DETERMINATION OF PEDESTRIAN LEVEL OF SERVICE FOR WALKWAYS: METU CAMPUS EXAMPLE

A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES
OF
MIDDLE EAST TECHNICAL UNIVERSITY

BY
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IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR
THE DEGREE OF MASTER OF SCIENCE
IN
CIVIL ENGINEERING

JUNE 2015

Approval of the Thesis:

DETERMINATION OF PEDESTRIAN LEVEL OF SERVICE FOR WALKWAYS: METU CAMPUS EXAMPLE

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ABSTRACT

DETERMINATION OF PEDESTRIAN LEVEL OF SERVICE FOR WALKWAYS: METU CAMPUS EXAMPLE

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June 2015, 128 Pages

While studying the level of pedestrian activity on the campus of Middle East Technical University (METU), Ankara, pedestrian flow maps, counted manually and multiple times a day, showed changes in directionality and volumes of pedestrians during a day. Also, a student survey revealed that, in overall, 60% of the participants found the METU campus walkways sufficient, while the remaining 40% found it insufficient. Students stated that existence of sidewalks on both sides, infrastructure, protection against to weather, and etc. had an important effect on increase in walking. To encourage a greater modal shift to walking on the campus, first, it is important to understand and evaluate walkability and walking concepts. While walkability assessment studies mainly deal with perception and built environment aspects, engineering studies focused on evaluating pedestrian level of service (PLOS) based on flow and infrastructure capacity measures. This perspective difference and methodological details resulted in requirement of a wide range of data, which vary greatly based on the scope of the study. PLOS evaluations for METU Campus walkways are performed using Highway Capacity Manual (HCM), Gainesville and Trip Quality methods, which resulted in contradicting ratings. Comparison of the results revealed insights about the strength and weaknesses of each method, and led to a series of recommendations to improve walkability assessments, which was the main goal of this study

Keywords: Walkability, Pedestrian Level of Service (PLOS), Pedestrian Data Collection Methods, Pedestrian Survey

ÖZ

YÜRÜME YOLLARI İÇİN YAYA HİZMET SEVİYESİNİN BELİRLENMESİ: ODTÜ KAMPÜS ÖRNEĞİ

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Yüksek Lisans, İnşaat Mühendisliği Bölümü
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Haziran 2015, 128 Sayfa

Orta Doğu Teknik Üniversitesi (ODTÜ), Ankara' da yaya hareketlilik seviyeleri incelenirken, yaya akım haritaları ile, elle ve gün içinde birden çok kez sayılarak, gün içerisindeki yön ve yaya yoğunluğu değişimleri gösterilmiştir. Ayrıca öğrencilere uygulanan bir anket sonuçlarında, genel olarak katılımcıların %60'ı ODTÜ kampüs yürüme yollarını yeterli bulurken, kalan %40 yetersiz görmüştür. Öğrenciler yolun her iki tarafında da kaldırım bulunması, altyapı, hava koşullarına karşı iyileştirme ve bu gibi özelliklerin yürümeyi arttırmak için önemli etkileri olduğunu belirtmiştir. Yürümeye olacak ciddi bir mod kaymasını teşvik edebilmek için öncelikle yürünebilirliğin ve yürüme kavramının belirlenmesi ve anlaşılması önemlidir. Yürünebilirlik değerlendirme çalışmaları genellikle algı ve altyapı özellikleri ile ilgilenirken, mühendislik çalışmaları değerlendirme tabanlı, akım ve altyapı kapasitesin özelliklerine bağlı Yaya Hizmet Seviyesine odaklanmaktadır. Bu değişik bakış açısı ve metodolojik ayrıntılar çalışmanın kapsamına bağlı olarak çok değişkenlik gösteren, çok geniş kapsamlı data ihtiyacına neden olmuştur. ODTÜ kampüsü yürüme yolları için Yaya Hizmet Seviyesi "Highway Capacity Manual (HCM)", "Gainesville" ve "Trip Quality" metodları kullanılarak hesaplanmış ve birbiri ile çelişen sonuçlar gözlenmiştir. Sonuçların karşılaştırılması ile her bir metodun güçlü ve zayıf yönleri hakkında öngörüler ortaya konmuş, ve yürnebilirlik değerlendirme çalışmalarının iyileştirilmesi için öneriler oluşturmuştur, ki bu çalışmanın ana hedefidir.

Anahtar Kelimeler: Yürünebilirlik, Yaya Hizmet Seviyesi, Yaya Data Toplama Yöntemleri, Yaya Anketi

To My Family for Their Love and Support

ACKNOWLEDGEMENT

First and foremost, I would like to express my sincere gratitude to my supervisor Assoc. Prof. Dr. Hediye Tüydeş Yaman for her endless support, valuable guidance, and patience throughout this study.

Besides my advisor, I would like to thank Assoc. Prof. Dr. Ela Babalık Sutcliffe and Oruç Altıntaşı for the data assistance from the Sustainable Transportation Projects for Campuses (BAP-08-11-DPT.2010K121500).

My sincere thanks to Başar Özbilen and Gülçin Dalkıç for the wonderful teamwork during survey process, especially to my friend Ezgi Kundakçı, for all her help during my data collection period.

To my fellow colleagues Meltem Tangüler, Yalçın Karakaya, Ezgi Kundakçı, Ayhan Öner Yücel and Can Ceylan for their continuous support and all the fun we have had together during this study.

The last but not the least, I sincerely thank my mentor, Mehmet Karataş; my heartthrob mother, Güllü Karataş, and my dear brothers, Kaan and Cihan for their endless support and confidence during my life.

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CHAPTER 1

INTRODUCTION

In Ankara, Middle East Technical University (METU) is located at the 20th km of the former Ankara-Eskişehir highway, now called Dumlupınar Boulevard. As a big campus university, METU has a very large area and a population of approximately 30,000 people. Originally, METU campus was designed as a "pedestrian friendly" layout with a main central alley connecting all the academic buildings in the core loop (in Region 4) with nearby dormitories (in Region 1) and academic housings (in Region 3) in 1960s (Figure 1.1).

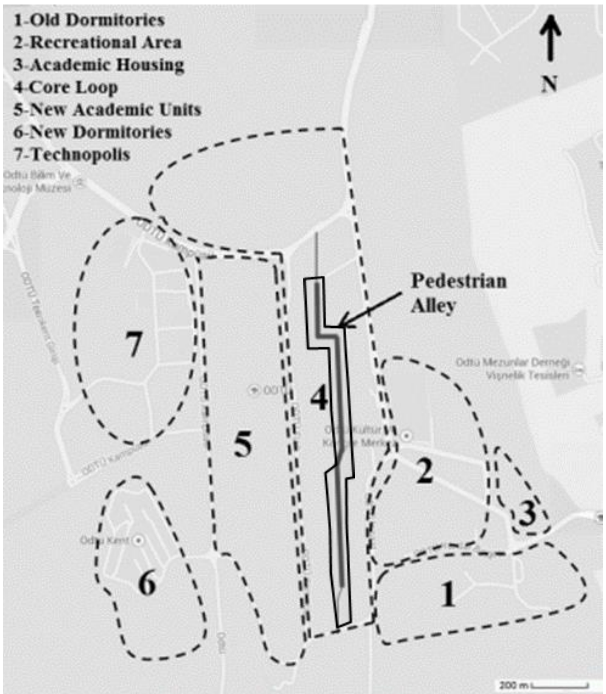


Figure 1.1 The Layout of the METU Campus

Over time, with the rapid growth in campus population, the academic units in the core loop and dormitories became insufficient. After the construction of the new academic units (in Region 5) and dormitories and academic housing (in Region 6), built environment spread out increasing the walking distances. Starting with the opening of Technopolis, the research and development park in Region 7, and parallel to the recent increase in the private car ownership and usage in Ankara, METU Campus has become a more "car oriented" with number of vehicles exceeding 15000 per day (Altintasi, 2013).

1.1 Motivation

The limited roadway capacity under high private car demand resulted in campus problems, such as traffic congestion during peak hours, illegal parking problems, and reduction in walking. To encourage modal shift towards more sustainable modes, such as walking, cycling and public transit, first, it is important to assess the current conditions and walkability in the campus. In a recent survey among METU students (with a sample size of 307), 60% of the participants found the METU campus walkways sufficient, while the remaining 40% found it insufficient. Students stated that existence of sidewalks on both sides of the road, infrastructure, protection against to weather, and etc. had an important effect on increase in walking. This also shows the need to further study walking and walkability in our campus.

The evaluation of walkability and walking in a region, such as the METU Campus, requires very different sets of data and methods from vehicular mobility. But, there is a big chaos about the required data and its collection in the literature, mainly because of lack of a commonly accepted method for pedestrian mobility and walking activity. Also, pedestrian data collection requires more flexible definitions in terms of network and routing, and thus, methods to analyze them. Such new approaches need special attention and use of new techniques customized for pedestrian purpose and utilities. We believe, a successful evaluation of walkability, and development of more sustainable transportation policies on METU campus will be a good example for the city of Ankara and other campuses.

1.2 Scope of the study

To monitor the current conditions of walkability at METU Campus, we aimed to evaluate the Pedestrian Level of Service (PLOS) first. As there is no consensus on a PLOS methodology connecting design and capacity aspects, we employed three methods as i) Highway Capacity Manual (HCM), ii) Gainesville and iii) Trip Quality, using very different data sets. As the former have very different measures and scales than the latter, PLOS evaluations of the campus with the HCM method resulted in very different ratings than the others. Comparison of the results revealed insights about strength and weaknesses of each method, and led to a series of recommendations to improve walkability assessments, which was the main goal of this study. As determination of PLOS for the walkways (sidewalks and pedestrian alleys), crosswalks and stairways require much different data and methodology, the study focused on obtaining PLOS values for walkways, only.

The layout of this thesis is as follows: In Chapter 2, a brief summary of the literature on sustainable transportation, walking and walkability assessments, PLOS methods and their comparisons and pedestrian data collection techniques is provided. Since the Trip Quality method involves subjective evaluations, a summary of interrater reliability is included in this chapter. Dimension on PLOS evaluations, three PLOS methods, which are used in the case study part of the thesis, and determination of walkability are scrutinized in Chapter 3. METU Campus case study analysis and results are presented in Chapter 4. Finally conclusions and further recommendations on walking, PLOS and walkability evaluations are discussed in Chapter 5.

CHAPTER 2

LITERATURE REVIEW

Due to decreasing resources, living in urban regions focus on sustainability in many aspects, including transportation. Sustainable transportation recommends more usage of non-motorized modes, which are walking and cycling, and shared ride options, which include walking to a station, inherently. Thus, analyses of walking, walkability and pedestrian level of service are important to evaluate our real potential towards more sustainable lives. Before implementing any of these measures for METU campus, it is essential to define these concepts and their relationships in this chapter, as established in the literature. Additionally, a short introduction is provided for the concept of inter rater reliability for subjective measurement techniques, which is necessary for some of the PLOS methods.

2.1 Sustainable Transportation

A sustainable transportation system has been defined as "the current transport and mobility needs without compromising the ability of future generations to meet their needs" (Black, 1997; Richardson, 1999). Black (2010) defines the terms, related with "sustainable" and "non-sustainable transport" in detailed, categorized them into groups to define the whole concept. According to the study "A sustainable transport system is one that provides transport and mobility with renewable fuels while minimizing emissions detrimental to the local and global environment and preventing needless fatalities, injuries, and congestion." With this basic perspective Babalik-Sutcliffe (2013) recommended that the focus of transport policy should be the "reducing car trips and encouraging alternative modes such as public transport, walking and cycling". Most of the sustainable campus initiatives in the USA aim to reduce carbon emissions by encouraging walking, biking and public transit use. Furthermore, walkability and biking are encouraged due to their positive impacts on human health (Brown et al 2009; Rosenberg et al, 2009;, Van Dyck et al, 2011). Balsas, 2003 studied eight bike and pedestrian friendly campuses in the US to understand the reasons behind the success of non-motorized modes, which were simply the implementation of Travel Demand Management (TDM) strategies. Miralles-Guasch and Domene (2010) determined the travel pattern and transportation challenges of a university in Barcelona, where the lack of adequate infrastructure, the marginal role of walking and cycling and longer time involved using public transport were detected as the main barriers to shift from private car to non-motorized modes.

2.2 Walking as a Mode

Walking is one of the main modes encouraged as a sustainable way of transportation. Rodrigue et. al. (2006) defined walking as one of the individual transportation modes, which is the consequence of personal preferences. During 1800-1890s, which were called “walking /horse-car era”, the dominant mode was walking due to small city sizes. Cities were compact and their shapes were mostly circular with less than 5 km walking distance. After the invention of railroad, the urban morphology had changed. After 1930s up to now, called “the automobile era”, the dominant mode becomes private cars. Traditional perspective on transportation planning discourse the improvements on infrastructure, however every increase in capacity creates its own traffic demand (Babalık-Sutcliffe, 2005; Kaiser et. al, 1995). The increase in vehicular infrastructure caused a significant decrease in walking areas and walking, and it also deteriorates the cities integrity. Traffic has become more car-oriented. To tackle with the situation, the perspective in recent years changed to the encouragement of non-motorized modes and public transit. Walking counted as one of the base modes of transportation and as a mode.

The examination of the interaction between travel mode choice and the characteristics of the physical environment revealed a great influence especially in non-motorized modes (Rodriguez and Joo, 2004). Yazıcıoğlu Halu and Yürekli (2011) focused on the walkability and walking in urban spaces and suggested a conceptual model for more walkable public spaces with an example of Bağdat Street, Istanbul. They drew attention to the individual, group, regional, and spatial environmental variables on walking, which had a direct influence on walking choice.

As a mode, walking needs special attention on Origin-Destination (OD) estimation and also pedestrian traffic assignment methods. There are some studies on these areas, but because of the open-ended situations on walking, the studies became insufficient (Ferguson et. al., 2012; Hanseler et. al., 2015; Hoogendoorn and Bovy, 2004; Borgers and Timmermans, 1986). Pedestrian OD estimation is a very challenging area, which needs promising data sets and validations for urban regions which have a complex land use pattern (Ferguson et. al., 2012). The OD pairs and the route choice are very varied and the number of routes can be extremely high according to the purpose of the trip, familiarity of the routes, etc. Even though within the concept of more limited OD pairs in a rail station, Hanseler et. al. (2015) studied dynamic assignment for pedestrian activity with timetables and ridership estimates. Pedestrians were described as a "subjective utility maximizers" because they arrange their activities, activity areas and the paths between the activities synchronically to maximize the predicted utility of their efforts and walking (Hoogendoorn and Bovy, 2004). Because of this uncertainty in everything the pedestrian traffic assignment needs significant assumptions and attention. In another study pedestrians are modeled according to "O'Kelly's model of the demand for retail facilities in the presence of multistep, multipurpose trips" (Borgers and Timmermans, 1986). In the model, there were three submodels for i) destination choice, ii) route choice and iii) impulse stops. The analysis gave logical results for city center of Maastricht, notwithstanding, for other regions with different characteristics model should be rearranged.

2.3 Walkability

Walkability assessment studies mostly have a planning perspective and focus on major factors. Gori et al. (2014) focused on the indicators of “pedestrian friendly design”, for which three major aspects of walkability were listed as, i) connectivity, ii) quality of road network and iii) the proximity. Connectivity represented the node and link condition; number and density of nodes, number of links, density and total length of the walking area. Quality of road network classified the links into groups based on number of lanes and traffic volume. Proximity indicated the travel distances pedestrian intended to walk, and also travel times. The study presented a set of measures to evaluate these aspects numerically with examples from some urban neighborhoods in the cities of Rome, Lucca and Venice. Similarly, Leslie et al. (2007) studied the walkability according to proximity and connectivity characteristics with a spatial data set to define a GIS-based “Walkability Index”, which was basically the transfer of a previous walkability index in Australia to GIS environment. Also, Hajna et al. (2013), performed GIS-based analyses of walkability, in addition to street-level audits and participant-reported ones, where GIS was used to derive to land use mix, street connectivity and residential density.

Gallimore, et al. (2011) studied walkability of routes to schools in different suburban regions, from different aspects (i.e. traffic safety, accessibility, pleasurability, density of housing). The study compared the perception of walkability of a region under two different land use patterns, where “shorter more direct” pathways were claimed to be more walkable. Other studies suggested even much shorter and simpler walkability evaluation tools, which are simple checklists of a selected number of local destination points as in Bias et al. (2010). As another auditing-based assessment tool, Scottish Walkability Assessment Tool was designed to assess walkability according to functional elements (walking surface and permeability), safety (personal and traffic), aesthetic (streetscape, architecture, views) and destinations (parking, land use mix, services, public transport, parks) (Millington et al, 2009). The effect of path choice decision and the environment on a commuter's walking choice after exiting the subway was investigated by Guo (2009). The results showed that walking environment significantly affect the one's walking experience and the utility of walking. Papadimitriou et al. (2009) presented a through literature review to develop models for the route choice and crossing behaviors of pedestrians, and suggested that such models should be more flexible, disaggregate and non-stochastic.

2.4 Data Collection Techniques for Walking

Cottrell and Pal (2001) reported that before evaluating pedestrian data collection methods, one should understand the pedestrian data needs according to age distribution, how much a person walks, in what period of the day, how much distance a person intended to walk, etc. The study included comparison of three pedestrian data collection methods of "counting by hand or board", "recording with push button use" and "taping with video cameras". For a proposed "pedestrian data monitoring guide", the study foresaw the need of data characteristics should include

- time-dependent pedestrian volume,
- traveler demographic information (age, gender, time of day, season, physical ability, etc.)
- behavioral aspects that may change by location and demographics,
- available continuous counting technologies and their layout in the long-term study sites,
- issues related to short-term counts, such as sampling rates, frequency of counting, etc.
- and concluded with a highlight reminding the need of GIS contribution for data display.

Diogenes et al. (2007) further discussed the reliability of these three counting methods performed simultaneously at 10 different intersections in San Francisco, CA. The results showed that both manual count by hand and clickers gave fewer number of pedestrians than actual condition. For pedestrian counts at 50 intersections in Alameda County, CA. Schneider et al. (2009) defined a methodology for which five infrared sensors were rotated among 13 intersections to capture variations in pedestrian volume patterns due to time of day, location and weather condition. The 2-hour manual counts were used in combination with the adjustment factors to estimate weekly pedestrian volumes to be used in traffic safety analysis.

Intelligent Transportation Systems (ITS) has enabled a rapid growth in transportation field, which meets high quality data with real time information (Leduc, 2008). Unfortunately, so far, ITS has supported data collection techniques mostly for vehicular traffic. While there is a clear need for pedestrian and walkability data, it is not easy to use vehicle count technologies directly, as pedestrian flow is very flexible compared to vehicular traffic; so, data collection and location definition becomes harder. There are different automated pedestrian count products and systems in the market, such as passive infrared sensors and piezoelectric pads, infrared beam counters, Laser scanners, computer vision systems. A detailed comparative analysis of field performances of passive infrared sensors and thermal sensors on pedestrian data collection showed that thermal sensors pedestrian counts were more realistic with less error, and EcoCounter was reported to underestimate significantly more than the others (Ozbay et al, 2010). Another study focused on use of GPS data collection capability to monitor pedestrian activity along an urban corridor in London, to determine route choice, start and end points of a pedestrian trip (Bolbol & Cheng, 2010). Bauer et al. (2011) focused measurement of service times at border checkpoints and airport security controls, and used sensors (consists of light barriers) and switching mats. Both data collection tools represented high performances for this aim. As an example of pedestrian counting sensors, computer vision techniques were evaluated for automated pedestrian count, tracking and walking speed estimation purposes as in Li et al. (2012).

2.5 Level of Service Concept (LOS)

The concept of "Level-of-service (LOS)" is merely an abstraction of quality of the considered phenomenon at the study time and location. If it is traffic we are considering, LOS shows the state of traffic in a qualitative way. There may be some difference in the LOS techniques among different regions, but, LOS is generally represented by levels of A through F, where A shows high levels of comfort and/or available capacity while F stand for congestion and/or sever delays in the system. While a LOS A is the most favorable condition from a user perspective, it is not the best case from a system manager perspective, who should focus on better utilization of the existing capacity with acceptable negative outcomes for the users, such as in LOS C.

For different traffic flows (vehicular, pedestrian, bicycle, transit, etc.) different definitions of LOS are needed, based on the characteristics and factors affecting such flows. Furthermore, for a given mode, such as pedestrian or vehicular, LOS concept can be defined based on different measures, such as capacity usage, delay, fluidity of the flow, etc. However, more recently, a new and integrated approach of "multimodal LOS (MMLOS)" has been introduced in the literature, that considers interactions between modes in the assessment of traffic in a region. As this study focus on understanding and evaluating PLOS, here, we are going to focus on this concept and relevant ones needed in the assessment of PLOS, only.

2.5.1 Vehicular LOS in HCM

In HCM, which is a major reference document in traffic engineering measures mostly used in North America, the concept of "Level of Service (LOS)" basically represents a quantitative ranking of the traffic condition under flow and capacity characteristics experienced by users (2000, 2010). The concept objective has two points of views; "identifying a future problem" or "evaluating the post-implementation success of an action" and includes the choosing of suitable countermeasure for the problem. The representation of LOS differs through the use of a familiar A (best) to F (worst) "operating condition according to traveler's perspective". For congested time periods any type of systems could reflect the LOS A condition as an expectation. For vehicular LOS A represents the free flow condition without delay, and LOS F represents the forced flow with maximum delay; while PLOS A represents the best operating condition without any need to change route and PLOS F represents the worst operating condition with severe speed restriction and frequent contact with other users. Because of high flexibility in pedestrian route choice, the delay becomes unimportant for descriptions.

The vehicular LOS concept defined in HCM is determined based upon roadway type (highway, freeway, etc.), free flow speed, hourly vehicular volume, number of lanes, widths of lanes and shoulders. The vehicular LOS could be analyzed according to volume to capacity relation, speed, and density characteristics with available data. A notable situation in vehicular LOS evaluations is that if volume-to-capacity ratio exceeds 1.0, the procedure determines a LOS F, regardless of the other characteristics (see Table 2.1). With a similar approach, HCM defines a Pedestrian LOS (PLOS) measure according to type of walkway (sidewalks, stairways, and crossings separately), effective width and hourly pedestrian volume, which will be discussed in Chapter 3 with more details

Table 2.1 Level of Service (LOS) for Automobile Mode in HCM (2010).

Travel Speed as a Percentage of Base Free-Flow Speed (%)	LOS by Volume-to-Capacity Ratio[a]	
	≤1.0	**>1.0**
>85	A	F
>67-85	B	F
>50-67	C	F
>40-50	D	F
>30-40	E	F
≤30	F	F

Notes: [a] The critical volume-to-capacity ratio is based on consideration of the through movement volume-to-capacity ratio at each boundary intersection in the subject direction of travel. The critical volume-to-capacity ratio is the largest ratio of those considered.

2.5.2 Pedestrian LOS (PLOS) Studies

HCM (2010) provides different formulations of the PLOS on sidewalks, crosswalks and stairways. As pedestrian flow data for more than 70 points in METU campus was available, HCM PLOS method is selected for the campus evaluation. The details of the HCM PLOS for sidewalks are provided in the next methodology chapter. However, for pedestrian areas, HCM method has many disputable constraints (Singh and Jain, 2011), so there are lots of different perspectives and methods for PLOS, which have to be considered. A comprehensive evaluation of design and traffic flow conditions along sidewalks was suggested by Dixon (1996) for the city of Gainesville, which will be referred as Gainesville PLOS method in this study. Another PLOS methodology focusing more on the design aspects on/along sidewalks was proposed by Jaskiewicz (1999), and called as Trip Quality method. As we were able to collect data for these two methods, as well, they are also included and introduced in more details, in the following chapter.

To be able to recommend suggestions for an improved PLOS concept, it is necessary to review the other PLOS methods and concepts in the literature. Unfortunately, PLOS got less attention than vehicular LOS, even in the handbook by Yukubousky (1994), which itself supported the importance of PLOS in design, maintenance and improvement of pedestrian sidewalks, walkways and alleys for the purposes of safety, security, continuity and comfort.

For defining an accepted and better classified method there are numerous studies; some of which try to improve existing methods with comparisons and some try to create new methods (Singh and Jain, 2011; Mori and Tsukaguchi, 1986). It can be easily seen that the most apparent but highly criticized method is HCM based pedestrian LOS method (Lovas et. al. 2015). As an early attempt, Polus et. al. (1983) investigated features and properties of a pedestrian flow on sidewalks in Haifa, Israel. The data was collected with a videotape recorder connected with a digital clock, to specify the walking speeds. Level of service was determined by speed and density relationship, with linear models. The results demonstrated that there was an inverse proportion between speed and density.

Another research focused on a method to evaluate “ordinary sidewalks” with two concepts; evaluation based on pedestrian behavior and evaluation based on pedestrian opinion (Mori and Tsukaguchi, 1986). In the study the determination of PLOS was mentioned as a basic calculation using pedestrian density and sidewalk width, while evaluation of it needs detailed analysis consist of pedestrian awareness of sidewalk. Muraleetharan et al. (2003) used conjoint technique to analyze the PLOS by determining the importance of the sidewalks characteristics such as, flow rate of pedestrians, sidewalk width, existence of obstacles, crossing facilities, etc. They found that the most significant factor to determine the PLOS was the pedestrian flow rate and the sidewalk width. However, existence of an obstacle was not found significant enough to determine the PLOS.

Petritsch et. al. (2008) studied on a user-based method for pedestrians instead of a provider- based method on evaluating the quality of service. As part of the study; sidewalk width, separation of walkway from traffic, buffer width, traffic volume and speed, pedestrian volume and on-street parking effect was analyzed for pedestrian level of service on walkway segments. As a more special case, Asadi-Shekari et. al. (2014) focused on the pedestrian level of service for campus streets to evaluation and improvement. Within the scope of the study "pedestrian design indicators" based on different guidelines listed, and these 27 indicators were discussed according to 20 different guidelines. The researchers composed a formulation depending on all 27 indicators and determine the PLOS for Universiti Teknologi Malaysia (UTM).

Tan et al. (2007) assessed the PLOS by analyzing the relationship between the pedestrian perceptions and the quality of road facilities, moreover the traffic flow operation. Pedestrian survey was conducted to investigate their perceptions. Those who answered 'I am pleasant when walking' was considered as PLOS A, while if the answer was 'the sidewalks are unsuitable' the PLOS was determined as F. An average they determined the PLOS as C for their region. Another study focused on pedestrians' perception of safety and comfort in the roadside environment to provide a measure of PLOS supported by Florida Department of Transportation (Landis et. al., 2001). Within the concept of the study researchers tried to describe the factors in the right of way which significantly affect the pedestrians' feeling.

They grouped the factors had a significant effect on pedestrian environment under three perspective; performance measures (sidewalk capacity), quality (enjoyment) aspects, perceived safety or comfort. As an output the model provided guidance to designer on how to better design pedestrian environments on presence of sidewalk, lateral separation between vehicle traffic, motor vehicle volume and speed.

The Danish Road Directorate also sponsored a method to measure pedestrian and bicyclist stated satisfaction for road sections according to existing traffic operations, geometric conditions, and other variables (Jensen, 2007). Attendees rated the segments on a six-point scale ranging from “very dissatisfied” to “very satisfied”. The results demonstrated that vehicular volume and speed, urban land uses, rural landscapes, type and width of pedestrian and bicycle facilities, number and width of drive lanes, pedestrian volumes, bicyclists and parked cars, presence of median, trees and bus stops significantly affect the level of satisfaction.

Besides the pedestrian level of service on segments, there are numerous studies focused on pedestrian level of service on crosswalks (Muraleetharan et. al., 2003 and 2005; Petritsch et. al., 2006 and 2008; Muraleetharan and Hagiwara, 2007; Baltes and Chu, 2002). It can be easily seen that crossing facilities, space at corner, turning vehicles, delay, number of lanes crossed, presence of crosswalk, and median type had a significant effect on pedestrian crossing level of service. As a subtitle, another research area in the literature is pedestrian level of service for signalized intersections. Petritsch et. al. (2005) studied on the pedestrians’ perception of safety, comfort and operations on signalized intersections, and design and operational characteristics of the intersections. For signalized intersections signal delay became more important than crosswalks. Likewise, on the signalized intersections the factors affecting pedestrian level of service using pedestrian’s perception on comfort and safety was identified (Vegadiri and Nagraj, 2013; Bian et. al., 2009).

2.5.3 Studies Comparing PLOS Methods

In the literature there are numerous studies discussed the advantages and disadvantages of PLOS methods according to the factors used in the method. Singh and Jain (2011) compares six methods in detailed (the necessary variables and features and method of calculation for each method) and some others externally in a literature review study. In the study, the methods were divided into two categories; capacity based methods and roadway characteristics based methods. Capacity based methods are mostly useful in planning progress to give base information about pedestrian facilities such as HCM method; and roadway characteristic based methods mostly focus on pedestrian perception, characteristics of walkways such as Trafitec Model (Jensen, 2007) and SCI Model (Landis et al., 2001) of Pedestrian LOS. Another study categorized the assessment of PLOS methods under three different perspectives (Tan et al, 2007). The first type only considers the pedestrian flow operation like in HCM, second type was based on road environment quality like Trip Quality method and the third type consider both of them like Australian method and Landis method.

Sisiopiku et. al. (2007) reviewed, compared and contrasted the more commonly used and accepted five methods in the literature (Table 2.2). As a test application they applied all the five methods to 13 sidewalks, in the downtown Birmingham, Alabama to compare the consistency of outcomes. The analysis confirmed that it could receive varied PLOS results for same segment according to different methods. Another remarkable result was HCM (200) overestimated the condition in general.

Table 2.2 Comparison of Factors Included in Pedestrian Sidewalk Assessment Methods-Sisiopiku et. al., 2007

Issue	**HCM 2000**	**Australian**	**Trip Quality**	**Landis**	**Conjoint**
Geometry	Ped. Space v/c ratio	Path width	Ped. Path components	Motor path width; On-street parking	Width and separation
Flow	Pedestrian flow; Speed	Pedestrian volume; Mix of users	Not considered	Vehicle flow; Speed	Flow rate
Path	Not considered	Obstructions; Connectivity; Environment	Route; Buffer; Trees/ Overhangs	Sidewalk an buffer widths	Obstructions
Vehicle Conflicts	Not considered	Potential for conflicts; Crossing opportunities	Not considered	Not considered	Bicycle events
Security	Not considered	State of security	Buffer; Transition to other spaces	Not considered	Not considered
Support facilities	Not considered	Exist or not	Not considered	Not considered	Not considered
Quality of path	Not considered	Surface quality	Path condition	Not considered	Not considered

In a more comprehensive study, Christopoulou (2012) compares 11 methods which were created based on the USA conditions (Table 2.3). In the study vehicle volume was interpreted as a factor which affects the pedestrians' perception of safety and comfort. The study focused on the five of the methods (6, 7, 9, 10 from Table 2.2 and HCM Method) to create a new model for Greek conditions. The results revealed that level of service results could greatly differ according to method, and the inclusion of both qualitative and quantitative parameters could reflect the actual condition.

Table 2.3 Comparison of the pedestrian level of service methodologies with regard to their criteria (Christopoulou and Pitsiava-Latinopoulou, 2012)

	Methodologies	**Volume (veh, ped, bic)**	**Traffic incidents**	**Safety/comfort**	**User's aspect**
1	Mozer D.	Veh volume and speed, ped volume	-	Buffer zone	Taken into account
2	Dowling R et. al.	Veh volume and speed, ped volume	Ped crossing	Buffer zone, on street parking	Taken into account
3	Landis B. et al	Veh volume and speed	-	Buffer zone, on street parking	Taken into account
4	FDOT	Veh volume and speed	-	Buffer zone, on street parking	Taken into account
5	TRB	Ped volume	-	-	-
6	Jaskiewicz F.	-	-	Buffer zone, accessibility	-
7	Gallin N.	Ped volume, users' categories		Personal Safety	-
8	Jensen S.	Veh, ped and bic volume	-	Buffer zone, land uses, trees	Taken into account
9	Muraleetharan T. et al	Ped volume	-	Trees, parked cars etc	Taken into account
10	Tan D. et al	Ped, veh and bic volume	Roadway crossing	Distance between sidewalk-outside traffic lane	Taken into account
11	Dixon L.	Veh volume	Taken into account	Facilities easing pedestrian movement	-

2.6 Inter Rater Reliability in Subjective Measurements

Determination of PLOS with Trip Quality method is open-ended and can greatly differ by point of view. For the reliability of the results inter rater reliability should control between at least 2 raters. The study compares three inter rater estimation methods, consensus estimates, consistency estimates and measurement estimates, with their advantages and disadvantages. Within the concept of consensus estimates, raters are trained on how to interpret the rating scale, while consistency estimates based upon that there is not necessary for two raters have the same knowledge on rating scale. Measurement estimates based upon the idea that one should use all of the information available from all raters (including discrepant ratings) when attempting to create a summary score for each respondent.

Cohen's Kappa is one of the statistical methods analyzes the consistency between two raters and is under consistency estimates methods. This method is widely used and commonly accepted method on inter rater reliability between two raters (Viera, 2005; Landis and Koch, 1977). Method considers the agreement between raters and analyzes the agreement if it occurs by change or there is a relationship between ratings. It gives more reliable results than basic proportion of agreement. The interpretation of the Kappa results has confusions and there are 3 benchmark scales see Table 2.4, Table 2.5, Table 2.6 (Gwet, 2012)

Table 2.4 Fleiss' (1981) Benchmark Scale for the Kappa

Less than 0.40	Poor
0.40 to 0.75	Intermediate to good
More than 0.74	Excellent

Table 2.5 Landis&Koch(1977) Benchmark Scale for the Kappa

Less than 0.0	Poor
0.00 to 0.20	Slight
0.21 to 0.40	Fair
0.41 to 0.60	Moderate
0.61 to 0.80	Substantial
0.81 to 1.00	Almost perfect

Table 2.6 Altman's (1991) Benchmark Scale for the Kappa

Less than 0.20	Poor
0.21 to 0.40	Fair
0.41 to 0.60	Moderate
0.61 to 0.80	Good
0.81 to 1.00	Very good

CHAPTER 3

EVALUATING PLOS VIA DIFFERENT METHODS

To be able to suggest any improvement encouraging walking on METU campus, it is important to understand dimensions of pedestrian mobility, and properties of selected PLOS evaluation methods, which are presented in this section. As the final part, ideas for cross evaluation of different PLOS method ratings are presented.

3.1 Dimensions of Pedestrian Level of Service Evaluation

Based upon the literature, the PLOS can be analyzed in five dimensions; i) user characteristics, ii) traffic characteristics, iii) land use characteristics, iv) infrastructure characteristics and v) safety/ comfort characteristics (See Figure 3.1). Among user characteristics, the age and gender distribution crates a difference on the walking tendency, and the perception has a significant effect on the walkability of a segment. In terms of traffic aspects, pedestrian traffic on the walkway and traffic of other modes are found to be important, as well as the composition of traffic and speed variations create significant differences. The prevention of incidents, vehicular LOS, lightning and the buffer area created by trees, parked car are very important under safety/comfort issues. Land use characteristics provide convenience to users by sidewalk on both side (two-sideness), directness between origin and destination, connectivity within the network, complexity of network and parallel alternative routes; while having attraction by aesthetic, building articulation and such kind of design aspects. A major dimension which gets the highest attention in the literature is the sidewalk infrastructure characteristics and it could be analyzed under two subtitles.

According to type of the infrastructure (cross-section, sidewalks, intersections and walkways) the determination method varies. For example if walkways are the walking areas which is disengaged from vehicular traffic, there will not be a vehicular traffic effect on that segments. Under segment characteristics that have direct relationship on walking continuity, width of the segment, obstacles such as signs, trees, etc., medians and the area vs pedestrian ratio should be considered.

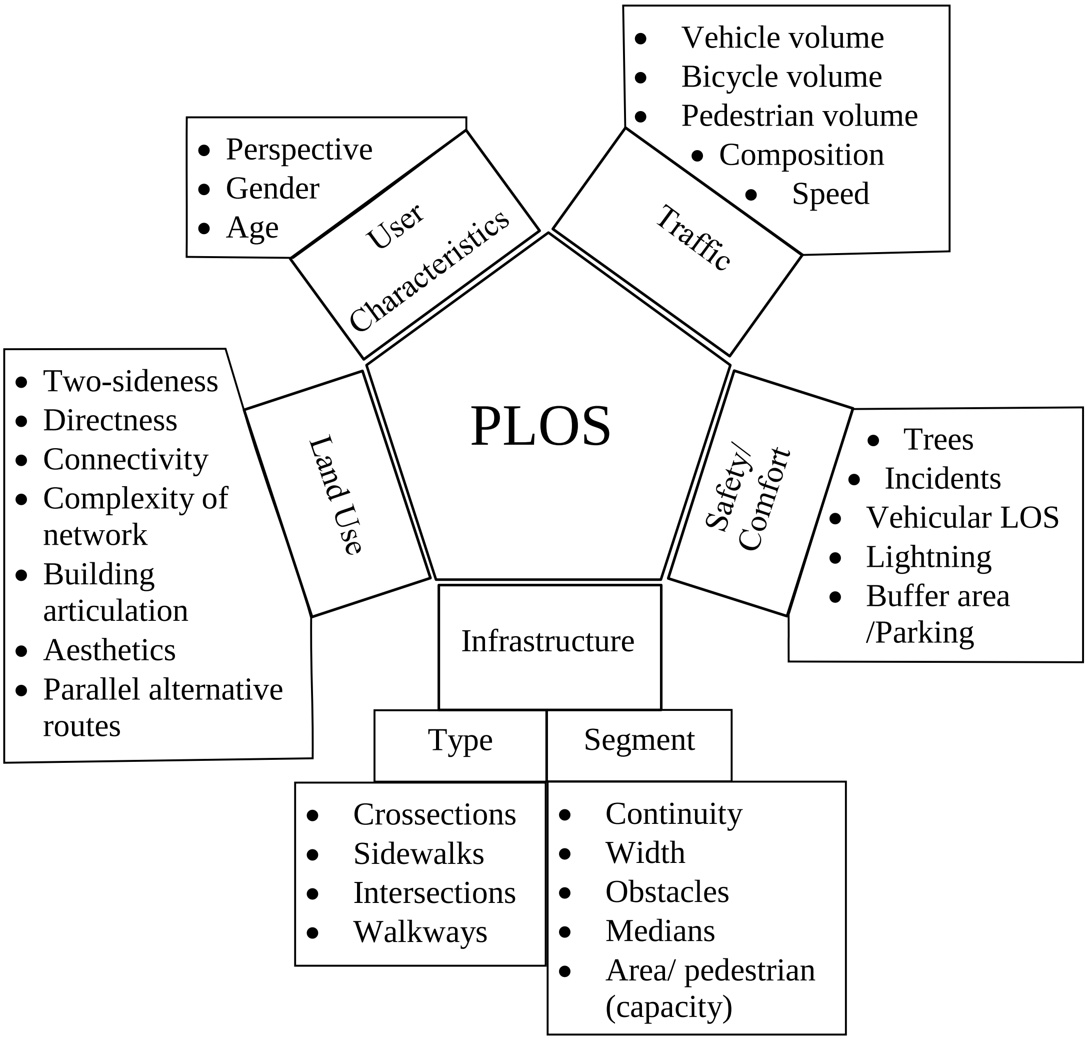


Figure 3.1 Dimensions of Pedestrian Level of Service Measures

3.2 PLOS Evaluation Methods Used in the Study

In this section three PLOS determination methods which are applied in the case study part of the thesis are analyzed in detailed. The calculation method, necessary data and determination tables are summarized.

3.2.1 HCM-based PLOS Method

HCM (2010) allocated a special chapter on pedestrian and bicycle level of service and examined at 3 conditions; exclusive off street pedestrian facilities, off street bicycle facilities and shared used facilities. Analyses are considered in the segments and segments are determined by street crossings or significant width changes or intersections where user volumes changed significantly or facility type changes such as stairways.

HCM considers three types of pedestrian facilities: walkways, cross-flow areas, and stairways. The PLOS thresholds for each category are different, but all are based on the concept of "space per pedestrian", which is considered a measure of pedestrian comfort and mobility. For each facility type LOS scores were determined in tables according to effective width and 15-minute pedestrian volume at any segment. The main steps of PLOS determination are given as:

- Step 1 Determination of effective walkway width, w_E,
- Step 2 Calculation of pedestrian flow rate, v_p,
- Step 3 Calculation of average pedestrian space, A_p,
- Step 4: Determination of LOS (for walkways with and w/o platooning, and stairway)

The effective walkway width determination is rather cumbersome, which require measurement of total walkway width, fixed-object (such as trees, signs, etc.) effective width and shy distance. This effective width has to be calculated at every point of change. Pedestrian flow rate per unit width, $v_p = \frac{v_{15}}{15xW_E}$ (p/ft/min) is taken as 15-minute pedestrian counts. The average pedestrian space, A_p , is a surrogate measure for density calculated by dividing pedestrian speed, S_p , by pedestrian flow, v_p, if speed is measured. The guidebook also suggested a capacity value of 23 p/min/ft. value for walkways with random flow. PLOS limits from A to F are decided using Table 3.1. The table allows different measures for PLOS determination according to data availability; average space, flow rate, average speed and v/c ratio.

Table 3.1 Average Flow Level of Service for Walkways and Sidewalks w/o platooning in HCM (2010).

LOS ($PLOS_{HCM}$)	Average Space (AS) (ft2/p)	Related Measures		
		Flow Rate (p/min/ft.)[a]	Average Speed (ft./s)	v/c Ratio[b]
A	AS >60	Score ≤5	4.25<Score	Score≤0.21
B	60≥ AS >40	5< Score ≤7	4.17<Score≤4.25	0.21<Score≤0.31
C	40≥ AS >24	7< Score ≤10	4.00<Score≤4.17	0.31<Score≤0.44
D	24≥ AS >15	10<Score≤15	3.75<Score≤4.00	0.44<Score≤0.65
E	15≥ AS >8	15<Score≤23	2.50<Score≤3.75	0.65<Score≤1.00
F	8≥ AS	Variable	Score≤2.50	Variable

Notes: [a] Pedestrians per minute per foot of walkway width
[b] v/c ratio= flow rate/23. LOS is based on average space per pedestrian

HCM, as a principle, does not provide any PLOS evaluation measure for locations not designed for pedestrian activity. But, pedestrians may walk along forestry, walking on the shoulder or roadway designed for vehicles, walking along bicycle lanes, which are observed in our campus evaluation. For such locations, PLOS, as a concept is considered as LOS F, as there is pedestrian flow (v) but no infrastructure capacity available (c), conceptually suggesting a v/c ratio definitely greater than “1”.

3.2.2 Gainesville Method

It was developed by Dixon (1996) using a grading point system of 1 to 21, and evaluates the PLOS of a walkway segment by six categories (see Table 3.2). Category I, pedestrian facility provided, evaluates the characteristics of the pedestrian walking area according to existing of sidewalks in sides of vehicular lanes, sidewalk width and off-street parallel alternatives and gives up to 10 points. This category gets approximately half of 21 points and the most important indicators of the method. Following category, conflicts, gets up to 4 points and gives information about interaction between the motor vehicles and pedestrians.

Table 3.2 Pedestrian Level of Service (PLOS) categories in Gainesville Method (Dixon, 1996)

($PLOS_{GM}$)	Score* (points)
A	Score >17
B	14< Score ≤17
C	11< Score ≤14
D	7< Score ≤11
E	3< Score ≤7
F	Score ≤ 3

***Score: C1+ C2+ C3+C4+C5+C6**

Point Categories and Criteria

Category	Criterion	Points	Category	Criterion	Points
C1: PEDESTRIAN FACILITY PROVIDED (Max Value=10)	• No Continuous or Non-existing	0	**C3: AMENITIES (Max Value=2)**	Buffer not Less Than 1m(3.5’)	1
	• Continuous on One Side	4		Benches or Pedestrian Scale Lightning	0.5
	• Continuous on Both Sides	6			
	Min. 1.53m(5’) Wide& Barrier Free	2		Shade Trees	0.5
	Sidewalk Width>1.53m(5’)	1	**C4: MOTOR VEHICLE LOS (Max Value=2)**	LOS E,F or 6 or More Travel Lanes	0
	Off-Street/ Parallel Alternative Facility	1		LOS D and <6 Travel Lanes	1
C2: CONFLICTS (Max Value=4)	Driveways & Side streets	1		LOS A,B,C and <6 Travel Lanes	2
	Pedestrian Signal Delay 40Sec. or Less	0.5	**C5: MAINTENANCE (Max Value=2)**	Major or Frequent Problems	-1
	Reduced Turn Conflict Implementation	0.5		Minor or Frequent Problems	0
	Crossing Width 18.3m(60’) or Less	0.5		No Problems	2
	Posted Speeds	0.5	**C6: TDM/ MULTI-MODAL (Max Value=2)**	No Support	0
	Medians Present	1		Support Existing	1

Category III, IV and V give up to 2 points. Amenities stated the condition of sidewalk in the right-of-way, comfort and convenience for pedestrians, and Motor vehicle LOS determine the effect of the motorized LOS on pedestrians. Category V evaluate impact of the obstacles (i.e. holes, tree root intrusion, patching) which have a big impact on pedestrian flows. Category VI represents the existence of a bus stop on the connection of intermodal accessibility. For each sidewalk/walkway segment, category points are determined, and then the summation of all category points gives the total grade for segments. According to Pedestrian LOS ratings given in Table 3.2 and the total segments grade; LOS for pedestrians are defined in the scale of A to F. Finally, segment score could be turned into corridor score by using weighted averages by the ratio of segment length over corridor length and the available segment scores.

3.2.1 Trip Quality Method

Jaskiewicz (1999) defined nine specific qualitative evaluation measures; enclosure/definition, complexity of path network, building articulation, complexity of spaces, transparency, buffer, shade trees, overhangs/ awnings/ varied roof lines, and physical component/ condition; to analyze pedestrian system for pedestrians' pleasantness, safety and comfort. For each measure 5 scale rating was applied in the mean of 5= excellent, 4=good, 3=average, 2=poor and 1=very poor. The scores of each measure averaged and overall LOS was determined according to Table 3.3. The method mostly suitable for city street design aspects such as shopping areas and working places through a street.

Enclosure / definition symbolizes the degree to which the edges of the street are defined, when buildings are constructed side-by-side along the sidewalk in the focus of minimizing the empty places between in and in front of buildings. Good enclosure increases the positive effect on safety and also on aesthetics. Complexity of path network indicates the route choice alternative in a well-designed land use pattern; and the alternative paths between each origin-destination pair. Building design, materials, color and décor has a good impact on pedestrian walking choice, speed and interest under the title of building articulation. The varied, interesting and rapidly changing areas increases the level of interest on walking such as, natural elements, spaces, plazas and parks shows the complexity of spaces.

Table 3.3 Overall Pedestrian LOS Rating According to Trip Quality Method (Jaskiewicz, 1999)

LOS ($PLOS_{TQ}$)	Averaged Score* (Points)	Pedestrians' Pleasantness
A	4.0 ≤ Score ≤ 5.0	Very Pleasant
B	3.4 ≤ Score ≤ 3.9	Comfortable
C	2.8 ≤ Score ≤ 3.3	Acceptable
D	2.2 ≤ Score ≤ 2.7	Uncomfortable
E	1.6 ≤ Score ≤ 2.1	Unpleasant
F	1.0 ≤ Score ≤ 1.5	Very Unpleasant

***Average Score Points= (M1+M2+ …M9)/9**

Evaluation Measures and Point Levels

Category	Very Poor	Poor	Average	Good	Excellent
M1: Enclosure/Definition	1	2	3	4	5
M2: Complexity of Path Network	1	2	3	4	5
M3: Building Articulation	1	2	3	4	5
M4: Complexity of Spaces	1	2	3	4	5
M5: Overhangs/ Awnings/ Varied Roof Lines	1	2	3	4	5
M6: Buffer	1	2	3	4	5
M7: Shade Trees	1	2	3	4	5
M8: Transparency	1	2	3	4	5
M9: Physical Component/ Condition,	1	2	3	4	5

Overhangs/ awnings/ varied roof lines has importance on both appearance and functional perspectives. Like building articulation, it increases the level of interest, besides that it works as a protection against to sunlight and rainfall. Buffer is the barrier between pedestrians and vehicular traffic and it is very important on safety. Shade trees improve the sun protection and also the aesthetic of the sidewalks. Transparency determines the interaction between public and private by the use of windows, outdoor displays and sidewalk cafes with a smooth interface. The last measure defines the physical component/ condition, both structural and functional view, concurred by sidewalk configuration and condition, vehicular speed and lightning characteristics.

3.3 Comparison of PLOS Ratings

To develop a more comprehensive PLOS method, we need a combination of both qualitative and quantitative measures together, which somehow reflects the user's perception and choice measures. In this study pairwise comparisons between methods are investigated to see the consistency of the method results. First, cross tabulation of the 3 PLOS rating results will prepared following the format shown in Table 3.4 for each study point and method, respectively.

Table 3.4 Cross tabulation of PLOS ratings for a subset of study points in METU Campus Study

Point	**PLOS $_{HCM}$**							**PLOS $_{GM}$**	**Rater 1 Score**	**Rater 2 Score**	**PLOS$_{TQ}$ Rating Avg.**
	T1	**T2**	**T3**	**T4**	**T5**	**T6**	**Worst case**				
….											
A5	A	A	A	A	A	A	**A**	**B**	2.5	2.5	**D**
A6	A	A	A	A	A	A	**A**	**B**	3.1	3.1	**C**
….											
B2	A	A	A	---	A	A	**A**	**D**	2.1	2.1	**E**
….											
B4	B	A	B	A	A	A	**B**	**D**	2.3	2.2	**D**
….											
B6	A	A	C	A	A	A	**C**	**C**	3.4	3.3	**C**
….											
D6	F	---	F	F	F	F	**F**	**D**	2.5	2.1	**D**
….											
E4	A	A	A	A	A	A	**A**	**B**	2.9	2.3	**D**
….											
H9	A	A	A	A	A	A	**A**	**B**	3.5	3.5	**B**
….											
J6	A	A	B	A	A	A	**B**	**F**	2.4	2.1	**D**
….											
K1	A	A	A	A	A	A	**A**	**C**	2.4	2.9	**D**
….											
K7	A	A	A	A	A	A	**A**	**C**	3.3	3.3	**C**
….											

In the process of the cross-tabulation,

- time-dependent HCM PLOS rating can be summarized into a representative rating which is defined as the "worst score" of the six time intervals. For example, at point B6, despite the high PLOS A levels in five tim intervals, PLOS degrades to C during the third time interval, T3, and thus, is assumed to be the representative level for this point.
- results of multiple raters in Trip Quality, must be reduced to a representative rating, which is simply done by taking the average of score points at each point. For example, at E4, Rater 1 and Rater 2 scores were 2.9 and 2.3, respectively, which is generating an average score of 2.6, that corresponds to a $PLOS_{TQ}$ of D according to Table 3.3.

After the cross-tabulation, the frequency tables for combinations of PLOS rating pairs are prepared for HCM versus GM, HCM versus TQ, and GM versus TQ comparisons. As an example, frequency of PLOS rating combinations by HCM versus GM is shown in Table 3.5, where "$f_{X,Y}$" denotes the number of locations at which HCM produced a rating of "X" while GM produced a rating of "Y". Such frequencies can also be visually depicted in a graph shown in Figure 3.2. In this pairwise evaluation, higher frequencies on the diagonals of the tables such as $f_{A,A}$, $f_{B,B}$, etc. show higher consistency between the two rating methods. This interpretation of consistency can be extended by accepting "close ratings" consistent; for example pairwise ratings of (C,C), (C,B),(C,D),(B,C),(D,C) can be interpreted as consistent. However, observance of cases with extreme combinations, such as (A,D), (F,B), (C,F), etc. is an indicator of inconsistency of the two model results. While one suggests very good operating conditions, the other indicates failing conditions.

Table 3.5 An example frequency table for pairwise evaluation of HCM and Gainesville PLOS ratings

Frequency of locations		Gainesville PLOS					
		A	**B**	**C**	**D**	**E**	**F**
HCM PLOS	**A**		$f_{A,B}$	$f_{A,C}$	$f_{A,C}$		
	B				$f_{B,D}$		$f_{B,F}$
	C			$f_{C,C}$			
	D						
	E						
	F				$f_{F,D}$		

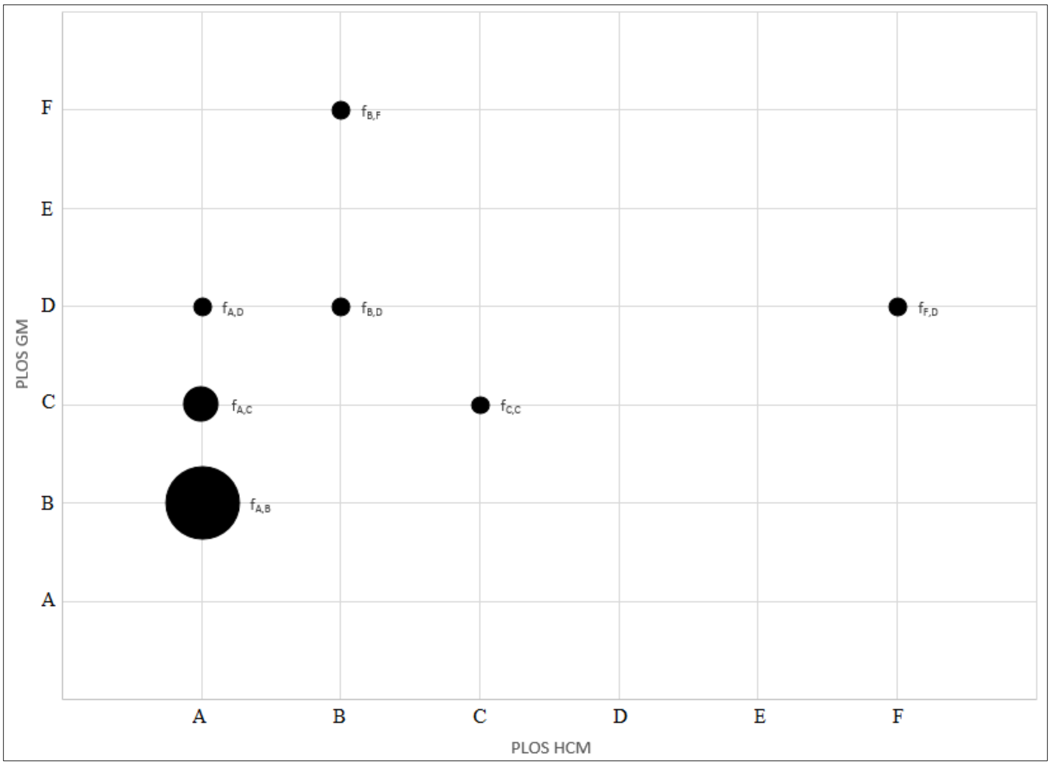


Figure 3.2 An example frequency graph for pairwise evaluation of HCM and Gainesville PLOS ratings

CHAPTER 4

CASE STUDY: METU CAMPUS PLOS AND WALKABILITY EVALUATIONS

METU campus was originally designed as "pedestrian friendly". However, change in the campus layout, the mode choice of the campus users as a function of change in the city it is located, it is necessary how it is perceived now. Thus, as a start point, in Section 4.1, we would like to give a picture of current state of walkability in the campus from a user perspective, which was evaluated as a subsection in a "METU Campus and Transportation Survey- Student Perspective". In this section, after a brief summary of the participant profile, walking choice of students in their in-campus accessibility and their perception on walkability will be presented.

In Section 4.2, the data collection for three PLOS methods is discussed in detail from points of pedestrian data, vehicular flow data and infrastructure data. After presentation of the PLOS evaluations by individual methods, comparative analyses of the rating are presented according to the methodology discussed in the previous chapter.

4.1 Walking and Walkability at METU Campus

"METU Campus and Transportation Survey- Student Perspective" was conducted in autumn (12 Nov.-1 Dec. 2014) with a five-pollster-group to 307 students. Within the scope of the survey, basically, all transportation habits while arriving to campus and also all the mode choices within the campus data, sustainability concept, all the possible modes' satisfaction level/ possible improvements, and pedestrians' walking routes was investigated for students. But, for the evaluation of walking and walkability on campus, results of the relevant parts (presented in Appendix A) are used in this study.

Sampling was done according to departmental populations, which were grouped into 25 sub regions based on proximity. Also, proportionality between the students residing in the dormitories and in the city is maintained according to the campus shares (approximately 1/3 of the total population lives in the campus). The participant profile is summarized in Table 4.1.

Table 4.1 Participant Profile for METU Campus and Transportation Survey- Student Perspective

	F	(%)
Gender (N=307)		
Male	153	49.8
Female	154	50.2
Ages (N=297)		
16-25	276	89.9
26-35	21	6.8
Marital Status (N=297)		
Married	1	.3
Unmarried	296	96.4
Class (N=307)		
Prep School	18	5.9
1.Class	45	14.7
2. Class	79	25.7
3. Class	70	22.8
4. Class	73	23.8
Master	20	6.5
Income (TL) (N=301)		
000-500TL	72	23.5
500-1000	156	51.8
1000-2000	50	16.6
2000-3500	18	6.0
3500-5000	5	1.7
Housing Location (N=306)		
METU Campus	115	37.5
City Center	191	62.4

4.1.1 In-Campus Mode Choice for METU Campus

One of the most important result from the survey is the high walking preference within campus transportation (Table 4.2). 68 % of the students prefer walking as a first alternative while going somewhere in the campus. This shows us there is a high demand to walking in the campus movements and there should be more effort on walking, walkway infrastructure and etc.

Table 4.2 In-Campus Student Mode Choice Results (N= 307 Students)

	First Choice		Second Choice		Third Choice	
Mode	**Frequency**	**%**	**Frequency**	**%**	**Frequency**	**%**
Walking	209	**68,1**	67	**21,8**	11	3,6
Bicycle	-	-	3	1,0	3	1,0
METU In-campus Shuttle	43	14,0	86	**28,0**	32	10,4
Dolmus	3	1,0	13	4,2	11	3,6
Hitchhiking	17	5,5	65	**21,2**	52	**16,9**
Private Car	28	9,1	27	8,8	4	1,3
Taxi	5	1,6	4	1,3	2	0,7
EGO In-Campus Shuttle	-	-	1	0,3	1	0,3

4.1.2 Students' Perception of Walkability in METU Campus

METU Campus and Transportation Survey includes some questions to get a rough idea on the perceptions' on walking, quality of walking area and safety described in detailed. As a beginning the respondents were evaluated the sufficiency of infrastructure characteristics in a general perspective for whole campus. With the data from evaluations analyzed with a basic descriptive statistics revealed in Table 4.3. Results revealed that the walking infrastructure was mostly sufficient, but lightning, safety precautions, and arrangement for disabled users were very problematic. Also there were a considerable amount of users who evaluate the characteristics; pavement quality, width, and shading; as insufficient.

Table 4.3 Evaluation of METU Campus walking areas according to selected design, network and infrastructure parameters by students

Is the walking area (walkways, sidewalks, crosswalks) sufficient in	**Sufficient (%)**	**Insufficient (%)**
a) Pavement Quality **(N= 302)**	**58.0**	40.4
b) Continuity **(N=302)**	**66.1**	32.2
c) Width **(N=305)**	**58.6**	40.7
d) Shortcuts **(N=305)**	**67.1**	32.2
e) Shading **(N=300)**	**51.5**	46.3
f) Safe Lightning **(N=303)**	34.5	**64.2**
g) Planned according to disabled person **(N=301)**	9.4	**88.6**
h) Other safety precautions (stragglers, vehicle conflicts, etc.) **(N=302)**	18.6	**79.8**
i)Marked crosswalks **(N=295)**	**61.9**	34.2

Attendees evaluated the features in “not important” to “extremely important” scale on walking preferences (Table 4.4). The statistics revealed a parallel interactions with walking as expected. Walkway capacity, continuity and width identified as a partially important feature, while the precautions against to weather conditions, shortcuts, arrangement for disabled users, infrastructure, and lightning were highly important. Existing of sidewalk on both sides of the road and the width of the sidewalks were extremely important, as in the literature. The decrease in obstacles as plague and mast was partially important; however decrease in trees was not important. 50% of the attendees determine the planning the network according to disabled persons as extremely important. Also the prevention of vehicle-pedestrian conflicts with barriers define as highly important. As safety precautions, crosswalks, presence of a median and traffic lights seem important. In-campus speed limit should importantly decrease in spite of current low speed limits.

Table 4.4 Evaluation of sidewalk design and possible improvements for METU Campus walking areas by students

		Not Important (%)	Slightly Important (%)	Moderately Important (%)	Extremely Important (%)
a)	**Walkway,** **a1)** should increase **(N=297)**	14.7	**29.0**	**36.5**	16.6
	a2) should be continuous **(N=302)**	10.7	**24.4**	**44.6**	18.6
	a3) should enlarge **(N=304)**	16.0	**27.0**	**36.5**	19.5
	a4) should be sheltered against bad weather conditions **(N=304)**	7.2	12.1	**40.7**	**39.1**
	a5) should be sheltered against sun effects **(N=302)**	10.7	22.8	**34.2**	**30.6**
	a6) should have **shortcuts (N=305)**	3.3	16.0	**38.1**	**42.0**
	a7) planned according to disabled person **(N=300)**	8.5	8.8	**32.6**	**47.9**
	a8) infrastructure should improve (smooth service, durable design, etc.) **(N=305)**	7.5	20.5	**39.4**	**31.9**
	a9) should be better lighten **(N=297)**	6.2	18.6	**36.2**	**35.8**
b)	**Sidewalks,** **b1)** should be at both sides of the road **(N=304)**	5.9	9.4	**42.7**	**41.0**
	b2) should enlarge **(N=305)**	8.1	21.8	**37.1**	**32.2**
	b3)number of obstacles (plaque/mast) should be decrease **(N=304)**	17.3	**32.2**	**30.0**	19.5
	b4) number of impediment trees should be decrease **(N=305)**	**52.1**	**20.2**	16.0	11.0
	b5) planned according to disabled person **(N=298)**	7.5	6.5	**32.9**	**50.2**
	b6) possible vehicle-pedestrian conflicts should be decrease by a buffer (shrubbery, concrete barriers, etc.) **(N=303)**	10.4	19.5	**32.9**	**35.8**
c)	**Marked Crosswalks;** **c1)** should be increase **(N=305)**	7.8	22.1	**42.3**	**27.0**
	c2) should design with a median in the middle **(N=299)**	12.7	**28.7**	**37.5**	18.6
	c3) equipped with traffic lights **(N=300)**	15.3	**29.0**	**36.5**	16.9
d)	In-campus speed limit should decrease **(N=303)**	13.7	22.8	**33.6**	**28.7**
e)	Parking which affecting the pedestrian flow should avoid **(N=302)**	7.5	15.6	**32.6**	**42.7**

After all the research on METU campus walkability and walking analysis, there are a lot of different results and comments for same region. Three different PLOS methods include mostly different features and also the pedestrian perceptions vary. Neither of the results can be the case for a region but to evaluate METU campus walkability, one should gather the necessary piece of each result into a new point of view. Because of the deficiency of location based perception data, the evaluation for campus will be concluded as one whole system with a conversion of location based PLOS results into a general result. Besides the PLOS determination, walkability in METU campus evaluated as sufficient according to pedestrian perception. With this summary situation assessment, it can be concluded that METU is a walkable campus but not at highest level of confidence because of infrastructure deficiencies.

4.2 Campus Walking and PLOS Data Collection

For walkability and PLOS evaluations there are lots of different points of views as mention in the Chapters 2 and 3. For each perspective there is a need for different types of data, and data collection becomes complicated. In this part of the study collected necessary data for 3 PLOS methods were explained under three sub-titles; i) pedestrian counts, ii) infrastructure data, and iii) vehicular traffic data.

4.2.1 Pedestrian Counts

METU Campus has a big pedestrian activity which differs according to time of day, day of week and also seasonal. To determine the walkability and PLOS in the campus, the demand and flow characteristics should be analyzed, firstly. At the beginning, a comprehensive pedestrian count in the campus was planned in detailed to catch the whole day mobility spatially and temporarily. The campus was divided into 11 main regions, from Zone A to Zone Z as shown in Figure 4.1.a. To study many locations where pedestrian flows intersect (such as a main roundabout in Zone E shown in Figure 4.1b) or volumes changed drastically (such as bus stops). A total of 102 count points (see Figure 4.1a) included six points on the pedestrian alley, a few more on the stairways leading to the sidewalks, and many locations either at the crosswalks or along the campus roads, with observation points on both sides of the roads, regardless of existence of sidewalks. To increase data quality, every walking direction at each location is coded in the counting sheets as shown in Figure 4.1c, and also every count points are shown in Appendix B.

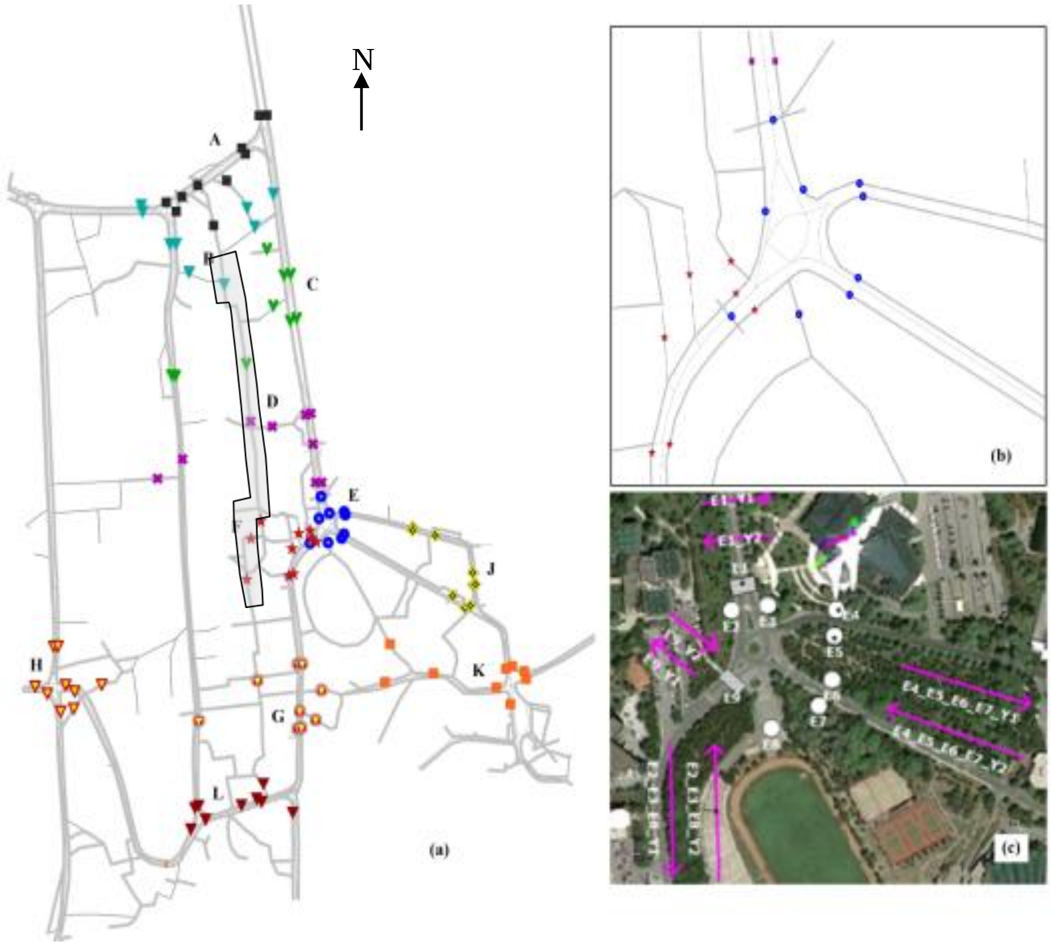


Figure 4.1 Count Locations of (a) All Campus and (b) Pedestrian Zone E, and (c) with Direction Instructions for Zone E

The survey was conducted on October 11, 2011 with 10 observers (Zone G was excluded due to personnel problem) at 6 different time periods (8:15-9:00, 9:15-10:00, 12:15-13:00, 13:15-14:00, 16:00-16:45, 17:00-17:45) to capture the mobility in the morning, during noon and in the evening. All observers have the data collection sheet shown in Figure B.1 to define a common procedure within all regions. To cover a zone with one observer during the allocated 45-minute period, each location was observed for 3 minutes only. Though, this is rather short period, it was chosen for the sake completeness of the survey, but, there are also some example pedestrian studies with this short observation time in the literature (Parma et al, 2013; Maddock et al, 2012). Pedestrian movements and directions are recorded by gender, as well, to investigate the difference.

No strong walking pattern based on gender was observed for METU campus. However very strong directionality pattern was observed. The 3-minute counts differed greatly by time interval, direction and location, as expected. As an example, at the point of F10 there were 400 pedestrians in 3-minutes going southbound, at 09:15 to 10:00 interval (Table D.1). Besides, there were 92 pedestrians in the opposite direction (northbound) at 17:00- 17:45 interval (Table D.3). Likewise at point B6 there were 231 pedestrians in 3-minute counts to southbound at 12:15 to 13:00; however there were 4 pedestrians at 09:15 to 10:00 interval (Table D.2). The whole count results for every count points were demonstrated in the Appendix D, and hourly total values were calculated by summation of 3-minute counts for 2 directions and multiplied by 20 to achieve 60 minutes values.

To indicate the directionality with count location data and the interpretation of it became very complicated and meaningful. By a notation in GIS environment data was investigated and converted to maps using PTV VISUM software with directionality and gender based pedestrian count data. To represent the time-dependent nature of the pedestrian flows multiple GIS maps was prepared as shown in Figure 4.2 a-b. In order to reveal the time- dependent difference, a morning and an evening time interval was chosen in the representation. Comparative analysis of the different time period maps showed the change of directionality and volumes of pedestrian activity in METU campus.

The figure indicates that there was a great number of pedestrian movement from the gates to the academic buildings at the morning, and the reverse of it at the evening, as expected. While there was more pedestrian activity originating from the dormitories in the morning, there was more activity on the alley and the recreational areas in the evening. Also, on the walkway leading to the north campus entrance, there is a sign of strong “entrance” flow, where more people walked south towards the campus in the morning, and vice versa in the evening.

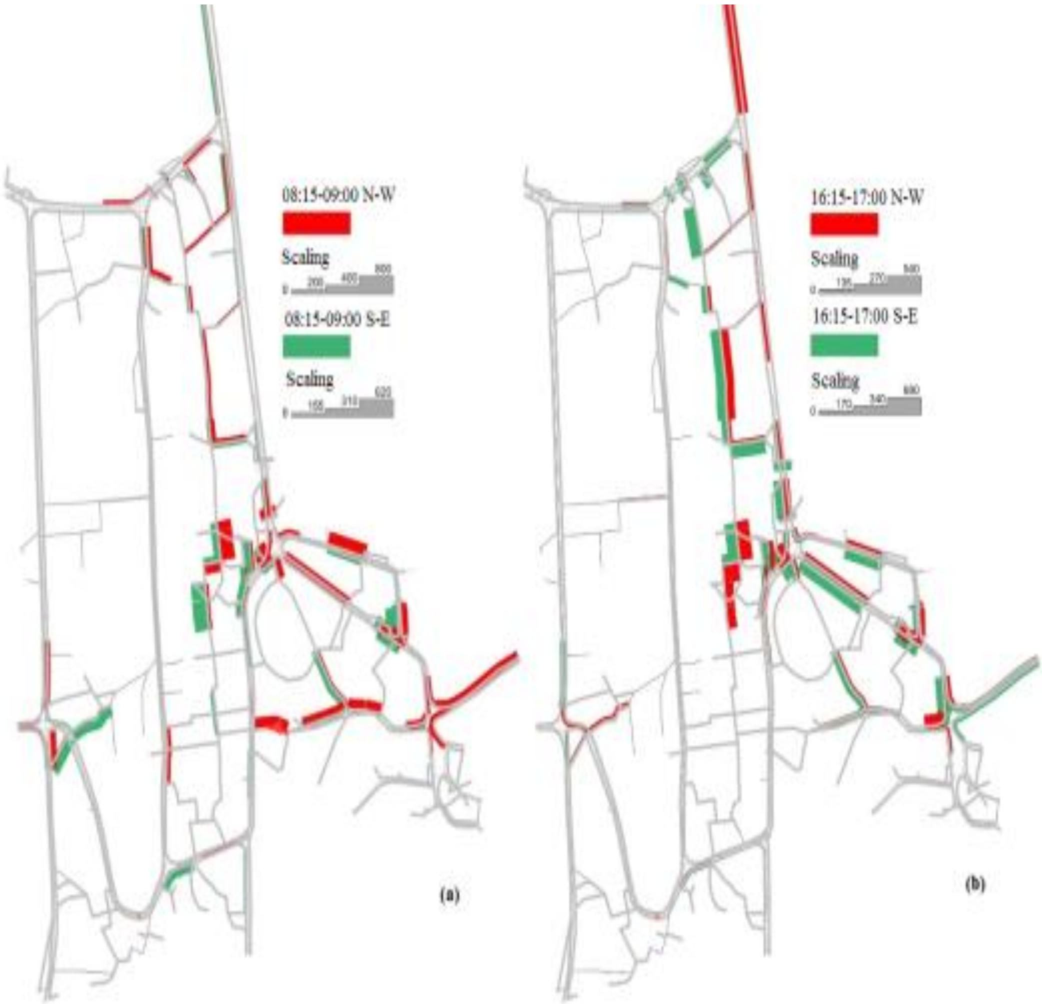


Figure 4.2 Mapping of Volumes and Directions of Pedestrian Flows for a) Morning (08:15-09:00) and b) Evening (16:15-17:00) Hours

For noon times, which create a mobility for lunch break, pedestrians were mostly in tendency to go cafeteria for lunch. In Figure 4.3, the noon time pedestrian flow was on the road to cafeteria can be seen obviously.

Figure 4.3 A Photo Shows Noon-time Pedestrian Flow on Alley

This analysis revealed the following challenges of pedestrian mobility on the representations on GIS mapping:

- The display of both walking directions at each count location can be challenging, especially at short walkway segments. This requires definition of directional pedestrian links at each count location regardless of existence of a walkway or not; which in return, requires a much more complex network definition.
- Display of directionality in such a dense pedestrian network poses a challenge; it was overcome in our study by color coding the mobility into two main directions “north-or-west” and “east-or-south” as shown in Figure 4.2. Using the line thickness feature, it was possible to display the pedestrian volumes in

the same map. But, this may be further improved by employing advanced GIS techniques, such as 3D mapping.

- Interpretation of the validity of the point based pedestrian volumes over the links is another challenge; although a link in a vehicular traffic network has a much more definite and concrete meaning, it is a more vague concept in case of pedestrian networks. In our analysis, we had to make judgment on the length of the segment for which the counts would be representative. For some corridors along which we had no pedestrian attraction/production points, we were able to extend the counts over a long distance; but, some observations were at critical locations serving many nearby nodes, and thus, were valid for very short distances.

4.2.2 Infrastructure Data

The infrastructure data on walkways, sidewalks and crosswalk have an approved impact on walking choice as mentioned in the literature. Nearly all the methods which determine PLOS or walkability in a region, contained one or more physical and design characteristics. Within the part of the thesis the infrastructure data was collected for the three PLOS determination methods for each count point at three stages. The first stage was the collection of accurate features such as width of sidewalk/ walkway, presence of trees, buffer, median, etc. Second and third stages were the collection of relative features by two raters at different dates. The relative features were identified according to Trip Quality Method as explained in the Section 3.2.1 and coded with numbers (Table 3.3)

To show evaluation of infrastructure characteristics for different methods, data reports were prepared for every study location. Examples of such reports are given in Tables 4.5 through 4.7. For example, Point A3 has a good physical separation, trees, between vehicular traffic. The location also has well designed against to sun, but the lightning is insufficient (see Table 4.5). For both locations, there is no bus stop or any other connection to public transportation. For location B9, there are major and frequent problems; trees interrupt the flow frequently

Table 4.5 The Infrastructure Data of Count Points A3 and B9

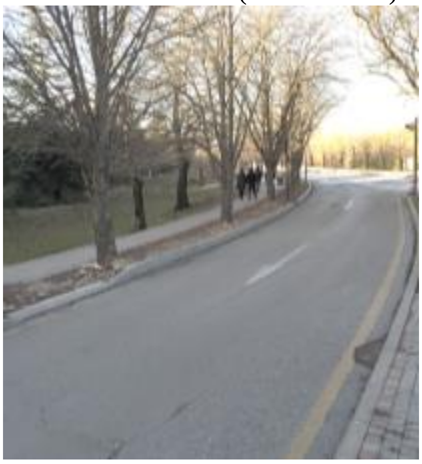
Point A3 (Width=1.9 m)	**Point B9** (Width=2.0 m)
	
✓ Continuous on both sides ✓ Medians ✓ Buffer not less than 1 m ✓ Shade trees ✓ Vehicular LOS=A, B(off-peak) ✓ Vehicular LOS=F (morning-peak) ✓ No maintenance problems	✓ Continuous on one side ✓ Off street parallel alternative route ✓ Medians ✓ Lightning ✓ Shade trees ✓ All campus vehicular LOS=A, B or C
× No-off street parallel alternative route × No lightning × NoTDM support	× No-off street parallel alternative route × No Buffer × NoTDM support × Major or frequent problems
• Enclosure =Very Poor • Network Complexity =Very Poor • Building Articulation =Very Poor • Complexity of spaces =Poor • Transparency =Very Poor • Buffer =Good • Shade trees = Excellent • Awnings = Very Poor • Physical component/ condition= Good	• Enclosure =Very Poor • Network Complexity =Poor • Building Articulation =Very Poor • Complexity of spaces =Very Poor • Transparency =Very Poor • Buffer =Very Poor • Shade trees = Excellent • Awnings = Very Poor • Physical component/ condition= Average

Table 4.6 The Infrastructure Data of Count Points D8 and E8

<table>
<tr><td>Points D8 (Width=2.0 m)
</td><td>Point E8 (Width=24.77 m)
</td></tr>
<tr><td>✓ Continuous on both sides
✓ Off street parallel alternative route
✓ Medians
✓ Lightning
✓ Shade trees
✓ All campus vehicular LOS=A, B
✓ No maintenance problems</td><td>✓ Continuous on both sides
✓ Buffer not less than 1 m
✓ Lightning
✓ Shade trees
✓ All campus vehicular LOS=A, B or C
✓ No maintenance problems</td></tr>
<tr><td>× No buffer
× NoTDM support</td><td>× No-off street parallel alternative route
× No medians
× NoTDM support</td></tr>
<tr><td>• Enclosure =Average
• Network Complexity =Good
• Building Articulation =Very Poor
• Complexity of spaces =Poor
• Transparency =Very Poor
• Buffer =Very Poor
• Shade trees = Excellent
• Awnings = Very Poor
• Physical component/ condition= Good</td><td>• Enclosure =Poor
• Network Complexity =Average
• Building Articulation =Very poor
• Complexity of spaces =Average
• Transparency =Very poor
• Buffer =Excellent
• Shade trees =Average
• Awnings =Very poor
• Physical component/ condition= Excellent</td></tr>
</table>

Table 4.7 The Infrastructure Data of Count Points F3 and F10

Points F3 (Width=1.57 m)	**Point F10** (Width=**1**2.8 m)
	
✓ Continuous on both sides ✓ Shade trees ✓ All campus vehicular LOS=A, B ✓ Minor or infrequent problems	✓ Continuous on both sides ✓ Off street parallel alternative route ✓ Medians present ✓ Buffer not less than 1 m ✓ Lightning ✓ Shade trees ✓ All campus vehicular LOS=A, B or C ✓ Minor or infrequent problems
× No-off street parallel alternative route × No lightning × No buffer × NoTDM support	× No-off street parallel alternative route × No medians × NoTDM support
• Enclosure =Very poor • Network Complexity =Very poor • Building Articulation =Very poor • Complexity of spaces =Average • Transparency =Very poor • Buffer =Very Poor • Shade trees = Good • Awnings = Very poor • Physical component/ condition= Average	• Enclosure =Good • Network Complexity =Good • Building Articulation =Excellent • Complexity of spaces =Very Poor • Transparency =Good • Buffer =Excellent • Shade trees =Excellent • Awnings =Very poor • Physical component/ condition =Good

and effective width decreases. Lightning is better than location at A3. At both points there are not any buildings or awnings. Physical condition at A3 is better than B9. This regions are both out of the academic departments and the network and spaces are not complex. As another case, infrastructure at Points D8 and E8 are summarized in Table 4.6. Point D8 has a very good physical separation between vehicular traffic, and is designed as a small alley. Both D8 and E8 have lightning and shade trees, but there is no bus stop or any other connection to public transportation. Physical condition is good at Point D8 and excellent at Point E8;

also there is no maintenance problems. There is no building, awnings and transparency effect. For location F3 (in Table 4.7) sidewalk width is minimum and there is a minor maintenance problem; so physical condition become average and reflects lower condition. However, Point F10 is on the main alley, and gets the higher grades from most of the aspects. For whole campus there is no awning contribution.

4.2.3 Vehicular Traffic Data

A thesis on sustainable transportation in METU campus assessed some scenarios to reduce in-campus private car emissions with the encouragement of non-motorized modes (Altintasi, 2013). In the concept of the study the vehicular mobility in the campus was quantified comprehensively; campus origin-destination matrix was determined, in-campus vehicle-km was calculated, and carbon emissions were detected. For these quantifications campus RFID system was used with parking lot surveys. In the study the campus speed profiles, volumes and capacity were defined for morning peak, evening peak and off-peak hours, respectively. The vehicular LOS for METU campus was investigated for each time period with available data, and represented in PTV VISSUM maps shown in Appendix C (see figures C.1, C.2, and C3). According to results, nearly most of the locations in the campus determined as LOS A, B, and C, which are counted as free flow or under-capacity conditions and represented with green. For morning peak hours only two corridors got congested and determined as LOS F, while only one corridor became congested for evening peak.

4.3 PLOS Analyses

METU campus PLOS were determined by 3 methods described previously in Chapter 3 with all the collected data. In this section, the results of the determination methods are examined with each methods' campus results map. The data and calculation tables were investigated by a classification of walkway type within the results section. Walkways, which have no interaction between vehicular traffic, such as alley, were represented respectively from walkways which have interaction between vehicular traffic in this section.

4.3.1 HCM Method Results

For HCM method, the effective walkway width, the obstacle (trees, benches, signs, etc.) widths are measured at the pedestrian count locations. 3-minute pedestrian flow values from pedestrian survey were converted to 15-minute values, by simple proportionality. However, more research on the validity of this assumption has to be made by taking longer observations at different locations, which probably must be done by continuous data collection techniques. Any overestimation due to the use of short observation time was welcomed in our study, as we aimed to get the PLOS for the worst demand conditions, and arranged the 45-minute periods to capture the class change times (8:40, 9:40, etc.) as much as possible.

Assuming no platooning on the campus walkways and with no pedestrian speed data, PLOS values were determined according to flow rate (p/min/ft.) values as presented. Since we had 6 different flow values observed, PLOS maps were created for each observation time period separately (takes place in Appendix D). This method resulted in PLOS A levels at almost every location and time period, except for some critical cases as shown in the noon-time (during 12:15-13:00) PLOS map in Figure 4.2. In this time period (12:15-13.00), PLOS at the sidewalks (see Figure 4.4) between the core loop and the new academic unit had experienced the lowest PLOS values of F; because,

- The Foreign Languages School, located at the northern part of the campus, serve close to 2000 students who are taught in two sessions; the morning one ends around 12:30 and the afternoon one starts around 13:30, and approximately 2/3 of these students live in the dormitories, which creates an enormous number of pedestrian activity between this region, cafeteria and the dormitories.

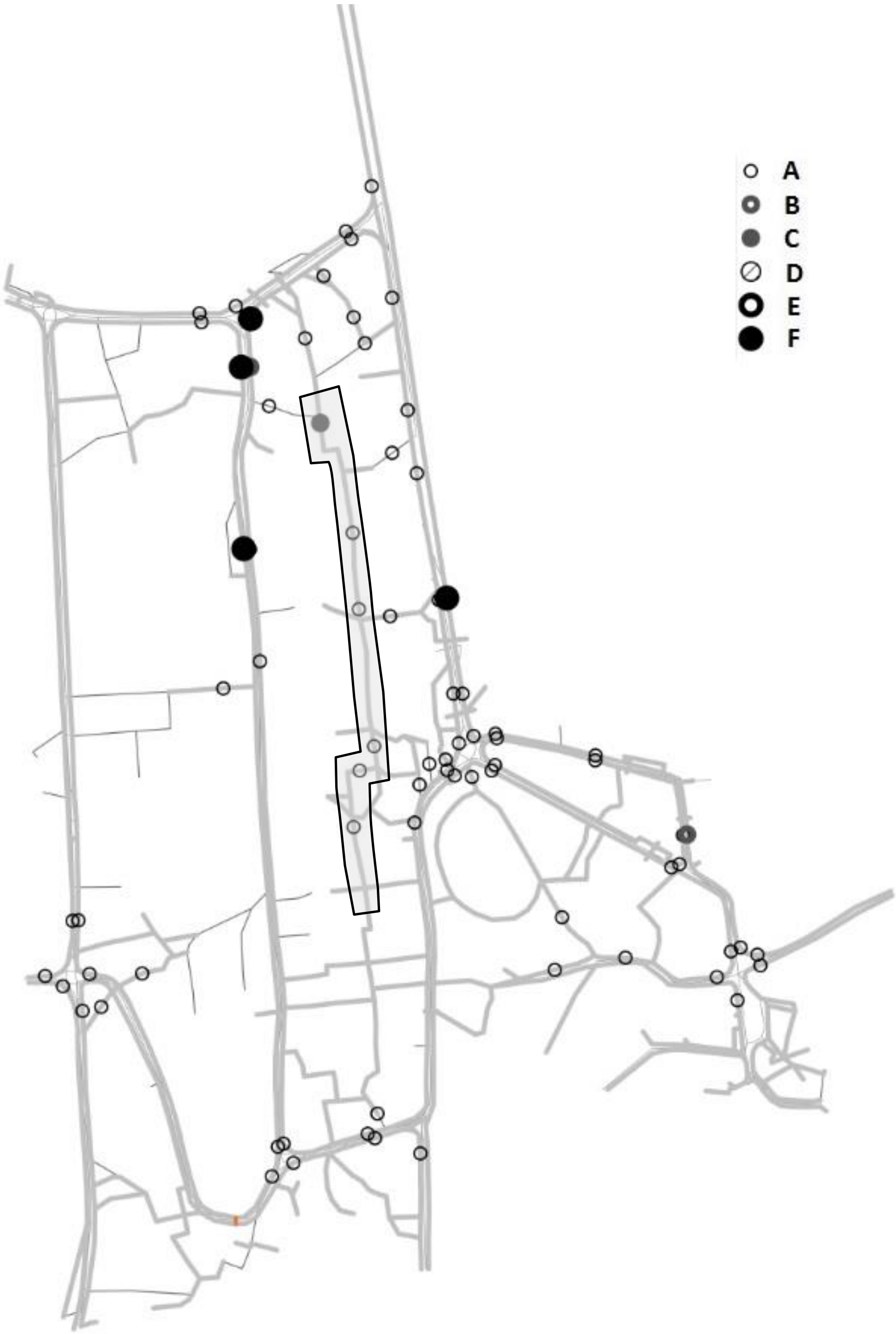


Figure 4.4 Pedestrian PLOS results with HCM Method for 12.15- 13.00

- Also, the lack of sidewalk on one side of the road connecting the prep school to the new academic units does not stop pedestrians from walking, as it is a part of the shortcut walking route.

Within the scope of the calculation part, the locations which have no walkway infrastructure were rated PLOS F without any calculation.

4.3.2 Gainesville Method Results

Gainesville method evaluated the PLOS with available walking infrastructure capacity as mentioned previously. For determination necessary data was collected for each count location by in point observations. Data was analyzed according to methodology, and resulted in a great variety in PLOS B to F for off-peak hours in the campus (see Figure 4.5). Additionally the location based categorical grading tables were represented for walkways had interaction between vehicular traffic and no interaction between vehicular traffic, respectively (Tables E.1, E.2, and E.3).

In the categories there is not any variables depend on the pedestrian usage or flow aspects, and also method do not focus on the design characteristics of the walking area. Within the concept of the study, the best walking area, alley, has the PLOS B; because the location could not get any point from Conflicts category. The locations were rated as PLOS F get the lowest grades, where there is no sidewalk but pedestrian activity. The other sides of the PLOS F regions lost grade because of the inadequacy of the other sidewalk. In the campus most of the regions are weak because of Conflict category as in the alley. Also, another problematic category is maintenance, and most of the campus walkways have minor or major problems.

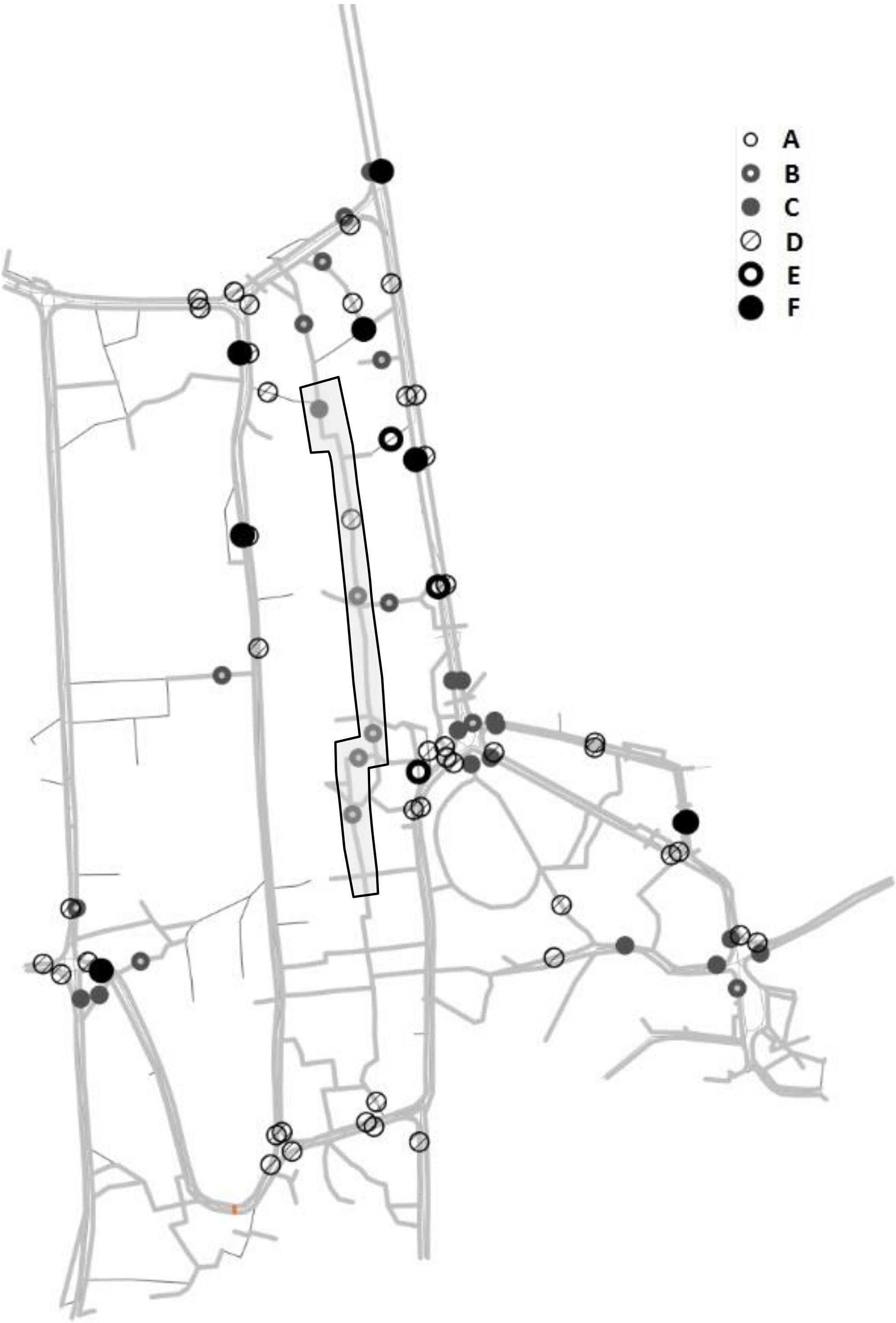


Figure 4.5 Pedestrian PLOS results with Gainesville Method

For the vehicular LOS, all locations got the same and highest grade for off-peak hours and did not represent any difference. However for morning- peak hours, at 5 pedestrian count locations (A3, A8, E3, K2 and K3), vehicular LOS were determined as PLOS F, and each of them lost 2 grades from total Gainesville Score (Tables 4.8 and 4.9). However only two of the locations decreased one level of PLOS (A3 and E3 got PLOS C instead of B). Likewise, 3 locations (J8, K1 and K4) were determined as LOS F for vehicular traffic, and two of the three locations decreased one level of PLOS (K1 and K4 got PLOS D instead of C).

Table 4.8 Changes in Gainesville Method PLOS Results for Morning and Off-Peak Hours

Point	PFP	Conf	Amen	VLOS	Maint	TDM	* Score	$PLOS_{GM}$
At A3								
Morning peak (VLOS F)	9	0.5	1.5	0	2	0	13	**C**
Off-peak (VLOS A)				2			15	**B**
At A8								
Morning peak (VLOS F)	8	0	1	0	-1	0	8	**D**
Off-peak (VLOS A)				2			10	**D**
At E3								
Morning peak (VLOS F)	8	1	1	0	2	1	13	**C**
Off-peak (VLOS A)				2			15	**B**
At K2								
Morning peak (VLOS F)	7	1	1	0	0	0	9	**D**
Off-peak (VLOS A)				2			11	**D**
At K3								
Morning peak (VLOS F)	7	1	1	0	0	0	9	**D**
Off-peak (VLOS A)				2			11	**D**

Table 4.9 Changes in Gainesville Method PLOS Results for Evening and Off-Peak Hours

Point	PFP	Conf	Amen	VLOS	Maint	TDM	* Score	$PLOS_{GM}$
At J8								
Off-peak (VLOS A)	7	1	1	2	0	0	11	**D**
Evening peak (VLOS F)				0			9	**D**
At K1								
Off-peak (VLOS A)	8	1	1	2	0	0	12	**C**
Evening peak (VLOS F)				0			10	**D**
At K4								
Off-peak (VLOS A)	7	1	1	2	0	1	12	**C**
Evening peak (VLOS F)				0			10	**D**

4.3.3 Trip Quality Method Results

Trip Quality method requires relative data and critical assessment; therefore two rater were employed to determine the walking area. For each location, raters decided the sufficiency of measures. After the determination, the PLOS calculated for each location and each rater separately. The methodology for Trip Quality method is mostly applicable for city center streets and design. Raters were trained according to evaluate the campus as a city center street, not as a campus standard. The campus may be in a good design and building articulation as a campus but according to manual it could get low grade.

The similarity between two raters' PLOS results is 69.8 %, which is the lower acceptable limit as mentioned in the literature. Secondly, an inter rater reliability analysis using the Kappa statistic was performed to determine consistency among raters. The inter rater reliability for the raters was found to be Kappa = 0.57 (p <.0.001). As a rule of thumb values of Kappa from 0.41 to 0.60 are considered moderate (Viera et. Al, 2005; Landis & Koch, 1977; Altman, 1991). According to Fleiss (1981) the results reflect the intermediate to good gap.

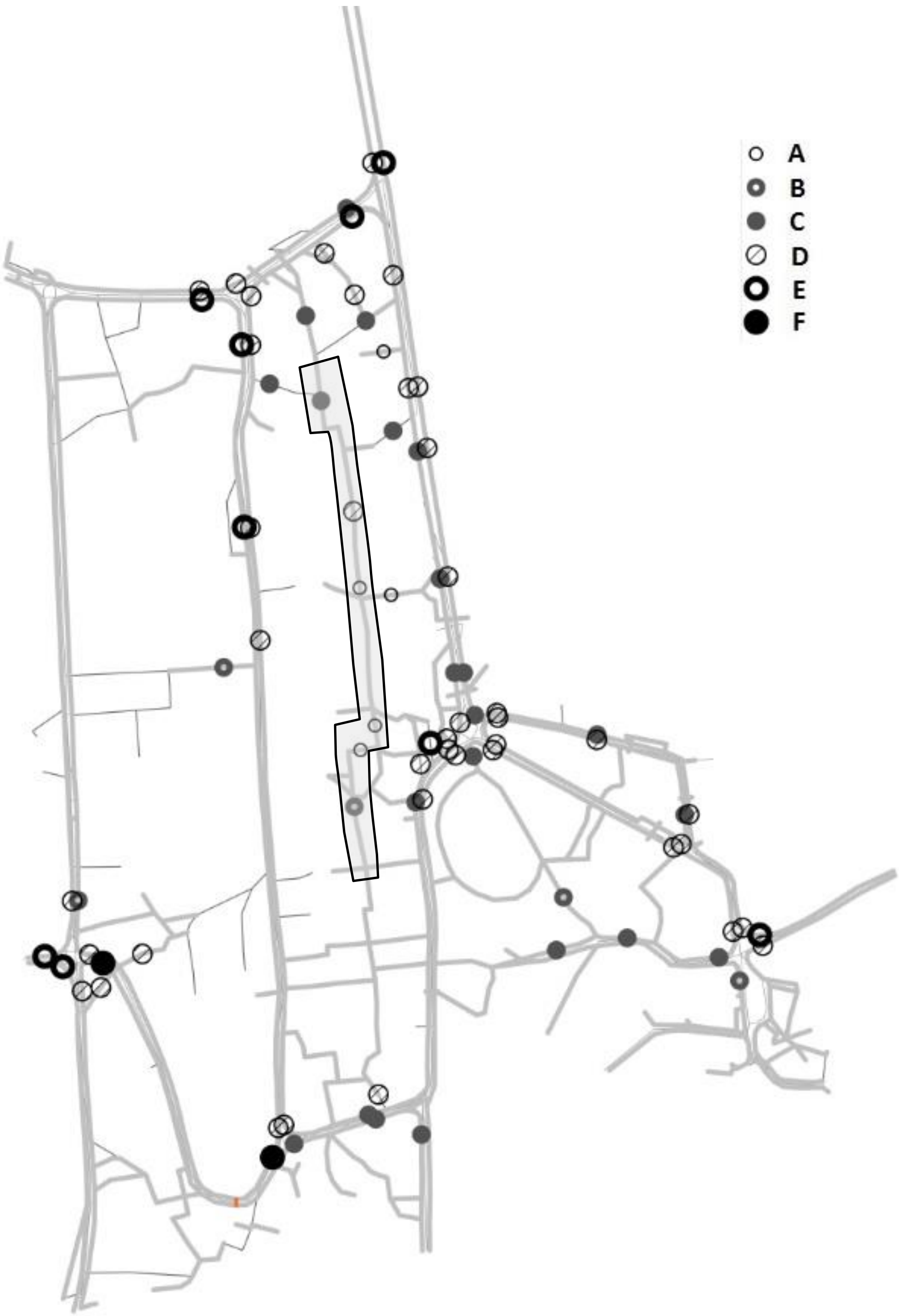


Figure 4.6 Pedestrian PLOS results with Trip Quality Method

Acceptable agreement between raters extinguished the re-evaluation process and to finalize the process, average of the ratings were calculated. According to average determination, the PLOS values were defined for each count location (Figure 4.6). Additionally, the location based measure classification was tabulated for each rater and also each walkway type, respectively (Appendix F). It can be seen from the Figure 4.6 that, this method reflects a great variety from PLOS A to F. The highest PLOS values can be seen on the alley, where building articulation and transparency got the highest grades. METU campus designed in a pedestrian friendly layout and the major walking areas were surrounded by academic unit and it became a boundary. Alongside the vehicular roads, all the locations lost grades because of transparency, building articulation and complexity of spaces at most.

4.4 Comparisons of PLOS Rating for METU Campus

Campus PLOS ratings were determined using the three methods which have different perspectives. To see the differences among methods and consistency of the ratings, the ratings are cross-tabulated for each location as shown in Tables 4.10, 4.11 and 4.12. According to the HCM method, which depends on mostly pedestrian flow rates, campus PLOS ratings look very high, despite the varying ratings by the other two methods. 87 % of the locations were rated as PLOS A (Tables 4.10, 4.11 and 4.12). In Gainesville Method, most of the locations (52 %) received PLOS D rating, while almost half of the locations (48 %) received PLOS D in Trip Quality method. Despite the insensitivity of HCM to infrastructural differences, Gainesville and Trip Quality methods produced higher PLOS ratings for the walkways that have no interaction with vehicular traffic (in Table 4.12) than locations that have interaction (in Tables 4.10 and 4.11). The overall evaluation of different ratings are summarized in the frequency tables for pairwise analysis of the methods presented in Tables 4.13 through 4.15.

Table 4.10 Comparison of PLOS Values for METU Campus for Walkways Having Interaction with Vehicular Traffic (Locations A through E)

Point	PLOS $_{HCM}$						PLOS $_{GM}$	PLOS$_{TQ}$
	08:15-09:00	09:15-10:00	12:15-13:00	13:15-14:00	16:00-16:45	17:00-17:45		
Sidewalks Alongside the Roads								
A1	A	A	A	A	A	A	C	D
A3	A	A	A	A	A	A	B	C
A4	-	A	A	A	A	A	D	E
A8	A	A	A	A	A	A	D	D
A9	F	F	F	F	F	F	D	D
B1	A	A	A	A	A	A	D	D
B2	A	A	A	A	A	A	D	E
B4	B	A	B	A	A	A	D	D
B8	A	A	A	A	A	A	F	C
B9	A	A	A	A	A	A	D	D
C1	A	A	A	A	A	A	F	C
C3	A	A	A	A	A	A	E	C
C4	A	A	A	A	A	A	D	D
C8	A	A	A	A	A	A	D	D
D2	A	-	A	A	A	A	D	D
D5	A	A	A	A	A	A	E	C
D8	A	A	A	A	A	A	C	C
D9	A	A	A	A	A	A	C	C
E2	A	A	A	A	A	A	C	D
E3	A	A	A	A	A	A	B	C
E4	A	A	A	A	A	A	B	D
E6	A	A	A	A	A	A	D	D
E7	A	A	A	A	A	A	C	D
Sidewalks at Parking Lots								
B5	A	A	A	A	A	A	D	C
B7	A	A	A	A	A	A	D	D
C5	-	-	-	-	-	-	D	D
C9	-	-	F	-	-	F	F	E
Pedestrian Activity Locations with No Sidewalk Capacity								
A2	F	-	-	F	-	-	F	E
B3	F	F	F	F	F	F	F	E
C2	-	F	-	-	-	F	D	D
C7	F	F	F	F	F	F	D	D
D6	F	-	F	F	F	F	D	D

Table 4.11 Comparison of PLOS Values for METU Campus for Walkways Having Interaction with Vehicular Traffic (Locations F through L)

Point	$PLOS_{HCM}$						$PLOS_{GM}$	$PLOS_{TQ}$
	08:15-09:00	09:15-10:00	12:15-13:00	13:15-14:00	16:00-16:45	17:00-17:45		
Sidewalks Alongside Roads								
F2	A	A	A	A	A	A	D	D
F3	A	A	A	A	A	B	D	D
F6	A	A	A	A	A	A	D	C
F7	A	A	-	A	A	A	D	D
H1	-	-	-	-	-	-	F	F
H4	A	A	A	A	A	A	C	D
H5	A	A	A	A	-	A	D	E
H6	A	A	A	-	A	A	D	D
H7	A	A	A	-	A	A	D	E
H8	A	A	A	A	A	A	D	D
H9	A	A	A	A	A	A	B	B
J1	A	A	A	A	A	A	D	C
J2	A	A	A	A	A	A	D	D
J5	A	A	A	A	A	A	D	C
J6	A	A	B	A	A	A	F	D
J7	A	A	A	A	A	A	D	D
J8	A	A	A	A	A	A	D	D
K1	A	A	A	A	A	A	C	D
K2	A	A	A	A	A	A	D	D
K3	A	A	A	A	A	A	D	E
K4	A	A	A	A	A	A	C	D
K5	A	A	A	A	A	A	B	B
K6	A	A	A	A	A	A	C	C
K7	A	A	A	A	A	A	C	C
K8	A	A	A	A	A	A	D	C
L1	-	A	A	A	A	A	D	C
L3	A	A	A	A	A	-	D	C
L4	A	A	A	A	-	A	D	C
L6	-	A	A	-	-	A	D	D
L7	A	-	A	A	A	A	D	D
L8	-	A	-	A	-	A	D	F
L9	A	A	A	A	A	A	D	C
Sidewalks at Parking Lots								
F1	A	A	A	A	A	B	D	D
F4	A	A	A	A	A	A	D	E
F5	A	A	A	A	A	A	E	D
L2	A	A	A	A	-	A	D	D

Table 4.12 Comparison of PLOS Values for METU Campus for Walkways with No-interaction with Vehicular Traffic

Point	PLOS HCM						PLOS GM	PLOS$_{TQ}$
	08:15-09:00	09:15-10:00	12:15-13:00	13:15-14:00	16:00-16:45	17:00-17:45		
Walkways								
A5	A	A	A	A	A	A	B	D
A6	A	A	A	A	A	A	B	C
B6	A	A	C	A	A	A	C	C
C6	A	A	-	A	-	A	B	A
D1	A	A	A	A	A	A	B	B
D3	A	A	A	A	A	A	B	A
D4	A	A	A	A	A	A	B	A
E5	A	A	A	A	A	A	C	D
E8	A	A	A	A	A	A	C	C
F8	A	A	A	A	A	A	B	B
F9	A	A	A	A	A	A	B	A
F10	-	A	A	A	A	A	B	A
H2	A	A	A	A	A	A	B	D
H3	A	A	A	A	A	A	C	D
K9	A	A	A	A	A	A	D	B

To investigate reasons behind different rating by the selected methods, we have look into PLOS ratings of the locations individually. For example, at Location A3 (a sidewalk near the prep school) for which the infrastructure data was given in Table 4.5, HCM resulted in PLOS A rating while Gainesville and Trip Quality methods resulted in PLOS B and PLOS C, respectively (see Table 4.10). Because, despite the narrow sidewalk design at this point, low pedestrian flow values suggested a high PLOS rating in HCM. However, nonexistence of off-street parallel alternative, lightning and public transportation support, the location got a lower PLOS rating according to Gainesville method. Rating exacerbated even worse according to the Trip Quality method, as the segment has not got any impressive design aspects, such as well-articulated building, enclosure, awnings, etc. More drastic contradictory results were observed at locations B2, B8, H5, J6, L8, etc. where HCM reported PLOS A but the other two failing ratings of PLOS D, E or PLOS F. Such significantly different PLOS evaluation results for METU campus can be explained by the existence of "low pedestrian volumes on the walkways and sidewalks, even when their capacities are low". But, it is imperative to analyze whether such low sidewalk capacity is responsible for the low pedestrian volumes. The main reason behind such contradiction is the difference in the evaluation philosophy. While HCM method focuses on the flow rates (thus, congestion levels inherently) it does not consider the infrastructure condition, design aspects and safety issues, which are factors affecting pedestrians' perception and mode choice.

The results of the three selected methods at the 84 study locations are summarized in the frequency tables prepared in a pairwise fashion as suggested in Section 3.3 (see Tables 4.13 to 4.15). The same information is also depicted visually in Figures 4.7 and 4.8, where the size of the circle at any PLOS pair represent the frequency of the combination observed among the study locations. As can be seen clearly in Figure 4.7, there is a big clustering on the left side of the graph, where HCM ratings are PLOS A and other method results varied from A to F. On the other hand, the pairwise comparisons between Gainesville and Trip Quality method in Figure 4.8 has more scatteredness in the middle of the graph around PLOS levels of B to D (at 27 locations, they both reported PLOS D).

HCM ratings greatly differ from the other two methods, which suggest no consistency or correlation with the other two methods. On the other hand, checking all the consistent results of Gainesville and Trip Quality methods, such as (A, A), (B, B), etc., we see that at 39 locations, almost half of the analysis points, both methods produced the same ratings. If we accept a level difference close to consistent, such as (B, C), (B, A), (A, B) or (C, B), the consistency of the two methods increased to 88 % of the points. There are only 3 locations where Gainesville method produced a good level of PLOS B, but Trip Quality suggested a low rating of PLOS D. Vice versa, Trip Quality method produced a good level of PLOS B, but Gainesville suggested a low rating of PLOS D at one location.

Table 4.13 Frequency Table of Sample Locations for PLOS Result Comparison

Frequency of locations		Gainesville PLOS					
		A	**B**	**C**	**D**	**E**	**F**
HCM PLOS	**A**	---	15	13	37	3	3
	B	---	---	---	3	---	1
	C	---	---	1	---	---	---
	D	---	---	---	---	---	---
	E	---	---	---	---	---	---
	F	---	---	---	3	1	2

Table 4.14 Frequency Table of Sample Locations for PLOS Result Comparison

Frequency of locations		Trip Quality PLOS					
		A	**B**	**C**	**D**	**E**	**F**
HCM PLOS	**A**	5	5	21	32	7	1
	B	---	---	---	4	---	---
	C	---	---	1	---	---	---
	D	---	---	---	---	---	---
	E	---	---	---	---	---	---
	F	---	---	---	3	3	---

Table 4.15 Frequency Table of Sample Locations for PLOS Result Comparison

Frequency of locations		Trip Quality PLOS					
		A	**B**	**C**	**D**	**E**	**F**
Gainesville PLOS	**A**	---	---	---	---	---	---
	B	5	4	3	3	---	---
	C	---	---	6	8	---	---
	D	---	1	9	27	6	1
	E	---	---	2	1	1	---
	F	---	---	2	1	3	1

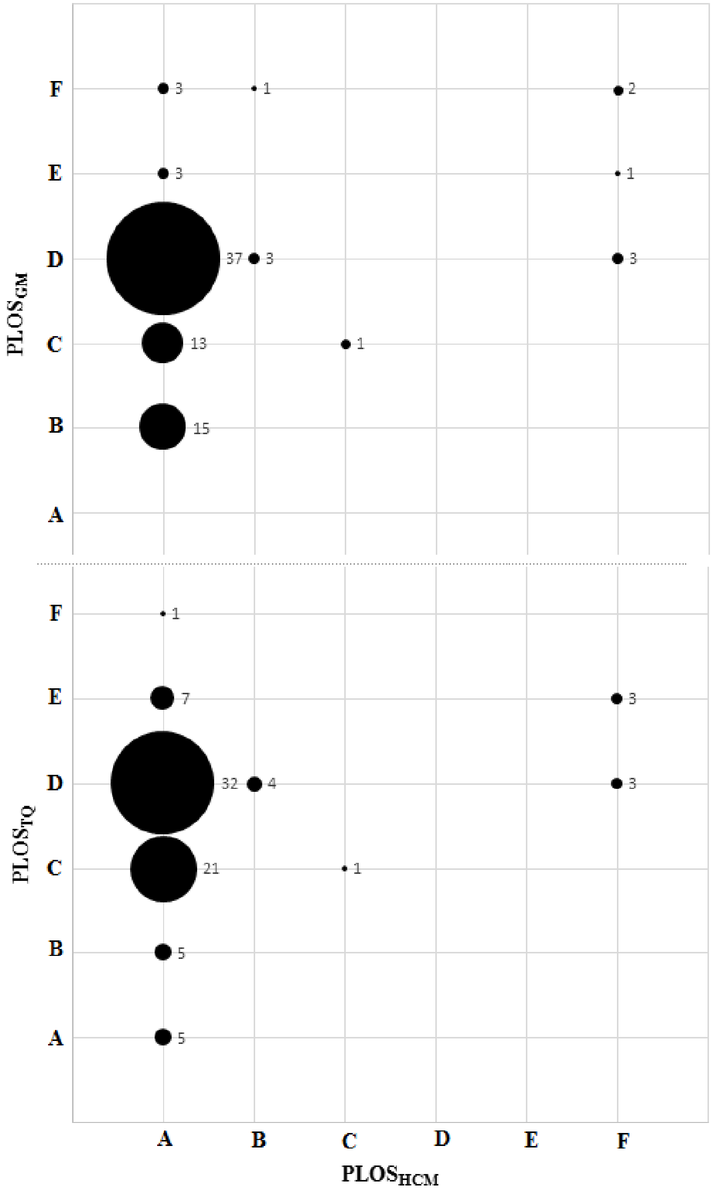


Figure 4.7 Pairwise Analysis between HCM Method Results versus Trip Quality and Gainesville Method Results

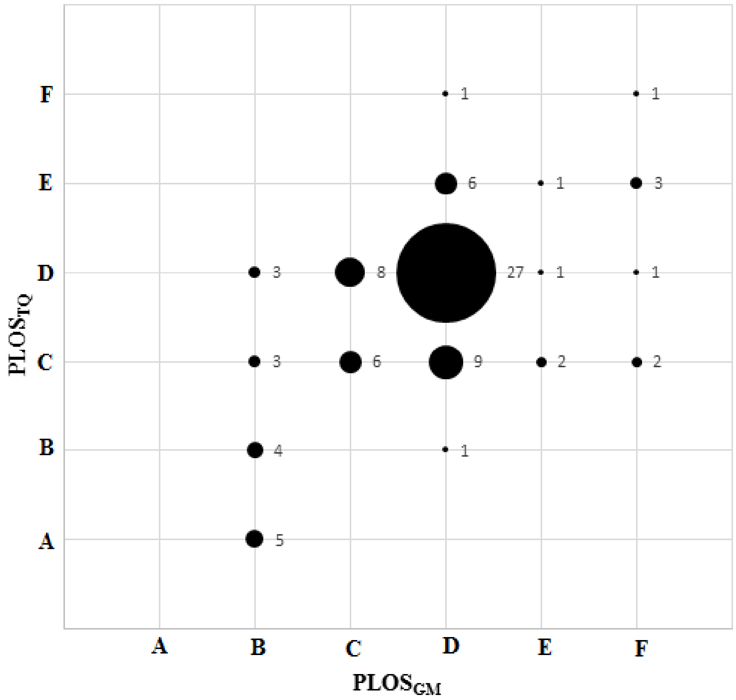


Figure 4.8 Pairwise Analysis between Trip Quality Method Results versus Gainesville Method Results

CHAPTER 5

CONCLUSIONS AND FURTHER RECOMMENDATIONS

This study showed the need to further investigation of the concept of pedestrian level of service (PLOS) and calculation methodologies over a case study of evaluation of PLOS ratings at 84 locations at METU Campus. The main findings and future research recommendations are summarized as follows.

5.1 Walkability and PLOS Ratings

In the literature, though defined and studied separately, both walkability and pedestrian level of service have similar dimensions of

i) user characteristics,
ii) traffic characteristics,
iii) land use characteristics,
iv) infrastructure characteristics and
v) safety/ comfort characteristics.

However, none of the existing PLOS methods includes measures covering all these dimension, thus, produce partial information about walkability at a point. Another result of this situation is the lack of consensus on a methodology for evaluation of walkability or PLOS at a point. This problem can be seen clearly in the comparison of the three selected PLOS methods in this study: HCM method, which consider only width of walkway and pedestrian flow, can capture changes in pedestrian flow levels in a time-dependent way and compared to infrastructure capacity. It can give fast and easy ratings, because of less data requirements, but this result could not reflect the real condition without infrastructure, perception, and land use and safety characteristics. On the other hand, both Gainesville and Trip Quality methods do not take into account the pedestrian flow characteristics, focus on design aspects; but they do not incorporate any information about the usage of a location which can change drastically over time, as well. However, infrastructure properties, such as continuity, lightening, etc., are repeatedly mentioned in the walkability assessments and thus, should be considered in the revised PLOS evaluations, as in the case of Gainesville and Trip Quality method. Even if the infrastructures are designed adequately and similarly, utility of walking may vary greatly between cultures and locations. PLOS, either from planning or capacity perspective, is a step that evaluates only current available conditions (capacity or volumes). Contrary to HCM, Gainesville Method evaluates the locations for existing of sidewalk alongside the vehicular roads as a couple and assign higher PLOS score. Because of this deficiency, HCM Method reflects the condition into a worse case. HCM should include the effect of existing of sidewalk on the other side of the vehicular traffic. Trip Quality Method unnecessarily focuses on building articulation and architecture for campuses.

As a starting step towards an improved PLOS evaluation, it is helpful to keep track of both PLOS ratings from two methods with different focuses jointly as a pair (such as HCM vs Gainesville or HCM vs Trip Quality) for each location, and display them in a 2-D graph. A more comprehensive PLOS definition is needed to show both design and flow based attributes. The revised PLOS ratings should be time-dependent as pedestrian mobility is dynamic, like HCM model, and should be GIS-based as much as possible. The improved PLOS method must be accompanied with other elements of walkability assessment (such as connectivity and proximity) like in the Trip Quality method. This may even yield to determination of network-level PLOS concept, which would be beyond the current point- or corridor-based perspectives. PLOS evaluation should be flexible for customized ratings for specific regions, such as campuses, city centers, shopping areas, suburban regions, etc., because user needs and perceptions may change based on the trip purpose and location. For example, it is not very meaningful to use Trip Quality method directly for a campus area, which has a totally different design aspects disregarding the building articulation emphasized in a city street.

Through the evaluation of METU Campus pedestrian activity and PLOS ratings, it is concluded that,

- while pedestrian flows had time-dependent and directional characters as vehicular traffic, it was more challenging to detect due to the lack of strict definition of a walkway and traveler path choices.
- The definitions of “walking” network (walkways, path choices, utility of walking, etc.) have to be reconsidered carefully.
- GIS enables strength in the display of pedestrian mobility, and contributes greatly to understanding of walking pattern.
- Even short-term manual counting of pedestrian activity over a campus requires much manpower, mainly because the concept of “walkway” and “path choice” for walking is very flexible.
- Pedestrian perception on walkability and walking should be determined by respondents for each count location respectively to include the perception into a new model.
- The current available PLOS methods are totally different from each other because of their perspectives and may result in very different and even contradicting ratings.
- At these contradicting rating points, it is important to conduct further survey with the pedestrians to decide which method captures the reality more. Such survey has to be designed very carefully to include main parameters used in PLOS evaluations by the selected methods.

5.2 Data Requirements for Evaluation of Walkability and Walking

As, sustainable transportation goal needs a modal shift towards walking; it is important to change individual travel behaviors, thus, it is important to understand individual perceptions of walking, which can be observed with surveys. Pedestrian surveys and walking network data must eventually lead to flexible and disaggregate mathematical models of walking choices that will in turn provide information on the parameters that would encourage or discourage walkability. Considering the quality problems of manual counting, it is necessary to develop cheap but precise technologies and tools to monitor pedestrian volumes and directions. The data requirement of a comprehensive walkability evaluation should merge

a) network data (capacity, land-use and control measures),

b) traffic data (pedestrian, bicycle and vehicle traffic volumes and their spatio-temporal distribution; number and type of conflicts between pedestrian flows and other flows) and

c) traveler based characteristics (gender, age, profession, auto ownership, commuter behavior, public transit usage, income, etc.).

It should be noted that network capacity should include data about

- walkway/shoulder width,
- fixed object and obstacle widths and locations,
- walkway pavement types,
- parking capacities and their usage,
- presence of alternative path choices,

while land-use must be evaluated by

- landscape and roadside development
- land use pattern (existence of shopping, residential, mixed, rural/forestry areas)
- roadside development
- geometry of vehicular road (such as number of driving lanes).

Also, network control measures that affect walkability are listed as,

- existence of refuge or medians
- signalization
- lightening levels
- Crosswalks or pedestrian markings.

5.3 Recommendations to Improve Walking and PLOS Ratings at METU Campus Walkways

HCM results showed that despite high pedestrian volumes at some of the walkways, the high capacity along the alley and width of the sidewalks portray good conditions in terms of PLOS; however, existence of pedestrian activity on road with no sidewalks (or in the directions with no sidewalks) result alarming levels of PLOS F at these locations. These locations are potential problems in terms of pedestrian safety. Such usage of vehicular road capacity or forested regions must be taken into consideration while reconfiguring the walking network in the campus.

Analyzing the alley at METU campus has to be done with caution. In the HCM evaluation, PLOS A, which is mostly the observed rating at the locations along the alley, means low pedestrian volume compared to capacity. However, this is a rather misleading result, obtained when very large width of the alley is interpreted as the walkway width in the HCM formulation. In reality, the capacity of the alley is not utilized only for walking, it is also used as gathering and waiting location. The real capacity used for walking should be measured, if possible.

The lower PLOS rankings from the Gainesville method are mostly due to conflicts with vehicular traffic and obstructions along the sidewalks, such as trees, etc. However, the locations with PLOS levels of C or D should be accepted as optimally used ones. For locations with PLOS E and F, improvements should be made. Considering the high level of positive perception of trees on METU sidewalks by the students, sidewalks should be redesigned and have higher capacities and continuity without compromising the trees.

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APPENDIX A

THE METU CAMPUS AND TRANSPORTATION SURVEY

(Related Parts)

ODTÜ YERLEŞKE VE ULAŞIM ANKETİ

Anket No: Yer/Tarih: Anketör:

A. KATILIMCI BİLGİLERİ

A1. Cinsiyetiniz: ( ) Kadın ( ) Erkek

A2. ODTÜ'de kayıtlı olduğunuz **Bölüm:**
A3. Sınıf : ( ) Hazırlık **( )** 1. Sınıf **( )** 2. Sınıf **( )** 3. Sınıf **( )** 4. Sınıf
( ) Yüksek Lisans **( )** Doktora

A4. Yaşınız: ( ) 16-25 ( ) 26-35 ( ) 36-50 ( ) 51-60 ( ) 61-64 ( ) >65

A5. Medeni Durumunuz: ( ) Evli ( ) Bekar

A6. Aylık Ortalama Geliriniz: ( ) <500 TL ( ) 500-1000 TL ( ) 1000-2000 TL
( ) 2000-3500 TL ( ) 3500-5000 TL ( ) >5000 TL

D1. (Anketör Eşliğinde Doldurunuz) Kampüs içi erişimde kullandığınız ulaşım türlerini kullanım tercihinize, sıklığına ve bölgesine göre belirtiniz.

Tercih Sırası	**Tür**	**Kullanım Sıklığı**	**Bölümünüzden hangi bölgelere erişirken kullanıyorsunuz?**
	Yürüme		
	Bisiklet		
	Ring		
	Dolmuş		
	Otostop		
	Özel Araç		
	Diğer(Belirtiniz:.......................**)**		

D11. ODTÜ Kampüsündeki yürüme alanlarının (yaya yolları, kaldırımlar ve yaya geçitleri) yürünebilirlik açısından SİZCE yeterliliğini değerlendiriniz.

Yürüme alanlarının,	**Yeterli**	**Yetersiz**
a) kaplama kalitesi		
b) sürekliliği		
c) genişlikleri		
d) kestirme güzergahları içermesi		
e) gölgelendirilmesi		
f) güvenli şekilde aydınlatılması		
g) engelli erişimine uygun düzenlenmesi		
h) diğer güvenlik önlemleriyle desteklenmesi (başıboş hayvanlar, araç-yaya etkileşimi, vb)		
ı) işaretlenmiş yaya geçidi içermesi		

D12. Kampüs içi erişimde sizin **YÜRÜME**'yi daha fazla tercih etmeniz için aşağıdakiler ne derece önemlidir?

	Hiç önemli değil	**Biraz önemli**	**Oldukça önemli**	**Çok önemli**
a) Yürüme yollarının, **a1)** arttırılması				
a2) kesintisiz olması				
a3) genişliklerinin artırılması				
a4) kötü hava koşullarına karşı korunaklı olması				
a5) güneşli hava koşulları karşı korunaklı olması				
a6) kestirme güzergahlarda tasarlanması				
a7) engelli erişimine uygun olarak düzenlenmesi				
a8) kaplamalarının iyeleştirilmesi (düzgün yüzey, dayanaklı tasarım, vb şekilde)				
a9) daha iyi aydınlatılması				
b) Kaldırımların, **b1)** Yolun her iki tafında da kaldırımın bulunması				
b2) genişliklerinin arttırılması				
b3) üzerindeki levha/direklerin azaltılması				
b4) üzerinde engel yaratan ağaçların azaltılması				
b5) engelli erişimine uygun düzenlenmesi				
b6) olası yaya-araç etkileşimin azaltacak şekilde tasarlanması (çalılık, beton mantarlar, vb ile)				
c) İşaretlenmiş yaya geçitlerinin; **c1)** Sayısının artırtılması				
c2) tasarımında yol ortasında refüj bulundurulması				
c3) trafik ışıklarıyla donatılması				
d) Kampus yollarında araç hızlarının azaltılması				
e) Yaya akışını engelleyen araç parklanmasının önlenmesi				

APPENDIX B

DATA COUNTS INFORMATION SHEETS

08:15 – 9:00
09:15 – 10:00

12:15 – 13:00
13:15 – 14:00

16:00 – 16:45
17:00 – 17:45

Zaman aralığı(Time Interval): ....

A1	**Yön1:** A1 kapısı veya Eskişehir Yoluna doğru **(Direction 1:**Through A1 Gate& Eskişehir Highway)	**Yön2:** Kampüs içi, stadyuma doğru **(Direction 2:** Through in-campus &stadium)
Bayan için **K**; (**K** for Female) Erkek için **E** (**E** for Male)		

A2	**Yön1:** A1 kapısı veya Eskişehir Yoluna doğru **(Direction 1:**Through A1 Gate& Eskişehir Highway)	**Yön2:** Kampüs içi, stadyuma doğru **(Direction 2:** Through in-campus &stadium)
Bayan için **K**; (**K** for Female) Erkek için **E** (**E** for Male)		

A3	**Yön1:** A1 kapısı veya Eskişehir Yoluna doğru **(Direction 1:**Through A1 Gate& Eskişehir Highway)	**Yön2:** Kampüs içi, stadyuma doğru **(Direction 2:** Through in-campus &stadium)
Bayan için **K**; (**K** for Female) Erkek için **E** (**E** for Male)		

A4	**Yön1:** A1 kapısı veya Eskişehir Yoluna doğru **(Direction 1:**Through A1 Gate& Eskişehir Highway)	**Yön2:** Kampüs içi, stadyuma doğru **(Direction 2:** Through in-campus &stadium)
Bayan için **K**; (**K** for Female) Erkek için **E** (**E** for Male)		

Figure B.1 A Screenshot of Data Count Sheet for Location A

Figure B.2 Data Collection Points and Direction Map for location A

Figure B.3 Data Collection Points and Direction Map for location B

Figure B.4 Data Collection Points and Direction Map for location C

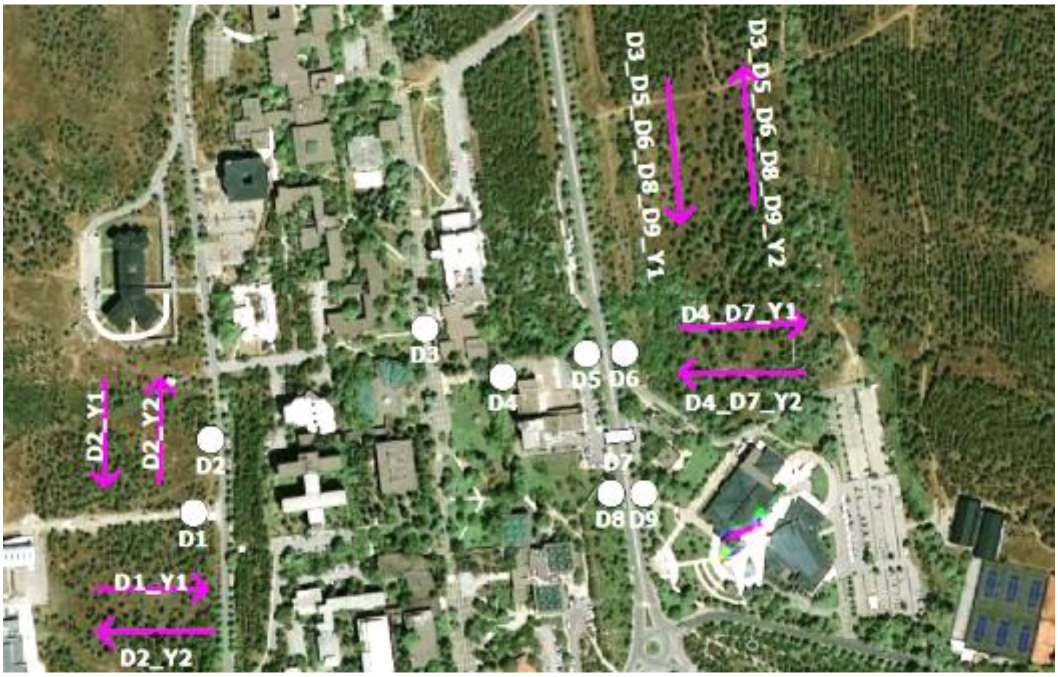

Figure B.5 Data Collection Points and Direction Map for location D

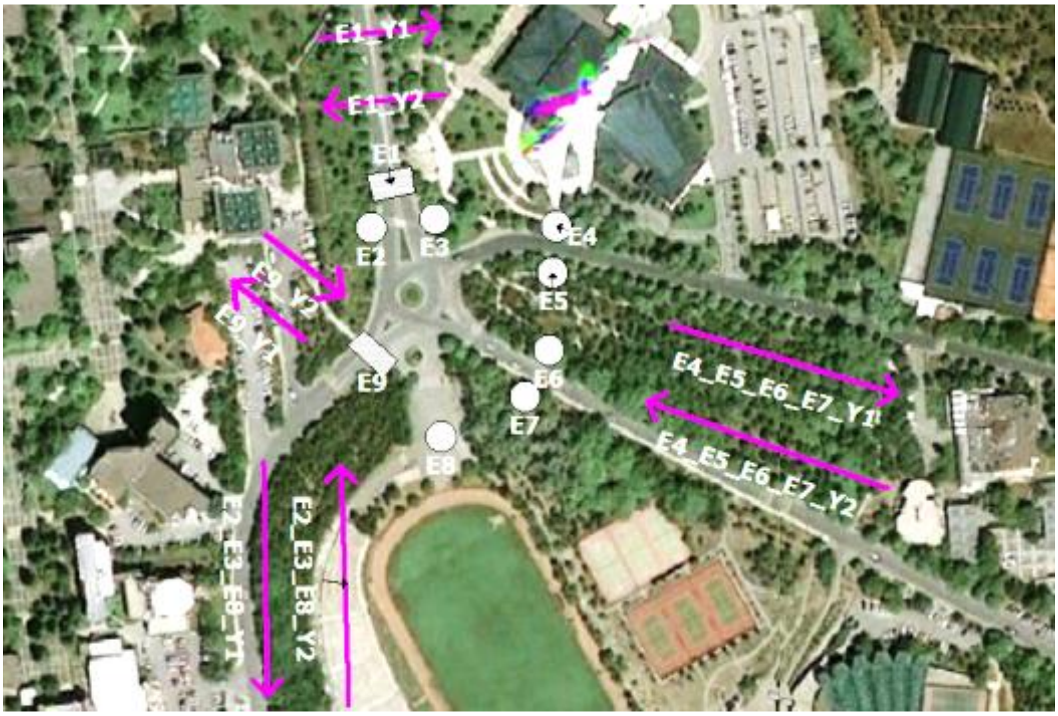

Figure B.6 Data Collection Points and Direction Map for location E

Figure B.7 Data Collection Points and Direction Map for location F

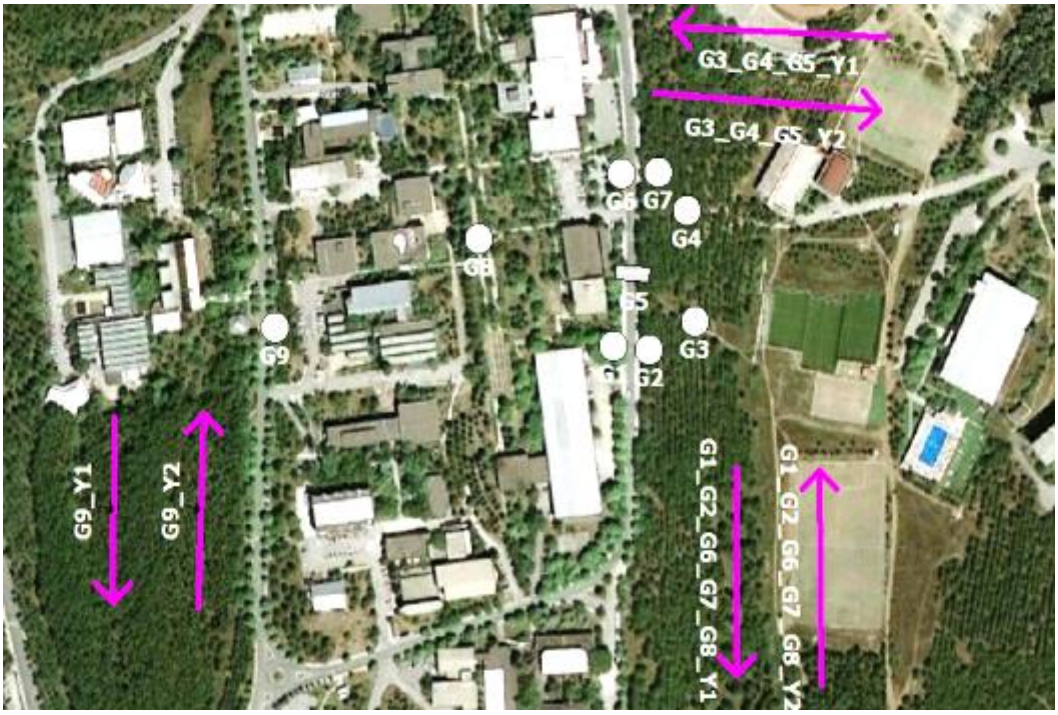

Figure B.8 Data Collection Points and Direction Map for location G

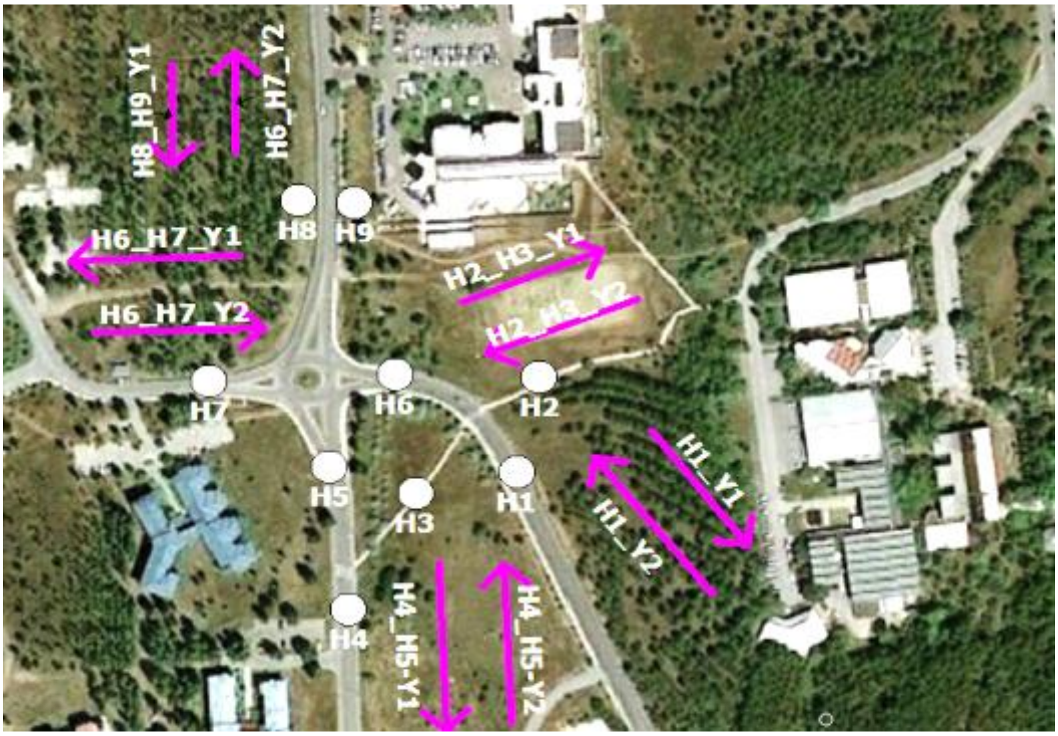

Figure B.9 Data Collection Points and Direction Map for location H

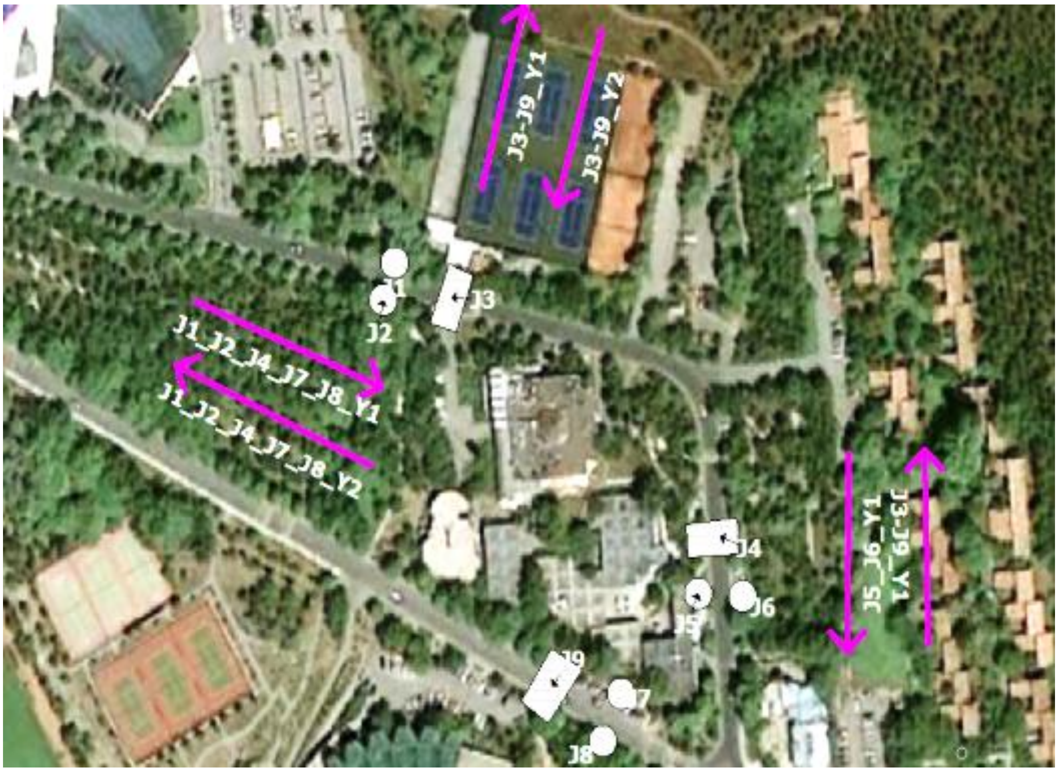

Figure B.10 Data Collection Points and Direction Map for location J

Figure B.11 Data Collection Points and Direction Map for location K

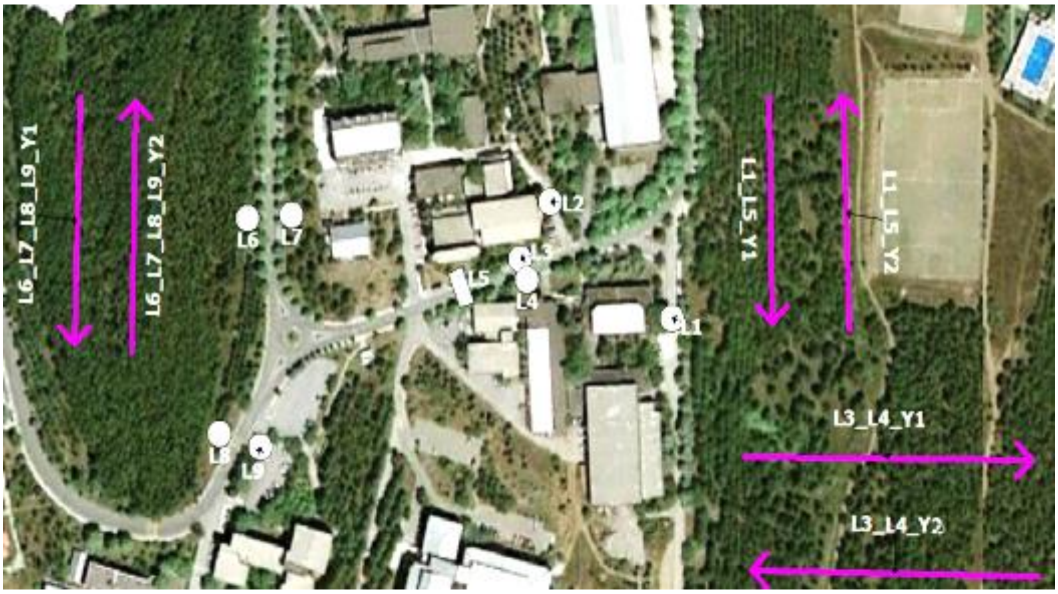

Figure B.12 Data Collection Points and Direction Map for location L

APPENDIX C

METU CAMPUS VEHICULAR LEVEL OF SERVICE

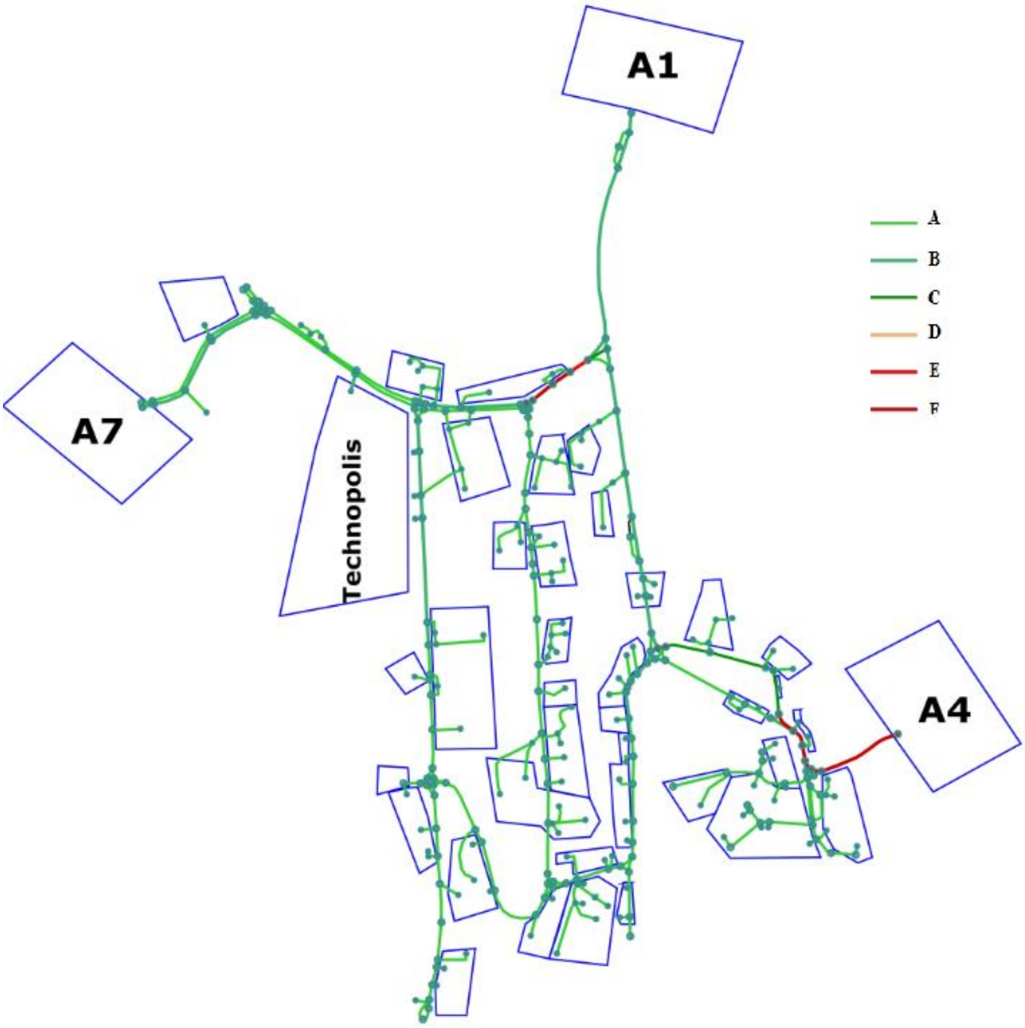

Figure C.1 HCM Vehicular LOS for Morning Peak Hours

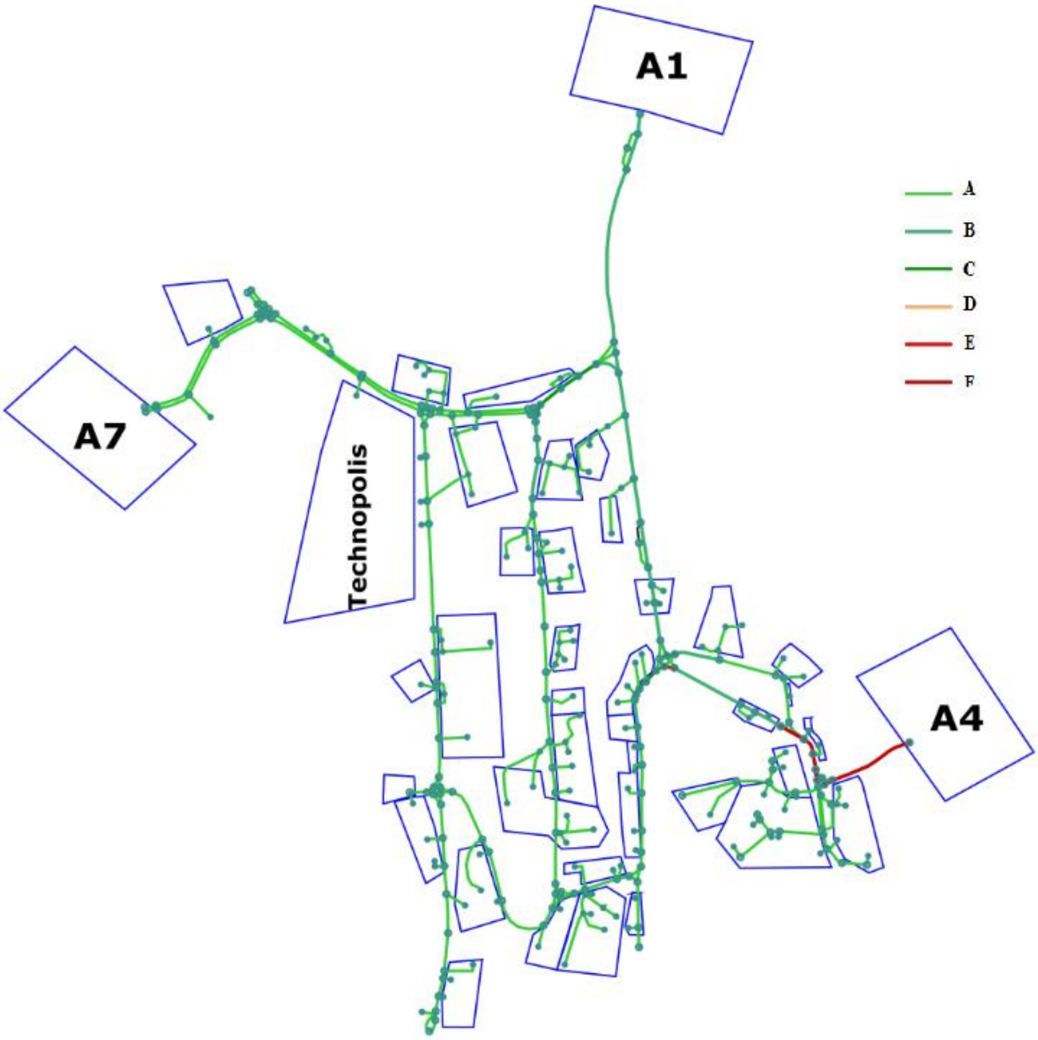

Figure C.2 HCM Vehicular LOS for Evening Peak Hours

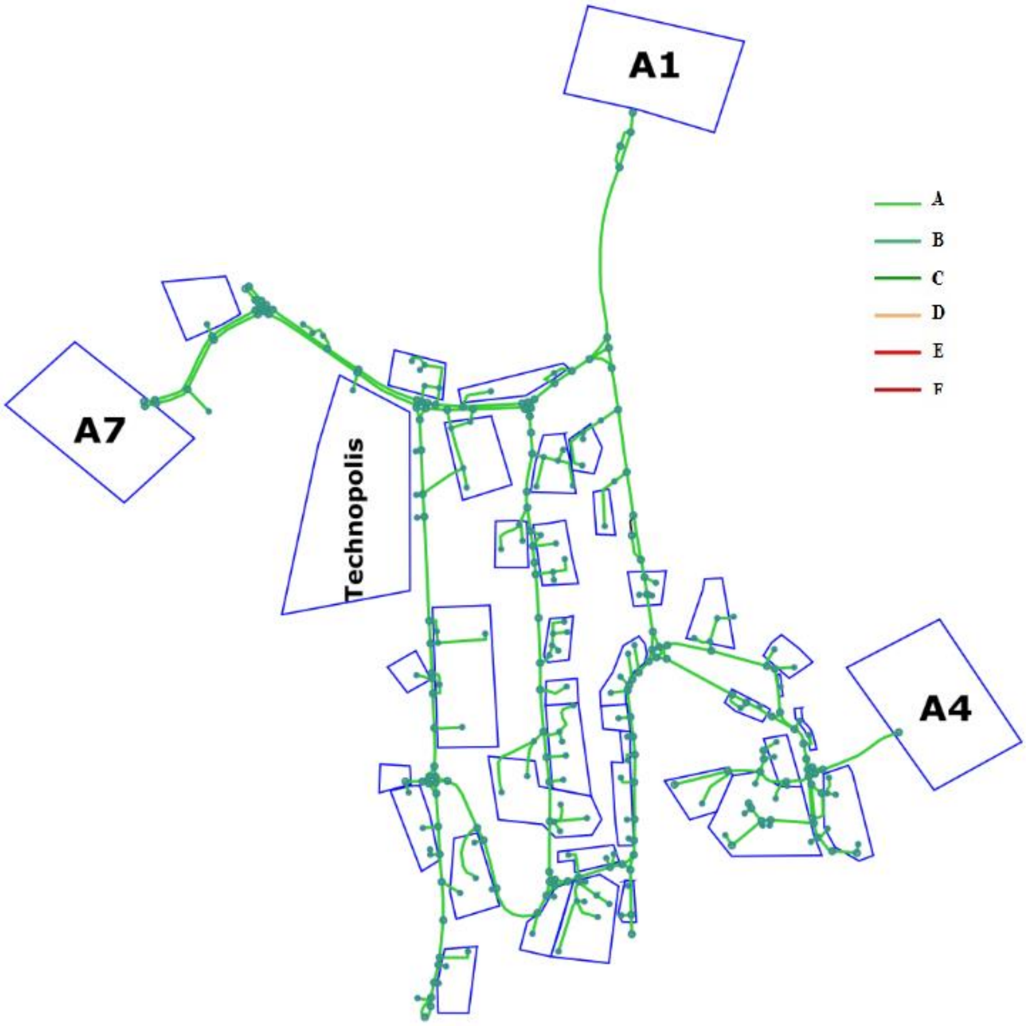

Figure C.3 HCM Vehicular LOS for Off- Peak Hours

APPENDIX D

HCM PLOS RESULTS

Table D.1 HCM 2010 Pedestrian LOS Model Results for Walkways for 08:15-09:00 and 09:15-10:00 intervals

Point	Effective Width (m)	Direction	8:15-09:00 3 mins Female	8:15-09:00 3 mins Male	8:15-09:00 3 mins Total	8:15-09:00 Hourly Total	8:15-09:00 Ped. Space (ft^2/ped)	8:15-09:00 $PLOS_{HCM}$	09:15-10:00 3 mins Female	09:15-10:00 3 mins Male	09:15-10:00 3 mins Total	09:15-10:00 Hourly Total	09:15-10:00 Ped. Space (ft^2/ped)	09:15-10:00 $PLOS_{HCM}$
Walkways (No-Interaction with Vehicular Traffic)														
A5	2.43	1	5	3	8	180	1260	**A**	2	4	6	220	1031	**A**
		2	1	0	1				2	3	5			
A6	4.80	1	0	0	0	180	564	**A**	0	2	2	40	2539	**A**
		2	3	6	9				0	0	0			
B6	4.80	1	2	6	8	1740	130	**A**	2	2	4	240	945	**A**
		2	28	23	51				2	6	8			
C6	6.75	1	3	3	6	340	903	**A**	1	1	2	220	1396	**A**
		2	8	3	11				3	6	9			
D1	6.75	1	0	0		100	3189	**A**	0	0	0	20	15945	**A**
		2	3	2	5				0	1	1			
D3	10.00	1	5	4	9	320	1476	**A**	0	4	4	360	1312	**A**
		2	3	4	7				4	10	14			
D4	11.30	1	0	0	0	120	4449	**A**	3	2	5	280	1907	**A**
		2	3	3	6				4	5	9			
E5	1.93	1	0	0	0	20	4559	**A**	0	1	1	60	1520	**A**
		2	0	1	1				1	1	2			
E8	24.77	1	1	4	5	880	1330	**A**	0	2	2	380	3080	**A**
		2	15	24	39				7	10	17			
F8	6.20	1	4	5	9	800	93	**A**	9	22	31	760	98	**A**
		2	12	19	31				2	5	7			
F9	8.40	1	11	13	24	600	488	**A**	10	10	20	580	505	**A**
		2	3	3	6				5	4	9			
F10	12.80	1				Count not taken			7	6	13	1060	374	**A**
		2							20	20	400			
H2	1.76	1	4	6	10	200	416	**A**	8	9	17	380	219	**A**
		2	0	0	0				0	2	2			
H3	2.08	1	6	8	14	280	351	**A**	7	12	19	440	223	**A**
		2	0	0	0				1	2	3			
K9	2.25	1	14	13	27	580	183	**A**	5	5	10	300	354	**A**
		2	1	1	2				2	3	5			

Table D.2 HCM 2010 Pedestrian LOS Model Results for Walkways for 12:15-13:00 and 13:15-14:00 intervals

Point	Effective Width (m)	Direction	12:15-13:00						13:15-14:00					
			3 mins			Hourly Total	Ped. Space (ft^2/ped)	$PLOS_{HCM}$	3 mins			Hourly Total	Ped. Space (ft^2/ped)	$PLOS_{HCM}$
			Female	Male	Total				Female	Male	Total			
Walkways (No-Interaction with Vehicular Traffic)														
A5	2.43	1	3	7	10	380	597	**A**	3	2	5	140	1620	**A**
		2	3	6	9				0	2	2			
A6	4.80	1	1	4	5	100	1016	**A**	2	4	6	380	267	**A**
		2	0	0	0				9	4	13			
B6	4.80	1	109	122	231	8100	28	**C**	38	40	78	2140	106	**A**
		2	26	39	65				12	17	29			
C6	6.75	1	42	61	103	2520	122	**A**	40	61	101	2500	123	**A**
		2	12	11	23				12	12	24			
D1	6.75	1	0	0		100	3189	**A**	0	0	0	20	15945	**A**
		2	3	2	5				0	1	1			
D3	10.00	1	5	4	9	320	1476	**A**	0	4	4	360	1312	**A**
		2	3	4	7				4	10	14			
D4	11.30	1	0	0	0	120	4449	**A**	3	2	5	280	1907	**A**
		2	3	3	6				4	5	9			
E5	1.93	1	2	3	5	160	570	**A**	2	1	3	140	651	**A**
		2	3	0	3				2	2	4			
E8	24.77	1	11	26	37	870	1345	**A**	5	15	20	1060	1104	**A**
		2	0	5	5				19	14	33			
F8	6.20	1	9	36	45	1200	62	**A**	15	14	29	920	81	**A**
		2	5	10	15				9	8	17			
F9	8.40	1	6	9	15	920	318	**A**	6	5	11	640	458	**A**
		2	14	17	31				11	10	21			
F10	12.80	1	17	22	39	1600	248	**A**	17	18	35	1440	276	**A**
		2	20	21	41				14	23	37			
H2	1.76	1	1	3	4	100	831	**A**	1	3	4	140	594	**A**
		2	1	0	1				1	2	3			
H3	2.08	1	1	3	4	100	983	**A**	3	5	8	200	491	**A**
		2	0	1	1				1	1	2			
K9	2.25	1	10	23	33	720	148	**A**	9	12	21	640	166	**A**
		2	1	2	3				2	9	11			

Table D.3 HCM 2010 Pedestrian LOS Model Results for Walkways for 16:00-16:45 and 17:00-17:45 intervals

Point	Effective Width (m)	Direction	16:00-16:45						17:00-17:45					
			3 mins Female	3 mins Male	3 mins Total	Hourly Total	Ped. Space (ft^2/ped)	$PLOS_{HCM}$	3 mins Female	3 mins Male	3 mins Total	Hourly Total	Ped. Space (ft^2/ped)	$PLOS_{HCM}$
Walkways (No-Interaction with Vehicular Traffic)														
A5	2.43	1	2	0	2	380	597	**A**	1	1	2	200	1134	**A**
		2	6	11	17				5	3	8			
A6	4.80	1	0	1	1	560	181	**A**	0	1	1	160	635	**A**
		2	15	12	27				4	3	7			
B6	4.80	1	6	6	12	360	630	**A**	3	11	14	460	493	**A**
		2	4	2	6				5	4	9			
C6	6.75	1	13	9	22	740	415	**A**	17	19	36	860	357	**A**
		2	5	10	15				1	6	7			
D1	6.75	1	0	1	1	60	5315	**A**	0	9	9	240	1329	**A**
		2	1	1	2				0	3	3			
D3	10.00	1	8	6	14	380	1243	**A**	10	3	13	500	945	**A**
		2	3	2	5				6	6	12			
D4	11.30	1	9	15	24	560	953	**A**	33	24	57	1180	452	**A**
		2	2	2	4				1	1	2			
E5	1.93	1	0	1	1	40	2280	**A**	2	3	5	260	351	**A**
		2	1	0	1				5	3	8			
E8	24.77	1	3	5	8	260	4501	**A**	11	13	24	840	1393	**A**
		2	2	3	5				10	8	18			
F8	6.20	1	0	1	1	360	206	**A**	13	12	25	740	100	**A**
		2	10	7	17				6	6	12			
F9	8.40	1	12	15	27	860	341	**A**	9	12	21	800	366	**A**
		2	9	7	16				7	12	19			
F10	12.80	1	13	13	26	1020	389	**A**	42	50	92	2120	187	**A**
		2	12	13	25				7	7	14			
H2	1.76	1	1	1	2	140	594	**A**	1	2	3	80	1039	**A**
		2	1	4	5				0	1	1			
H3	2.08	1	0	0	0	60	1638	**A**	0	7	7	260	378	**A**
		2	1	2	3				3	3	6			
K9	2.25	1	9	2	11	300	354	**A**	4	5	9	540	197	**A**
		2	4	0	4				12	6	18			

Table D.4 HCM 2010 Pedestrian LOS Model Results for Location A and B for 08:15-09:00 and 09:15-10:00 intervals

Point	Effective Width (m)	Direction	8:15-09:00 3 mins Female	8:15-09:00 3 mins Male	8:15-09:00 3 mins Total	8:15-09:00 Hourly Total	8:15-09:00 Ped. Space (ft²/ped)	8:15-09:00 $PLOS_{HCM}$	09:15-10:00 3 mins Female	09:15-10:00 3 mins Male	09:15-10:00 3 mins Total	09:15-10:00 Hourly Total	09:15-10:00 Ped. Space (ft²/ped)	09:15-10:00 $PLOS_{HCM}$
Sidewalks Alongside the Roads														
A1	1.90	1	12	4	16	360	249	**A**	0	3	3	180	499	**A**
		2	1	1	2				2	4	6			
A3	1.89	1	3	3	6	120	555	**A**	0	1	1	60	1110	**A**
		2	0	0	0				1	1	2			
A4	1.41	1	0	0	0	No pedestrian activity observed[2]			0	0	0	180	638	**A**
		2	0	0	0				4	5	9			
A8	2.15	1	6	1	7	140	726	**A**	0	0	0	100	1016	**A**
		2	0	0	0				3	2	5			
A9	1.97	1	1	1	2	40	2303	**A**	0	1	1	20	4606	**A**
		2	0	0	0				0	0	0			
B1	2.15	1	0	0	0	160	635	**A**	0	0	0	160	635	**A**
		2	3	5	8				4	4	8			
B2	0.90	1	1	0	1	20	2126	**A**	1	0	1	20	2126	**A**
		2	0	0	0				0	0	0			
B4	1.97	1	0	0	0	2020	46	**B**	1	0	1	220	423	**A**
		2	58	43	101				3	7	10			
B8	1.95	1	1	0	1	40	2303	**A**	0	0	0	140	658	**A**
		2	1	0	1				5	2	7			
B9	1.15	1	1	0	1	120	453	**A**	2	4	6	180	302	**A**
		2	1	4	5				0	3	3			
Sidewalks at Parking Lots														
B5	2.14	1	0	0	0	420	241	**A**	2	0	2	260	389	**A**
		2	13	8	21				4	7	11			
B7	2.43	1	0	0	0	600	191	**A**	0	1	1	60	1913	**A**
		2	14	16	30				0	2	2			
Pedestrian Activity Locations with No Sidewalk Capacity														
A2	0.00	1	0	1	1	20	---	**F**[1]	0	0	0	No pedestrian activity observed[2]		
		2	0	0	0				0	0	0			
B3	0.00	1	0	0	0	60	---	**F**[1]	2	0	2	120	---	**F**[1]
		2	2	1	3				3	1	4			

1 These locations have pedestrian flows but not formal pedestrian infrastructure capacity as a walkway

2 For locations with pedestrian inftrastructure capacity and flow, no PLOS evaluation is provided

Table D.5 HCM 2010 Pedestrian LOS Model Results for Location A and B for 12:15-13:00 and 13:15-14:00 intervals

Point	Effective Width (m)	Direction	12:15-13:00 3 mins Female	Male	Total	Hourly Total	Ped. Space (ft²/ped)	PLOS HCM	13:15-14:00 3 mins Female	Male	Total	Hourly Total	Ped. Space (ft²/ped)	PLOS HCM
Sidewalks Alongside the Roads														
A1	1.90	1	6	6	12	680	132	**A**	6	4	10	340	264	**A**
		2	14	8	22				2	5	7			
A3	1.89	1	0	0	0	160	416	**A**	2	1	3	100	666	**A**
		2	2	6	8				1	1	2			
A4	1.41	1	1	1	2	100	1148	**A**	0	0	0	140	820	**A**
		2	3	0	3				2	5	7			
A8	2.15	1	0	2	2	120	846	**A**	1	1	2	100	1016	**A**
		2	3	1	4				1	2	3			
A9	1.97	1	3	1	4	220	419	**A**	1	1	2	100	921	**A**
		2	4	3	7				1	2	3			
B1	2.15	1	1	2	3	80	1270	**A**	1	0	1	80	1270	**A**
		2	0	1	1				2	1	3			
B2	0.90	1	0	1	1	40	1063	**A**	1	0	1	100	425	**A**
		2	0	1	1				4	0	4			
B4	1.97	1	0	0	0	1540	60	**B**	5	2	7	260	358	**A**
		2	33	11	44				4	2	6			
B8	1.95	1	2	2	4	180	512	**A**	5	1	6	200	461	**A**
		2	4	1	5				2	2	4			
B9	1.15	1	1	0	1	100	543	**A**	6	5	11	300	181	**A**
		2	2	2	4				1	3	4			
Sidewalks at Parking Lots														
B5	2.14	1	4	8	12	520	194	**A**	5	1	6	1000	101	**A**
		2	5	5	10				23	11	44			
B7	2.43	1	4	7	11	320	359	**A**	4	1	5	180	638	**A**
		2	4	1	5				4	0	4			
Pedestrian Activity Locations with No Sidewalk Capacity														
A2	0.00	1	0	0	0	No pedestrian activity observed[2]			1	20	-	20	---	**F**[1]
		2	0	0	0				0	0	0			
B3	0.00	1	1	0	1	40	---	**F**[1]	0	2	2	80	---	**F**[1]
		2	0	1	1				2	0	2			

1 These locations have pedestrian flows but not formal pedestrian infrastructure capacity as a walkway

2 For locations with pedestrian inftrastructure capacity and flow, no PLOS evaluation is provided

Table D.6 HCM 2010 Pedestrian LOS Model Results for Location A and B for 16:00-16:45 and 17:00-17:45 intervals

Point	Effective Width (m)	Direction	16:00-16:45						17:00-17:45					
			3 mins			Hourly Total	Ped. Space (ft^2/ped)	PLOS $_{HCM}$	3 mins			Hourly Total	Ped. Space (ft^2/ped)	PLOS $_{HCM}$
			Female	Male	Total				Female	Male	Total			
Sidewalks Alongside the Roads														
A1	1.90	1	7	13	20	440	204	**A**	0	0	0	100	898	**A**
		2	1	1	2				2	3	5			
A3	1.89	1	2	11	13	260	256	**A**	1	1	2	120	555	**A**
		2	0	0	0				3	1	4			
A4	1.41	1	1	6	7	140	820	**A**	1	0	1	100	1148	**A**
		2	0	0	0				3	1	4			
A8	2.15	1	0	0	0	20	5079	**A**	0	3	3	160	635	**A**
		2	1	0	1				3	2	5			
A9	1.97	1	1	0	1	20	4606	**A**	1	2	3	120	768	**A**
		2	0	0	0				0	3	3			
B1	2.15	1	1	3	4	140	726	**A**	2	3	5	180	564	**A**
		2	0	3	3				0	4	4			
B2	0.90	1	1	0	1	20	2126	**A**	5	1	6	120	354	**A**
		2	0	0	0				0	0	0			
B4	1.97	1	1	1	2	80	1163	**A**	0	2	2	60	1551	**A**
		2	2	0	2				1	0	1			
B8	1.95	1	0	1	1	60	1535	**A**	0	1	1	80	1152	**A**
		2	1	1	2				1	2	3			
B9	1.15	1	2	1	3	200	272	**A**	4	3	7	400	136	**A**
		2	2	5	7				4	9	13			
Sidewalks at Parking Lots														
B5	2.14	1	4	5	9	180	562	**A**	2	3	5	120	843	**A**
		2	0	0	0				1	0	1			
B7	2.43	1	0	0	0	No pedestrian activity observed[2]			1	0	1	20	5740	**A**
		2	0	0	0				0	0	0			
Pedestrian Activity Locations with No Sidewalk Capacity														
A2	0.00	1	0	0	0	No pedestrian activity observed[2]			0	0	0	No pedestrian activity observed[2]		
		2	0	0	0				0	0	0			
B3	0.00	1	1	0	1	20	---	**F**[1]	5	0	5	100	---	**F**[1]
		2	0	0	0				0	0	0			

[1] These locations have pedestrian flows but not formal pedestrian infrastructure capacity as a walkway

[2] For locations with pedestrian inftrastructure capacity and flow, no PLOS evaluation is provided

Table D.7 HCM 2010 Pedestrian LOS Model Results for Location C and D for 08:15-09:00 and 09:15-10:00 intervals

Point	Effective Width (m)	Direction	8:15-09:00						09:15-10:00					
			3 mins			Hourly Total	Ped. Space (ft^2/ped)	PLOS HCM	3 mins			Hourly Total	Ped. Space (ft^2/ped)	PLOS HCM
			Female	Male	Total				Female	Male	Total			
Sidewalks Alongside the Roads														
C1	1.15	1	1	0	1	120	453	**A**	0	0	0	40	1358	**A**
		2	1	4	5				0	2	2			
C3	2.43	1	0	0	0	100	661	**A**	0	0	0	60	1102	**A**
		2	1	4	5				2	1	3			
C4	6.50	1	1	1	2	40	1358	**A**	1	2	3	80	679	**A**
		2	0	0	0				0	1	1			
C8	1.97	1	0	0	0	20	4654	**A**	0	0	0	No pedestrian activity observed[2]		
		2	0	1	1				0	0	0			
D2	1.97	1	1	0	1	40	2327	**A**	0	0	0	No pedestrian activity observed[2]		
		2	0	1	1				0	0	0			
D5	3.81	1	0	1	1	80	2250	**A**	2	2	4	80	2250	**A**
		2	2	1	3				0	0	0			
D8	2.00	1	0	1	1	280	337	**A**	0	4	4	400	236	**A**
		2	8	5	13				5	11	16			
D9	4.00	1	0	1	1	20	9449	**A**	1	2	3	60	3150	**A**
		2	0	0	0				0	0	0			
Sidewalks at Parking Lots														
C5	1.97	1	0	0	0	No pedestrian activity observed[2]			0	0	0	No pedestrian activity observed[2]		
		2	0	0	0				0	0	0			
C9	0.00	1	0	0	0	No pedestrian activity observed[2]			0	0	0	No pedestrian activity observed[2]		
		2	0	0	0				0	0	0			
Pedestrian Activity Locations with No Sidewalk Capacity														
C2	0.00	1	0	0	0	No pedestrian activity observed[2]			0	20	0	20	---	**F**[1]
		2	0	0	0				0	1	1			
C7	0.00	1	0	0	0	40	---	**F**[1]	0	0	0	20	---	**F**[1]
		2	1	1	2				1	0	1			
D6	0.00	1	0	1	1	20	---	**F**[1]	0	0	0	No pedestrian activity observed[2]		
		2	0	0	0				0	0	0			

1 These locations have pedestrian flows but not formal pedestrian infrastructure capacity as a walkway

2 For locations with pedestrian inftrastructure capacity and flow, no PLOS evaluation is provided

Table D.8 HCM 2010 Pedestrian LOS Model Results for Location C and D for 12:15-13:00 and 13:15-14:00 intervals

Point	Effective Width (m)	Direction	12:15-13:00						13:15-14:00					
			3 mins			Hourly Total	Ped. Space (ft^2/ped)	PLOS HCM	3 mins			Hourly Total	Ped. Space (ft^2/ped)	PLOS HCM
			Female	Male	Total				Female	Male	Total			
Sidewalks Alongside the Roads														
C1	1.15	1	1	1	2	100	543	**A**	1	2	3	100	543	**A**
		2	1	2	3				1	1	2			
C3	2.43	1	2	0	2	60	1102	**A**	2	2	4	80	827	**A**
		2	0	1	1				1	1	2			
C4	6.50	1	2	2	4	200	272	**A**	2	1	3	60	906	**A**
		2	1	5	6				0	0	0			
C8	1.97	1	1	3	4	120	776	**A**	1	3	4	80	1163	**A**
		2	2	0	2				0	0	0			
D2	1.97	1	4	1	5	160	582	**A**	4	0	4	320	291	**A**
		2	1	2	3				2	6	8			
D5	3.81	1	5	1	6	220	818	**A**	1	0	1	60	3000	**A**
		2	4	1	5				1	1	2			
D8	2.00	1	1	7	8	740	128	**A**	7	11	18	580	163	**A**
		2	19	10	29				4	7	11			
D9	4.00	1	9	5	14	360	525	**A**	11	10	21	480	394	**A**
		2	3	1	4				0	3	3			
Sidewalks at Parking Lots														
C5	1.97	1	0	0	0	No pedestrian activity observed[2]			0	0	0	No pedestrian activity observed[2]		
		2	0	0	0				0	0	0			
C9	0.00	1	0	1	1	20	---	**F**[1]	0	0	0	No pedestrian activity observed[2]		
		2	0	0	0				0	0	0			
Pedestrian Activity Locations with No Sidewalk Capacity														
C2	0.00	1	0	0	0	No pedestrian activity observed[2]			0	0	0	No pedestrian activity observed[2]		
		2	0	0	0				0	0	0			
C7	0.00	1	0	0	0	No pedestrian activity observed[2]			0	0	0	20	---	**F**[1]
		2	0	0	0				1	0	1			
D6	0.00	1	0	4	4	80	---	**F**[1]	1	0	1	20	---	**F**[1]
		2	0	0	0				0	0	0			

1 These locations have pedestrian flows but not formal pedestrian infrastructure capacity as a walkway

2 For locations with pedestrian inftrastructure capacity and flow, no PLOS evaluation is provided

Table D.9 HCM 2010 Pedestrian LOS Model Results for Location C and D for 16:00-16:45 and 17:00-17:45 intervals

Point	Effective Width (m)	Direction	16:00-16:45						17:00-17:45					
			3 mins						3 mins					
			Female	Male	Total	Hourly Total	Ped. Space (ft^2/ped)	PLOS HCM	Female	Male	Total	Hourly Total	Ped. Space (ft^2/ped)	PLOS HCM
Sidewalks Alongside the Roads														
C1	1.15	1	0	1	1	140	388	**A**	2	3	5	200	272	**A**
		2	1	5	6				2	3	5			
C3	2.43	1	0	0	0	20	3307	**A**	7	3	10	240	276	**A**
		2	0	1	1				2	0	2			
C4	6.50	1	1	0	1	60	906	**A**	1	3	4	200	272	**A**
		2	1	1	2				2	4	6			
C8	1.97	1	0	1	1	20	4654	**A**	1	0	1	20	4654	**A**
		2	0	0	0				0	0	0			
D2	1.97	1	0	0	0	40	2327	**A**	0	6	6	140	665	**A**
		2	0	2	2				1	0	1			
D5	3.81	1	1	3	4	200	900	**A**	0	3	3	300	600	**A**
		2	2	4	6				5	7	12			
D8	2.00	1	7	12	19	640	148	**A**	17	11	28	1200	79	**A**
		2	8	5	13				9	23	34			
D9	4.00	1	0	8	8	180	1050	**A**	4	4	8	280	675	**A**
		2	0	1	1				4	2	6			
Sidewalks at Parking Lots														
C5	1.97	1	0	0	0	No pedestrian activity observed[2]			0	0	0	No pedestrian activity observed[2]		
		2	0	0	0				0	0	0			
C9	0.00	1	0	0	0	No pedestrian activity observed[2]			0	0	0	40	---	**F**[1]
		2	0	0	0				1	1	2			
Pedestrian Activity Locations with No Sidewalk Capacity														
C2	0.00	1	0	0	0	No pedestrian activity observed[2]			0	0	0	20	---	**F**[1]
		2	0	0	0				0	1	1			
C7	0.00	1	0	0	0	No pedestrian activity observed[2]			0	2	2	40	---	**F**[1]
		2	0	0	0				0	0	0			
D6	0.00	1	0	1	1	40	---	**F**[1]	0	0	0	20	---	**F**[1]
		2	0	1	1				1	0	1			

[1] These locations have pedestrian flows but not formal pedestrian infrastructure capacity as a walkway

[2] For locations with pedestrian inftrastructure capacity and flow, no PLOS evaluation is provided

Table D.10 HCM 2010 Pedestrian LOS Model Results for Location E and F for 08:15-09:00 and 09:15-10:00 intervals

Point	Effective Width (m)	Direction	8:15-09:00						09:15-10:00					
			3 mins			Hourly Total	Ped. Space (ft²/ped)	PLOS HCM	3 mins			Hourly Total	Ped. Space (ft²/ped)	PLOS HCM
			Female	Male	Total				Female	Male	Total			
Sidewalks Alongside the Road														
E2	2.00	1	0	3	3	140	675	**A**	0	0	0	180	525	**A**
		2	1	3	4				3	6	9			
E3	2.00	1	1	0	1	500	189	**A**	1	0	1	80	1181	**A**
		2	11	13	24				2	1	3			
E4	2.07	1	0	1	1	260	376	**A**	0	1	1	200	489	**A**
		2	5	7	12				4	5	9			
E6	1.97	1	1	2	3	520	179	**A**	0	1	1	200	465	**A**
		2	7	16	23				5	4	9			
E7	2.00	1	0	0	0	120	787	**A**	0	0	0	140	675	**A**
		2	2	4	6				3	4	7			
F2	2.00	1	3	3	6	320	1890	**A**	5	8	13	440	1374	**A**
		2	5	5	10				4	5	9			
F3	1.57	1	10	14	24	1060	89	**A**	14	14	28	700	135	**A**
		2	15	14	29				4	3	7			
F6	1.36	1	10	20	30	800	80	**A**	3	10	13	340	189	**A**
		2	4	6	10				1	3	4			
F7	1.57	1	1	3	4	100	643	**A**	1	3	4	100	643	**A**
		2	0	1	1				0	1	1			
Sidewalks at Parking Lots														
F1	1.90	1	23	27	50	1120	80	**A**	13	10	23	640	140	**A**
		2	3	3	6				4	5	9			
F4	1.10	1	3	4	7	640	116	**A**	9	9	18	460	161	**A**
		2	11	14	25				3	2	5			
F5	1.36	1	8	11	19	580	90	**A**	5	5	10	260	200	**A**
		2	5	5	10				1	2	3			

Table D.11 HCM 2010 Pedestrian LOS Model Results for Location E and F for 12:15-13:00 and 13:15-14:00 intervals

Point	Effective Width (m)	Direction	12:15-13:00						13:15-14:00					
			3 mins			Hourly Total	Ped. Space (ft²/ped)	PLOS HCM	3 mins			Hourly Total	Ped. Space (ft²/ped)	PLOS HCM
			Female	Male	Total				Female	Male	Total			
Sidewalks Alongside														
E2	2.00	1	2	4	6	200	472	**A**	4	5	9	240	394	**A**
		2	2	2	4				1	2	3			
E3	2.00	1	0	2	2	60	1575	**A**	5	1	6	340	278	**A**
		2	0	1	1				4	7	11			
E4	2.07	1	0	0	0	260	376	**A**	1	4	5	280	349	**A**
		2	10	3	13				4	5	9			
E6	1.97	1	5	13	18	500	186	**A**	8	3	11	400	233	**A**
		2	4	3	7				3	6	9			
E7	2.00	1	23	35	58	1440	66	**A**	6	10	16	580	163	**A**
		2	4	10	14				4	9	13			
F2	2.00	1	15	8	23	500	1209	**A**	10	9	19	480	1260	**A**
		2	1	1	2				2	3	5			
F3	1.57	1	2	6	8	1440	66	**A**	5	3	8	860	110	**A**
		2	19	45	64				19	16	35			
F6	1.36	1	0	5	5	280	229	**A**	1	5	6	240	268	**A**
		2	0	9	9				0	6	6			
F7	1.57	1	0	0	0	No pedestrian activity observed[1]			0	0	0	20	3213	**A**
		2	0	0	0				0	1	1			
Sidewalks at Parking Lots														
F1	1.90	1	15	14	29	800	112	**A**	11	11	22	620	145	**A**
		2	4	7	11				4	5	9			
F4	1.10	1	4	10	14	300	247	**A**	5	5	10	240	309	**A**
		2	0	1	1				1	1	2			
F5	1.36	1	4	18	22	580	90	**A**	10	10	20	520	100	**A**
		2	0	7	7				1	5	6			

[1] For locations with pedestrian inftrastructure capacity and flow, no PLOS evaluation is provided

Table D.12 HCM 2010 Pedestrian LOS Model Results for Location E and F for 16:00-16:45 and 17:00-17:45 intervals

Point	Effective Width (m)	Direction	16:00-16:45						17:00-17:45					
			3 mins			Hourly Total	Ped. Space (ft^2/ped)	PLOS HCM	3 mins			Hourly Total	Ped. Space (ft^2/ped)	PLOS HCM
			Female	Male	Total				Female	Male	Total			
Sidewalk Alongside the Road														
E2	2.00	1	7	1	8	220	429	**A**	4	10	14	360	262	**A**
		2	2	1	3				1	3	4			
E3	2.00	1	1	4	5	200	472	**A**	4	0	4	180	525	**A**
		2	0	5	5				3	2	5			
E4	2.07	1	3	3	6	160	611	**A**	7	9	16	360	272	**A**
		2	1	1	2				2	0	2			
E6	1.97	1	7	1	8	280	332	**A**	7	7	14	400	233	**A**
		2	5	1	6				3	3	6			
E7	2.00	1	10	9	19	400	236	**A**	25	22	47	1080	87	**A**
		2	0	1	1				4	3	7			
F2	2.00	1	7	6	13	360	1680	**A**	10	13	23	600	1008	**A**
		2	3	2	5				4	3	7			
F3	1.57	1	8	7	15	780	121	**A**	7	6	13	1820	52	**B**
		2	10	14	24				35	43	78			
F6	1.36	1	2	2	4	140	459	**A**	3	4	7	620	104	**A**
		2	1	2	3				9	15	24			
F7	1.57	1	0	2	2	80	803	**A**	1	2	3	220	292	**A**
		2	0	2	2				1	7	8			
Sidewalks at Parking Lots														
F1	1.90	1	6	7	13	940	95	**A**	9	9	18	1920	47	**B**
		2	14	20	34				36	42	78			
F4	1.10	1	9	7	16	480	155	**A**	4	3	7	300	247	**A**
		2	4	4	8				5	3	8			
F5	1.36	1	3	2	5	200	260	**A**	4	4	8	320	162	**A**
		2	2	3	5				4	4	8			

Table D.13 HCM 2010 Pedestrian LOS Model Results for Location H and J for 08:15-09:00 and 09:15-10:00 intervals

Point	Effective Width (m)	Direction	8:15-09:00						09:15-10:00					
			3 mins			Hourly Total	Ped. Space (ft^2/ped)	PLOS HCM	3 mins			Hourly Total	Ped. Space (ft^2/ped)	PLOS HCM
			Female	Male	Total				Female	Male	Total			
Sidewalks Alongside the Roads														
H1	1.45	1	0	0	0	No pedestrian activity observed[1]			0	0	0	No pedestrian activity observed[1]		
		2	0	0	0				0	0	0			
H4	1.52	1	0	0	0	260	276	**A**	0	0	0	340	211	**A**
		2	4	9	13				8	9	17			
H5	1.30	1	0	0	0	100	614	**A**	2	0	2	100	614	**A**
		2	2	3	5				1	2	3			
H6	1.45	1	0	0	0	40	1713	**A**	1	0	1	80	856	**A**
		2	0	2	2				0	3	3			
H7	1.80	1	5	1	6	200	425	**A**	3	0	3	120	709	**A**
		2	2	2	4				1	2	3			
H8	1.85	1	1	0	1	80	1093	**A**	0	2	2	160	546	**A**
		2	1	2	3				2	4	6			
H9	1.45	1	0	2	2	180	381	**A**	2	2	4	200	343	**A**
		2	3	4	7				2	4	6			
J1	1.33	1	2	1	3	160	393	**A**	4	2	6	660	95	**A**
		2	3	2	5				13	14	27			
J2	1.33	1	0	1	1	120	524	**A**	4	3	7	420	150	**A**
		2	1	4	5				7	7	14			
J5	1.60	1	0	5	5	140	540	**A**	14	13	27	1060	71	**A**
		2	0	2	2				18	8	26			
J6	1.20	1	1	6	7	140	405	**A**	6	11	17	680	83	**A**
		2	0	0	0				12	5	17			
J7	1.60	1	3	1	4	180	420	**A**	6	9	15	600	126	**A**
		2	2	3	5				7	8	15			
J8	2.00	1	1	0	1	60	1575	**A**	6	8	14	540	175	**A**
		2	0	2	2				8	5	13			

[1] For locations with pedestrian inftrastructure capacity and flow, no PLOS evaluation is provided

Table D.14 HCM 2010 Pedestrian LOS Model Results for Location H and J for 12:15-13:00 and 13:15-14:00 intervals

Point	Effective Width (m)	Direction	12:15-13:00						13:15-14:00					
			3 mins			Hourly Total	Ped. Space (ft^2/ped)	PLOS $_{HCM}$	3 mins			Hourly Total	Ped. Space (ft^2/ped)	PLOS $_{HCM}$
			Female	Male	Total				Female	Male	Total			
Sidewalks Alongside the Roads														
H1	1.45	1	0	0	0	No pedestrian activity observed[1]			0	0	0	No pedestrian activity observed[1]		
		2	0	0	0				0	0	0			
H4	1.52	1	1	1	2	240	299	**A**	1	6	7	500	144	**A**
		2	6	4	10				2	16	18			
H5	1.30	1	3	4	7	280	219	**A**	1	0	1	80	768	**A**
		2	3	4	7				0	3	3			
H6	1.45	1	0	4	4	120	571	**A**	0	0	0	No pedestrian activity observed[1]		
		2	1	1	2				0	0	0			
H7	1.80	1	1	0	1	20	4252	**A**	0	0	0	No pedestrian activity observed[1]		
		2	0	0	0				0	0	0			
H8	1.85	1	1	1	2	60	1457	**A**	0	1	1	20	4370	**A**
		2	1	0	1				0	0	0			
H9	1.45	1	1	5	6	240	285	**A**	0	2	2	60	1142	**A**
		2	1	5	6				1	0	1			
J1	1.33	1	22	14	36	940	67	**A**	6	11	17	840	75	**A**
		2	6	5	11				14	11	25			
J2	1.33	1	3	7	10	480	131	**A**	11	6	17	880	71	**A**
		2	11	3	14				12	15	27			
J5	1.60	1	2	1	3	280	270	**A**	7	3	10	480	157	**A**
		2	6	5	11				9	5	14			
J6	1.20	1	8	12	20	940	60	**B**	4	6	10	400	142	**A**
		2	15	12	27				6	4	10			
J7	1.60	1	5	11	16	680	111	**A**	8	10	18	880	86	**A**
		2	12	6	18				13	13	26			
J8	2.00	1	9	7	16	640	148	**A**	15	13	28	1080	87	**A**
		2	5	11	16				14	12	26			

[1] For locations with pedestrian inftrastructure capacity and flow, no PLOS evaluation is provided

Table D.15 HCM 2010 Pedestrian LOS Model Results for Location H and J for 16:00-16:45 and 17:00-17:45 intervals

Point	Effective Width (m)	Direction	16:00-16:45						17:00-17:45					
			3 mins			Hourly Total	Ped. Space (ft^2/ped)	PLOS $_{HCM}$	3 mins			Hourly Total	Ped. Space (ft^2/ped)	PLOS $_{HCM}$
			Female	Male	Total				Female	Male	Total			
Sidewalks Alongside the Roads														
H1	1.45	1	0	0	0	No pedestrian activity observed[1]			0	0	0	No pedestrian activity observed[1]		
		2	0	0	0				0	0	0			
H4	1.52	1	2	3	5	120	598	**A**	0	4	4	160	449	**A**
		2	0	1	1				0	4	4			
H5	1.30	1	0	0	0	No pedestrian activity observed[1]			1	1	2	40	1535	**A**
		2	0	0	0				0	0	0			
H6	1.45	1	4	1	5	100	685	**A**	0	2	2	60	1142	**A**
		2	0	0	0				0	1	1			
H7	1.80	1	0	0	0	20	4252	**A**	1	1	2	40	2126	**A**
		2	1	0	1				0	0	0			
H8	1.85	1	1	3	4	100	874	**A**	3	0	3	120	728	**A**
		2	0	1	1				2	1	3			
H9	1.45	1	3	4	7	160	428	**A**	4	2	6	160	428	**A**
		2	0	1	1				0	2	2			
J1	1.33	1	10	15	25	620	101	**A**	3	2	5	340	185	**A**
		2	4	2	6				3	9	12			
J2	1.33	1	4	13	17	580	108	**A**	6	6	12	400	157	**A**
		2	7	5	12				4	4	8			
J5	1.60	1	4	4	8	440	172	**A**	6	10	16	620	122	**A**
		2	9	5	14				7	8	15			
J6	1.20	1	4	4	8	180	315	**A**	4	5	9	400	142	**A**
		2	0	1	1				6	5	11			
J7	1.60	1	4	9	13	380	199	**A**	13	6	19	400	189	**A**
		2	4	2	6				0	1	1			
J8	2.00	1	11	10	21	500	189	**A**	18	21	39	1040	91	**A**
		2	2	2	4				7	9	16			

[1] For locations with pedestrian inftrastructure capacity and flow, no PLOS evaluation is provided

Table D.16 HCM 2010 Pedestrian LOS Model Results for Location K and L for 08:15-09:00 and 09:15-10:00 intervals

Point	Effective Width (m)	Direction	8:15-09:00						09:15-10:00					
			3 mins			Hourly Total	Ped. Space (ft^2/ped)	PLOS HCM	3 mins			Hourly Total	Ped. Space (ft^2/ped)	PLOS HCM
			Female	Male	Total				Female	Male	Total			
Sidewalks Alongside the Roads														
K1	2.00	1	0	3	3	460	205	**A**	0	0	0	160	591	**A**
		2	8	12	20				5	3	8			
K2	1.47	1	2	1	3	640	109	**A**	0	0	0	140	496	**A**
		2	10	19	29				6	1	7			
K3	1.47	1	0	1	1	720	96	**A**	0	0	0	280	248	**A**
		2	11	24	35				9	5	14			
K4	1.53	1	1	2	3	660	110	**A**	0	0	0	240	301	**A**
		2	13	17	30				6	6	12			
K5	1.64	1	3	2	5	380	204	**A**	0	0	0	100	775	**A**
		2	5	9	14				2	3	5			
K6	1.66	1	6	10	16	520	151	**A**	2	7	9	220	356	**A**
		2	5	5	10				1	1	2			
K7	2.02	1	11	20	31	820	116	**A**	5	16	21	480	199	**A**
		2	7	3	10				0	3	3			
K8	1.57	1	9	19	28	580	128	**A**	2	15	17	400	185	**A**
		2	0	1	1				0	3	3			
L1	1.46	1	0	0	0	No pedestrian activity observed[1]			2	1	3	80	862	**A**
		2	0	0	0				1	0	1			
L3	2.09	1	2	0	2	320	309	**A**	0	0	0	20	4937	**A**
		2	7	7	14				1	0	1			
L4	1.48	1	1	1	2	460	152	**A**	0	0	0	60	1165	**A**
		2	4	17	21				1	2	3			
L6	2.07	1	0	0	0	No pedestrian activity observed[1]			0	0	0	20	4890	**A**
		2	0	0	0				0	1	1			
L7	2.03	1	0	0	0	20	4795	**A**	0	0	0	No pedestrian activity observed[1]		
		2	1	0	1				0	0	0			
L8	2.07	1	0	0	0	No pedestrian activity observed[1]			0	1	1	40	2445	**A**
		2	0	0	0				0	1	1			
L9	1.96	1	2	2	4	120	772	**A**	6	7	13	300	309	**A**
		2	2	0	2				1	1	2			
Sidewalks at Parking Lots														
L2	1.50	1	1	0	1	60	1181	**A**	1	0	1	20	3543	**A**
		2	1	1	2				0	0	0			

1 For locations with pedestrian inftrastructure capacity and flow, no PLOS evaluation is provided

Table D.17 HCM 2010 Pedestrian LOS Model Results for Location K and L for 12:15-13:00 and 13:15-14:00 intervals

Point	Effective Width (m)	Direction	12:15-13:00						13:15-14:00					
			3 mins			Hourly Total	Ped. Space (ft²/ped)	PLOS HCM	3 mins			Hourly Total	Ped. Space (ft²/ped)	PLOS HCM
			Female	Male	Total				Female	Male	Total			
Sidewalks Alongside the Roads														
K1	2.00	1	0	1	1	40	2362	**A**	1	2	3	160	591	**A**
		2	0	1	1				2	3	5			
K2	1.47	1	4	2	6	240	289	**A**	3	1	4	180	386	**A**
		2	4	2	6				0	5	5			
K3	1.47	1	1	0	1	40	1736	**A**	3	1	4	360	193	**A**
		2	1	0	1				3	11	14			
K4	1.53	1	0	1	1	80	904	**A**	0	4	4	220	329	**A**
		2	1	2	3				1	6	7			
K5	1.64	1	0	2	2	120	646	**A**	1	2	3	80	969	**A**
		2	1	3	4				0	1	1			
K6	1.66	1	2	5	7	180	436	**A**	2	3	5	200	392	**A**
		2	1	1	2				3	2	5			
K7	2.02	1	3	10	13	480	199	**A**	3	14	17	640	149	**A**
		2	3	8	11				12	3	15			
K8	1.57	1	0	5	5	440	169	**A**	1	11	12	340	218	**A**
		2	1	16	17				1	4	5			
L1	1.46	1	1	8	9	180	383	**A**	0	0	0	240	287	**A**
		2	0	0	0				2	10	12			
L3	2.09	1	0	0	0	80	1234	**A**	2	5	7	180	549	**A**
		2	1	3	4				0	2	2			
L4	1.48	1	1	2	3	80	874	**A**	0	1	1	60	1165	**A**
		2	1	0	1				2	0	2			
L6	2.07	1	0	2	2	40	2445	**A**	0	0	0	No pedestrian activity observed[1]		
		2	0	0	0				0	0	0			
L7	2.03	1	1	0	1	60	1598	**A**	0	1	1	40	2398	**A**
		2	0	2	2				1	0	1			
L8	2.07	1	0	0	0	No pedestrian activity observed[1]			0	2	2	40	2445	**A**
		2	0	0	0				0	0	0			
L9	1.96	1	0	1	1	40	2315	**A**	2	3	5	160	579	**A**
		2	1	0	1				2	1	3			
Sidewalks at Parking Lots														
L2	1.50	1	1	2	3	100	709	**A**	2	2	4	120	591	**A**
		2	1	1	2				1	1	2			

[1] For locations with pedestrian inftrastructure capacity and flow, no PLOS evaluation is provided

Table D.18 HCM 2010 Pedestrian LOS Model Results for Location K and L for 16:00-16:45 and 17:00-17:45 intervals

Point	Effective Width (m)	Direction	16:00-16:45						17:00-17:45					
			3 mins			Hourly Total	Ped. Space (ft^2/ped)	$PLOS_{HCM}$	3 mins			Hourly Total	Ped. Space (ft^2/ped)	$PLOS_{HCM}$
			Female	Male	Total				Female	Male	Total			
Sidewalks Alongside the Roads														
K1	2.00	1	9	8	17	380	249	**A**	4	10	14	580	163	**A**
		2	1	1	2				4	11	15			
K2	1.47	1	11	9	20	520	134	**A**	7	7	14	480	145	**A**
		2	1	5	6				3	7	10			
K3	1.47	1	3	4	7	180	386	**A**	4	7	11	320	217	**A**
		2	2	0	2				3	2	5			
K4	1.53	1	2	5	7	140	516	**A**	2	3	5	180	402	**A**
		2	0	0	0				2	2	4			
K5	1.64	1	0	2	2	140	553	**A**	2	2	4	160	484	**A**
		2	1	4	5				1	3	4			
K6	1.66	1	9	6	15	500	157	**A**	5	8	13	420	187	**A**
		2	7	3	10				4	4	8			
K7	2.02	1	0	2	2	140	682	**A**	13	9	22	680	140	**A**
		2	2	3	5				4	8	12			
K8	1.57	1	0	2	2	140	530	**A**	2	0	2	260	285	**A**
		2	3	2	5				1	10	11			
L1	1.46	1	0	1	1	40	1724	**A**	0	1	1	40	1724	**A**
		2	1	0	1				0	1	1			
L3	2.09	1	1	0	1	20	4937	**A**	0	0	0	No pedestrian activity observed[1]		
		2	0	0	0				0	0	0			
L4	1.48	1	0	0	0	No pedestrian activity observed[1]			2	1	3	100	699	**A**
		2	0	0	0				0	2	2			
L6	2.07	1	0	0	0	No pedestrian activity observed[1]			0	1	1	20	4890	**A**
		2	0	0	0				0	0	0			
L7	2.03	1	0	1	1	20	4795	**A**	2	0	2	40	2398	**A**
		2	0	0	0				0	0	0			
L8	2.07	1	0	0	0	No pedestrian activity observed[1]			1	0	1	20	4890	**A**
		2	0	0	0				0	0	0			
L9	1.96	1	3	1	4	120	772	**A**	0	0	0	220	421	**A**
		2	0	2	2				5	6	11			
Sidewalks at Parking Lots														
L2	1.50	1	0	0	0	No pedestrian activity observed[1]			2	5	7	140	506	**A**
		2	0	0	0				0	0	0			

1 For locations with pedestrian inftrastructure capacity and flow, no PLOS evaluation is provided

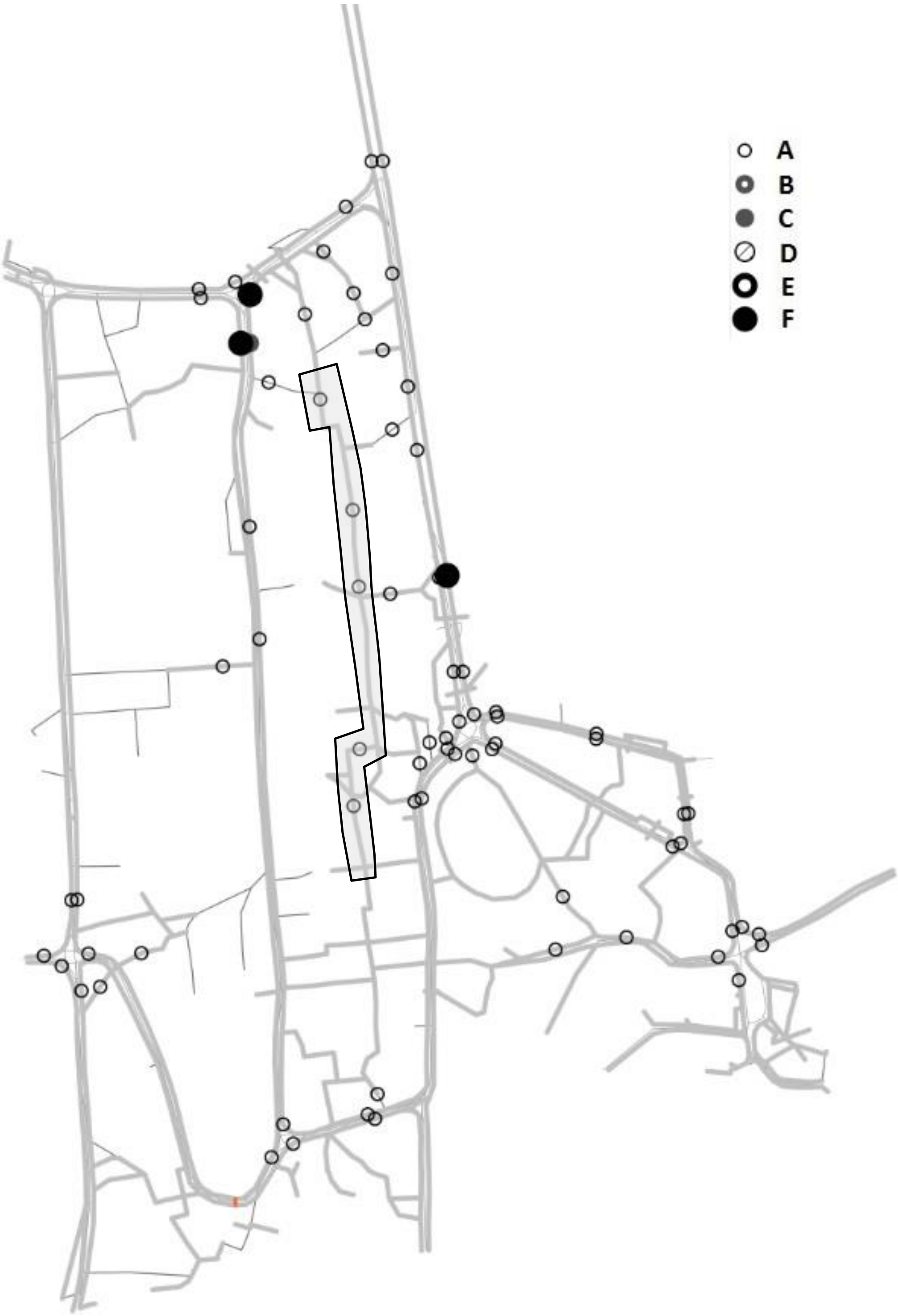

Figure D.1 HCM PLOS for 08:15- 09:00

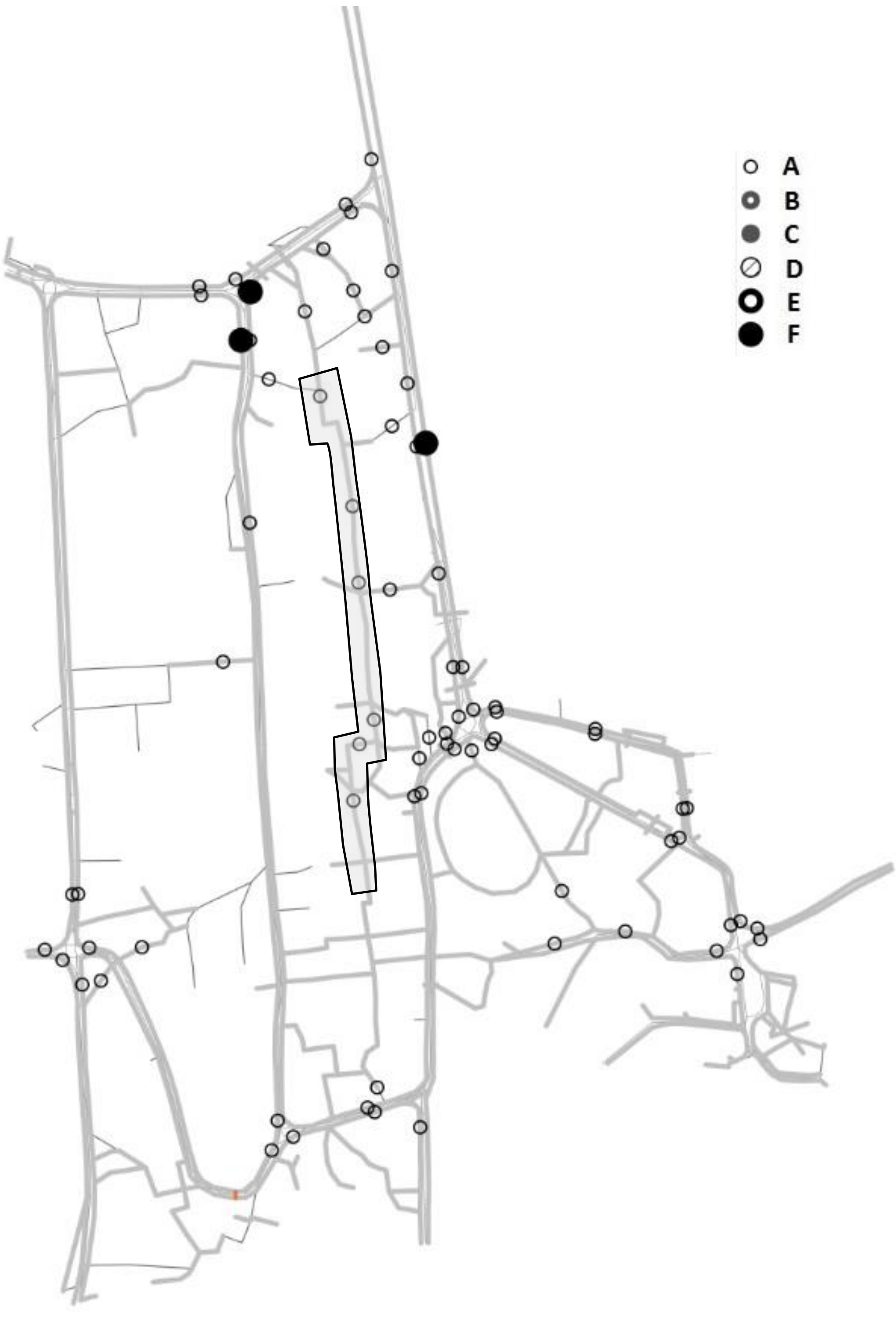

Figure D.2 HCM PLOS for 09:15- 10:00

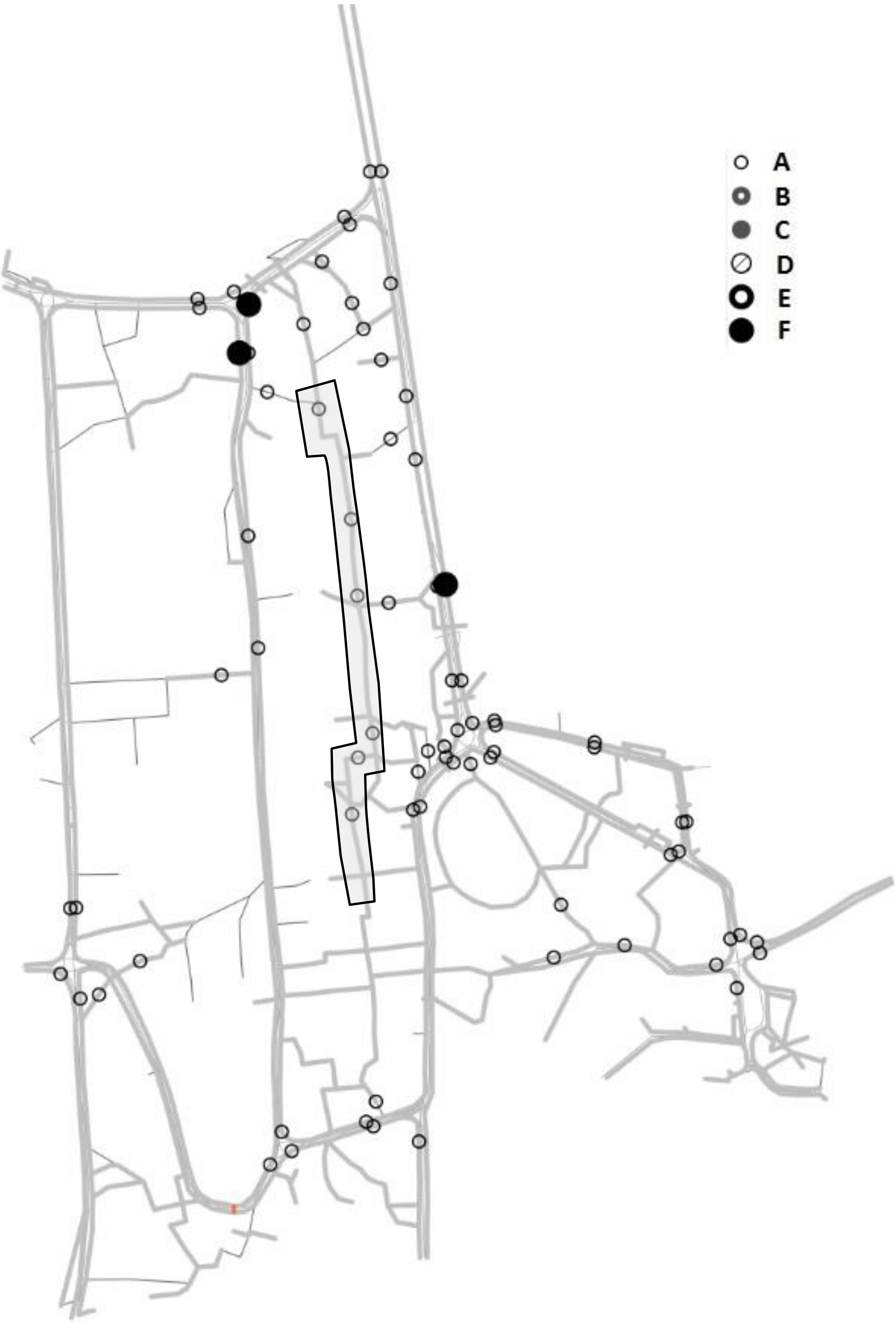

Figure D.3 HCM PLOS for 13:15- 14:00

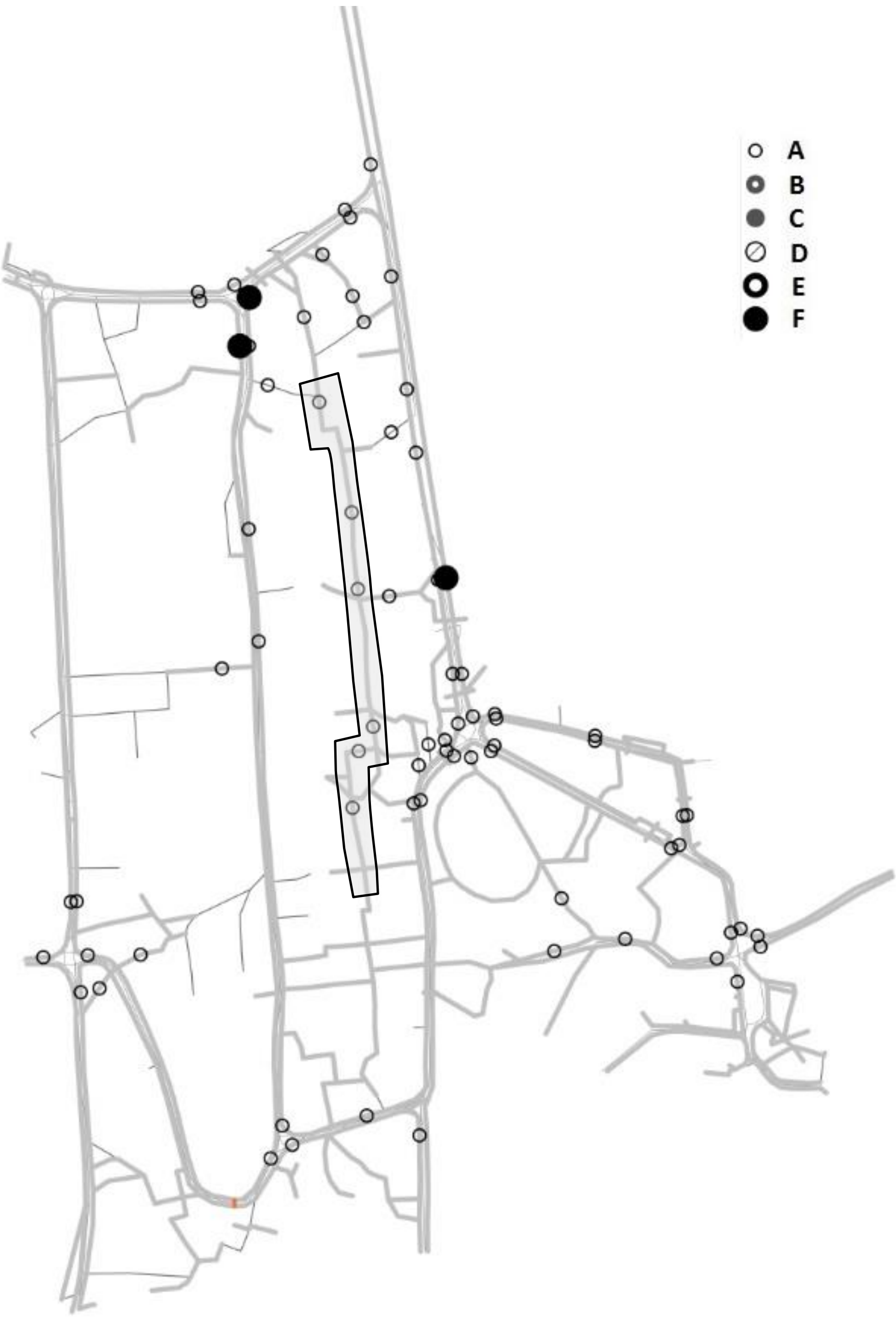

Figure D.4 HCM PLOS for 16:00- 16:45

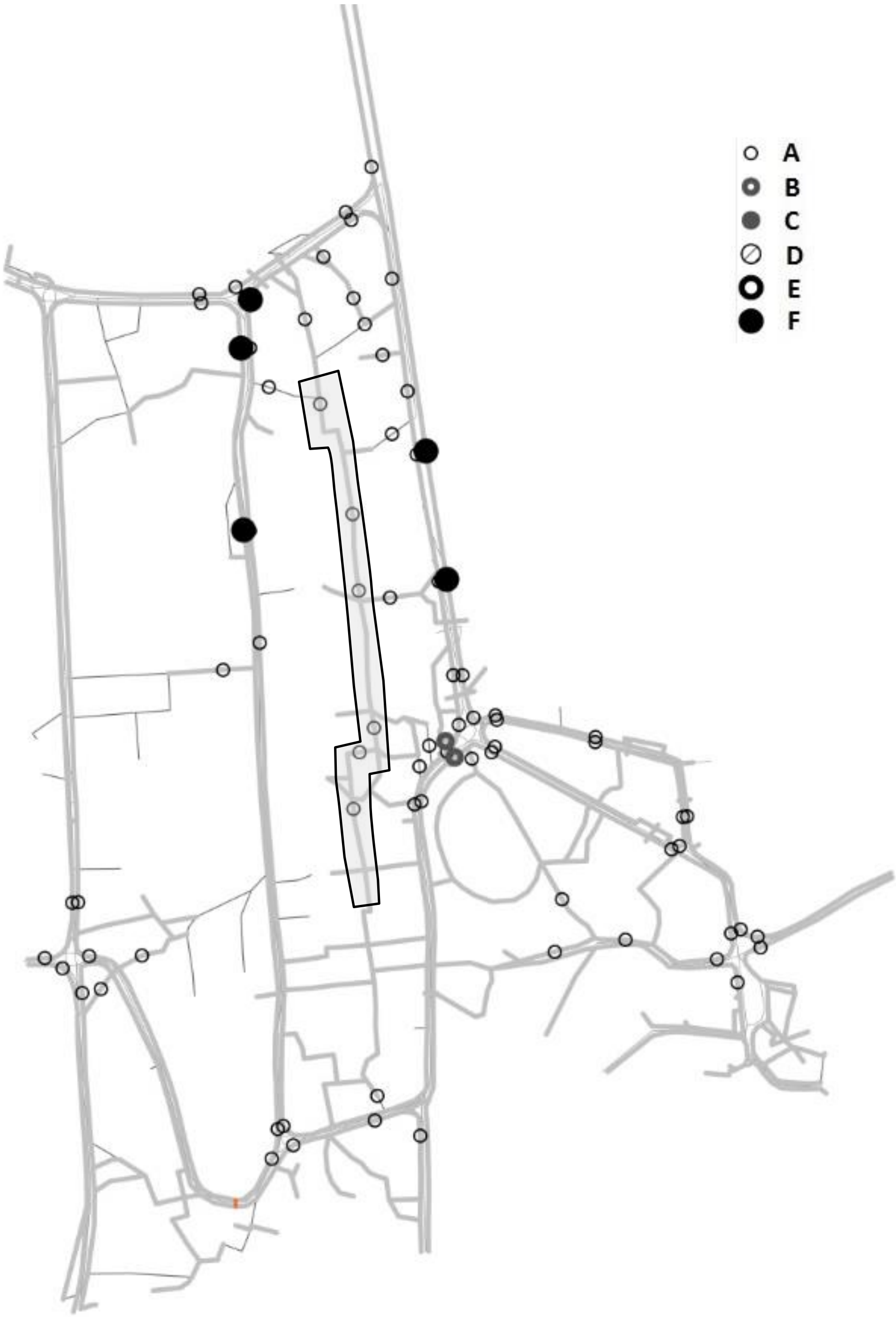

Figure D.5 HCM PLOS for 17:00- 17:45

APPENDIX E

GAINESVILLE METHOD MANUAL AND PLOS RESULTS

Pedestrian LOS Performance Measures for Gainessville PLOS Method

1- Pedestrian Facility Provided (PFP)

Dominant Facility Type What are the characteristics of the pedestrian facility provided in the corridor? The dominant facility can be either noncontinuous or nonexistent, continuous on one side, or continuous on both sides.
Minimum 1.53 m (5 ft) Wide and Barrier Free The sidewalk must be at least 1.53 m (5 ft) wide for its entire length. The 1.53 m clearance must be maintained around all utility poles, traffic signal poles, cafe railings, benches, newspaper boxes, and other fixtures that may encroach on the sidewalk space.
Sidewalk Width Greater than 1.53 m When the sidewalk provided is greater than 1.53 m wide the corridor segment will score points in this category. When the sidewalk is greater than 1.53 m but has significant barriers that decrease the useable, clear space to less than 1.53 m, the segment will still score points, but will not score for the criterion of a minimum 1.53 m wide and barrier-free facility.
Off-Street Parallel Alternative Facility This facility must be located within 0.4 km of the roadway segment and provide access to the same primary destination points served by the roadway network. This facility is typically located on a separate right of way instead of within the roadway right of way.

2- Conflicts (Conf)

To what degree are conflicts created or alleviated for the pedestrian because of visibility, motor-vehicle turning movements, pedestrian exposure times, and pedestrian convenience, which increases risktaking behavior?
Less Than 22 Driveways and Sidestreets per 1.61 km Driveway and sidestreet access points create conflicts for pedestrians. Statistics reveal a high proportion of crashes caused by this type of conflict. At each access point a bicyclist and pedestrians must scan for hazards and be prepared to execute an evasive maneuver.
Pedestrian Signal Delay of 40 Sec or Less The pedestrian signal delay is calculated for sidestreet crossings along the corridor segment, but not for movements across the major corridor being evaluated.
Reduced Turn-Conflict Implementations Intersection designs must provide properly located crosswalks and sight distances to maximize visibility for pedestrians.
Crossing Widths 18.3 m (60 ft) or Less The pedestrian crossing widths are measured for sidestreet crossings along the corridor, but not for movements across the corridor being evaluated. Crosscorridor widths could be used, but would require more extensive data collection. Generally, the through-crossing distance and other.
Posted Speed 56 kph or Less High-speed traffic greatly decreases the comfort of pedestrians and can be a major deterrent to pedestrian trips.

Medians Present Points will be received for this criterion when medians are a dominant characteristic within the corridor or when they are present at locations with frequent motor-vehicle turning movements or frequent pedestrian midblock crossing movements.

3- Amenities in Right-of-Way (Amen)

Does the segment provide features that increase comfort and convenience for pedestrians using the facility? These features must be located primarily within the roadway right of way.

Buffer not Less Than 1 m (3.3 ft) The buffer is the space between the existing sidewalk and the curb or roadway edge.

Benches or Pedestrian-Scale Lighting Benches or pedestrianscale lighting must be a dominant feature of the segment or at

least be provided in locations along the segment adjacent to highpedestrian- traffic generators, such as activity centers, office complexes, retirement communities, schools, transit transfer stations, and so forth.

Shade Trees Shade trees must be a dominant feature of the segment or at least be provided in locations along the segment adjacent to high-pedestrian-traffic generators.

4- Motor Vehicle LOS (VLOS)

To what degree do motor vehicle volume and congestion affect the comfort and safety level of pedestrians in the segment?

5- Maintenance (Maint)

Does the corridor suffer from maintenance deficiencies, including cracking, patching, buckling, weathering, holes, tree root intrusion, vegetative encroachment, rough railroad crossing, standing water, and so forth?

6- TDM and Multimodal Support (TDM)

Does the corridor have the available support of TMO services or intermodal links to transit that assist in overcoming nonroadway barriers and affect the decision to walk?

Table E.1 Gainesville Method PLOS Results and Raodway Characteristics for Walkway (No-interaction with Vehicular Traffic) Locations

Point	Effective Width	PFP	Conf	Amen	VLOS	Maint	TDM	* Score	$PLOS_{GM}$
A5	2.43	10	0	1.5	2	2	0	15.5	**B**
A6	4.8	10	0	2	2	2	0	16	**B**
B6	4.8	8	0	2	2	0	0	12	**C**
C6	2.43	10	0	2	2	2	0	16	**B**
D1	6.75	9	0	2	2	2	0	15	**B**
D3	10	10	0	2	2	2	0	16	**B**
D4	11.3	10	0	2	2	2	0	16	**B**
E5	1.93	8	1	1	2	0	0	12	**C**
E8	24.77	9	0	1	2	2	0	14	**C**
F8	6.2	10	0	2	2	2	0	16	**B**
F9	8.4	10	0	2	2	2	0	16	**B**
F10	12.8	10	0	2	2	2	0	16	**B**
H2	1.76	9	0	2	2	2	0	15	**B**
H3	2.08	9	0	1	2	2	0	14	**C**
K9	2.25	8	0	2	2	-1	0	11	**D**

Table E.2 Gainesville Method PLOS Results and Raodway Characteristics for Region A, B, C, D and E

Point	Effective Width	PFP	Conf	Amen	VLOS	Maint	TDM	* Score	$PLOS_{GM}$
Sidewalks Alongside the Roads									
A1	1.9	7	0	2	2	2	0	13	**C**
A3	1.89	9	0.5	1.5	2	2	0	15	**B**
A4	1.41	6	0	1	2	-1	0	8	**D**
A8	2.15	8	0	1	2	-1	0	10	**D**
A9	1.97	8	0	1	2	-1	0	10	**D**
B1	2.15	8	1	1	2	-1	0	11	**D**
B2	0.9	6	1	1	2	-1	0	9	**D**
B4	1.97	6	0	1	2	-1	0	8	**D**
B8	1.95	6	1	1	2	-1	0	3	**F**
B9	1.15	5	1	1	2	-1	0	8	**D**
C1	1.15	6	1	1	2	-1	0	9	**F**
C3	1.4	6	1	1	2	-1	1	13	**E**
C4	1.15	5	1	1	2	-1	0	8	**D**
C8	1.97	8	0	1	2	-1	1	11	**D**
D2	1.97	6	0	1	2	-1	0	8	**D**
D5	3.81	6	1	1	2	-1	1	12	**E**
D8	2	8	1	1	2	2	0	14	**C**
D9	4	8	1	1	2	2	0	14	**C**
E2	2	8	1	1	2	0	0	12	**C**
E3	2	8	1	1	2	2	1	15	**B**
E4	2.07	8	1	1	2	2	1	15	**B**
E6	1.97	8	0.5	0.5	2	0	0	11	**D**
E7	2	8	0.5	1	2	0	0	11.5	**C**
Sidewalks at Parking Lots									
B5	2.14	8	0	1	2	0	0	11	**D**
B7	2.43	9	0	1	2	2	0	10	**D**
C5	1,97	9	0	1	2	2	0	13	**D**
C9	0	0	0	0.5	2	-1	0	1.5	**F**
Pedestrian Activity Locations with No Sidewalk Capacity									
A2	0	1	0	0	2	-1	0	2	**F**
B3	0	0	0	0	2	-1	0	1	**F**
C2	0	5	1	1	2	-1	0	8	**D**
C7	0	5	0	0.5	2	0	0	7.5	**D**
D6	0	5	1	1	2	-1	0	8	**D**

Table E.3 Gainesville Method PLOS Results and Raodway Characteristics for Region F, H, J, K and L

Point	Effective Width	PFP	Conf	Amen	VLOS	Maint	TDM	* Score	$PLOS_{GM}$
Sidewalks Alongside the Roads									
F2	2	8	0	1	2	0	0	11	**D**
F3	1.57	7	0	0.5	2	0	0	9.5	**D**
F6	1.36	7	0	1	2	0	0	10	**D**
F7	1.57	7	0	0.5	2	-1	0	8.5	**D**
H1	1.45	0	0	0	2	-1	0	1	**F**
H4	1.52	7	1	0.5	2	0	1	11.5	**C**
H5	1.3	7	0	0	2	0	1	10	**D**
H6	1.45	6	0	0.5	2	0	1	9.5	**D**
H7	1.8	7	0.5	1	2	0	0	10.5	**D**
H8	1.85	7	0	0.5	2	0	0	9.5	**D**
H9	1.45	8	0.5	2	2	2	0	14.5	**B**
J1	1.33	7	0	0.5	2	0	1	10.5	**D**
J2	1.33	7	0	1	2	0	0	10	**D**
J5	1.6	6	0	1	2	0	0	9	**D**
J6	1.2	0	0	1	2	-1	1	3	**F**
J7	1.6	8	1	1	2	-1	0	11	**D**
J8	2	7	1	1	2	0	0	11	**D**
K1	2	8	1	1	2	0	0	12	**C**
K2	1.47	7	1	1	2	0	0	11	**D**
K3	1.47	7	1	1	2	0	0	11	**D**
K4	1.53	7	1	1	2	0	1	12	**C**
K5	1.64	8	2	2	2	0	1	15	**B**
K6	1.66	8	1	1	2	0	0	12	**C**
K7	2.02	8	0.5	1	2	2	0	13.5	**C**
K8	1.57	5	0	1	2	0	0	8	**D**
L1	1.46	6	0	1	2	0	0	9	**D**
L3	2.09	7	0	1	2	-1	1	10	**D**
L4	1.48	6	0	1	2	0	0	9	**D**
L6	2.07	7	0	0.5	2	0	0	9.5	**D**
L7	2.03	8	0	1	2	-1	0	10	**D**
L8	2.07	7	0	0	2	-1	0	8	**D**
L9	1.96	5	0	1	2	0	0	8	**D**
Sidewalks at Parking Lots									
F1	1.9	6	0	1	2	0	1	10	**D**
F4	1.1	7	0	0.5	2	-1	0	8.5	**D**
F5	1.36	5	0	1	2	-1	0	7	**E**
L2	1.5	5	0	1	2	0	0	8	**D**

APPENDIX F

TRIP QUALITY METHOD MANUAL AND PLOS RESULTS

Nine Pedestrian Evaluation Measures for Trip Quality Method

1- Enclosure (Enc): The principle of **enclosure** measures the degree to which the edges of the street are defined. Good enclosure dictates that the pedestrian's eyes are focused *along the street* rather than among the blank spaces between, behind, or in front of buildings.
Commercial streets best demonstrate enclosure when buildings are constructed side-by-side along the sidewalk, minimizing the volume of empty space between and in front of buildings. Figure 1 shows, in plan view, the difference between a well-enclosed commercial street and a poorly enclosed one

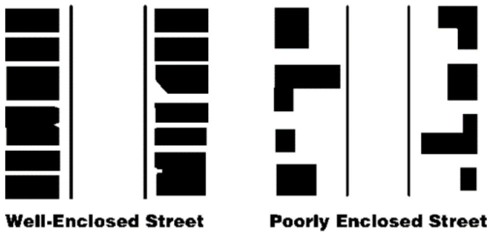

FIGURE 1 Enclosure/definition.

2- Complexity of Path Network (CPN): A complete/complex path network furnishes pedestrians with numerous route choices between origins and destinations. In other words, a complex path network ensures a high degree of connectivity between activity centers and residential units. Without a complex path network, pedestrians are often held hostage to the same route day after day, making even the most pleasant of paths very tiresome. Figure 2 illustrates a poor, incomplete path network in comparison to a complete, complex network, the former of which is all too commonly found in contemporary suburban areas.

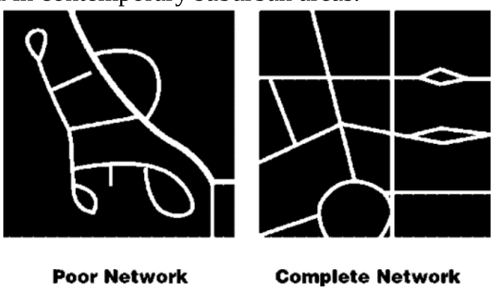

FIGURE 2 Complexity of path network.

3- Building Articulation (BA): Storefronts and houses add interest to the pedestrian experience through the varied application of materials, design, color, and décor. The best examples are found in historic town centers and close-in neighborhoods where structures were originally designed to appeal to slow-moving pedestrians rather than to high-speed automobile traffic, since walking was for a very long time the dominant form of transportation between homes and businesses.

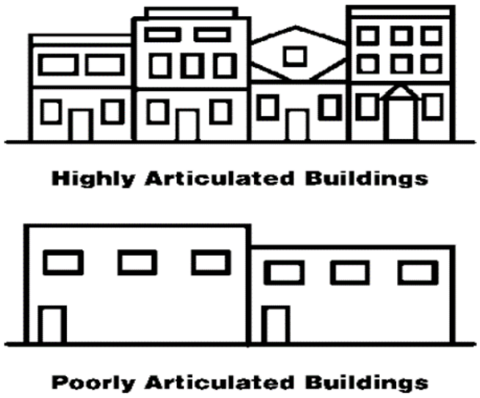

FIGURE 3 Building articulation.

4- Shade Trees (ST): The presence of shade trees improves the comfort level of pedestrians on hot summer days. Shade trees are effective at keeping pedestrians cool as well as blocking the sun from their eyes. Additionally, shade trees add a nice aesthetic element to the street and contribute to definition and buffer. In some cases, street trees also provide shelter from rain (but not during lightning storms, of course).

5- Transparency (Tr): *Transparency* addresses the transition between the public space and private space. In business areas, transparency is created through the use of windows, outdoor displays, and sidewalk cafes. In residential areas, front porches facilitate a smooth interface between the public street and private house.

6- Overhangs/Awnings/Varied Roof Lines (Awn): The degree to which items *above* street level contribute to the experience *at* street level, in terms of both aesthetics *and* functionality, is a very important aspect of pedestrian planning.
In terms of appearance, the presence of overhangs, awnings, and varied roof lines enhances the pedestrian experience in the same manner as does the articulation of buildings through diverse materials and décor, contributing variation and aesthetic quality. From a functional perspective, overhangs and awnings contribute to pedestrian comfort by providing shade from sunlight and shelter from rainfall.

7- Complexity of Spaces (CS): Frequent variation in the orientation and character of public spaces adds to the general level of interest of commercial districts and residential neighborhoods. Such spaces include courtyards, plazas, parks, and playgrounds. Natural elements, such as water features and indigenous trees, can be celebrated within these public spaces to help draw attention to the unique physical qualities of a particular area. The geometrics of public spaces should be such that interesting and rapidly changing views are facilitated.
The presence and variation of public spaces along pedestrian routes ensure that long walks are broken up with occasional sectors of heightened interest. Figure 4 illustrates in plan view the manner in which public spaces might be distributed throughout a town center district.

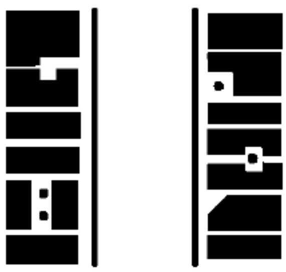

FIGURE 4 Complex spaces.

8- Buffer (Bf)

The presence of a "buffer zone" between pedestrians and moving vehicles greatly enhances pedestrian safety and comfort. Buffer improves *actual* safety through the placement of solid objects between moving vehicles and people, reducing the likelihood that a collision involving a pedestrian will occur. *Perceived* safety, which is roughly synonymous with pedestrian comfort, is likewise increased as the buffer zone is enlarged and solidified because pedestrians along the improved corridor would *feel* as if their chances of becoming involved in a collision have been lowered.

Figure 5 contains a pair of diagrams depicting a well-buffered street in comparison to a poorly buffered street. The former contains a "buffer lane" between the sidewalk and travel lanes consisting of extensive landscaping or parallel parking, or some intermittent combination of both.

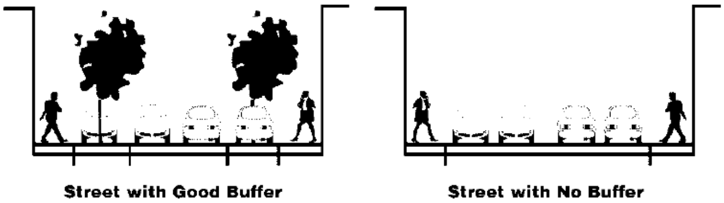

FIGURE 5 Buffer.

9- Physical Components/Condition (PC): This category of evaluation addresses the specific physical qualities of the sidewalk and its surroundings that are not explicitly covered by any of the other eight evaluation measures. As described below, *physical components/condition* addresses both the structural integrity and functionality of the sidewalk and the overall contribution (positive or negative) of other physical elements in the corridor, such as the street itself.

Sidewalk Configuration and Condition (SC)

For obvious reasons, the overall physical condition of sidewalks and streets profoundly impacts the quality of the pedestrian environment. Areas containing no sidewalks at all typically receive the lowest possible ratings in this category, except in the rare cases where streets themselves are designed to serve as safe, shared travelways. Low ratings are also assigned to areas with broken or cracked sidewalks, disproportionately narrow sidewalks, sidewalks having trees or poles obstructing the walking path, or sidewalks that collect and retain unreasonably high volumes of standing water during rainstorms.

Vehicular Speed (VS)

As previously mentioned, vehicular speed greatly affects the actual and perceived safety of pedestrians along a roadway. Speed is influenced by many factors, the least of which is probably the posted speed limit. Although *enclosure*, as facilitated by buildings and street trees, has a great deal of influence over driver speed, so does the physical design of the roadway itself.

Lighting (L)

The level of lighting along the street also has considerable implications for pedestrian safety—in terms of both *criminal activity* and *protection from vehicles*.

Table F.1 Trip Quality Method PLOS Results by Rater 1 for Walkway (No-interaction with Vehicular Traffic) Locations

Point	Rater 1												
	Enc	CPN	BA	CS	Awn	Bf	ST	Tr	PC			Avg Score	PLOS TQ
									SC	VS	L		
A5	1	1	1	1	1	5	5	1	5	5	1	2.5	**D**
A6	2	2	1	2	1	5	5	1	5	5	5	3.1	**C**
B6	3	3	3	4	1	4	5	3	2	5	4	3.4	**B**
C6	4	5	5	5	1	5	4	4	4	5	4	4.2	**A**
D1	3	2	3	4	1	5	4	2	4	5	5	3.5	**B**
D3	4	5	5	5	1	5	4	4	4	5	4	4.2	**A**
D4	4	4	5	4	1	5	5	4	4	5	4	4.1	**A**
E5	3	3	1	2	1	1	5	1	2	5	5	2.6	**D**
E8	2	3	1	3	1	5	3	1	5	5	5	3.1	**C**
F8	3	5	3	4	1	5	5	3	5	5	4	3.9	**B**
F9	4	5	4	5	1	5	5	4	4	5	4	4.2	**A**
F10	4	4	5	5	1	5	5	4	4	5	4	4.2	**A**
H2	1	1	1	2	1	5	3	1	4	5	4	2.5	**D**
H3	2	1	1	2	1	5	2	1	4	5	1	2.3	**D**
K9	3	4	1	5	1	5	5	5	4	5	4	3.8	**B**

Table F.2 Trip Quality Method PLOS Results by Rater 2 for Walkway (No-interaction with Vehicular Traffic) Locations

Point	Rater 1												
	Enc	CPN	BA	CS	Awn	Bf	ST	Tr	PC			Avg Score	PLOS TQ
									SC	VS	L		
A5	1	1	1	1	1	5	5	1	5	5	1	2.5	**D**
A6	2	2	1	2	1	5	5	1	5	5	5	3.1	**C**
B6	3	3	3	2	1	5	4	3	3	5	4	3.3	**C**
C6	5	5	4	5	1	5	4	5	4	5	4	4.3	**A**
D1	4	1	2	4	1	5	3	3	4	5	5	3.4	**B**
D3	5	5	4	5	1	5	4	5	4	5	4	4.3	**A**
D4	4	5	4	5	1	5	3	5	5	5	5	4.3	**A**
E5	2	3	1	1	1	1	4	2	3	5	2	2.3	**D**
E8	2	4	1	1	1	5	3	4	5	5	4	3.2	**C**
F8	3	5	3	3	1	5	4	3	4	5	4	3.6	**B**
F9	3	5	3	3	1	5	4	4	4	5	4	3.7	**B**
F10	4	5	3	5	1	5	5	3	4	5	4	4.0	**A**
H2	1	1	1	2	1	5	3	1	4	5	5	2.6	**D**
H3	1	1	1	2	1	5	2	1	4	5	1	2.2	**D**
K9	4	5	1	5	1	5	5	5	3	5	4	3.9	**B**

Table F.3 Trip Quality Method PLOS Results by Rater 1 for Region A, B, C, D and E

Point	Rater 1												
	Enc	CPN	BA	CS	Awn	Bf	ST	Tr	PC			Avg Score	PLOS TQ
									SC	VS	L		
Sidewalks Alongside the Roads													
A1	1	1	1	2	1	4	5	1	4	3	4	2.5	**D**
A3	1	1	1	2	1	4	5	1	4	5	3	2.5	**D**
A4	1	1	1	1	1	1	5	1	2	5	3	2.0	**E**
A8	1	2	2	2	1	1	5	1	2	5	3	2.3	**D**
A9	1	2	1	2	1	1	4	1	3	5	4	2.3	**D**
B1	1	1	1	2	1	5	5	1	3	5	3	2.5	**D**
B2	1	1	2	2	1	3	2	1	2	5	3	2.1	**E**
B4	1	2	1	2	1	3	3	1	3	4	4	2.3	**D**
B8	1	2	1	1	1	5	5	1	5	5	4	2.8	**C**
B9	1	2	1	1	1	5	5	1	2	4	4	2.5	**D**
B10	1	1	1	1	1	2	2	1	1	2	4	1.5	**E**
C1	1	2	1	1	1	5	5	1	5	5	4	2.8	**C**
C3	1	2	1	1	1	5	5	1	5	5	4	2.8	**C**
C4	1	2	1	1	1	5	5	1	2	4	4	2.5	**D**
C8	3	2	3	3	1	1	3	3	2	4	4	2.6	**D**
D2	2	3	2	3	1	1	5	1	3	4	5	2.7	**D**
D5	1	2	1	1	1	5	5	1	5	5	4	2.8	**C**
D8	3	4	1	2	1	1	5	1	2	5	5	2.7	**D**
D9	2	5	1	3	1	1	5	2	4	5	4	3.0	**C**
E2	3	4	1	2	1	1	5	1	2	5	4	2.6	**D**
E3	2	5	1	3	1	1	5	2	4	5	5	3.1	**C**
E4	2	3	2	4	1	1	5	3	3	5	3	2.9	**C**
E6	3	3	1	2	1	1	5	1	2	5	3	2.5	**D**
E7	3	3	1	2	1	1	5	1	2	5	4	2.5	**D**
Sidewalks at Parking Lots													
B5	2	1	2	2	1	5	5	2	3	5	3	2.8	**C**
B7	1	1	1	1	1	5	5	1	5	5	1	2.5	**D**
C5	1	1	1	1	1	5	5	1	5	5	1	2.5	**D**
C9	1	1	2	1	1	1	2	2	1	3	1	1.5	**F**
Pedestrian Activity Locations with No Sidewalk Capacity													
A2	1	2	1	1	1	1	2	1	1	4	3	1.6	**E**
B3	1	2	1	2	1	3	3	1	1	2	1	1.6	**E**
C2	1	2	1	1	1	5	5	1	2	4	4	2.5	**D**
C7	2	1	3	2	1	1	3	2	3	4	2	2.2	**D**
D6	1	2	1	1	1	5	5	1	2	4	4	2.5	**D**

Table F.4 Trip Quality Method PLOS Results by Rater 1 for Region F, H, J, K and L

Point	Rater 1												
	Enc	CPN	BA	CS	Awn	Bf	ST	Tr	PC			Avg Score	PLOS TQ
									SC	VS	L		
Sidewalks Alongside the Roads													
F2	1	1	1	2	1	1	5	1	4	5	4	2.4	**D**
F3	1	1	1	3	1	1	4	1	4	4	4	2.3	**D**
F6	2	3	3	3	1	1	4	2	4	5	5	3.0	**C**
F7	3	1	1	1	1	1	5	0	2	5	4	2.2	**D**
H1	1	1	1	1	1	1	1	1	1	2	1	1.1	**F**
H4	1	2	3	3	1	1	3	2	3	5	5	2.6	**D**
H5	1	2	3	2	1	1	1	2	3	5	2	2.1	**E**
H6	1	2	2	2	1	1	3	2	2	5	3	2.2	**D**
H7	1	2	2	1	1	1	3	1	3	5	3	2.1	**E**
H8	1	2	2	2	1	4	3	1	4	5	3	2.5	**D**
H9	3	2	3	3	1	4	5	4	4	5	5	3.5	**B**
J1	2	4	2	3	1	1	5	3	4	5	2	2.9	**C**
J2	1	3	1	3	1	1	4	1	2	5	4	2.4	**D**
J5	2	4	3	4	1	1	5	3	2	5	4	3.1	**C**
J6	3	2	1	3	1	1	4	1	1	5	4	2.4	**D**
J7	2	4	1	3	1	1	4	2	1	5	3	2.5	**D**
J8	2	3	1	2	1	1	5	2	3	5	4	2.6	**D**
K1	3	2	1	1	1	1	2	5	2	5	3	2.4	**D**
K2	3	2	3	1	1	1	4	1	2	5	2	2.3	**D**
K3	3	1	1	1	1	1	2	1	2	5	1	1.7	**E**
K4	3	1	1	1	1	1	4	5	2	5	5	2.6	**D**
K5	4	3	2	4	1	4	2	5	2	5	4	3.3	**C**
K6	3	3	3	2	1	4	3	3	1	5	4	2.9	**C**
K7	4	4	3	4	1	1	3	4	4	5	3	3.3	**C**
K8	1	4	1	4	1	1	2	5	3	5	4	2.8	**C**
L1	3	3	4	4	1	2	5	2	3	5	4	3.3	**C**
L3	4	2	3	3	1	1	5	2	2	5	5	3.0	**C**
L4	3	2	4	3	1	1	5	4	3	5	4	3.2	**C**
L6	2	1	1	2	1	1	5	1	3	5	4	2.4	**D**
L7	2	2	1	3	1	1	5	1	2	5	5	2.5	**D**
L8	1	1	1	1	1	1	1	1	1	1	1	1.0	**F**
L9	3	1	4	3	1	1	5	4	4	5	5	3.3	**C**
Sidewalks at Parking Lots													
F1	2	1	1	2	2	1	2	2	2	5	4	2.2	**D**
F4	2	3	1	3	1	1	2	1	1	5	3	2.1	**E**
F5	1	2	2	2	1	1	5	2	2	5	3	2.4	**D**
L2	1	3	2	2	1	1	5	1	2	5	4	2.5	**D**

Table F.5 Trip Quality Method PLOS Results by Rater 2 for Region A, B, C, D and E

Point	Rater 2												
	Enc	CPN	BA	CS	Awn	Bf	ST	Tr	PC			Avg Score	PLOS TQ
									SC	VS	L		
Sidewalks Alongside the Roads													
A1	1	2	1	2	1	5	5	1	5	4	5	2.9	**C**
A3	1	2	1	2	1	5	5	1	5	5	5	3.0	**C**
A4	1	2	1	1	1	1	4	1	3	5	3	2.1	**E**
A8	2	2	2	2	1	1	4	1	2	5	4	2.4	**D**
A9	1	2	1	1	1	1	4	1	3	5	5	2.3	**D**
B1	2	1	2	2	1	1	4	2	2	4	4	2.3	**D**
B2	1	1	2	2	1	1	4	2	2	3	4	2.1	**E**
B4	1	2	1	1	1	2	3	1	2	5	5	2.2	**E**
B8	1	1	1	1	1	4	5	4	4	5	4	2.8	**C**
B9	1	1	1	1	1	1	5	2	2	4	4	2.1	**E**
B10	1	1	1	1	1	1	3	1	1	4	4	1.7	**E**
C1	1	1	1	1	1	4	5	4	4	5	4	2.8	**C**
C3	1	1	1	1	1	4	5	4	4	5	4	2.8	**C**
C4	1	1	1	1	1	1	5	2	2	4	4	2.1	**E**
C8	3	3	3	4	1	1	3	3	2	5	3	2.8	**C**
D2	2	3	2	2	1	1	5	1	3	5	5	2.7	**D**
D5	1	1	1	1	1	4	5	4	4	5	4	2.8	**C**
D8	1	4	1	1	1	1	5	5	3	5	4	2.8	**C**
D9	2	5	2	3	1	1	3	4	4	5	5	3.2	**C**
E2	1	4	1	1	1	1	5	3	3	5	4	2.6	**D**
E3	2	5	2	3	1	1	5	4	5	5	5	3.5	**B**
E4	2	3	1	1	1	1	4	2	3	5	2	2.3	**D**
E6	2	3	1	1	1	1	4	2	3	5	3	2.4	**D**
E7	2	3	1	1	1	1	4	2	4	5	3	2.5	**D**
Sidewalks at Parking Lots													
B5	2	2	2	2	1	2	4	3	3	5	5	2.8	**C**
B7	1	1	1	1	1	5	5	5	5	5	1	2.8	**C**
C5	1	1	1	1	1	5	5	5	5	5	1	2.8	**C**
C9	1	1	2	1	1	1	3	2	1	5	1	1.7	**E**
Pedestrian Activity Locations with No Sidewalk Capacity													
A2	1	1	1	1	1	1	3	1	1	4	4	1.7	**E**
B3	1	1	1	1	1	1	3	1	1	5	3	1.7	**E**
C2	1	1	1	1	1	1	5	2	2	4	4	2.1	**E**
C7	3	2	3	2	1	1	3	2	2	5	2	2.4	**D**
D6	1	1	1	1	1	1	5	2	2	4	4	2.1	**E**

Table F.6 Trip Quality Method PLOS Results by Rater 2 for Region F, H, J, K and L

Point	Rater 2												
	Enc	CPN	BA	CS	Awn	Bf	ST	Tr	PC			Avg Score	PLOS TQ
									SC	VS	L		
Sidewalks Alongside the Roads													
F2	1	2	1	2	1	1	3	2	3	5	3	2.2	**D**
F3	1	3	1	2	1	1	3	2	3	5	2	2.2	**D**
F6	2	4	3	2	1	1	4	4	3	5	5	3.1	**C**
F7	2	2	1	2	1	1	5	2	2	5	2	2.3	**D**
H1	1	1	1	1	1	1	1	1	1	2	1	1.1	**F**
H4	1	2	2	3	1	1	2	2	3	5	4	2.4	**D**
H5	1	1	3	3	1	1	1	2	2	5	2	2.0	**E**
H6	1	1	3	2	1	1	3	2	2	5	3	2.2	**D**
H7	1	1	3	2	1	1	3	1	3	5	3	2.2	**D**
H8	1	2	2	2	1	1	5	1	2	5	2	2.2	**D**
H9	3	2	3	3	1	4	5	4	4	5	5	3.5	**B**
J1	2	3	1	2	1	2	5	4	3	5	4	2.9	**C**
J2	1	4	1	1	1	1	5	4	3	5	5	2.8	**C**
J5	3	4	3	3	1	1	5	5	2	5	5	3.4	**B**
J6	1	2	1	1	1	1	4	1	1	5	5	2.1	**E**
J7	2	4	1	3	1	1	5	3	3	5	4	2.9	**C**
J8	3	4	1	3	1	1	5	2	4	5	4	3.0	**C**
K1	4	2	3	2	1	1	3	4	3	5	4	2.9	**C**
K2	4	2	3	2	1	1	4	3	3	5	2	2.7	**D**
K3	4	1	1	1	1	1	3	1	3	5	2	2.1	**E**
K4	4	1	1	1	1	1	4	1	3	5	4	2.4	**D**
K5	3	4	3	5	1	4	2	4	3	5	5	3.5	**B**
K6	4	4	3	4	1	4	4	4	3	5	4	3.6	**B**
K7	5	3	3	3	1	1	4	4	4	5	3	3.3	**C**
K8	1	4	1	4	1	1	3	5	3	5	4	2.9	**C**
L1	3	2	3	4	1	1	5	1	2	5	3	2.7	**D**
L3	3	3	3	3	1	1	5	2	2	5	3	2.8	**C**
L4	2	2	3	3	1	1	5	4	2	5	2	2.7	**D**
L6	3	2	1	3	1	1	5	1	3	5	3	2.5	**D**
L7	3	2	1	3	1	1	5	1	2	5	4	2.5	**D**
L8	1	1	1	1	1	1	1	1	1	5	1	1.4	**F**
L9	3	2	3	3	1	1	5	3	3	5	4	3.0	**C**
Sidewalks at Parking Lots													
F1	1	2	1	2	3	1	2	2	2	5	3	2.2	**D**
F4	1	2	1	1	1	1	2	2	1	5	3	1.8	**E**
F5	2	4	3	3	1	1	3	3	1	5	3	2.6	**D**
L2	1	3	2	2	1	1	5	2	2	5	3	2.5	**D**