

PEDESTRIAN CROSSING LEVEL OF SERVICE (PCLOS) MODEL FOR
PROMOTING SAFE STREET CROSSING IN URBAN AREAS

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DEDICATION

This thesis work is dedicated to my beloved parents and friends whose prayers and support made me able to walk in every step of life and my supervisor whose guidance and encouragement leads to completion of my work.

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“The greatly blessed is the name of your RUBB, the majestic and the splendid” and WHOSE countless blessings cannot be gratitude in words. Bestowed I am, that the project is completed within the time.

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ABSTRACT

Crosswalks are the important location on the road because pedestrian are more exposed to vehicular traffic. It is important to plan and design pedestrian crossing more carefully. Currently, there are methods available for evaluating pedestrian level of service (LOS) of pedestrian crossings. However, very less number of pedestrian crossing facilities are considered by these methods in evaluating crosswalk condition. This study attempts to provide a comprehensive method for assessing crosswalks based on pedestrian facilities. The indicators in this research are taken from different guidelines available which consider pedestrian crossing facilities. A pedestrian crossing level of service (PCLOS) method is introduced in this research to evaluate pedestrian crosswalks. An analytical point system is used to compare the existing street crossing conditions to the standards available in the guidelines. The co-efficient of indicators is estimated by conducting a survey from pedestrian crosswalk user and experts. The proposed PCLOS is based both indicators score and coefficient of the indicators. This method was tested in four case studies for checking the results in in different scenario with different pedestrian crossing facilities available. The method proposed in the research can identify the existing problems in the crosswalks for pedestrian. Furthermore, the method can also be used for proposing improvements in the exiting conditions. The needs of disabled pedestrian are also considered in proposing the evaluating method.

ABSTRAK

Lintasan pejalan kaki adalah lokasi yang penting di jalan raya kerana pejalan kaki lebih terdedah kepada lalu lintas kenderaan. Lintasan pejalan kaki adalah penting untuk dirancang dan direkabentuk dengan lebih teliti. Terdapat kaedah sedia ada untuk menilai tahap perkhidmatan lintasan pejalan kaki. Walau bagaimanapun, bilangan kemudahan lintasan pejalan kaki sangat kurang dipertimbangkan oleh kaedah tersebut dalam menilai keadaan lintasan pejalan kaki. Kajian ini mencadangkan kaedah yang menyeluruh untuk menilai lintasan pejalan kaki berdasarkan kemudahan pejalan kaki. Indikator dalam kajian ini diambil dari pelbagai garis panduan sedia ada yang mengambil kira kemudahan lintasan pejalan kaki. Kaedah tahap perkhidmatan lintasan pejalan kaki (PCLOS) diperkenalkan dalam kajian ini untuk menilai lintasan pejalan kaki. Sistem poin analitik digunakan untuk membandingkan keadaan lintasan pejalan kaki sedia ada dengan piawaian yang terdapat dalam garis panduan. Pekali indikator dianggarkan dengan menjalankan kaji selidik dari pengguna lintasan pejalan kaki dan pakar. Kaedah yang dicadangkan adalah berdasarkan skor indikator dan pekali indikator. Kaedah ini telah diuji di empat kajian kes untuk menyemak keputusan dalam senario yang berbeza dan kemudahan lintasan pejalan kaki sedia ada yang berbeza. Kaedah yang dicadangkan dalam kajian ini dapat mengenalpasti masalah sedia ada lintasan pejalan kaki. Selain itu, kaedah ini juga boleh digunakan untuk mencadangkan penambahbaikan untuk keadaan semasa. Keperluan pejalan kaki kelainan upaya juga turut diambil kira dalam mencadangkan kaedah penilaian ini.

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LIST OF ABBREVIATIONS

LOS	Level of Service
PLOS	Pedestrian Level of Service
PCLOS	Pedestrian Crossing Level of Service
PCLOS%	Pedestrian Crossing Level of Service Percentage
WHO	World Health Organization
AASHTO	American association of State highway officials
FDOT	Florida Department of Transportation
HCM	Highway capacity Manual
TRB	Transportation Research Board

LIST OF SYMBOLS

i	Number of each indicators
C_i	Co-efficient of pedestrian crossing indicators
P_i	Pedestrian crossing indicator score
\sum	Summation

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Like cycling, walking is a sustainable and healthy mode of transportation that reduces traffic congestion in the cities. In addition, it has long term environmental impacts which helps in conserving energy and achieving pleasant environment without air and noise pollution. But at the same time, pedestrians are the most vulnerable users on the roads. Pedestrians are even more exposed with the increasing car ownership. According to World Health Organization (2015) every year 275,000 pedestrians dies globally because of traffic accidents. Pedestrians along with cyclist represent 26% of the total deaths occurred in road traffic crashes across the world (World Health Organization, 2018). Along the road the pedestrians are subjected to many circumstances which can significantly affect their safety, convenience and comfort (Archana and Reshma E.K, 2013).

Planners and designers are more emphasizing on sustainable and walkable cities. Furthermore, urban planners and transport planners have put more efforts during last two decades to revamp urban areas to make them pedestrian friendly (Anciaes and Jones, 2018). Streets are important in achieving sustainability hence, it should be designed carefully considering the needs of all end-users (Asadi-Shekari, Moeinaddini and Zaly Shah, 2014). Research over the years shows that the quality and quantity of the walking can be increased by appropriate design in term of providing pedestrian friendly crossing facilities or overall design (Kelly, Tight, Hodgson and Page, 2011). For example, construction of new or improvement in the existing crossing facilities and it can reduce the impact of road and traffics on pedestrian (Anciaes and Jones, 2018). In cities, pedestrian safety is one of the major concern these days. For instance, In European countries, every year around 10,000 pedestrians and cyclists lose their life in road accidents and it accounts 20% of overall road deaths (Antov, Rõivas, Antso

and Sürje, 2011). Research has shown that most of the pedestrian accidents happens during road crossing (Basile, Persia and Usami, 2010)

Evaluation methods are not only used for knowing the existing condition and improving needs of the users but also helps in maintaining complete street and making it inclusive (Asadi-Shekari, Moeinaddini and Zaly Shah, 2013). Different methodologies are used to evaluate pedestrian environment for example checklist for evaluating walkability of route, stated preference technique for determination of pedestrian values to certain specific aspects of walking and mobile methods for direct pedestrian experience (Kelly et al, 2011). LOS is used for qualitative measurement of a service to its user (Gopalakrishnan and Estate, 2018). LOS takes different factors into account while measuring the quality of service such as existing street conditions, pedestrian facilities and street furniture (Shekari and Shah, 2011). Similarly, pedestrian level of service (PLOS) method is used for assessing pedestrian facilities on the streets. PLOS use scale measurement from A to F to present the results. A shows “free flow” or “very satisfied” condition while F reflects “no movement” or “worse” or “very dissatisfied” condition. Although, pedestrian crossing facilities can affect pedestrian safety significantly, there are limited studies that evaluate PLOS for the pedestrian crossings. Therefore, this research propose a PCLOS model that covers various crossing facilities conditions for pedestrians with different ranges of abilities in the evaluation.

1.2 Problem Background

Peshawar, the capital of province Khyber Pakhtunkhwa, Pakistan is the centre of business, administration, education, health and political activities. The city is witnessing growing car ownership which is making situation of traffic is very bad in the city. According to Bureau of Statistics Khyber Pakhtunkhwa (2016) during 2008-2015 car ownership has been increased by 173% in Peshawar. Pedestrians are the most vulnerable road users in Peshawar exposed to traffic injuries and fatalities. There were total of 3,280 road traffic accidents reported in 30 police stations in Peshawar during year 2003-2012 (Akhtar, Shah, Ahmad and Ha, 2018). Pedestrians were involved in

73% of the total accidents. According Akhtar et al (2018) high involvement of pedestrian in road accident is caused by the absence of pedestrian crossing facilities and removal of pedestrian facilities for road extension.

There are different methods available to evaluate existing street condition for pedestrian. Level of service method is the most common method used by the researchers for the assessment of pedestrian facilities. LOS of the streets can be measured by two techniques based on qualitative and quantitative techniques. The first type that consider pedestrian capacity and volume was developed by Fruin (1971). Lautso and Murole (1974) considered environmental indicators for PLOS. Sarkar (1993) explored LOS for sidewalks using qualitative measures such as pedestrian safety, convenience, comfort, continuity and system coherence. Tan, Wang, Lu and Bian (2007) combined both qualitative and quantitative indicators for PLOS. Similarly, Asadi-shekari, Moeinaddini and Zaly (2013) incorporated physical, environmental, pedestrian behaviour and vehicle indicators for suggesting PLOS for non-motorized users.

Level of service studies has also been carried out for disabled pedestrian and cyclist as well. Bian, Ma, Rong, Wang and Lu (2009) developed a statistical PLOS model for pedestrian crossing at intersection based on survey opinion using Pearson and factor analysis. The taken for the study were safety and comfort opinion of the user and vehicle volume on the road. PLOS is also explored for midblock crosswalks (e.g. Baltes and Chu, 2002; Kadali and Vedagiri, 2015; Transportation Research Board, 2000). Although PLOS models have been developed for pedestrian crossing, these models have some major short comings. For example, the model developed by Kadali and Vedagiri (2015) considered only pedestrian perception in deciding LOS for crosswalks. Similarly the method developed by Baltes and Chu (2002) does not consider pedestrian with disability for midblock crossing.

Most of the previous studies that developed methods to assess the pedestrian crossing condition have some problems for example, previous studies have suggested models separately for both midblock crossing and intersection crossing. Some studies do not consider pedestrians with different ranges of ability in the models. Guidelines

are also available for pedestrian crossing facilities but there is need of complete and easy method for assessment which can combine all the indicators from standards and guidelines for assessing the crosswalks for all range of pedestrian. Moreover, the combination of indicators will make the model useful for universal applicability and cover all the aspects of the pedestrian crossing. In addition, the same model could be used to evaluate midblock crossings.

This research attempts to propose a model for pedestrian crossing level of service (PCLOS). The model considers different facilities and conditions for pedestrian during road crossing. Furthermore, the PCLOS model will not only be useful for studying the current service quality but will also be helpful in improvement of existing pedestrian crossing facilities and providing new crossing facilities.

1.3 Problem Statement

Crosswalks are the most important location on the roads because pedestrian have high chances of involvement in the accidents due to higher interaction with vehicles. The task of transportation and urban planners is to design safe and comfortable pedestrian crossing facilities at proper locations. These facilities should be well connected with other aspects of urban life to attract more people to walk. With ever growing car ownership, pedestrians are more at risk than any other road user. The needs of the pedestrians have changed, more facilities with greater safety and comfort are required. There is a need for evaluation method of crosswalks facilities keeping in consideration of pedestrian safety while crossing the road. The method is also needed to support planners in assessing and identifying the key elements in pedestrian crossing safety. Furthermore, a method that can help the decision makers to know the indicators that are detracting pedestrian from walking. Currently, methods are available for evaluating crosswalk but these methods have failed to incorporate all the crosswalks facilities to promote safe pedestrian crossing. Hence, a method development is required that can incorporate all the indicators for improving the existing crosswalks and provide a base for designing new crosswalk facilities.

1.4 Research Objectives

1. To identify effective indicators for the safe pedestrian crossing.
2. To weight the pedestrian crossing indicators.
3. To develop a LOS model for safe pedestrian crossing.
4. To propose improvements in the existing pedestrian crossing facilities using the proposed model.

1.5 Research Questions

1. What are the effective indicators for safe pedestrian crossing?
2. How important are the indicators in pedestrian crossing safety?
3. How can a LOS model be developed for safe pedestrian crossing?
4. What kind of improvements can be done in the existing crosswalks to achieve pedestrian crossing safety?

1.6 Theoretical Framework

Traffic accidents are happening because of unsafe pedestrian crossing. If pedestrian do not feel safe on the road especially at the crossing this will leading to reduced walking in the urban areas. Figure 1.1 shows theoretical framework for this research. There are indicators which have direct relationships with pedestrian safety and walkability. The lesser the number of indicators present at the crossing site, the more at risk are pedestrians. Walkability and safety can be encouraged by installing these facilities according to the standards at crosswalks location. These indicators can be used to evaluate the existing crossing facilities which will give a clear idea of how safe the pedestrian crossings are. The importance of each indicator is different depending on the co-efficient and point score given in the PCLOS method. The point scoring and co-efficient determination of indicators helps in rating the cross sections. Based on the ratings improvements can be suggested in the existing pedestrian crossings.

good quality of life along with decreasing pressure on the urban services in the capital city. Putrajaya is designed on neighbourhood concept and have good pedestrian and vehicle movement routes with good facilities and connectivity.

The second case study that is taken for the research is Peshawar, Pakistan. Peshawar is the capital of province Khyber Pakhtunkhwa, Pakistan. The largest city of Khyber-Pakhtunkhwa is Peshawar and it is also the most populated city of the province. Peshawar is situated in large valley near the eastern end of historic Khyber Pass, close to the Pak-Afghan border. It lies in 34.0150° North and 71.5805° east. Urban Policy Khyber Pakhtunkhwa have realized the importance of the improving existing pedestrian and establishing new networks of pedestrian facilities which includes Precincts and Parking Plaza. In June 2017, Urban Policy Unit (Government of Khyber Pakhtunkhwa) have published new design of pedestrian precincts and parking plaza in Peshawar city. The city administration wishes to provide more lively and walkable environment to the city residents.

Putrajaya is a new city with good pedestrian infrastructure. On the other hand, Peshawar is an old city where the importance of walkability is growing among city planners. It is important to evaluate the existing pedestrian facilities especially crossing based on the PCLOS model in both cities. The research also aims to compare the results for both cities to see the difference in the pedestrian crossing facilities and the level of service of these facilities.

1.8 Research Assumptions

It is assumed that pedestrian crossing facilities will remain unchanged during the research period and changes during the research period will not have significant impact on the result of the research. It is also assumed that co-efficients of the indicators are estimated by questionnaire represent the importance of the indicators in general.

1.9 Research Limitations

This research is limited to pedestrian crossing facilities at grade. Grade separated facilities like pedestrian bridges or pedestrian underpass have different indicators for evaluation and are not included in this research. The findings of the research are generalized to pedestrian crossing however, it cannot be used for assessing cyclist road crossing facilities. Furthermore, the research is limited in computation of model only for pedestrian crossings on the arterial roads. The needs and requirement for different type of roads are different. Hence, standards are only considered for arterial roads. So, the model developed in this research cannot be used for assessing the crosswalks condition on all type of roads. Moreover, the co-efficient of each indicator depends on the rating given by the respondents (Experts, Pedestrian crossing facility users).

1.10 Expected Contribution

This research propose a PCLOS method for assessing the pedestrian crossing facilities in urban areas. City planners and designers will be able to find the problems in existing pedestrian crossings using this model. The method will helps in identifying the critical indicators in crosswalks thus helping in proposing improvements in the existing crossings. The model could be used in different context and for all range of pedestrians hence providing opportunity to planners to think for changes in the pedestrian crossing guidelines and standards for promoting safer crossings. The proposed method can also be used to design new crossing facilities.

1.11 Significance of Research

Previous studies focused and suggested models for pedestrian crossing incorporating indicators like pedestrian perception, traffic volume and pedestrian-vehicle interaction while giving less attention to the importance of crossing facilities and their standards. Furthermore, there is lack of a method for evaluating pedestrian

crossings in urban areas for midblock crossing and crossing at the intersection using the same model. This research develop a PCLOS method based on combination of standards and guidelines implemented in different countries around the world so, the methods can be used universally for the evaluation of pedestrian crossings. In addition, the model could be used for all ranges of pedestrian abilities. At the same time, the same model could be used for midblock crossings and intersection crossings. Moreover, the method will help city planners in making policy intervention for the improvements needed to make the pedestrian crossings safer.

1.12 Research Design

For this study four objective has been formulated after defining the research problem. The research is conducted in phases. There are four phases set in order to achieve each objective. In the very first step the indicators for safe pedestrian crossing were identified. The identification was done through comprehensive literature review of currently available street crossing guidelines and other published material. Based on the identification of effective factors for street crossing a comprehensive guideline was formulated by combining all the effective indicators taken from different source in the second phase. In comprehensive guideline formulation the standard of every indicators was noted. In third stage of the research, these factors are assigned a score through point score method. The scores of indicators are based on the standards gathered at the end of second stage. The weightage of the indicators will help in prioritizing the factors for evaluation and suggesting improvements which is the final stage of the research.

Two types of data is needed for this study (i.e. questionnaire data and case study data). Questionnaire survey was conducted for finding the importance of each indicator. Survey data was collected from the filed experts and pedestrian crossing facilities users to rate the crossing indicators. Respondents rated the crossing indicators from 1-5 based on their experience. The questionnaire data will helps in finding the coefficient of each indicator which will later help in calculating PCLOS for pedestrian crosswalks. Four pedestrian crossing case studies are selected for conducting this

research. An audit tool will be made for collecting data from case studies. The audit tool is based on the indicators identified in the first stage and standards in the comprehensive guideline for pedestrian crossing facilities in the second stage.

After data collection, the data is analysed for each case study to find out the LOS of the crosswalk. PCLOS, PCLOS% and PCLOS grading is used for this purpose. A-F grade is assigned based on the data results. “A” means the highest quality crossing facility while “F” represents that there is no pedestrian crossing facility. Figure 1.2 presents the research methodology adopted for this study. Table 1.1 illustrates how specific objectives can be achieved. Data required and methodology adopted for achieving each objective is identified.



Figure 1.2 Methodology adopted for the research

Table 1.1 Research matrix

Sr. No	Specific Research Objective	Research Question	Required	Methodology
1	To identify effective indicators for the safe pedestrian crossing.	What are the effective indicators for safe pedestrian crossing?	Pedestrian crossing facilities and standards in different countries	Literature review of pedestrian crossing facilities in different countries.
2	To weight the indicators identified in first objective.	How significant are the indicators in pedestrian crossing safety?	Importance of pedestrian crossing facilities, Co-efficient of indicators	Questionnaire
3	To develop a LOS model for safe pedestrian crossing.	How can a LOS model be developed for safe pedestrian crossing?	PCLOS PCLOS%	Point system
4	To propose improvements in the existing pedestrian crossing facilities using proposed model.	What kind of improvements can be done in the existing cross sections to achieve pedestrian crossing safety?	PCLOS grade	Comparing existing conditions with the standards

1.13 Chapter Outlines

Chapter one deals with the background of the research problem, stating the research objectives, scope and underlining the research methods adopted for this study. Chapter two provides a comprehensive review on the research literature available on the LOS, PLOS and PCLOS. The literature review was done for establishing a theoretical understanding on the topic, identifying indicators and to choose a suitable method for conducting this research. Chapter three includes the research design and methodology adopted for the study. The sample size, case study area and respondents are also specified. Chapter four deals with presentation of data, statistical analyses, PCLOS calculation and PCLOS grading for the interpretation of the results. Chapter five provides the summary of the research finding. The results are also discussed in detail and recommendations are suggested for further research.

1.14 Chapter Summary

This chapter introduce the research problem of the study. Objectives of the study are defined based on the research problem. The scope for the study is also underlined. The study will be conducted in two cities that are Putrajaya, Malaysia and Peshawar, Pakistan. Furthermore, the chapter also presents the research design to be used to conduct this research. The data and material needed to achieve each objective are identified. To achieve objectives a comprehensive literature review of the past studies and currently available pedestrian street crossing guidelines was done. Two data collection method (i.e. questionnaire data and case study data) are recognized for the study. Certain assumptions are made for the study to achieve the desired results. The chapter also discuss the limitation, significance and expected contribution of this research.

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