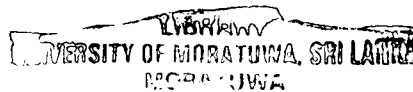



LB/DON/29/03

# DETERMINATION OF SAFETY PERFORMANCE FUNCTION FOR PEDESTRIANS AND CYCLISTS

THESIS SUBMITTED TO THE DEPARTMENT OF CIVIL  
ENGINEERING IN FULFILLMENT OF THE REQUIREMENT  
FOR THE DEGREE OF

**Master of Science**



By  
University of Moratuwa, Sri Lanka  
 P. A. Siriwardhana  
(M.Sc/C/02/2001)

Supervised by  
Dr. (Mrs.) C. Jayasinghe  
Prof. L. L. Ratnayake

677/001  
711.7:656.08

DEPARTMENT OF CIVIL ENGINEERING

UNIVERSITY OF MORATUWA

University of Moratuwa



77716

SRI LANKA

January 2003

77716

UM Thesis coll.

77716



## DECLARATION

I, Pearly Anusha Siriwardhana, hereby declare that the content of this thesis is the output of original research work carried out over a period of 15 months at the Department of Civil Engineering, University of Moratuwa. Whenever the work done by others was used, it was mentioned appropriately as a reference.



University of Moratuwa, Sri Lanka  
Electronic Theses & Dissertations  
[www.lib.mrt.ac.lk](http://www.lib.mrt.ac.lk)



## List of Tables

- Table 2.4.1 Variation of accident rate with pedestrian crossing flow
- Table 2.4.2. Variation of accident rate with traffic flow
- Table 3.1.1 Distribution of accidents in Sri Lanka
- Table 3.2.1 Distribution of pedestrian casualties in Sri Lanka
- Table 3.2.2 Distribution of Cyclist casualties in Sri Lanka
- Table 3.3.1 Distribution of pedestrian accidents in Sri Lanka
- Table 3.3.2 Distribution of bicycle accidents in Sri Lanka
- Table 3.4.1 Age distribution of pedestrian accidents casualties with respect to population
- Table 3.4.2 Age distribution of cyclists casualties with respect to population
- Table 3.5.1 Vehicle involvement in pedestrian accidents as a proportion of vehicle population
- Table 3.5.2 Vehicle involvement in bicycle accidents as a proportion of vehicle population
- Table 3.8.1. Cost analysis of unprotected road user accidents
- Table 3.8.2 Cost evaluation of accidents in Sri Lanka
- Table 5.1.1. Evaluation of EAN value
- Table 5.2.1 Variation of Unprotected road user accidents at selected locations
- Table 5.2.2 Variation of total accidents at selected locations
- Table 5.2.3 Variation of EAN, AR and N for pedestrians
- Table 5.2.4 Variation of EAN, AR and N for bicycle accidents
- Table 5.2.3 Variation of AR and EAN per accidents
- Table 5.3.1 Variation of AR value and EAN per pedestrian accidents
- Table 5.4.1. Variation of AR value and EAN per bicycle accidents



## List of Figures

- Figure 6.2.1.1. Bends at Nulluruwa
- Figure 6.2.1.2 Bends ahead
- Figure 6.2.1.3 Longitudinal markings for the bends
- Figure 6.2.1.4 The existing shoulder space at the junction
- Figure 6.2.1.5 Side walk is shared by both pedestrians and cyclists
- Figure 6.2.1.6 Pedestrian crossing at Nulluruwa
- Figure 6.2.1.7 Placement of bus stop
- Figure 6.2.1.8 Suggested plan for bus bays and crosswalk at the junction
- Figure 6.2.2.1 Existing bus bay at Nava;loka
- Figure 6.2.2.2 Suggested bus bay and crosswalk system a Nāvalōka
- Figure 6.2.2.3 Median barriers on the road
- Figure 6.2.2.4 Implemented pedestrian safety fences along the side walk
- Figure 6.2.3.1 Location of pedestrian crosswalk at he junction
- Figure 6.2.3.2 Suggested bus stop lay out at the junction
- Figure 6.2.3.3. Existing shoulder space at the junction
- Figure 6.2.3.4 Vehicle movement at the junction
- Figure 6.2.4.5 Traffic situation at the junction
- Figure 6.2.4.1 Pedestrian behaviour at the junction
- Figure 6.2.4.2 Vehicle movement at the junction
- Figure 6.2.4.3 Vehicle movement on cross road
- Figure 6.2.4.4 Well – designed junction
- Figure 6.2.4.5. Placement of pedestrian crosswalk
- Figure 6.2.4.6 Implemented pedestrian crosswalk along the sidewalk
- Figure 6.2.5.1 Traffic situation a Rawatawatta

- Figure 6.2.5.2. Pedestrian behaviour at the junction
- Figure 6.2.5.3 Pedestrian crossing behaviour at the junction
- Figure 6.2.5.4 Raised pedestrian crossing
- Figure 6.2.6.1 Pedestrian crosswalk at Korlawella
- Figure 6.2.6.2 Raised pedestrian crosswalk
- Figure 6.2.6.3 Speed cushions
- Figure 6.2.6.4 Pedestrian crossing behaviour on the stretch
- Figure 6.2.6.5 Implemented safety fences along the side walk
- Figure 6.2.7.1 Traffic environment at the junction
- Figure 6.2.7.2 Existing shoulders for pedestrians
- Figure 6.2.7.3 Placement of pedestrian crosswalk
- Figure 6.2.8.1 Traffic situation at the junction
- Figure 6.2.8.2 Vehicle movement at the junction



# Contents

Acknowledgement

Abstract

## Chapter 1

Introduction

1.0 General	1
1.1 Objectives	2
1.2 General Methodology	3
1.3 Arrangement of report	4

## Chapter 2

Literature Review

2.1 General	6
2.2 Studies done on unprotected road users	6
2.3 Relationships between accidents and flow established in other countries	9
2.4 Safety of pedestrians at provided crosswalks	12
2.5 Countermeasures adopted in other countries for unprotected road users	16
2.6 Summary	19

## Chapter 3

Analysis of unprotected road user accidents

3.1 Analysis of past pedestrian and cyclist accident data	22
3.2 Road accident casualties	23
3.3 Severity of accidents	24
3.4 Age group distribution of vulnerable road user casualties	26

3.5 Vehicle involvement in unprotected road user accidents	29
3.6 Hazardous locations for pedestrians	32
3.7 Time variation of unprotected road user accidents	33
3.8 Cost analysis of unprotected road user accidents	34
3.9 Summary	36

## Chapter 4

### Field study

4.0 General	38
4.1 General Methodology	38
4.2 Survey Results	40
4.2.1 Thihariya to Kalagedihene	40
4.2.1.1 Problem related to unprotected road users at Thihariya to Kalagedihene	41
4.2.1.2 Survey results	42
4.2.2. Havelock road Thunmulla junction	43
4.2.2.1 Problem related to unprotected road user accidents at Thunmulla	44
4.2.2.2 Survey results	45
4.2.3. Koongaha junction	46
4.2.3.1 Problem related to unprotected road user accidents at Kongaha junction	47
4.2.3.2 Survey results	48
4.2.4 Koralawella junction	49
4.2.4.1 Problem related to unprotected road user accidents at Koralawella	50
4.2.4.2 Survey results	51
4.2.5 Nalluruwa junction	53

★	4.2.5.1 Problem related to unprotected road user accidents at Nulluruwa	54
	4.2.5.2 Survey results	55
	4.2.6 Nittabuwa junction	58
	4.2.6.1 Problem related to unprotected road user accidents at Nittabuwa	59
	4.2.6.2 Survey results	60
★	4.2.7 James Peris junction	62
	4.2.7.1 Problem related to unprotected road user accidents at James peris	63
	4.2.7.2 Survey results	64
	4.2.8 Rawatawatta junction	66
	4.2.8.1 Problem related to unprotected road user accidents at Rawatawatta	67
★	4.2.7.2 Survey results	68
	4.2.9 Wadiyamankada junction	70
	4.2.9.1 Problem related to unprotected road user accidents at Wadiyamankada	71
	4.2.9.2 Survey results	72
★	4.2.10 Yakkala junction	73
	4.2.10.1 Problem related to unprotected road user accidents at Yakkala	74
	4.2.9.2 Survey results	75



## Chapter 5

### Analysis of field data

5.1 Analysis Methodology	78
5.1.1. Determination of EAN value	78
5.1.2 Definition of Accident rate value	79
5.2 Prioritization of unprotected road user accident prone location	80
5.3 Prioritization of pedestrian accident prone location	87
5.4 Prioritization of bicycle accident prone location	90
5.5 Summary of established mechanism	92
5.6 Pedestrian safety on zebra crossing	94
5.6.1 Determination of safety on the zebra crossing with respect to vehicle flow	94
5.6.2 Summary	98

## Chapter 6

Road safety countermeasures for unprotected road users	99
6.1 Suggested countermeasures for pedestrians and cyclists In Sri Lanka	100
6.2 Safety counter measures for vulnerable road users	102
6.2.1 Nulluruwa junction	105
6.2.2 Navaloka junction	112
6.2.3 Wadiyamankada junction	115
6.2.4 Nittabuwa junction	120
6.2.5 Rawatawatta junction	126
6.2.6 Korawella junction	131
6.2.7 Koongaha junction	135
6.2.8 Yakkala junction	137



◆ **Chapter 7**

Conclusion and Recommendations 141

References 144

Appendix A

Appendix B



University of Moratuwa, Sri Lanka  
Electronic Theses & Dissertations  
[www.lib.mrt.ac.lk](http://www.lib.mrt.ac.lk)

◆

## Acknowledgement

*I wish to thank University of Moratuwa for providing funds and Department of Civil Engineering for providing facilities to the entire research.*

*I would like to thank Prof. L. L. Ratnayake, who always gave his kind support to complete my research and my special thanks should go to*

*Dr. (Mrs.) C. Jayasinghe, who always encouraged me by giving correct advises and showing me the correct path to complete this research successfully.*

*I express my special thank to Mr. Kurt Fahleson, Swe Road for giving me funds and the other facilities to carry out the field study successfully. I would like to give my sincere thank to Mr. Robert Ortegren and Mr. Lars Persson from Swe Road for helping me through out the field study.*

*I also take this opportunity to express my sincere thank to my friends, Mr. Damith Dishantha, Mr. Asitha Jayawardana, Mr. Ranil Sugatadasa, Mr. Manoj Fernando, Mr. Crishantha Malnayaka, Mr. Chaminda, Mr. Sandun, Miss A. K. M. Priyanvada, Mrs. Vasana Jayasena and Miss. Tharanga Fernando who have spent their valuable time and energy to finish field study successfully.*

*All the help from Police Head Quarters is also gratefully appreciated. Specially I wish to express my sincere thanks to Mr. C. I. Sanders, ASP, Police head quarters and Mr. Premathilake, OIC, Statistical Branch, police head quarters for helping me to collect all the police accident data.*

## **Abstract**

A road traffic accident is an accident occurring or originating on the street open to public traffic, resulting in one or more persons being injured or killed and involving at least one moving vehicle. Out of these road traffic accidents unprotected road user accidents that is both pedestrians and cyclists involved in accidents make a big contribution to the accident statistics. In Sri Lanka, major proportion of accident victims is pedestrians and cyclists who also constitute the majority of road users. In year 1999, there were 6 485 pedestrian accidents and 2 753 bicycle accidents. According to the police accident statistics 33% and 12% of total accident casualties were pedestrians and cyclists respectively. Therefore, it is imperative to give more emphasis to bring down the unprotected road user accidents in Sri Lanka. Since there are so many places with unprotected road user accidents in the country, it is necessary to select the locations with more severe road safety problems. In order to identify such locations there are three mechanisms used in this research considering the number of accidents, severity of accidents and the traffic flow. The indicators used are the number of accidents, equivalent accident number (EAN) and the accident rate (AR). The safety performance functions for pedestrians and cyclists have been developed considering the selected indicators. The limits for the EAN per accident and AR have been determined in order to select the accident black spots for safety improvements giving prominence to the unprotected road user accidents. These limits can be revised in future as the road safety improves, in the country.

This research also includes the assessment of pedestrian crossing as a safety feature. This study revealed that the marked zebra crossings do not offer a well safe place for the pedestrians to cross the road. Therefore, more and more pelican crossings and other safety features around the pedestrian crosswalks should be introduced to improve the pedestrian behaviour and the driver compliance.

Analysis of unprotected road user/ motor vehicle crashes help to establish engineering, education and enforcement solutions. It is proposed that, although educational and enforcement counter measures may serve to increase safe cycling and walking, they are likely to provide benefit only in the short term. Engineering countermeasures that focus on changing the road environment to give cyclists and pedestrians their own space are imperative

to increase safe cycling and walking in long term. In this analysis, it was suggested suitable engineering countermeasures for unprotected road users at selected black spot locations corresponding to the observed safety problems.



University of Moratuwa, Sri Lanka  
Electronic Theses & Dissertations  
[www.lib.mrt.ac.lk](http://www.lib.mrt.ac.lk)

