,712	0,907	1,000	1,083	1,171	1,380	1,455
0,251	0,369	0,654	0,694	0,881	0,976	1,053	1,152	1,357	1,429
0,205	0,314	0,426	0,643	0,731	0,905	0,955	1,106	1,241	1,298
0,262	0,385	0,683	0,721	0,922	1,013	1,101	1,180	1,389	1,493
0,200	0,311	0,444	0,627	0,736	0,891	0,925	1,087	1,223	1,152
0,204	0,313	0,444	0,629	0,737	0,893	0,929	1,090	1,230	1,170
0,249	0,370	0,640	0,698	0,885	0,980	1,057	1,156	1,356	1,417
0,256	0,377	0,670	0,708	0,900	0,995	1,076	1,167	1,380	1,463
0,238	0,353	0,687	0,672	0,845	0,949	1,011	1,130	1,332	1,353
0,218	0,320	0,440	0,654	0,761	0,927	0,979	1,126	1,279	1,370
0,215	0,323	0,490	0,647	0,784	0,911	0,971	1,108	1,264	1,285
0,225	0,357	0,467	0,690	0,849	0,955	1,049	1,157	1,299	1,314
0,223	0,341	0,638	0,653	0,816	0,921	0,977	1,106	1,286	1,277
0,205	0,315	0,413	0,647	0,751	0,902	0,951	1,107	1,235	1,297
0,209	0,316	0,467	0,629	0,750	0,901	0,931	1,095	1,248	1,209
0,248	0,377	0,616	0,707	0,896	0,986	1,072	1,168	1,350	1,362
0,251	0,376	0,706	0,712	0,909	1,000	1,087	1,168	1,366	1,420

Table B.2 Training - Cross validation - Testing Output Data (Structural Parameters) for Neural Network

k1	k2	k3	k4	Ix	J	E	m
1,756	***6,548***	***2,318***	***4,320***	***0,615***	***0,934***	***3922***	***1,180***
4,686	***8,975***	***5,017***	***7,652***	***1,443***	***1,081***	***7174***	***0,960***
0,301	***6,174***	***0,301***	***5,430***	***1,300***	***1,342***	***2278***	***0,887***
4,649	***7,942***	***5,778***	***7,276***	***1,582***	***0,746***	***4009***	***1,160***
2,398	***6,931***	***1,398***	***4,173***	***1,378***	***1,849***	***5239***	***1,085***
4,201	***8,761***	***5,390***	***7,960***	***1,353***	***1,345***	***2998***	***1,151***
4,969	***8,975***	***5,001***	***7,684***	***1,181***	***0,682***	***6482***	***1,026***
2,943	***6,102***	***2,749***	***5,052***	***1,871***	***1,962***	***2976***	***0,922***
3,941	***8,911***	***5,669***	***7,655***	***1,021***	***0,573***	***6577***	***1,186***
4,494	***8,383***	***5,944***	***7,113***	***1,355***	***1,410***	***5464***	***1,044***
0,602	***6,011***	***1,690***	***5,874***	***1,756***	***1,599***	***6424***	***0,979***
4,887	***8,566***	***5,994***	***7,548***	***0,903***	***1,108***	***4544***	***1,011***
0,699	***6,444***	***1,771***	***5,839***	***1,635***	***1,070***	***4057***	***0,917***
4,223	***8,558***	***5,666***	***7,737***	***1,717***	***1,118***	***6164***	***1,043***
4,964	***8,961***	***5,552***	***7,312***	***1,726***	***1,164***	***4644***	***0,946***
1,959	***6,077***	***3,154***	***4,286***	***0,951***	***0,656***	***5004***	***0,822***
4,881	***8,814***	***5,582***	***7,616***	***1,009***	***1,166***	***7156***	***1,065***
2,737	***6,268***	***1,230***	***4,599***	***1,512***	***1,176***	***4551***	***1,043***
4,864	***8,908***	***5,847***	***6,876***	***1,220***	***1,458***	***2784***	***0,892***
4,891	***8,891***	***5,676***	***7,868***	***1,347***	***0,747***	***7114***	***0,925***
0,954	***6,874***	***3,965***	***5,502***	***1,743***	***1,191***	***4136***	***0,862***
1,633	***6,743***	***3,144***	***4,331***	***0,784***	***1,354***	***1865***	***0,905***
2,143	***6,597***	***0,477***	***4,931***	***1,063***	***1,631***	***3229***	***0,993***
2,561	***6,876***	***0,778***	***5,077***	***0,955***	***1,290***	***6068***	***0,996***
4,451	***8,916***	***5,813***	***7,421***	***1,740***	***1,793***	***6014***	***1,108***
1,146	***6,416***	***0,954***	***4,812***	***1,542***	***1,056***	***3627***	***1,162***
2,875	***6,712***	***0,903***	***5,549***	***1,301***	***0,523***	***5416***	***0,992***
0,778	***6,566***	***1,398***	***4,731***	***1,857***	***1,209***	***3572***	***0,960***
0,903	***6,398***	***0,000***	***5,552***	***0,922***	***1,276***	***5862***	***1,096***

Table B.2 (cont'd)

k1	k2	k3	k4	Ix	J	E	m
3,896	7,660	5,185	7,392	1,098	1,376	2679	0,915
0,000	6,722	2,348	5,101	1,505	0,830	6333	0,813
0,000	6,374	2,630	4,508	1,721	0,533	2278	1,168
0,477	6,643	2,853	5,005	1,730	1,622	4101	1,004
3,995	8,563	4,732	7,984	1,988	1,361	2943	0,802
1,301	6,478	1,447	4,179	1,171	1,551	6315	0,859
0,477	6,620	0,845	5,424	0,603	1,064	4248	1,004
1,672	6,457	1,505	4,394	1,530	0,953	2978	0,956
3,493	8,690	5,964	7,815	0,586	1,958	3764	0,814
2,854	6,463	3,163	5,318	0,778	0,727	3597	1,122
4,711	8,560	5,525	7,476	1,165	1,756	4204	0,946
4,765	8,908	4,605	6,738	1,346	0,972	4894	0,965
4,967	8,670	5,995	7,635	1,649	1,570	3296	0,882
4,943	8,919	5,423	7,716	1,631	1,990	5665	1,053
1,519	6,051	1,079	4,935	1,975	0,628	5629	0,806
2,358	6,609	1,602	5,371	1,317	1,632	2130	1,180
2,004	6,890	3,121	5,751	1,967	1,163	2240	1,169
2,049	6,444	1,279	5,306	1,185	1,362	5022	1,128
1,839	6,934	0,000	4,158	1,497	1,244	6509	0,970
4,584	8,758	5,395	7,971	1,125	0,926	2330	1,171
2,017	6,079	2,430	4,428	1,257	0,856	3020	0,966
4,384	8,904	5,174	7,675	0,612	1,234	6161	1,108
4,739	8,637	5,778	6,893	1,082	0,745	6809	1,163
1,806	6,675	2,623	5,115	0,511	0,699	5505	1,007
2,350	6,223	2,968	4,216	1,895	1,462	3652	0,864
4,640	8,569	5,993	7,531	1,040	1,960	4945	0,920
2,600	6,373	0,301	5,335	1,161	1,312	3239	0,867
0,301	6,441	2,517	5,652	1,453	1,916	6333	1,199
0,903	6,079	3,519	5,158	1,792	1,714	6677	1,107
2,401	6,325	3,891	5,609	1,512	1,858	1888	1,150
4,035	8,786	5,694	7,054	0,698	1,072	3882	1,161
4,930	8,496	5,781	7,116	0,547	1,747	7061	0,845
0,602	6,012	1,079	5,690	1,653	1,959	4491	1,050
4,810	8,714	5,349	7,766	1,623	1,185	3391	1,162
1,146	6,630	3,746	4,565	0,700	1,778	2406	0,828
2,436	6,064	1,756	4,716	0,735	0,543	3978	1,119
0,699	6,089	1,556	4,842	0,821	0,679	4740	1,096
4,854	8,915	5,887	7,743	1,990	0,875	1803	1,175
4,764	8,991	4,329	7,795	0,985	1,465	4086	1,044
1,748	6,808	0,000	4,109	1,346	0,972	4894	0,965
1,996	6,303	1,301	5,769	0,514	0,763	3373	0,897
1,613	6,406	3,389	5,652	1,509	1,583	4733	1,199
3,906	8,356	4,695	7,373	1,091	1,561	3478	1,037
0,954	6,960	2,305	4,939	0,875	1,202	2583	0,928
2,524	6,092	0,000	5,362	0,614	1,406	4070	0,828
1,663	6,327	0,699	5,127	0,917	1,179	7012	0,864
1,079	6,281	1,000	5,023	1,832	0,885	4535	1,138
1,230	6,176	1,531	5,389	1,478	0,542	4576	0,937
1,114	6,485	3,514	5,871	1,602	1,046	4057	1,035
4,759	8,199	4,234	6,707	1,693	1,944	3414	0,979
2,734	6,343	3,486	4,508	1,828	1,387	6266	1,145
1,415	6,271	1,041	5,153	1,199	0,813	2720	1,173
0,301	6,614	1,851	4,514	1,313	1,440	7131	1,096
4,799	8,191	5,729	7,983	1,491	1,366	4742	1,189
0,954	6,001	1,301	5,196	1,594	1,147	5200	0,890
1,204	6,133	2,865	4,151	1,032	1,075	2113	1,155
4,642	8,372	5,891	7,896	1,290	1,930	4561	1,169
4,944	8,214	5,396	7,784	1,048	1,293	4203	1,167
2,626	6,590	2,859	5,945	1,979	1,284	2980	0,948
2,690	6,433	1,851	5,785	1,598	1,654	3731	0,870
1,716	6,293	0,903	5,147	1,659	1,089	4357	0,828
4,949	8,474	5,545	7,897	1,053	1,831	4619	1,096
0,301	6,224	3,474	4,683	1,083	1,676	6013	0,870
2,674	6,822	0,699	4,218	0,515	0,727	3192	0,951

Table B.2 (cont'd)

k1	k2	k3	k4	Ix	J	E	m
1,699	6,982	0,477	5,840	1,270	1,745	2751	1,112
4,565	7,733	5,704	6,738	1,062	1,177	5671	0,919
2,887	6,705	0,954	5,596	0,999	0,525	7194	0,916
4,412	8,741	5,707	7,752	0,922	1,124	2544	0,940
2,097	6,610	0,778	5,918	1,725	1,490	4669	0,827
1,740	6,630	0,602	4,122	1,451	1,758	4417	1,056
0,301	6,626	2,498	4,370	1,288	1,065	2021	0,957
4,582	8,813	5,903	7,969	1,215	1,935	6228	0,939
0,954	6,467	1,568	4,008	1,544	1,973	4339	0,891
1,176	6,677	2,009	4,926	1,931	0,951	6339	1,197
4,725	8,726	5,218	7,901	1,995	0,581	3562	0,834
1,857	6,579	0,301	5,703	1,086	0,777	6094	1,101
2,265	6,206	0,301	4,259	1,410	1,077	3863	1,044
2,371	6,290	1,114	4,620	1,886	1,787	5975	1,167
0,301	6,076	0,602	4,032	1,782	1,884	6182	0,861
4,846	8,717	5,843	7,851	1,592	1,159	4193	0,876
1,301	6,128	1,806	5,412	1,938	0,627	3615	0,896
1,204	6,896	0,477	5,590	1,130	1,280	5843	0,993
2,664	6,205	3,632	4,545	1,170	0,589	3128	0,802
0,778	6,878	2,312	4,397	1,798	0,820	5756	0,923
4,686	8,858	5,651	7,608	1,691	1,665	5062	1,031
3,000	8,907	5,302	7,023	1,728	1,000	4831	0,805
1,447	6,719	1,908	4,455	1,390	1,381	2693	1,007
4,731	8,186	5,572	7,980	0,756	1,371	3845	0,943
1,301	6,470	1,613	5,839	0,675	0,827	3303	0,808
1,146	6,651	3,266	5,617	0,580	1,393	3063	0,931
4,930	8,987	5,812	7,977	1,594	0,933	6814	0,834
0,778	6,330	3,538	4,589	1,291	1,066	1922	0,947
0,699	6,678	3,946	5,092	0,650	1,519	2324	0,963
2,822	6,622	3,728	4,755	1,403	0,777	5620	1,142
4,888	7,774	5,913	7,109	0,673	1,015	3902	0,911
0,699	6,741	2,474	4,373	1,356	0,637	3177	1,078
4,870	8,853	5,267	6,761	0,869	0,797	5896	1,190
4,982	8,555	5,537	7,443	1,238	1,616	4307	0,994
2,086	6,773	0,954	4,419	1,850	1,861	3321	1,133
1,079	6,014	3,248	5,129	1,339	1,635	4037	1,122
4,834	8,999	3,940	7,743	1,790	0,587	3777	0,918
1,041	6,926	1,863	4,866	1,190	1,300	5257	0,815
3,940	8,802	5,739	7,763	1,761	1,901	3865	0,884
4,756	8,558	5,921	7,495	1,804	0,747	6597	1,026
4,658	7,925	5,732	7,764	1,871	1,228	2467	0,897
0,477	6,760	1,041	4,277	0,563	1,539	3578	1,138
2,500	6,055	1,204	4,526	1,948	0,549	4061	0,999
4,738	8,317	5,983	7,970	1,989	1,759	3631	0,964
4,951	8,630	5,728	7,723	0,909	1,704	6729	0,844
2,305	6,410	3,009	4,720	0,986	0,512	3996	0,966
1,000	6,276	2,170	5,666	1,066	1,150	3187	0,953
2,878	6,458	3,000	5,896	1,725	1,639	6390	0,989
2,916	6,849	1,146	4,411	1,165	1,528	4425	0,912
2,792	6,070	1,362	5,823	1,611	1,317	5716	0,979
2,760	6,961	0,301	4,834	1,992	1,207	6227	1,041
1,623	6,278	2,377	5,008	1,822	1,048	6244	0,902
1,114	6,646	3,768	4,197	0,778	0,789	4064	1,022
4,946	8,889	5,732	7,558	0,847	1,335	5301	1,184
4,587	8,360	5,453	7,910	1,740	1,883	6366	0,963
0,699	6,438	1,322	5,283	1,144	1,762	2092	0,986
1,000	6,095	2,360	4,340	1,891	0,647	2285	0,978
4,897	8,789	5,538	7,983	1,057	0,955	5887	0,887
0,301	6,861	3,518	5,080	0,648	1,606	3177	0,826
1,568	6,539	0,778	5,065	0,929	1,525	5933	1,082
1,146	6,660	3,049	4,102	0,633	0,802	2299	0,950
1,114	6,382	1,806	4,834	1,535	0,950	4581	0,949
0,477	6,762	0,845	4,839	1,706	1,392	7014	1,032
1,771	6,986	3,644	4,454	1,543	1,970	2340	0,898

Table B.2 (cont'd)

k1	k2	k3	k4	Ix	J	E	m
4,267	8,964	5,977	7,778	0,674	0,640	1902	1,109
2,471	6,962	3,780	4,485	0,946	0,842	5703	0,934
1,447	6,631	3,983	5,833	1,689	0,779	3334	0,852
1,892	6,025	1,230	4,983	1,287	1,432	3325	1,171
2,905	6,976	2,228	4,880	1,402	1,436	4269	0,890
4,991	8,454	5,791	7,487	1,778	0,978	1963	1,118
0,301	6,023	3,496	4,242	1,495	0,688	6805	1,065
0,301	6,283	1,230	4,358	1,135	0,566	2326	0,923
0,301	6,599	3,427	4,079	0,959	0,501	6090	1,048
2,371	6,297	0,954	4,961	0,882	1,011	3587	0,818
1,176	6,841	2,072	5,784	0,857	1,605	1961	1,127
0,903	6,766	3,483	4,902	1,568	1,791	2246	1,123
4,927	7,989	5,978	7,995	1,638	1,615	1868	0,837
4,618	8,082	5,830	7,637	1,352	1,817	3146	1,199
3,867	8,780	5,932	6,308	1,164	1,029	3991	0,911
1,663	6,048	3,449	5,920	1,603	0,712	3335	1,165
1,204	6,982	2,574	5,740	0,864	1,857	3629	1,107
1,301	6,310	1,519	5,004	1,738	1,586	5023	1,043
1,892	6,154	2,146	5,923	1,491	1,366	4742	1,189
0,699	6,979	0,301	4,781	1,047	1,235	5334	0,862
2,962	6,980	1,447	5,136	1,373	1,378	6888	1,051
1,623	6,272	2,456	4,873	0,668	1,393	4298	1,121
0,477	6,777	3,648	4,203	1,156	1,481	6347	1,007
4,788	8,243	5,752	7,786	1,257	1,507	6773	1,124
1,447	6,221	1,903	5,451	1,439	1,866	5554	0,913
4,878	8,836	5,361	6,467	0,522	1,763	4443	0,879
1,643	6,432	2,400	4,156	1,082	0,745	6809	1,163
2,086	6,972	0,000	5,163	1,108	1,293	6927	1,023
4,979	8,979	5,929	7,956	0,784	1,891	4479	0,845
2,861	6,390	0,845	5,613	1,302	1,586	2949	0,890
2,671	6,481	0,903	5,700	0,603	0,700	7042	1,186
2,522	6,399	0,699	5,933	1,912	1,770	3595	1,131
2,220	6,470	2,591	4,908	1,551	1,850	4008	1,068
0,845	6,046	1,176	4,764	0,951	1,923	4029	1,192
4,353	8,555	5,979	7,803	1,816	0,823	4461	0,877
4,360	8,867	5,821	7,994	1,076	0,527	6123	1,125
0,477	6,959	0,000	5,705	0,531	1,095	4102	1,125
0,301	6,129	0,845	4,342	1,062	1,104	2910	1,036
2,348	6,893	2,910	4,327	1,593	1,027	2963	1,086
4,581	8,693	5,872	7,828	1,285	0,506	2818	1,060
2,859	6,189	1,672	4,725	0,987	1,969	3118	1,032
1,255	6,520	0,845	5,153	1,743	0,547	6479	1,093
0,000	6,890	1,114	5,734	1,283	0,888	5113	0,853
0,000	6,897	0,954	4,105	1,671	0,555	5146	0,855
2,676	6,350	0,000	4,820	1,683	1,652	5066	1,069
3,401	8,574	5,818	7,405	1,721	0,533	2278	1,168
0,301	6,670	1,724	5,905	1,503	1,413	5621	1,084
1,000	6,214	3,555	4,621	1,093	0,545	5820	1,059
4,749	8,757	5,823	7,651	1,377	1,479	6936	0,880
1,914	6,034	0,778	4,303	1,510	1,679	6183	1,041
4,883	8,975	5,767	7,753	1,400	1,250	2467	1,192
1,114	6,377	2,029	4,250	1,903	1,183	3804	0,891
4,679	8,282	5,835	7,874	1,421	1,673	3850	0,865
1,447	6,944	0,477	4,897	1,443	1,081	7174	0,960
4,434	8,593	5,531	6,004	0,707	0,914	5869	0,993
2,314	6,367	3,942	4,705	0,903	1,108	4544	1,011
0,301	6,396	3,148	4,565	1,216	1,679	6965	0,948
0,301	6,030	0,699	4,586	1,992	1,380	6235	1,163
0,000	6,198	3,458	5,206	1,787	1,427	2328	1,180
4,736	8,556	4,895	7,939	1,004	1,037	6822	0,883
0,477	6,098	3,665	4,382	1,792	0,960	6579	1,117
1,820	6,813	3,150	5,049	0,528	1,038	4431	0,824
0,301	6,304	1,114	4,339	1,611	0,832	6675	0,955
4,433	8,908	5,929	7,319	1,044	0,710	6713	0,910

Table B.2 (cont'd)

k1	k2	k3	k4	Ix	J	E	m
2,630	6,445	2,265	4,324	0,784	1,402	6339	0,827
4,988	8,929	5,457	7,313	1,165	1,528	4425	0,912
3,704	8,695	5,850	7,939	1,507	1,026	5029	0,894
0,845	6,316	2,980	4,498	0,583	1,430	3545	0,866
1,748	6,547	2,423	4,024	1,598	1,536	6394	1,058
4,964	8,983	4,925	7,620	1,992	1,207	6227	1,041
2,869	6,199	1,322	5,598	1,233	0,604	7145	1,025
0,301	6,412	0,477	4,292	0,972	1,986	6903	1,042
2,537	6,904	0,301	5,726	0,836	0,621	2577	1,152
1,079	6,866	2,775	5,219	1,029	1,385	4147	1,066
4,423	8,789	4,755	7,842	1,356	1,264	3242	0,875
2,179	6,580	0,477	5,359	0,769	0,504	6412	1,101
0,778	6,243	1,672	5,755	0,847	1,865	1818	1,136
4,937	8,749	5,998	7,750	1,899	1,311	6035	1,097
0,301	6,307	2,117	5,261	1,556	0,936	3497	0,919
0,301	6,855	3,321	5,780	1,164	1,289	4852	0,896
1,431	6,268	0,954	5,457	1,619	0,740	5327	1,082
4,986	8,990	5,746	7,644	1,402	1,436	4269	0,890
2,255	6,015	1,114	5,530	0,739	1,029	3321	1,132
0,699	6,358	3,808	5,270	1,816	0,823	4461	0,877
2,464	6,372	2,025	4,358	1,436	1,757	5211	1,094
4,950	8,915	5,248	7,037	0,515	0,727	3192	0,951
1,505	6,105	3,989	5,282	1,152	1,726	3014	1,026
4,836	8,417	5,607	7,903	1,720	0,662	4409	0,964
1,740	6,606	1,079	5,016	1,690	1,786	3997	0,837
4,481	8,574	5,220	7,319	1,270	0,862	3022	0,926
2,061	6,589	1,663	5,551	1,807	1,983	4539	1,044
4,095	7,371	5,942	7,083	1,495	0,688	6805	1,065
4,382	8,560	5,898	7,755	1,594	1,539	2291	1,064
2,653	6,563	3,167	5,501	1,439	1,523	2137	1,062
1,544	6,225	0,602	5,318	1,966	1,098	5175	0,876
0,845	6,208	1,079	4,161	1,031	1,017	5744	0,851
0,301	6,045	0,602	4,492	1,098	1,376	2679	0,915
2,585	6,504	1,415	5,827	1,388	1,133	5825	1,009
4,841	7,940	5,570	7,750	1,303	1,880	4792	0,818
2,780	6,467	3,956	4,863	1,649	1,570	3296	0,882
2,400	6,014	3,388	4,720	1,208	0,682	2093	0,960
4,307	8,668	5,713	7,452	1,856	0,829	2974	1,171
1,633	6,359	0,301	5,737	1,004	1,037	6822	0,883
2,320	6,058	3,275	4,257	0,673	1,015	3902	0,911
4,939	8,927	5,373	7,736	1,794	0,671	3734	1,173
2,827	6,817	2,983	5,477	0,671	1,796	6484	0,868
0,903	6,026	1,041	5,527	0,969	1,167	6839	1,159
4,986	8,908	5,759	7,931	1,969	1,471	2977	1,074
2,468	6,210	1,875	5,736	1,743	1,116	2276	0,985
1,415	6,336	3,486	4,638	1,247	1,001	4639	1,158
0,845	6,384	1,146	4,781	1,006	1,483	6985	0,965
2,193	6,693	1,580	5,922	1,900	1,916	4412	0,926
4,382	8,642	5,519	7,807	1,144	1,762	2092	0,986
4,741	8,986	5,572	7,797	0,705	1,608	2198	1,086
0,301	6,224	3,207	5,489	1,361	0,571	1814	1,170
1,531	6,406	0,477	4,552	1,465	1,774	4214	0,999
4,293	8,792	5,813	6,988	1,736	1,065	3000	1,083
1,740	6,355	3,141	5,325	0,820	1,930	2872	1,096
2,957	6,817	1,415	4,157	1,379	1,953	6984	0,918
1,898	6,818	2,140	5,989	1,210	1,104	3969	1,082
2,614	6,056	3,798	4,728	1,287	1,651	3308	0,821
2,435	6,092	1,114	4,171	0,895	1,768	7088	1,176
0,000	6,512	3,683	4,862	1,075	0,525	6624	1,133
4,408	8,974	5,254	6,235	1,306	1,722	3578	1,062
1,806	6,572	1,146	5,394	1,233	1,979	3712	0,825
0,602	6,549	0,477	5,767	1,755	0,827	3335	1,016
0,000	6,267	1,813	4,888	1,274	0,655	5634	0,848
1,477	6,874	1,806	5,990	0,842	1,805	2648	0,842

Table B.2 (cont'd)

k1	k2	k3	k4	Ix	J	E	m
3,760	*8,441*	*5,983*	*7,515*	*1,472*	*1,045*	*5505*	*0,948*
0,845	*6,789*	*3,728*	*5,743*	*1,455*	*1,291*	*5767*	*0,994*
2,083	*6,420*	*1,431*	*5,272*	*0,827*	*0,741*	*6310*	*0,981*
4,399	*8,387*	*5,621*	*7,943*	*0,847*	*1,865*	*1818*	*1,136*
0,699	*6,765*	*1,833*	*5,866*	*1,310*	*1,335*	*2986*	*0,872*
0,000	*6,161*	*0,477*	*4,787*	*1,706*	*1,738*	*4129*	*0,877*
1,934	*6,516*	*0,903*	*5,166*	*1,623*	*1,185*	*3391*	*1,162*
4,560	*8,620*	*5,563*	*7,800*	*0,770*	*1,152*	*6068*	*0,863*
0,301	*6,890*	*3,667*	*4,118*	*1,474*	*1,647*	*2685*	*1,181*
2,968	*6,653*	*1,230*	*5,718*	*1,037*	*0,968*	*2373*	*0,914*
4,313	*8,999*	*5,479*	*7,897*	*1,707*	*0,892*	*6980*	*1,028*
0,477	*6,825*	*2,611*	*4,445*	*0,570*	*1,867*	*4206*	*0,996*
4,978	*8,666*	*5,898*	*7,819*	*0,778*	*0,727*	*3597*	*1,122*
1,978	*6,207*	*3,812*	*5,971*	*1,648*	*1,598*	*2781*	*0,840*
1,230	*6,273*	*3,339*	*4,199*	*0,715*	*1,155*	*5644*	*0,988*
0,000	*6,859*	*3,125*	*4,291*	*1,028*	*1,659*	*3500*	*1,030*
1,301	*6,836*	*0,903*	*5,462*	*1,849*	*0,826*	*5273*	*1,193*
4,883	*8,577*	*5,999*	*7,284*	*0,678*	*1,622*	*2580*	*1,129*
2,823	*6,257*	*0,477*	*5,070*	*1,945*	*1,392*	*4209*	*0,856*
1,863	*6,536*	*1,279*	*5,658*	*1,111*	*0,931*	*4222*	*1,195*
1,301	*6,873*	*0,000*	*5,402*	*0,561*	*1,461*	*2219*	*0,868*
0,477	*6,435*	*0,602*	*5,390*	*1,478*	*0,539*	*5477*	*0,943*
1,806	*6,248*	*0,845*	*4,059*	*0,671*	*0,868*	*6779*	*1,154*
0,699	*6,800*	*0,602*	*4,945*	*0,612*	*1,234*	*6161*	*1,108*
2,378	*6,762*	*1,690*	*4,344*	*1,127*	*0,703*	*4050*	*1,122*
4,914	*8,835*	*5,818*	*7,677*	*1,223*	*0,535*	*2078*	*1,162*
2,090	*6,765*	*1,079*	*4,169*	*1,030*	*0,965*	*2171*	*0,935*
2,873	*6,131*	*2,906*	*4,060*	*1,304*	*1,560*	*5463*	*0,925*
2,281	*6,651*	*1,531*	*4,825*	*1,009*	*1,166*	*7156*	*1,065*
4,757	*8,083*	*5,434*	*7,933*	*1,504*	*1,198*	*2236*	*1,026*
2,057	*6,763*	*1,519*	*4,862*	*0,894*	*1,602*	*2377*	*1,042*
0,301	*6,321*	*2,468*	*5,945*	*1,799*	*0,868*	*2330*	*0,845*
4,009	*8,352*	*5,939*	*7,534*	*1,083*	*1,676*	*6013*	*0,870*
2,525	*6,821*	*2,511*	*4,823*	*0,705*	*1,504*	*3354*	*0,853*
4,563	*8,887*	*5,336*	*7,528*	*0,918*	*1,227*	*3586*	*1,186*
2,053	*6,535*	*3,025*	*4,428*	*0,744*	*0,932*	*2974*	*0,875*
2,999	*6,042*	*3,530*	*5,792*	*1,903*	*1,274*	*6656*	*1,148*
2,771	*6,229*	*1,778*	*5,678*	*0,821*	*1,036*	*4150*	*0,925*
1,519	*6,175*	*2,083*	*5,739*	*1,024*	*0,907*	*5100*	*1,043*
4,340	*8,899*	*5,614*	*7,990*	*1,549*	*0,812*	*6860*	*1,134*
2,064	*6,249*	*1,785*	*5,298*	*1,019*	*0,910*	*3496*	*1,050*
0,903	*6,514*	*1,653*	*4,914*	*1,680*	*1,037*	*3593*	*0,860*
0,602	*6,884*	*3,828*	*5,730*	*1,177*	*1,547*	*2919*	*0,851*
0,477	*6,935*	*0,699*	*4,272*	*1,861*	*1,283*	*3734*	*0,833*
0,845	*6,365*	*1,279*	*4,708*	*0,853*	*1,389*	*6174*	*1,081*
2,459	*6,288*	*0,000*	*5,637*	*0,657*	*0,797*	*4312*	*0,900*
1,230	*6,094*	*3,417*	*5,200*	*1,949*	*1,992*	*4691*	*1,086*
4,947	*8,751*	*5,899*	*7,875*	*1,439*	*1,523*	*2137*	*1,062*
1,146	*6,861*	*2,233*	*4,929*	*1,164*	*1,033*	*2688*	*0,907*
4,703	*8,391*	*5,056*	*7,833*	*0,726*	*0,749*	*3565*	*0,810*
4,973	*8,062*	*5,993*	*7,801*	*1,398*	*1,854*	*3844*	*1,030*
4,777	*8,584*	*5,657*	*7,607*	*1,620*	*0,615*	*4794*	*0,880*
1,079	*6,301*	*0,301*	*4,912*	*1,882*	*1,339*	*3413*	*1,093*
2,083	*6,808*	*0,000*	*4,244*	*0,898*	*1,254*	*6464*	*1,192*
2,407	*6,165*	*3,688*	*5,100*	*1,484*	*0,958*	*3557*	*1,058*
4,938	*8,874*	*5,926*	*7,894*	*1,956*	*0,991*	*3328*	*1,074*
2,193	*6,808*	*2,811*	*4,150*	*1,220*	*1,458*	*2784*	*0,892*
2,545	*6,939*	*3,439*	*5,909*	*1,684*	*1,797*	*2689*	*0,835*
4,498	*8,449*	*5,788*	*7,563*	*1,317*	*1,455*	*3425*	*1,062*
4,377	*7,441*	*5,918*	*7,560*	*1,444*	*0,723*	*5666*	*1,129*
0,000	*6,565*	*1,477*	*4,522*	*1,039*	*1,531*	*5273*	*0,808*
2,653	*6,632*	*1,505*	*5,244*	*0,709*	*1,637*	*4884*	*1,032*
4,809	*8,228*	*5,505*	*7,141*	*1,322*	*1,490*	*1808*	*0,995*
1,322	*6,147*	*1,114*	*5,157*	*0,931*	*0,897*	*6268*	*0,883*

Table B.2 (cont'd)

k1	k2	k3	k4	Ix	J	E	m
4,938	8,784	5,839	7,986	0,858	0,579	7008	1,166
1,114	6,204	2,452	4,102	1,145	0,726	2345	1,042
0,000	6,642	3,133	4,186	1,469	1,216	5613	1,080
4,858	8,899	5,948	7,103	1,268	1,975	4228	1,150
2,758	6,887	2,130	4,773	0,715	1,782	3210	1,184
0,602	6,214	0,000	4,905	0,877	1,416	4270	0,981
2,152	6,013	2,375	5,776	1,377	1,538	2904	1,186
0,477	6,141	3,647	5,654	0,632	0,837	2480	0,896
4,670	8,282	5,892	7,259	0,734	1,438	2701	0,891
4,499	8,953	5,960	6,360	1,862	1,310	6520	1,188
2,764	6,348	3,002	5,868	1,846	1,105	5823	1,153
1,204	6,426	3,829	5,979	1,554	0,605	6973	1,055
1,633	6,070	3,237	4,167	1,205	1,433	2791	0,968
4,076	7,560	5,928	7,219	1,452	1,840	6973	0,922
0,000	6,859	2,057	5,512	0,640	1,740	2902	1,033
4,965	8,518	5,931	7,694	1,416	0,616	3811	0,968
2,146	6,821	3,085	5,107	1,990	0,875	1803	1,175
2,378	6,187	3,485	5,317	1,194	1,235	5992	0,910
0,301	6,013	1,929	5,108	1,376	1,549	2298	1,170
1,690	6,703	3,411	4,246	1,763	0,552	5085	1,038
4,927	8,957	4,977	7,936	0,836	0,621	2577	1,152
2,127	6,713	1,863	4,711	1,905	1,061	2770	1,082
0,602	6,495	1,505	5,717	1,596	0,627	3478	0,919
1,114	6,762	0,699	5,200	1,984	1,783	6616	0,937
4,729	9,000	5,499	7,830	1,031	1,969	3736	0,926
0,903	6,939	3,053	5,080	0,718	1,191	6126	0,923
4,387	8,991	4,785	7,592	1,047	1,235	5334	0,862
4,912	8,578	5,710	6,995	0,573	0,514	4229	1,153
0,477	6,420	1,041	4,443	1,361	1,635	4346	1,070
4,363	8,481	5,388	7,590	1,582	1,041	5451	1,090
0,954	6,814	1,398	4,274	0,918	0,929	3046	0,862
1,908	6,843	1,380	5,809	1,573	1,643	3727	0,949
1,176	6,238	0,477	5,241	0,980	1,527	6752	0,956
4,602	8,992	5,809	7,940	0,864	1,857	3629	1,107
0,699	6,915	2,061	4,490	0,722	0,652	2215	0,977
4,114	8,933	5,919	7,950	1,164	1,289	4852	0,896
1,792	6,207	2,021	5,352	1,475	0,811	5331	0,915
2,143	6,172	2,680	5,988	0,888	1,541	3707	1,156
1,954	6,203	0,301	4,877	0,756	0,835	3731	1,003
1,602	6,710	0,301	5,517	0,607	1,910	4598	0,840
1,987	6,420	2,589	5,814	1,982	0,648	3421	1,157
2,201	6,973	2,763	5,334	0,555	1,953	3755	0,895
1,602	6,067	3,661	4,952	0,744	1,899	4859	0,928
1,531	6,348	1,799	5,469	1,697	1,696	4748	0,967
1,602	6,864	0,602	5,920	0,872	0,598	3404	1,102
1,544	6,864	1,204	5,952	1,515	1,024	4034	0,877
2,962	6,167	0,954	5,252	1,021	1,217	4233	0,955
2,784	6,503	3,042	4,954	1,322	1,418	6946	1,112
2,149	6,321	3,033	4,255	1,499	0,574	5967	0,837
4,407	8,537	5,886	7,934	0,760	1,127	6777	0,926
0,301	6,881	2,996	4,285	1,488	1,936	5137	1,084
1,940	6,465	2,097	4,484	0,635	1,216	6379	1,082
4,749	8,842	5,961	7,922	0,534	1,315	3986	1,166
4,835	8,686	4,801	7,918	1,580	1,136	4100	0,943
1,875	6,403	0,301	4,726	0,810	1,528	2483	0,963
4,774	8,345	5,658	7,931	0,558	0,919	6007	0,943
1,322	6,991	0,903	4,518	1,432	0,696	3976	0,801
4,733	8,445	5,774	7,703	1,822	1,048	6244	0,902
4,433	8,666	5,960	7,965	1,250	1,827	5400	1,029
1,431	6,294	0,301	4,767	0,721	1,782	6812	1,171
4,896	8,096	5,483	7,800	1,601	0,665	6360	0,845
1,771	6,532	2,461	4,178	0,777	0,925	3991	0,808
4,918	7,919	5,283	7,832	1,181	1,036	4294	0,860
0,301	6,365	0,301	5,926	1,988	1,361	2943	0,802

Table B.2 (cont'd)

k1	k2	k3	k4	Ix	J	E	m
4,935	7,661	5,074	7,656	1,206	0,937	1857	0,959
1,447	6,720	1,792	4,812	1,691	1,665	5062	1,031
0,301	6,943	3,060	4,976	1,162	0,726	1952	1,002
1,672	6,909	2,629	4,882	1,539	0,597	2071	1,102
0,477	6,000	3,691	4,056	1,677	0,852	6790	1,164
0,301	6,940	3,199	4,627	0,764	0,972	4661	1,165
4,372	8,060	5,517	7,757	1,804	1,756	3959	1,014
0,903	6,349	1,146	5,372	1,293	1,775	2044	1,009
0,477	6,847	2,529	4,304	1,479	1,862	4272	0,824
0,699	6,734	2,648	5,971	1,076	0,527	6123	1,125
2,960	6,930	2,679	4,363	0,709	1,581	2614	1,120
1,000	6,760	2,509	5,927	1,742	1,331	5661	1,043
4,576	8,949	5,617	6,953	1,982	1,189	4733	1,094
2,255	6,356	0,903	4,017	0,760	0,614	2450	0,946
0,301	6,350	3,477	4,405	0,825	0,607	2280	0,801
1,279	6,628	2,124	5,458	0,652	0,533	3650	0,934
2,879	6,910	0,000	4,354	1,843	0,840	3063	1,184
0,477	6,026	3,090	5,396	0,671	0,837	5296	0,803
2,899	6,929	3,438	4,099	0,835	1,110	5716	1,172
2,246	6,954	2,680	5,914	1,221	1,540	2841	1,157
0,301	6,813	1,869	4,903	1,021	0,573	6577	1,186
1,771	6,452	0,477	5,685	0,828	0,948	6900	1,048
1,255	6,695	0,699	4,639	1,780	0,794	2962	1,010
1,041	6,721	2,553	4,496	0,539	1,710	3377	0,922
4,709	8,383	4,888	7,973	1,890	0,776	6916	1,175
2,334	6,681	0,000	4,392	1,583	0,649	5861	0,915
3,776	8,616	5,073	7,165	0,972	1,986	6903	1,042
2,173	6,676	2,223	4,291	1,073	1,388	6363	0,955
0,602	6,222	0,301	4,349	1,419	1,917	4219	0,879
2,689	6,609	1,643	5,240	1,743	1,458	3193	0,836
4,903	8,600	5,739	7,846	0,664	0,827	4398	0,835
2,307	6,678	0,602	5,237	0,906	0,500	1970	1,177
1,568	6,273	3,129	4,844	1,527	0,934	5486	0,994
3,927	8,488	5,724	7,800	1,556	0,936	3497	0,919
2,949	8,298	5,937	7,780	1,787	1,427	2328	1,180
4,509	8,653	5,728	7,513	1,244	0,930	6476	0,878
0,699	6,177	0,301	4,781	0,562	1,141	5390	0,977
1,176	6,346	2,185	4,354	0,918	1,892	3332	0,921
2,342	6,245	2,515	5,177	0,599	1,250	2447	1,116
4,810	8,960	5,930	7,431	1,973	1,808	5999	0,925
2,225	6,224	0,477	5,770	1,920	1,318	6639	1,035
0,301	6,062	2,427	4,743	1,349	1,175	7187	1,034
0,477	6,428	0,477	4,182	1,669	1,550	3615	0,866
1,146	6,082	1,000	4,696	1,909	1,138	4530	0,950
3,152	8,455	5,472	7,360	0,817	1,797	4242	0,917
2,937	6,284	2,473	4,613	1,778	0,978	1963	1,118
4,707	8,610	5,026	7,441	1,465	1,774	4214	0,999
1,716	6,120	1,079	5,714	1,504	1,198	2236	1,026
2,635	6,493	1,079	5,075	1,458	1,286	2471	0,995
2,483	6,082	0,778	5,358	1,181	1,036	4294	0,860
0,778	6,924	0,699	4,493	0,904	1,038	3782	1,121
1,041	6,593	1,568	5,760	1,177	1,347	3026	1,173
1,176	6,441	3,920	5,438	0,683	1,990	4586	0,930
4,767	8,689	5,973	7,738	1,290	0,672	2832	1,180
2,479	6,815	3,220	4,810	1,370	0,604	3899	1,098
2,785	6,413	1,204	4,128	0,780	1,246	6522	1,088
4,561	8,587	5,732	7,936	0,837	0,627	6174	1,140
0,301	6,667	3,771	5,817	0,976	0,663	3411	1,147
4,238	8,891	5,960	7,007	1,156	1,481	6347	1,007
0,301	6,388	0,301	5,512	0,869	1,871	2823	1,072
0,778	6,914	0,845	4,130	1,919	1,901	3428	0,906
0,845	6,496	2,652	4,242	1,342	1,602	6256	1,168
4,780	8,715	5,776	7,518	1,864	1,655	6937	1,030
0,699	6,114	1,322	5,142	1,804	1,756	3959	1,014

Table B.2 (cont'd)

k1	k2	k3	k4	Ix	J	E	m
0,699	6,135	1,362	4,584	1,127	0,582	2215	0,917
4,950	8,683	5,365	7,929	0,603	0,700	7042	1,186
1,898	6,189	1,204	4,136	0,731	1,484	1875	0,823
0,000	6,502	3,746	4,856	0,891	1,671	3239	0,942
2,930	6,093	3,122	4,088	1,949	2,000	2487	1,075
4,865	8,345	5,323	7,510	1,136	1,612	5169	0,847
4,875	8,932	5,408	7,541	1,802	1,788	5041	0,966
4,399	8,434	5,402	7,792	0,898	0,533	1949	1,144
2,079	6,629	0,477	4,440	1,854	1,696	4311	0,988
4,966	8,412	5,408	7,854	1,497	1,659	4788	1,104
0,477	6,282	0,301	5,283	1,729	1,249	4200	0,804
4,514	8,881	5,797	7,984	1,742	1,331	5661	1,043
4,937	8,913	5,637	7,784	1,550	1,276	4213	1,191
4,365	8,799	5,434	7,443	0,719	1,735	6936	0,852
4,976	8,854	5,529	7,069	1,263	0,631	5943	0,913
0,602	6,413	0,000	5,529	1,318	0,561	1802	0,891
0,602	6,326	1,653	4,305	1,430	0,649	4100	0,882
1,940	6,049	0,000	4,026	0,513	0,535	6094	0,864
0,602	6,117	2,324	4,065	1,749	1,860	6181	0,979
0,602	6,298	2,427	4,494	0,969	0,640	4020	0,801
4,770	7,426	5,831	7,429	1,312	1,288	6312	0,941
3,814	8,495	5,827	7,863	1,746	1,460	3094	0,826
1,362	6,168	0,000	5,881	1,150	0,688	3367	1,091
4,401	8,519	5,947	7,469	1,291	1,066	1922	0,947
1,544	6,030	1,204	4,983	1,391	0,805	3701	1,125
2,064	6,882	2,597	5,470	0,504	1,341	5861	1,196
4,297	8,460	5,793	7,414	0,677	0,729	3056	0,961
1,477	6,065	1,176	4,423	0,996	0,956	5663	1,032
3,613	8,753	5,568	7,417	1,039	1,531	5273	0,808
4,870	8,673	5,811	7,657	1,551	1,850	4008	1,068
4,803	8,823	5,636	5,337	1,029	0,585	6974	1,146
4,074	8,302	5,937	7,763	1,987	0,552	5574	0,901
1,114	6,002	3,096	5,815	1,767	1,935	2649	0,815
2,914	6,833	1,544	5,494	0,940	1,566	5714	0,990
0,000	6,460	1,114	5,526	0,768	0,875	4315	0,907
1,176	6,822	2,630	4,457	1,950	1,005	6518	1,065
0,477	6,332	2,747	4,923	0,955	0,826	3716	0,938
4,546	8,524	5,985	7,890	1,861	1,640	5644	1,062
4,399	7,107	5,906	7,802	0,815	0,838	2653	0,854
0,301	6,483	1,940	4,626	0,525	0,912	6498	1,032
1,447	6,195	2,477	4,201	0,620	1,710	3510	1,126
4,943	8,650	5,753	7,209	0,784	1,402	6339	0,827
2,267	6,760	3,072	4,234	1,464	0,929	6664	1,152
4,974	8,411	5,079	7,729	1,945	1,392	4209	0,856
3,919	8,685	5,685	7,496	0,525	0,912	6498	1,032
1,146	6,228	1,146	5,624	1,740	1,883	6366	0,963
1,398	6,190	3,116	4,363	0,734	1,438	2701	0,891
2,997	6,280	1,833	4,589	1,038	1,081	6412	1,130
0,477	6,731	1,690	4,914	1,580	1,642	2330	0,934
4,899	8,883	5,626	7,236	1,127	0,703	4050	1,122
4,680	8,889	5,237	7,752	0,975	0,820	5427	0,899
1,000	6,488	0,602	4,672	1,979	0,879	1997	1,196
0,301	6,608	3,615	5,340	0,649	1,346	2316	0,841
0,301	6,236	0,000	4,539	1,059	1,300	6304	1,130
4,769	8,170	5,985	7,654	1,787	1,985	6630	1,088
0,477	6,942	1,079	4,972	1,909	0,774	1925	1,131
1,279	6,509	0,903	5,238	1,235	1,521	4956	1,155
0,602	6,556	3,951	5,271	1,330	0,730	4517	0,992
4,229	8,175	5,853	7,978	0,701	1,750	5421	0,871
0,000	6,580	1,968	4,787	1,197	1,795	2295	0,808
1,230	6,260	3,550	5,814	1,740	0,604	2548	1,009
0,602	6,733	0,000	5,442	1,328	1,084	6927	0,830
1,114	6,053	2,025	4,109	1,062	1,177	5671	0,919
4,660	8,933	5,947	7,746	1,914	1,284	2455	1,104

Table B.2 (cont'd)

k1	k2	k3	k4	Ix	J	E	m
0,778	*6,808*	*0,000*	*4,327*	*0,619*	*0,866*	*3060*	*0,880*
1,342	*6,793*	*1,431*	*4,580*	*0,953*	*1,659*	*6970*	*0,812*
2,265	*6,685*	*0,903*	*4,058*	*0,522*	*1,763*	*4443*	*0,879*
4,942	*8,771*	*5,854*	*7,988*	*1,979*	*1,284*	*2980*	*0,948*
2,330	*6,597*	*2,241*	*5,671*	*0,804*	*1,189*	*4961*	*1,121*
2,616	*6,562*	*3,650*	*4,073*	*1,734*	*1,890*	*3460*	*0,966*
2,987	*6,231*	*3,122*	*5,603*	*1,130*	*1,186*	*6794*	*1,142*
2,346	*8,727*	*5,963*	*7,437*	*1,034*	*1,392*	*2645*	*1,043*
4,772	*8,727*	*5,789*	*6,951*	*0,777*	*0,925*	*3991*	*0,808*
1,863	*6,040*	*1,204*	*4,767*	*0,825*	*1,158*	*6286*	*1,119*
1,799	*6,238*	*1,230*	*5,156*	*0,533*	*1,790*	*5732*	*0,809*
4,474	*8,703*	*5,631*	*7,671*	*1,388*	*1,126*	*2629*	*1,019*
0,778	*6,513*	*3,071*	*4,682*	*0,949*	*0,992*	*1924*	*1,086*
4,031	*8,895*	*5,662*	*7,877*	*1,394*	*1,749*	*4699*	*0,808*
4,833	*7,372*	*5,938*	*7,211*	*1,216*	*1,800*	*3400*	*1,154*
4,292	*7,555*	*5,196*	*7,493*	*1,965*	*1,303*	*6265*	*0,950*
1,000	*6,861*	*3,907*	*5,922*	*1,546*	*1,036*	*2240*	*1,183*
3,883	*8,374*	*4,472*	*7,430*	*1,059*	*1,300*	*6304*	*1,130*
0,301	*6,328*	*0,602*	*5,475*	*1,264*	*1,246*	*4115*	*1,125*
1,041	*6,395*	*2,493*	*4,537*	*0,550*	*1,360*	*3569*	*1,055*
1,903	*6,900*	*0,000*	*4,657*	*0,607*	*1,708*	*5106*	*1,161*
2,176	*6,052*	*1,146*	*4,756*	*1,101*	*1,080*	*4538*	*0,983*
2,677	*6,230*	*2,876*	*4,365*	*1,533*	*1,127*	*2886*	*1,069*
4,497	*8,806*	*5,673*	*7,996*	*0,603*	*1,787*	*5362*	*1,045*
4,913	*8,985*	*5,990*	*6,149*	*1,066*	*1,701*	*7193*	*0,871*
0,000	*6,887*	*2,592*	*5,388*	*0,886*	*1,102*	*4241*	*1,062*
4,432	*8,765*	*5,322*	*6,897*	*1,843*	*0,667*	*5955*	*1,061*
4,454	*7,669*	*5,471*	*7,582*	*0,951*	*1,923*	*4029*	*1,192*
2,386	*6,095*	*1,602*	*4,613*	*1,720*	*1,334*	*4450*	*1,089*
4,894	*8,899*	*5,522*	*7,654*	*1,333*	*1,705*	*4098*	*1,026*
0,778	*6,181*	*2,919*	*5,127*	*0,958*	*0,928*	*6263*	*1,167*
0,954	*6,394*	*3,624*	*5,171*	*1,381*	*1,096*	*2542*	*1,084*
4,297	*8,576*	*4,980*	*7,789*	*1,554*	*1,159*	*4277*	*0,968*
2,057	*6,701*	*3,028*	*5,430*	*0,728*	*1,770*	*5621*	*1,172*
2,387	*6,451*	*1,041*	*5,843*	*1,016*	*1,754*	*3645*	*0,907*
0,699	*6,956*	*1,716*	*4,780*	*0,584*	*1,024*	*5461*	*1,113*
4,272	*8,996*	*5,705*	*7,792*	*1,962*	*1,652*	*2178*	*0,801*
0,845	*6,463*	*3,652*	*5,846*	*1,250*	*1,827*	*5400*	*1,029*
3,582	*8,812*	*5,954*	*7,532*	*0,676*	*1,138*	*2737*	*1,109*
2,173	*6,397*	*0,903*	*5,205*	*1,327*	*1,193*	*6969*	*1,060*
4,236	*8,652*	*5,953*	*7,196*	*0,854*	*1,046*	*5658*	*0,829*
3,566	*8,263*	*5,849*	*7,842*	*1,606*	*1,275*	*4137*	*1,057*
0,954	*6,241*	*3,514*	*4,259*	*1,355*	*1,410*	*5464*	*1,044*
0,845	*6,502*	*2,452*	*4,735*	*1,298*	*1,540*	*5172*	*0,973*
4,550	*8,450*	*5,407*	*7,709*	*1,832*	*0,885*	*4535*	*1,138*
1,204	*6,135*	*2,933*	*5,908*	*1,896*	*0,533*	*4348*	*1,148*
3,552	*8,541*	*5,862*	*6,890*	*0,857*	*0,601*	*3296*	*1,134*
4,837	*8,398*	*5,649*	*7,812*	*1,019*	*0,910*	*3496*	*1,050*
4,701	*8,904*	*5,903*	*7,749*	*1,537*	*0,502*	*5621*	*0,862*
1,531	*6,241*	*0,301*	*5,878*	*1,890*	*0,776*	*6916*	*1,175*
4,826	*8,481*	*5,456*	*7,143*	*1,775*	*1,760*	*7045*	*1,075*
0,602	*6,549*	*3,573*	*4,541*	*1,390*	*0,795*	*3906*	*1,143*
0,301	*6,833*	*1,079*	*4,944*	*0,530*	*1,740*	*6758*	*0,896*
1,342	*6,086*	*2,400*	*4,377*	*1,582*	*0,746*	*4009*	*1,160*
4,428	*7,792*	*5,551*	*7,948*	*1,603*	*1,696*	*2811*	*1,191*
0,954	*6,962*	*1,732*	*4,602*	*1,313*	*0,848*	*4747*	*0,845*
2,204	*6,808*	*2,673*	*4,568*	*1,305*	*1,127*	*4595*	*0,818*
2,737	*6,053*	*2,393*	*4,999*	*1,813*	*1,168*	*7076*	*1,132*
4,298	*7,130*	*5,429*	*7,927*	*1,653*	*1,959*	*4491*	*1,050*
1,301	*6,044*	*3,773*	*5,018*	*1,568*	*1,008*	*2664*	*1,175*
2,681	*6,063*	*2,839*	*5,485*	*1,117*	*0,560*	*4522*	*0,975*
2,086	*6,970*	*0,301*	*4,988*	*1,659*	*0,666*	*2882*	*1,104*
0,000	*6,793*	*3,562*	*4,179*	*1,552*	*0,765*	*2287*	*0,802*
4,938	*8,573*	*4,954*	*7,824*	*1,161*	*1,312*	*3239*	*0,867*

Table B.2 (cont'd)

k1	k2	k3	k4	Ix	J	E	m
1,146	*6,492*	*2,977*	*5,344*	*1,285*	*0,506*	*2818*	*1,060*
0,000	*6,324*	*3,607*	*4,479*	*1,551*	*1,746*	*5163*	*0,835*
1,114	*6,768*	*0,903*	*4,531*	*1,360*	*1,043*	*1962*	*0,818*
4,249	*8,816*	*5,785*	*6,416*	*1,426*	*0,884*	*6773*	*0,916*
4,982	*8,853*	*5,362*	*7,889*	*1,301*	*0,523*	*5416*	*0,992*
1,362	*6,910*	*2,442*	*5,431*	*1,198*	*1,939*	*2819*	*0,973*
2,201	*6,772*	*3,570*	*4,537*	*1,416*	*0,665*	*5786*	*0,890*
1,869	*6,810*	*2,659*	*4,577*	*1,311*	*1,030*	*4649*	*0,959*
4,698	*8,382*	*5,306*	*7,288*	*0,902*	*1,757*	*3398*	*1,177*
2,004	*6,678*	*0,301*	*4,265*	*1,934*	*0,897*	*3969*	*0,875*
0,301	*6,894*	*3,269*	*5,242*	*0,758*	*1,353*	*4156*	*0,968*
1,204	*6,117*	*3,386*	*4,877*	*0,506*	*0,830*	*6433*	*0,809*
0,301	*6,633*	*2,196*	*5,159*	*1,761*	*1,901*	*3865*	*0,884*
4,518	*7,984*	*5,771*	*7,230*	*1,891*	*0,647*	*2285*	*0,978*
1,903	*6,842*	*1,477*	*5,574*	*0,840*	*1,630*	*5640*	*1,129*
2,702	*6,220*	*2,810*	*4,746*	*1,542*	*1,499*	*4291*	*0,853*
2,430	*6,569*	*1,708*	*5,765*	*0,665*	*1,384*	*6602*	*1,141*
4,829	*8,682*	*5,271*	*7,123*	*1,670*	*0,974*	*2122*	*0,984*
4,763	*8,800*	*5,144*	*6,786*	*1,451*	*1,758*	*4417*	*1,056*
4,213	*8,681*	*5,898*	*7,719*	*0,509*	*1,175*	*4351*	*1,051*
1,568	*6,475*	*2,346*	*5,549*	*0,990*	*0,894*	*6993*	*1,146*
1,602	*6,383*	*0,000*	*4,068*	*1,879*	*1,057*	*3062*	*1,152*
1,898	*6,208*	*0,778*	*5,167*	*0,621*	*1,187*	*5189*	*1,162*
0,301	*6,051*	*2,601*	*4,411*	*0,756*	*0,980*	*3854*	*1,170*
2,250	*6,854*	*1,041*	*4,695*	*1,802*	*1,788*	*5041*	*0,966*
0,699	*6,435*	*1,362*	*5,200*	*1,371*	*0,964*	*5308*	*0,920*
1,968	*6,166*	*0,954*	*5,325*	*0,736*	*0,927*	*6174*	*0,902*
0,301	*6,665*	*0,301*	*4,420*	*1,164*	*1,473*	*7154*	*1,002*
0,000	*6,684*	*2,149*	*4,383*	*0,904*	*1,776*	*3388*	*1,140*
0,778	*6,550*	*2,037*	*5,130*	*0,922*	*1,124*	*2544*	*0,940*
4,220	*8,948*	*5,510*	*7,818*	*1,094*	*1,846*	*2927*	*0,972*
0,301	*6,771*	*2,583*	*5,511*	*1,864*	*1,908*	*4602*	*1,026*
0,301	*6,588*	*2,152*	*4,100*	*0,665*	*0,622*	*3308*	*1,161*
1,477	*6,844*	*2,517*	*4,391*	*1,126*	*1,895*	*3313*	*0,818*
0,301	*6,606*	*2,761*	*5,939*	*0,835*	*0,687*	*4241*	*1,048*
4,161	*8,881*	*5,423*	*7,142*	*0,563*	*1,539*	*3578*	*1,138*
4,040	*8,465*	*5,601*	*7,748*	*0,966*	*0,943*	*5357*	*1,123*
2,872	*6,877*	*1,000*	*4,315*	*0,552*	*1,349*	*4575*	*1,069*
1,863	*6,305*	*2,833*	*5,141*	*1,188*	*0,962*	*2636*	*0,962*
4,631	*8,708*	*5,358*	*7,792*	*1,235*	*1,521*	*4956*	*1,155*
4,891	*8,374*	*5,853*	*7,225*	*1,745*	*1,558*	*6241*	*1,073*
4,489	*7,902*	*5,944*	*7,763*	*1,792*	*1,714*	*6677*	*1,107*
2,117	*6,459*	*0,000*	*4,609*	*0,852*	*0,566*	*4913*	*0,802*
2,420	*6,795*	*0,477*	*5,606*	*1,281*	*1,759*	*5548*	*1,064*
1,580	*6,154*	*1,813*	*4,920*	*1,127*	*1,320*	*4321*	*0,937*
0,845	*6,833*	*2,657*	*4,176*	*1,623*	*1,864*	*7029*	*0,875*
2,568	*6,715*	*0,602*	*4,629*	*0,711*	*1,276*	*7178*	*0,805*
1,724	*6,085*	*1,756*	*4,336*	*0,933*	*1,917*	*3325*	*0,845*
1,934	*6,168*	*1,279*	*4,276*	*1,322*	*1,490*	*1808*	*0,995*
1,681	*6,694*	*3,655*	*5,670*	*0,534*	*1,315*	*3986*	*1,166*
4,903	*8,513*	*5,988*	*7,905*	*1,512*	*1,858*	*1888*	*1,150*
1,322	*6,545*	*3,583*	*4,584*	*1,162*	*1,876*	*3238*	*1,162*
1,301	*6,969*	*1,748*	*4,455*	*1,933*	*1,116*	*6452*	*0,927*
4,717	*8,677*	*5,768*	*7,889*	*0,990*	*0,894*	*6993*	*1,146*
0,699	*6,750*	*2,644*	*5,695*	*0,830*	*0,867*	*4244*	*1,172*
4,599	*8,899*	*5,906*	*7,784*	*1,034*	*1,378*	*4153*	*1,064*
3,734	*8,689*	*5,856*	*7,943*	*1,312*	*0,585*	*4386*	*0,867*
1,279	*6,698*	*0,477*	*5,110*	*1,746*	*0,819*	*4536*	*1,051*
0,699	*6,291*	*0,602*	*5,935*	*1,977*	*1,365*	*5636*	*0,824*
0,000	*6,234*	*1,230*	*5,203*	*1,782*	*1,479*	*2298*	*1,110*
0,477	*6,618*	*0,778*	*5,606*	*1,454*	*0,720*	*2572*	*1,109*
0,301	*6,013*	*1,531*	*4,301*	*1,847*	*1,170*	*2889*	*1,046*
1,544	*6,744*	*0,301*	*5,109*	*1,172*	*1,274*	*2463*	*0,902*
4,291	*8,515*	*5,616*	*7,184*	*1,430*	*0,649*	*4100*	*0,882*

Table B.2 (cont'd)

k1	k2	k3	k4	lx	J	E	m
1,908	6,437	3,154	5,806	1,612	1,427	5658	1,199
4,854	8,540	5,801	7,823	1,368	1,603	3966	1,105
2,551	6,377	0,845	5,777	1,986	0,878	6000	1,181
0,000	6,498	3,738	4,955	1,969	0,528	4780	0,981
4,845	8,965	5,467	7,704	1,370	0,735	5530	0,887
1,531	6,527	1,556	4,977	1,723	1,856	3973	1,048
4,754	8,106	5,412	7,944	1,482	1,024	2320	0,955
4,893	8,391	5,798	7,770	0,599	1,250	2447	1,116
0,000	6,559	1,255	5,283	1,338	0,600	6389	1,180
0,301	6,189	0,699	5,664	1,565	1,162	2280	0,936
0,000	6,703	2,654	4,519	1,591	1,239	1850	1,150
2,829	6,383	1,398	4,080	1,835	1,240	4746	0,963
3,619	8,877	5,388	7,524	0,578	1,813	5038	1,063
4,916	8,463	5,989	7,060	1,691	1,093	4767	1,145
1,146	6,520	2,453	4,411	1,251	1,005	6538	1,141
2,328	6,648	1,041	4,383	1,684	1,600	4394	1,151
4,818	8,791	5,704	7,993	1,706	1,284	6571	0,803
3,640	8,813	5,926	7,824	1,494	0,820	2634	0,855
2,465	6,032	2,158	4,075	0,756	1,742	7147	1,150
1,613	6,153	1,491	5,908	0,756	1,371	3845	0,943
4,399	8,580	5,779	7,739	1,330	1,908	5689	1,108
4,770	8,994	5,960	7,356	1,543	1,970	2340	0,898
4,591	8,767	5,080	7,771	1,446	0,642	5509	0,855
0,301	6,003	1,362	5,010	0,765	1,383	4242	0,903
0,301	6,388	0,301	5,124	0,676	1,145	3434	1,097
4,900	7,984	5,603	7,486	1,720	1,334	4450	1,089
1,748	6,514	3,172	4,373	0,500	1,270	1896	0,918
0,602	6,375	0,301	5,231	1,554	1,159	4277	0,968
2,838	8,529	4,638	7,431	0,868	0,940	6520	0,965
1,041	6,863	3,320	5,647	1,768	1,567	3845	1,002
4,693	8,593	5,537	7,992	0,900	1,637	3661	0,973
1,898	6,053	0,477	4,733	1,964	0,556	3963	0,950
4,807	8,526	5,553	7,618	1,329	0,716	5623	1,016
0,602	6,209	0,602	5,454	1,184	1,869	2851	1,121
4,825	8,950	5,892	7,942	1,967	1,163	2240	1,169
0,602	6,039	0,903	5,777	1,893	1,436	2965	0,912
2,079	6,733	1,987	5,978	1,780	0,759	2381	1,066
1,839	6,174	2,262	5,221	1,257	1,507	6773	1,124
3,798	8,753	5,240	7,642	0,589	1,831	4033	1,009
0,602	6,114	2,377	5,951	0,584	0,618	6977	0,962
4,866	8,695	5,742	7,910	1,119	1,096	5037	0,913
0,477	6,110	3,809	5,727	1,255	1,103	4988	0,975
1,653	6,741	2,834	5,288	0,522	0,963	4369	0,960
0,301	6,622	2,086	5,692	1,230	1,486	6573	0,822
2,467	6,633	3,738	4,535	0,860	1,021	5573	0,854
1,531	6,087	0,000	5,353	0,557	1,817	3828	1,109
0,602	6,691	0,301	5,988	1,636	1,550	1902	0,945
1,079	6,372	2,636	4,534	1,584	1,181	1878	0,859
0,000	6,347	2,912	4,155	0,857	0,601	3296	1,134
0,602	6,001	1,505	4,613	0,566	0,754	4798	1,187
0,000	6,649	3,373	5,334	1,494	0,820	2634	0,855
2,117	6,028	2,458	5,265	1,898	1,866	2938	1,012
2,786	6,771	0,602	5,472	1,241	1,406	4920	0,923
4,678	8,430	5,376	7,862	1,619	0,740	5327	1,082
2,509	6,335	2,369	5,999	1,887	1,470	2845	0,869
1,708	6,437	1,505	4,739	1,462	0,528	3977	0,998
1,000	6,143	0,903	5,866	1,452	1,983	2597	1,095
4,767	8,739	5,763	7,205	0,615	0,934	3922	1,180
2,634	6,163	1,000	5,216	1,048	1,293	4203	1,167
2,879	6,358	1,380	4,554	1,238	1,616	4307	0,994
2,914	6,115	2,789	4,693	1,851	1,504	4312	0,903
4,925	8,915	5,798	7,614	0,705	1,504	3354	0,853
3,195	8,636	5,604	7,440	1,978	1,704	2456	1,078
4,636	8,991	5,560	7,758	1,328	1,594	6755	0,815

Table B.2 (cont'd)

k1	k2	k3	k4	Ix	J	E	m
1,176	6,584	0,477	5,181	1,446	0,642	5509	0,855
4,842	8,932	5,875	7,580	0,839	1,125	4510	1,139
0,301	6,471	2,458	5,283	1,813	0,752	6298	0,998
3,325	7,863	5,706	7,941	1,169	1,483	4751	0,973
1,462	6,001	3,023	4,041	0,994	0,545	6081	0,894
4,350	7,941	5,775	7,337	1,389	1,524	6217	1,180
1,415	6,498	3,498	5,678	1,025	1,311	3985	1,193
2,985	8,900	5,455	7,857	1,060	1,223	2345	0,850
0,301	6,907	3,827	5,333	1,467	0,989	2533	1,049
0,903	6,880	0,699	5,313	1,740	0,989	4342	1,194
4,133	8,955	5,706	7,621	0,758	1,100	3590	0,973
4,527	8,856	5,902	7,517	0,652	1,437	2568	1,087
0,000	6,316	0,602	5,547	0,772	0,710	5304	1,163
0,778	6,379	2,405	5,096	1,330	1,908	5689	1,108
2,966	6,506	0,778	5,686	1,160	1,946	3600	1,054
2,346	6,136	1,114	5,381	1,451	0,761	3549	1,053
0,778	6,230	2,053	4,829	0,719	1,374	3429	1,027
2,701	6,724	2,740	5,886	1,148	0,669	3376	1,127
1,806	6,518	2,386	4,659	1,864	1,655	6937	1,030
4,076	8,907	5,340	7,998	0,978	0,998	4032	1,008
4,974	8,736	5,605	7,421	0,579	1,255	3636	1,154
2,859	6,619	3,366	5,895	1,992	1,542	6448	0,903
0,845	6,717	1,544	5,621	1,894	0,981	3308	0,836
4,382	8,240	5,967	7,658	0,782	1,958	5742	1,143
0,301	6,362	1,041	5,487	1,165	1,763	2000	0,935
1,987	6,260	2,412	5,215	0,778	1,420	3228	0,812
2,248	6,032	0,778	4,234	1,720	0,891	6687	0,998
4,702	8,953	5,327	7,343	0,534	0,612	4961	1,092
2,662	6,386	3,322	4,228	0,646	1,376	6398	0,801
1,114	6,827	3,449	5,911	1,645	0,519	4355	0,972
2,049	6,141	0,477	4,963	0,718	1,981	3905	0,859
0,602	6,863	0,000	5,126	1,275	0,543	6494	1,024
0,477	6,668	2,631	5,214	1,537	1,371	6858	1,069
4,904	8,809	4,739	7,653	0,596	1,643	4136	0,893
1,041	6,333	3,861	5,553	1,861	1,640	5644	1,062
3,130	8,813	5,045	6,750	1,882	0,739	3232	0,852
1,322	6,015	0,301	4,073	1,170	0,779	3226	0,897
4,841	8,799	5,060	7,342	1,854	1,696	4311	0,988
2,017	6,231	2,772	4,657	0,573	1,917	3180	0,909
2,853	6,140	2,930	5,830	0,755	1,902	5362	0,896
0,778	6,070	1,447	5,514	1,162	1,595	5688	0,811
2,493	6,292	3,596	5,088	1,850	1,844	5731	1,161
4,665	8,498	4,925	7,383	0,573	1,592	5254	1,031
0,000	6,309	0,602	5,921	0,879	0,552	7031	1,160
4,995	8,816	5,484	7,934	1,037	0,968	2373	0,914
1,230	6,051	0,602	4,319	1,804	1,309	4598	0,928
2,807	6,173	2,699	5,932	1,081	0,763	6899	1,136
2,193	6,732	0,602	4,036	1,562	1,677	5404	0,920
4,908	8,883	5,434	6,812	1,132	0,620	5096	0,843
2,677	6,812	0,903	5,794	1,746	0,704	3397	0,834
4,916	8,188	5,899	7,632	1,316	0,607	3876	0,823
0,954	6,728	3,690	4,961	0,605	1,173	7090	0,824
2,053	6,484	0,301	5,655	1,580	1,136	4100	0,943
2,707	6,598	1,690	5,295	1,343	1,990	4650	0,946
2,747	6,132	0,301	5,614	1,329	1,416	3050	1,096
0,602	6,165	1,944	4,338	1,806	1,173	4671	1,143
4,960	7,735	5,777	7,699	1,813	1,168	7076	1,132
2,807	6,893	1,398	4,846	1,335	0,567	2105	0,840
0,602	6,272	3,434	5,929	1,612	0,592	2503	0,935
1,230	6,350	1,279	4,997	1,083	1,060	5342	1,057
1,833	6,374	1,556	5,721	1,379	1,897	1814	1,007
0,845	6,624	3,621	5,038	1,988	1,351	6049	0,819
1,898	6,771	3,229	5,565	0,944	1,061	2385	0,988
0,301	6,109	2,907	4,457	1,015	0,618	5850	1,127

Table B.2 (cont'd)

k1	k2	k3	k4	Ix	J	E	m
0,845	6,287	3,470	5,553	1,684	1,201	4107	0,988
1,724	6,157	0,000	4,102	1,693	1,944	3414	0,979
0,301	6,784	1,839	5,507	1,394	1,749	4699	0,808
0,602	6,113	2,220	4,430	1,952	1,173	2829	1,190
4,587	8,377	5,357	6,845	1,685	1,734	2623	0,933
1,447	6,098	0,778	4,942	1,407	0,986	3611	1,198
1,114	6,032	2,502	5,056	1,183	1,561	5014	0,815
0,000	6,648	3,598	4,681	0,676	1,138	2737	1,109
1,875	6,490	2,272	5,499	1,471	1,344	3146	0,872
4,985	8,969	5,934	6,695	0,835	1,110	5716	1,172
2,255	6,384	0,301	5,472	0,919	1,839	5561	1,003
4,802	8,614	5,982	7,060	1,885	1,430	3665	0,939
1,146	6,127	3,858	5,272	1,634	1,895	2017	1,199
4,732	8,537	5,329	7,304	0,694	1,407	6301	1,034
4,908	8,748	5,704	7,705	1,487	1,520	6858	0,951
4,615	8,546	5,504	7,698	1,083	1,060	5342	1,057
1,886	6,606	3,372	4,115	0,983	1,612	6308	0,813
1,833	6,980	3,050	4,347	1,029	1,274	4606	0,844
0,699	6,388	3,361	4,063	1,254	1,838	2595	1,001
4,861	8,764	5,045	7,832	0,769	0,504	6412	1,101
4,876	7,193	5,445	7,884	0,739	1,029	3321	1,132
0,699	6,019	3,199	5,191	1,226	1,894	3854	0,979
4,213	7,848	5,387	7,681	0,775	1,661	4098	0,834
1,505	6,897	0,845	4,440	0,534	0,612	4961	1,092
4,918	8,868	5,408	7,595	1,387	0,652	2981	0,979
4,939	8,771	5,891	7,779	1,485	1,775	6621	0,949
1,653	6,560	3,240	5,340	1,921	1,221	5991	1,189
1,724	6,706	2,859	5,849	0,916	0,812	2407	1,053
4,464	8,563	5,507	7,549	0,853	1,389	6174	1,081
2,671	6,444	1,813	5,699	0,606	0,680	5254	0,808
0,301	6,059	3,626	5,203	1,231	1,784	2115	1,144
4,795	8,388	4,720	6,801	1,106	0,799	2290	1,018
4,979	8,279	5,620	7,560	0,987	1,969	3118	1,032
4,440	8,796	5,957	7,715	1,988	1,351	6049	0,819
0,000	6,729	2,571	4,310	1,313	1,319	2796	0,890
0,778	6,581	0,845	4,157	1,843	0,667	5955	1,061
2,792	6,943	0,477	4,966	1,181	0,682	6482	1,026
2,688	6,255	2,127	4,154	0,504	1,223	5623	0,985
0,301	6,807	0,903	5,989	0,978	0,998	4032	1,008
1,519	6,842	2,079	5,736	1,057	0,730	5207	0,848
4,898	8,475	5,372	7,682	0,882	1,011	3587	0,818
4,704	8,537	5,710	7,598	0,889	0,601	2109	1,056
4,019	8,270	4,890	7,636	1,939	1,313	2549	0,998
0,477	6,070	0,954	4,960	0,775	1,661	4098	0,834
2,403	6,454	0,778	4,640	1,392	1,619	5167	1,022
3,773	8,967	4,645	7,988	0,523	1,007	2246	0,886
1,633	6,425	2,686	5,428	1,893	0,795	4407	1,137
2,732	6,223	2,386	5,962	0,502	1,034	2223	0,893
2,710	6,207	3,037	4,300	1,283	1,563	7154	0,971
1,447	6,134	0,000	4,677	0,778	0,550	4892	1,004
2,400	6,231	2,182	4,433	0,572	1,932	4172	0,888
2,049	6,996	0,000	5,106	1,790	0,587	3777	0,918
4,210	8,220	5,834	7,996	0,756	0,873	5911	0,942
0,301	6,030	0,903	5,841	1,498	1,870	4476	1,164
0,903	6,134	2,696	4,639	0,907	1,532	3420	1,124
0,699	6,464	0,602	4,981	1,939	0,530	2967	1,050
4,375	8,949	5,822	7,771	1,620	1,110	6130	0,888
2,935	6,337	1,204	5,439	0,824	1,131	6000	1,165
4,921	8,669	5,920	7,578	1,239	1,747	5938	1,183
2,906	6,207	0,699	5,367	1,433	0,962	3434	1,173
2,772	6,609	0,602	4,280	0,503	1,882	4271	1,133
0,845	6,670	1,996	5,073	1,310	0,684	4633	1,114
4,757	8,468	5,355	7,759	1,659	1,089	4357	0,828
4,882	8,842	5,034	7,829	0,853	1,566	4880	1,199

Table B.2 (cont'd)

k1	k2	k3	k4	Ix	J	E	m
4,920	8,467	5,954	7,736	1,850	1,844	5731	1,161
2,326	6,219	3,348	5,153	0,895	1,141	7023	0,979
0,301	6,291	1,591	5,118	0,966	0,943	5357	1,123
0,000	6,324	0,000	5,256	1,188	1,682	2152	1,008
0,954	6,422	2,720	5,371	0,534	1,831	2011	1,140
4,793	8,620	4,646	7,745	1,285	0,578	5579	0,943
4,844	8,786	5,272	7,982	1,725	1,490	4669	0,827
1,544	6,092	3,819	4,029	1,364	1,411	6467	1,020
4,313	8,061	5,774	7,989	0,584	0,618	6977	0,962
0,845	6,703	1,623	5,623	1,613	1,156	5002	0,831
0,000	6,807	0,778	4,211	1,728	1,000	4831	0,805
0,778	6,820	3,799	4,986	1,622	0,901	6342	0,818
1,415	6,124	0,602	4,999	1,754	1,521	5065	1,109
1,322	6,383	3,458	5,871	1,793	1,406	3841	0,800
2,823	6,543	1,613	4,527	0,579	1,255	3636	1,154
0,903	6,597	3,653	5,430	1,618	0,928	3426	1,184
4,428	8,725	5,733	7,748	0,554	1,915	6574	0,958
2,465	7,000	2,934	4,333	1,483	1,648	6188	1,157
0,477	6,937	0,778	5,938	1,549	0,913	4107	0,973
0,602	6,035	0,602	4,621	1,965	1,303	6265	0,950
0,301	6,846	0,602	4,074	1,499	1,801	6213	0,875
0,000	6,444	1,505	4,609	0,544	0,914	5604	0,985
0,301	6,586	2,619	4,733	0,745	1,874	4072	0,966
1,672	6,824	0,699	4,192	0,652	1,579	3593	0,859
0,699	6,086	2,382	4,434	1,389	1,524	6217	1,180
1,591	6,531	0,699	5,590	1,995	0,581	3562	0,834
1,079	6,667	3,384	4,984	1,532	1,450	4214	0,954
2,730	6,443	1,146	5,759	1,139	1,582	6486	0,887
4,827	8,366	5,841	7,517	0,573	1,917	3180	0,909
3,770	8,309	5,583	7,648	0,712	1,018	5416	0,814
4,441	8,502	5,872	7,397	0,583	1,430	3545	0,866
4,540	8,936	5,919	7,916	1,768	1,567	3845	1,002
2,501	6,466	3,330	4,757	1,239	1,747	5938	1,183
4,028	8,768	5,816	7,564	0,745	1,874	4072	0,966
2,338	6,549	3,286	5,399	1,498	1,860	4681	1,181
3,000	6,233	2,923	4,165	0,773	1,039	4829	1,036
4,741	8,688	5,408	7,816	0,536	0,739	5394	0,883
0,301	6,491	0,301	5,169	1,860	1,238	3358	0,906
0,301	6,716	1,000	5,289	0,757	1,049	2517	1,057
1,826	6,434	0,301	4,653	1,687	1,262	5376	0,885
1,919	6,118	2,653	5,055	0,681	1,582	4103	1,186
1,602	6,976	1,813	4,126	1,702	1,726	4434	0,904
2,161	6,245	0,699	4,559	1,926	1,962	4998	1,191
0,000	6,182	2,822	5,389	1,606	1,275	4137	1,057
0,301	6,102	2,943	4,473	0,820	1,677	5207	1,100
0,301	6,231	0,301	4,342	1,620	0,760	4917	1,047
0,602	6,215	3,791	5,885	0,605	0,938	4116	0,801
0,602	6,503	1,875	4,446	1,536	0,561	4089	1,169
4,762	8,406	5,601	7,949	0,992	0,837	5124	0,833
0,954	6,325	1,146	5,816	0,804	1,708	4584	1,090
2,281	6,455	2,241	4,225	1,309	1,918	5175	1,143
4,275	7,431	5,448	7,813	1,742	1,057	3407	1,080
1,708	6,736	2,377	4,764	1,423	0,598	4824	0,980
2,630	6,972	1,633	4,752	1,002	1,700	4168	1,026
0,778	6,270	1,000	5,240	0,898	0,533	1949	1,144
0,602	6,423	3,716	4,371	1,672	1,753	3408	0,934
1,602	6,322	1,613	4,483	0,753	0,511	5002	1,128
3,188	8,491	5,139	7,982	0,879	0,552	7031	1,160
1,929	6,183	1,000	4,867	1,138	1,610	5970	0,844
2,551	6,504	1,813	4,634	0,917	1,512	5234	1,133
0,699	6,301	0,954	4,779	1,582	1,041	5451	1,090
4,861	8,879	4,774	7,610	0,913	1,808	5875	1,066
4,856	7,150	5,773	7,948	1,377	1,538	2904	1,186
0,602	6,072	3,878	4,204	1,877	1,654	6242	1,002

Table B.2 (cont'd)

k1	k2	k3	k4	Ix	J	E	m
2,648	6,774	2,158	4,722	0,847	1,335	5301	1,184
1,204	6,792	3,223	5,215	1,034	1,378	4153	1,064
4,951	8,910	5,356	7,953	1,746	0,704	3397	0,834
2,061	6,194	3,125	4,268	1,133	1,188	3793	1,134
1,279	6,726	3,712	4,922	0,707	0,828	4615	1,132
4,830	8,730	5,919	7,884	0,790	0,709	5312	1,121
2,876	6,809	2,588	4,808	0,515	1,247	5315	0,920
2,350	6,791	1,322	4,902	1,333	1,705	4098	1,026
4,229	8,917	5,815	7,347	0,570	1,867	4206	0,996
1,146	6,572	1,000	5,868	1,125	0,926	2330	1,171
0,954	6,449	2,137	4,651	1,244	0,930	6476	0,878
1,146	6,909	0,903	4,098	1,923	0,585	6031	1,000
1,447	6,852	2,636	5,896	1,452	1,782	2704	1,017
4,445	8,848	5,607	7,909	1,613	1,156	5002	0,831
4,746	8,959	5,818	7,645	1,539	0,597	2071	1,102
2,452	6,377	2,049	4,198	0,573	0,514	4229	1,153
1,342	6,276	1,845	4,637	0,787	0,770	2978	1,032
4,764	8,783	5,428	7,706	1,690	1,786	3997	0,837
4,556	8,927	5,913	6,722	1,366	0,884	4049	1,060
4,688	7,670	5,667	7,568	1,788	1,572	2451	0,947
4,369	8,428	5,624	7,806	1,444	1,489	2257	1,105
1,462	6,067	1,380	5,792	1,667	1,188	3107	1,050
0,301	6,003	1,079	5,876	0,827	1,163	4884	1,105
3,498	8,512	5,955	7,380	1,551	1,746	5163	0,835
3,813	8,508	5,790	7,988	1,799	0,868	2330	0,845
1,079	6,820	0,000	4,346	0,787	1,231	3732	1,095
0,000	6,330	3,399	5,003	1,399	0,627	6499	0,991
2,394	6,147	0,301	5,712	1,293	0,972	3273	1,094
4,667	8,102	5,299	7,389	1,993	0,523	6792	0,931
2,689	6,830	0,301	5,212	1,829	1,133	6101	1,148
2,990	6,164	0,699	4,065	1,201	0,642	5112	1,042
0,000	6,337	0,000	4,539	0,868	0,940	6520	0,965
0,845	6,255	0,301	5,780	1,018	0,664	6127	1,045
4,710	8,872	4,728	7,744	1,172	1,274	2463	0,902
1,431	6,759	1,114	4,120	1,075	1,031	4854	1,124
2,856	6,952	3,398	5,807	0,784	1,891	4479	0,845
2,013	6,900	2,791	4,563	0,930	1,913	6826	0,861
1,114	6,770	0,845	4,675	0,918	1,227	3586	1,186
1,079	6,168	3,634	5,205	1,195	1,983	2894	0,911
4,285	8,475	5,783	7,393	0,969	0,640	4020	0,801
4,951	8,711	4,006	7,947	1,786	0,634	2550	0,851
0,301	6,436	3,424	5,009	1,289	1,248	4324	1,062
4,859	8,802	5,917	7,961	1,013	1,873	2680	1,124
4,731	8,610	5,928	7,917	1,509	1,583	4733	1,199
4,982	8,662	5,875	7,977	1,725	1,639	6390	0,989
2,646	6,401	3,154	4,461	1,660	1,213	2791	1,027
4,209	8,633	5,015	6,958	1,669	1,550	3615	0,866
0,301	6,276	1,255	4,404	0,832	0,568	4104	0,847
1,146	6,114	0,000	4,796	1,484	1,516	2459	0,966
2,199	6,220	0,845	4,646	1,136	1,612	5169	0,847
1,792	6,806	3,704	5,515	1,061	0,693	6229	0,897
4,842	8,987	4,760	7,694	1,659	0,666	2882	1,104
0,699	6,984	0,699	5,366	1,430	0,985	4321	1,144
4,479	7,424	5,419	7,883	0,969	1,167	6839	1,159
4,438	8,921	5,822	6,944	1,623	1,864	7029	0,875
4,604	8,500	5,795	7,995	1,565	0,546	7008	1,123
2,893	6,660	1,959	5,377	1,574	1,552	6676	1,091
2,041	6,023	3,468	4,325	1,216	1,800	3400	1,154
0,477	6,097	0,477	4,118	1,917	1,988	4280	1,169
0,778	6,572	1,447	4,480	1,319	1,637	6128	1,166
0,000	6,118	1,690	5,937	1,453	1,497	6457	1,070
4,724	8,679	5,701	7,423	0,717	1,916	6839	0,966
0,778	6,814	3,343	4,461	1,023	0,537	6797	0,838
2,795	6,988	3,270	5,543	0,906	1,439	3969	0,875

Table B.2 (cont'd)

k1	k2	k3	k4	Ix	J	E	m
0,954	6,639	1,886	5,983	0,603	1,787	5362	1,045
0,301	6,016	2,025	4,774	1,065	1,179	2671	0,911
1,653	6,967	1,491	5,252	0,705	1,608	2198	1,086
1,114	6,265	0,602	4,401	1,374	1,838	5143	1,114
4,490	8,873	5,940	7,795	1,501	1,366	3246	1,164
4,727	8,852	4,847	7,880	0,607	1,910	4598	0,840
4,547	8,802	5,206	7,957	1,054	1,722	4577	0,866
4,776	8,907	5,967	7,880	1,061	0,693	6229	0,897
1,380	6,313	0,301	4,483	0,573	1,592	5254	1,031
0,000	6,987	2,904	4,666	1,587	1,772	5064	1,108
4,893	8,898	5,552	7,503	0,708	1,250	3590	0,854
4,347	8,853	5,936	7,993	1,362	1,832	2641	1,153
0,000	6,230	2,164	4,498	1,833	1,425	6247	1,072
2,037	6,381	2,899	5,577	0,502	0,632	5337	1,136
0,301	6,252	2,286	5,749	1,799	0,692	6124	1,128
1,519	6,344	2,053	4,793	0,889	0,601	2109	1,056
4,322	8,335	5,977	7,974	0,605	0,938	4116	0,801
1,633	6,354	0,477	5,480	1,781	1,112	5994	0,898
0,301	6,203	1,531	4,889	0,712	1,018	5416	0,814
2,837	6,713	1,362	4,234	1,263	0,631	5943	0,913
1,978	6,680	0,477	5,573	1,321	1,743	1973	0,991
2,405	6,237	1,982	4,926	0,528	1,870	3088	1,094
3,750	8,953	5,380	6,722	1,671	0,555	5146	0,855
2,908	8,803	5,397	7,554	1,788	1,724	3270	1,102
2,507	6,816	2,866	5,851	0,881	1,012	3187	0,820
0,778	6,332	3,089	5,896	1,427	1,929	7116	0,840
4,283	7,864	5,987	7,009	1,877	1,654	6242	1,002
0,301	6,396	3,286	4,147	1,131	0,510	5154	1,022
1,623	6,607	2,427	4,928	0,517	1,925	3954	1,032
2,117	6,404	1,415	5,639	0,749	1,729	4652	1,187
2,533	6,097	3,807	5,977	1,638	1,615	1868	0,837
2,193	6,125	3,209	5,266	0,854	0,616	6387	1,116
1,230	6,233	0,000	4,921	1,223	0,732	2873	0,846
4,260	8,437	5,934	7,984	1,612	0,592	2503	0,935
2,769	6,328	3,412	4,989	1,416	0,616	3811	0,968
0,301	6,226	0,301	4,472	1,091	1,561	3478	1,037
2,427	6,401	1,785	4,559	1,340	0,976	2889	0,974
1,041	6,099	1,826	5,882	1,261	1,522	5567	1,091
4,506	8,950	5,953	7,215	0,792	1,324	6384	0,932
4,791	8,639	5,984	7,943	0,982	1,055	4104	0,908
4,860	8,600	5,365	7,780	1,327	1,193	6969	1,060
0,477	6,900	2,033	4,836	0,758	1,100	3590	0,973
1,892	6,494	1,996	4,266	1,954	0,766	2247	1,036
2,627	6,573	3,234	5,120	1,430	1,151	6132	0,878
1,799	6,435	0,477	5,725	1,841	0,596	5293	1,180
2,777	6,258	1,041	5,429	1,497	1,659	4788	1,104
4,678	8,851	5,771	7,808	0,627	1,849	6539	0,890
0,699	6,949	1,602	5,244	1,866	0,694	3650	0,963
1,690	6,582	2,276	5,821	1,505	1,970	5325	0,989
0,845	6,012	2,053	4,756	1,052	1,374	2562	1,028
1,519	6,245	0,477	5,360	0,726	0,749	3565	0,810
4,960	8,570	5,849	7,999	1,880	1,555	6396	1,153
4,952	8,409	5,726	6,888	0,504	1,223	5623	0,985
4,768	8,439	5,314	7,937	0,825	0,676	3443	1,090
4,420	8,522	5,888	7,977	1,427	1,929	7116	0,840
4,062	8,242	4,682	7,854	1,300	1,342	2278	0,887
1,176	6,970	2,965	4,785	0,845	0,924	2819	1,047
0,000	6,162	2,560	4,539	1,817	1,245	6337	0,999
4,028	8,774	5,788	7,742	1,132	1,541	4105	0,968
4,341	8,135	5,535	7,466	1,127	0,582	2215	0,917
4,672	8,099	5,199	7,699	1,754	1,521	5065	1,109
2,352	6,973	0,954	4,790	1,649	0,562	3034	0,895
0,778	6,322	3,548	4,697	0,772	1,954	3141	1,173
2,865	6,811	2,665	4,534	1,487	1,763	5129	0,962

Table B.2 (cont'd)

k1	k2	k3	k4	Ix	J	E	m
2,225	6,711	0,699	4,115	0,869	0,797	5896	1,190
0,602	6,465	2,068	4,566	1,856	0,829	2974	1,171
3,868	8,800	5,837	7,891	1,108	1,640	6542	0,869
4,966	8,361	5,649	7,924	0,821	1,036	4150	0,925
2,210	6,093	3,759	4,177	0,899	1,704	5325	0,870
2,550	6,312	2,418	4,261	0,547	1,747	7061	0,845
1,732	6,254	1,602	5,778	0,992	0,837	5124	0,833
4,898	7,562	5,900	7,684	0,810	1,403	6949	1,164
0,477	6,019	1,806	5,379	0,582	1,485	5815	1,178
2,717	6,573	2,173	4,311	1,150	0,789	3113	0,930
0,602	6,589	2,943	5,697	1,314	0,948	2394	1,082
0,477	6,489	3,236	4,634	0,608	1,860	5925	0,916
2,820	6,114	3,937	5,266	1,398	1,854	3844	1,030
2,017	6,513	0,000	5,856	1,484	1,855	7179	0,822
1,041	6,795	0,903	4,139	1,731	1,466	4584	0,853
4,990	7,975	5,892	6,646	1,949	2,000	2487	1,075
1,875	6,243	0,301	4,126	1,106	0,799	2290	1,018
0,778	6,146	3,504	5,985	1,121	1,659	5438	0,806
1,380	6,772	1,415	4,986	0,669	0,619	2011	1,155
1,398	6,125	0,778	4,490	1,993	0,523	6792	0,931
1,771	6,355	2,762	4,457	1,507	0,666	4021	1,070
2,473	6,153	3,173	4,857	1,316	0,607	3876	0,823
2,140	6,346	2,526	5,330	1,368	1,603	3966	1,105
0,000	6,572	1,301	4,954	1,211	0,584	4747	1,112
0,477	6,576	1,000	5,826	1,353	1,345	2998	1,151
4,486	8,708	5,498	6,945	1,838	0,574	3303	0,824
0,301	6,602	3,418	4,040	1,164	1,029	3991	0,911
1,903	6,410	3,842	4,229	1,885	1,430	3665	0,939
4,804	8,047	5,866	7,213	1,493	1,631	7101	1,160
1,643	6,206	3,851	5,866	1,989	1,759	3631	0,964
4,802	8,319	5,270	7,766	0,621	1,187	5189	1,162
0,903	6,284	2,961	5,142	0,751	0,578	3766	1,025
3,733	7,344	5,713	7,441	1,918	0,550	2248	1,068
0,000	6,773	0,778	4,976	1,464	1,920	3936	1,168
1,845	6,835	2,310	5,173	1,311	1,504	6796	1,000
1,556	6,491	2,111	5,957	1,454	1,358	2031	0,890
1,230	6,829	1,820	4,766	1,803	1,303	3500	0,941
2,375	6,035	3,177	4,967	0,810	1,403	6949	1,164
1,708	6,521	3,541	5,133	1,832	1,647	4928	1,118
1,230	6,458	2,777	4,558	0,998	1,537	6153	0,899
2,678	6,406	2,662	5,851	1,570	1,374	4769	0,986
1,544	6,295	2,960	4,939	1,668	0,941	3639	1,042
4,841	8,866	5,696	7,995	1,780	0,759	2381	1,066
2,326	6,154	0,903	5,637	0,955	0,511	2683	1,043
1,362	6,891	2,732	4,910	1,069	1,734	3177	0,812
4,795	8,606	4,986	7,560	0,810	1,528	2483	0,963
2,720	6,422	1,748	4,288	1,175	0,797	4019	0,857
2,140	6,524	2,260	4,930	1,070	1,591	5053	1,038
2,598	6,817	1,732	5,217	1,550	1,276	4213	1,191
2,369	6,662	0,301	4,645	1,839	1,896	4998	1,104
0,778	6,482	3,743	5,235	0,692	1,796	3893	0,816
4,404	8,944	5,762	7,298	1,798	0,820	5756	0,923
4,786	8,575	5,591	7,935	1,379	1,897	1814	1,007
1,380	6,141	0,477	5,019	0,525	1,258	6113	0,879
1,079	6,874	2,386	4,244	0,735	0,733	4077	0,814
1,756	6,488	3,756	5,093	1,290	0,672	2832	1,180
4,307	8,969	5,865	7,909	1,693	0,680	3488	1,002
4,305	7,943	5,900	6,382	1,947	0,781	5036	1,029
4,707	8,722	5,591	7,689	1,723	1,856	3973	1,048
4,521	8,629	5,777	7,205	1,870	0,910	4836	1,009
0,699	6,173	3,706	4,910	0,782	1,958	5742	1,143
0,845	6,067	0,699	5,817	0,831	1,539	4686	0,896
2,716	6,831	3,972	4,253	1,341	1,541	5388	0,870
0,602	6,302	2,288	4,843	1,368	1,894	6711	1,039

Table B.2 (cont'd)

k1	k2	k3	k4	Ix	J	E	m
2,276	6,745	3,343	5,704	1,432	1,694	1943	0,805
0,602	6,997	1,204	5,579	1,707	0,892	6980	1,028
4,595	8,915	5,818	7,359	1,950	1,005	6518	1,065
4,189	8,690	5,908	7,501	0,608	1,860	5925	0,916
2,888	6,647	2,332	4,482	1,339	1,504	5307	0,933
4,778	8,379	5,488	7,762	0,533	1,790	5732	0,809
0,602	6,078	3,040	4,604	1,405	1,780	5087	1,131
1,826	6,226	1,204	5,424	0,876	0,921	2533	0,975
1,477	6,391	1,380	5,963	0,900	1,637	3661	0,973
2,439	6,971	3,942	5,837	1,812	1,515	3791	0,979
0,602	6,227	0,000	4,576	0,750	1,400	2627	0,913
4,915	8,324	5,671	7,939	1,743	1,116	2276	0,985
1,954	6,808	1,672	5,594	1,582	1,540	2985	1,092
1,380	6,346	3,682	5,869	1,045	1,403	3844	0,999
1,869	6,029	1,398	4,435	1,732	0,963	2953	0,855
2,079	6,086	1,491	5,125	1,303	1,880	4792	0,818
2,265	6,837	1,255	4,287	1,338	1,324	4603	0,822
1,255	6,439	2,928	4,455	0,953	1,000	2922	1,064
1,079	6,899	1,898	5,258	0,820	0,877	2634	1,181
2,680	6,883	3,167	5,741	1,858	1,888	1810	1,073
2,676	6,997	0,477	5,734	1,944	1,417	2096	0,818
0,903	6,293	2,752	5,596	0,912	1,044	5982	1,093
2,164	6,791	3,549	4,253	1,268	1,975	4228	1,150
1,230	6,183	1,491	5,373	1,673	0,983	5219	0,964
4,712	8,979	5,891	7,521	0,892	1,455	5254	0,884
1,146	6,888	1,531	4,567	0,675	1,915	4122	1,069
4,636	8,923	5,340	7,864	1,849	0,826	5273	1,193
4,421	8,169	5,943	7,997	1,121	1,659	5438	0,806
4,959	8,647	5,453	7,944	1,139	1,582	6486	0,887
1,255	6,821	1,826	4,873	1,284	0,690	4720	1,167
4,365	8,616	5,759	7,624	1,355	1,985	4857	0,924
2,360	6,126	1,176	5,345	1,375	1,464	3143	0,911
1,531	6,232	0,602	5,271	0,769	1,097	3397	0,952
2,675	6,203	3,555	4,819	1,698	1,574	3314	1,160
4,694	8,652	5,995	7,778	1,628	0,929	4430	1,160
0,903	6,654	1,724	4,185	1,726	1,182	4734	0,919
1,544	6,931	3,599	5,581	1,120	1,397	2177	0,829
0,903	6,205	0,954	4,526	1,234	1,830	2392	1,062
0,903	6,416	3,567	4,940	1,114	1,262	6146	1,060
4,408	8,684	5,971	7,791	0,692	1,796	3893	0,816
1,544	6,362	1,342	4,599	1,165	1,756	4204	0,946
2,600	6,607	2,760	5,935	0,858	0,579	7008	1,166
1,491	6,448	3,958	5,199	1,628	0,929	4430	1,160
2,292	6,512	0,699	5,757	1,053	0,607	3471	1,052
4,914	8,642	5,083	7,957	1,592	1,502	4709	1,128
1,431	6,816	3,827	4,968	1,609	1,096	6233	0,936
1,708	6,127	1,041	5,759	1,482	1,024	2320	0,955
2,167	6,633	3,302	5,828	1,013	1,873	2680	1,124
0,000	6,575	2,461	5,397	1,287	1,633	5718	0,849
4,814	8,908	5,620	7,902	1,582	1,540	2985	1,092
4,704	8,926	5,716	7,939	1,057	0,730	5207	0,848
0,301	6,420	2,746	5,344	0,568	1,810	2036	1,094
3,889	8,560	5,417	7,871	1,165	1,763	2000	0,935
1,146	6,025	2,013	4,653	1,652	1,468	4352	1,039
0,699	6,354	3,274	4,950	0,558	1,528	5982	1,167
1,362	6,348	3,906	5,146	0,541	1,806	4827	1,165
3,111	8,863	5,808	7,190	1,313	1,319	2796	0,890
2,754	6,567	1,863	5,338	0,574	1,813	4737	1,074
2,410	6,705	2,695	4,362	0,654	1,918	3313	1,113
1,301	6,459	1,771	5,567	1,366	1,518	4811	0,846
1,763	6,501	3,295	4,223	0,759	0,732	2287	1,159
1,041	6,514	3,568	5,175	1,552	1,541	4073	1,160
4,672	8,968	5,523	7,332	1,946	1,215	5504	1,138
1,146	6,649	3,198	5,861	1,215	1,935	6228	0,939

Table B.2 (cont'd)

k1	k2	k3	k4	Ix	J	E	m
0,954	6,755	2,881	4,895	0,633	1,453	6052	1,108
1,653	6,486	1,041	5,309	0,536	0,739	5394	0,883
1,690	6,682	3,908	5,132	0,599	1,551	4987	1,032
4,604	8,586	5,313	7,943	0,727	1,102	6777	1,044
1,505	6,801	3,200	5,121	1,537	0,502	5621	0,862
1,591	6,952	2,585	4,245	1,556	1,802	5235	1,135
0,000	6,021	2,068	4,552	1,918	0,550	2248	1,068
2,086	6,854	3,000	4,760	0,839	1,125	4510	1,139
1,602	6,577	3,408	4,524	0,522	1,621	3418	1,106
4,975	8,584	5,541	6,601	1,835	1,240	4746	0,963
4,528	8,864	5,853	7,854	1,320	1,214	5054	1,041
1,255	6,894	0,000	5,026	0,736	1,443	4199	0,876
0,000	6,275	3,842	4,654	1,472	1,045	5505	0,948
2,021	6,768	1,820	5,836	1,470	0,579	6153	0,899
0,845	6,846	2,161	5,428	0,660	0,695	5367	1,057
2,025	6,936	1,756	5,012	0,903	0,544	2045	1,115
4,713	8,969	5,954	7,898	1,120	1,397	2177	0,829
0,903	6,212	0,778	4,928	1,514	1,940	4845	1,015
1,380	6,805	0,477	5,055	1,852	0,554	2919	0,821
0,699	6,108	1,505	4,680	1,740	0,761	2064	1,160
0,477	6,654	3,627	4,473	1,513	0,520	5002	0,889
1,415	6,928	1,342	4,430	1,946	1,215	5504	1,138
2,702	6,557	2,719	4,946	0,948	0,716	5571	1,131
0,000	6,635	1,000	4,716	1,788	1,724	3270	1,102
4,799	8,694	5,698	7,125	1,954	0,766	2247	1,036
2,766	6,378	2,270	5,527	1,347	1,901	4599	1,079
2,250	6,371	0,602	4,607	0,576	0,734	6613	1,196
2,948	6,034	0,301	5,544	1,834	1,861	3715	1,173
0,000	6,475	0,301	5,697	1,248	1,343	3057	1,007
2,553	6,961	2,831	5,349	1,757	0,639	2736	0,913
1,079	6,887	2,408	5,945	2,000	1,160	4855	1,097
0,602	6,929	2,929	5,623	1,693	0,680	3488	1,002
0,602	6,408	3,883	4,138	0,658	1,916	7015	1,109
3,950	8,783	5,839	7,987	0,835	0,687	4241	1,048
1,690	6,275	1,643	5,250	1,707	1,606	5800	1,086
1,000	6,612	1,924	4,344	1,841	0,921	5719	1,059
1,000	6,450	1,663	4,049	1,057	1,620	2732	1,023
1,146	6,223	1,362	5,040	0,609	0,616	5589	0,905
1,568	6,619	2,829	5,498	1,094	0,616	3583	0,940

APPENDIX C

TESTING PERFORMANCES

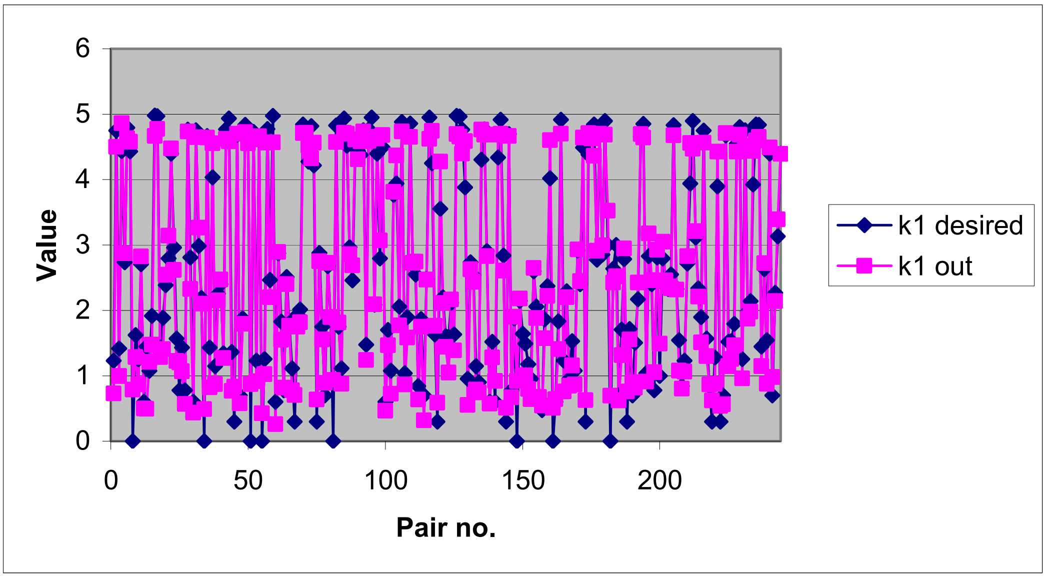

Figure C.1 Testing Performance for k_1

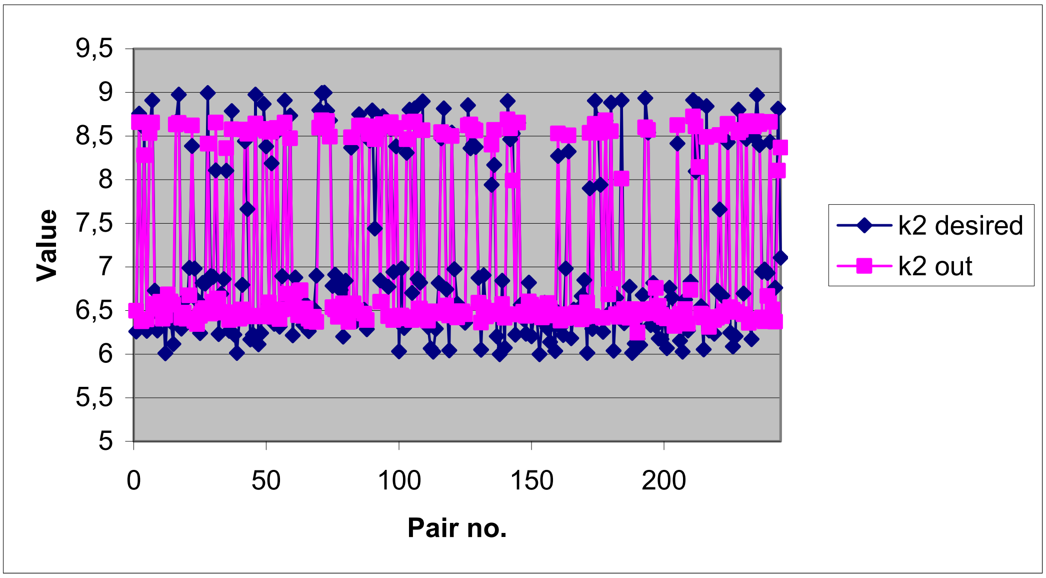

Figure C.2 Testing Performance for k_2

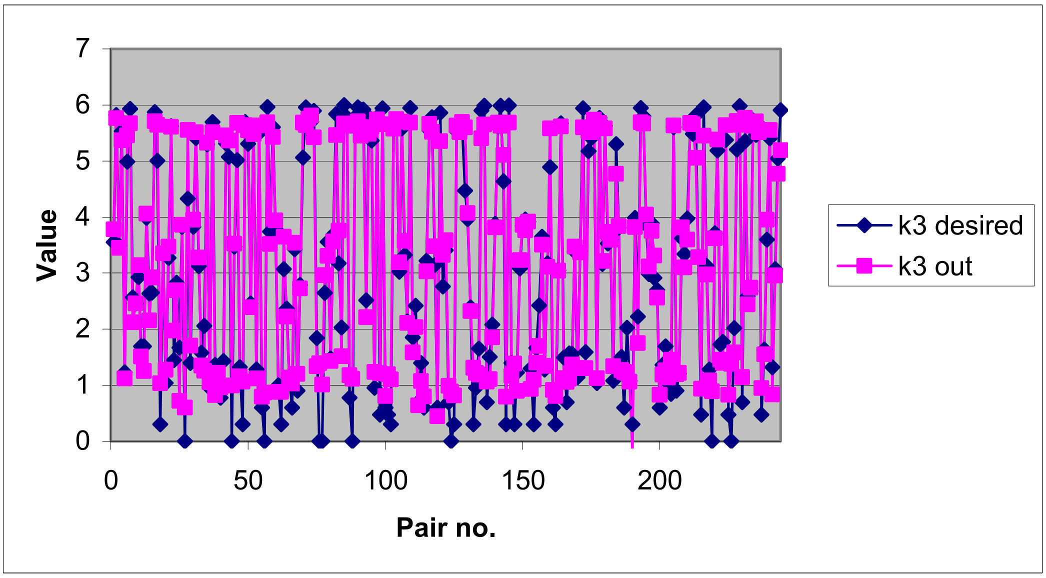

Figure C.3 Testing Performance for k_3

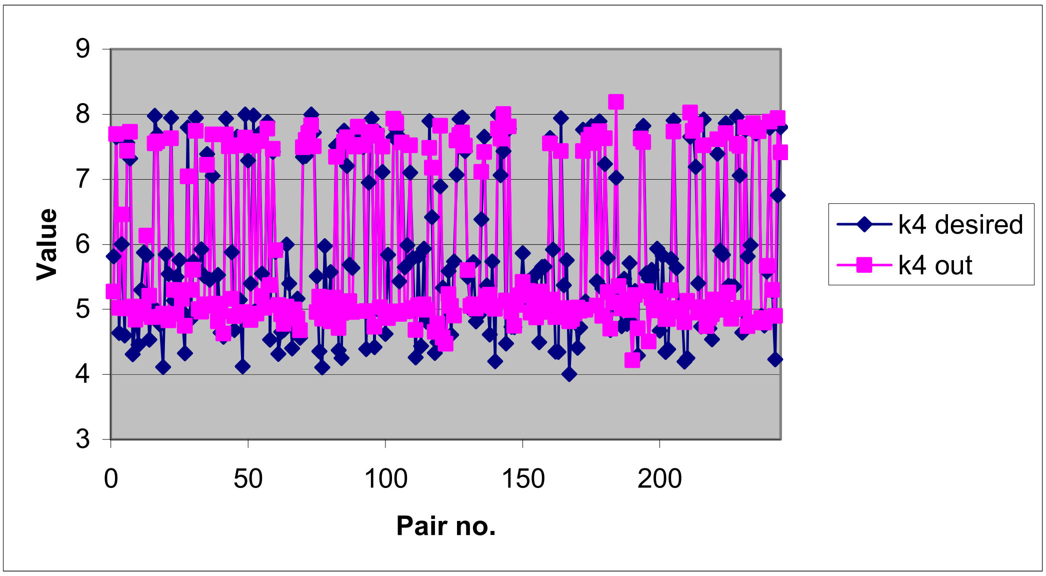

Figure C.4 Testing Performance for k_4

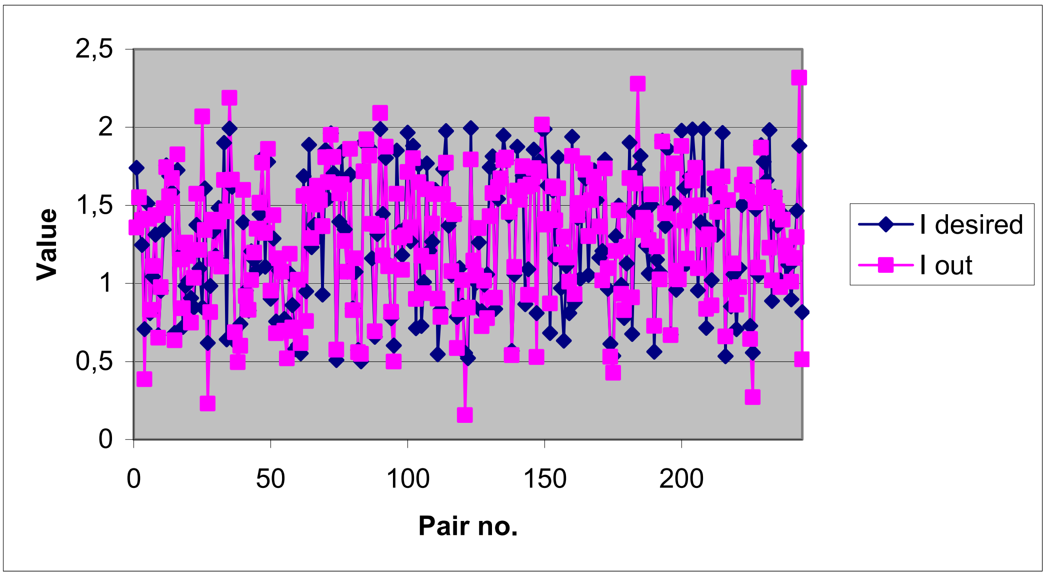

Figure C.5 Testing Performance for I_x

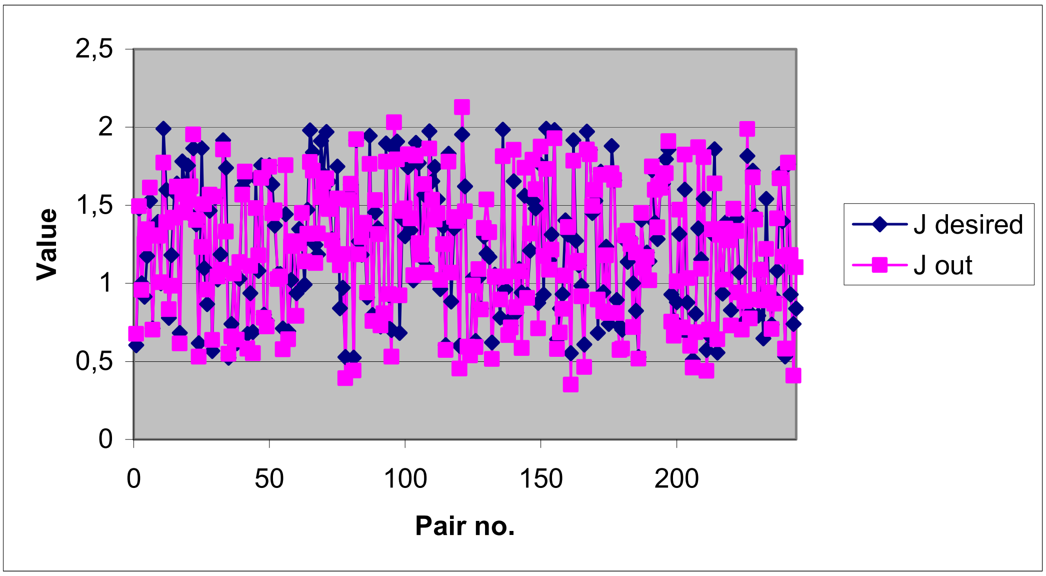

Figure C.6 Testing Performance for J

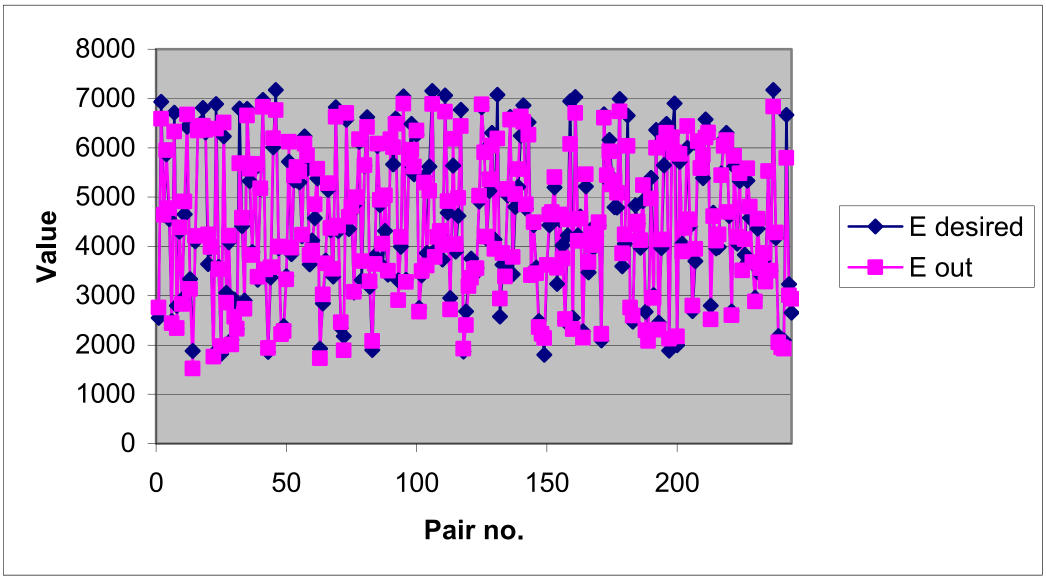

Figure C.7 Testing Performance for E

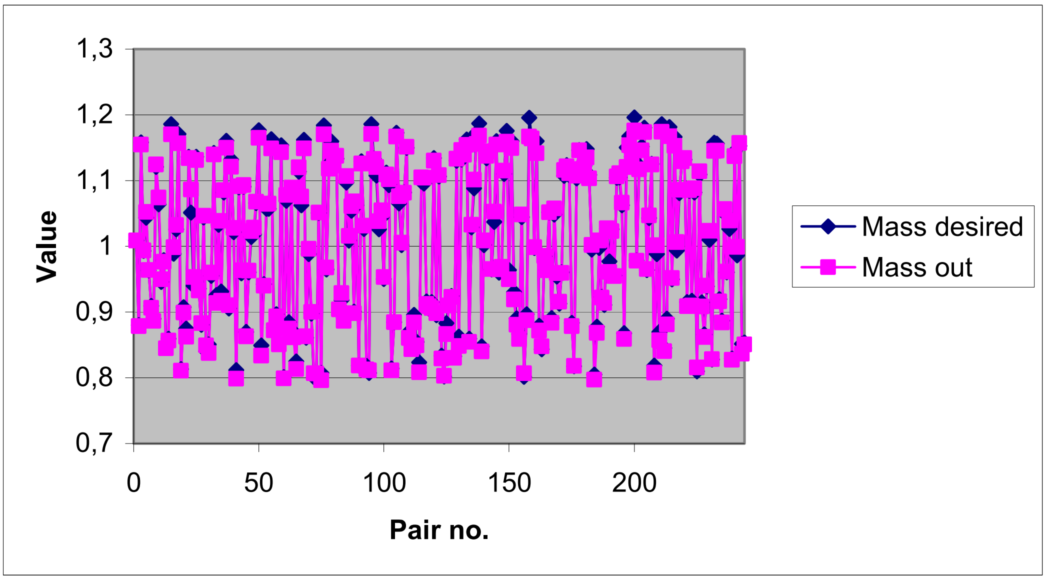

Figure C.8 Testing Performance for Mass