

# DEVELOPMENT OF A MIX DESIGN METHOD FOR PERVIOUS CONCRETE

G.D.M.Pathmakumara

(Admission No: 09/8922)



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

Department of Civil Engineering

University of Moratuwa  
Sri Lanka

March 2014

# **DEVELOPMENT OF A MIX DESIGN METHOD FOR PERVIOUS CONCRETE**

Gamaethige Don Mahinda Pathmakumara

(Admission No: 09/8922)



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

Thesis Submitted in Partial Fulfillment of the Requirements for the  
Degree Master of Science

Department of Civil Engineering

University of Moratuwa  
Sri Lanka

March 2014



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

## **CHAPTER 01 – INTRODUCTION**



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

## **CHAPTER 02 – LITERATURE REVIEW**



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

## **CHAPTER 03 – EXPERIMENTAL STUDY**



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

## **CHAPTER 04 – TESTING PROCEDURE**



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

## **CHAPTER 05 – ANALYSIS OF TEST RESULTS AND DISCUSSION**



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

**CHAPTER 06 – CONCLUSIONS AND  
RECOMMENDATIONS FOR FURTHER RESEARCH**





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

## **APPENDIX A – PICTURES OF CONSISTENCY TEST**



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

## **APPENDIX B – TEST RESULTS AND CALCULATIONS**



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

**APPENDIX C – SAMPLE CALCULATION USING  
PROPOSED MIX DESIGN METHOD**

## DECLARATION

I declare that this is my own work and this thesis does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any University or other institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

Also, I hereby grant to University of Moratuwa the non-exclusive right to reproduce and distribute my thesis, in whole or in part in print, electronic or other medium. I retain the right to use this content in whole or part in future works (such as articles or books).

Signature:.....

Date:.....



University of Moratuwa, Sri Lanka.

Electronic Theses & Dissertations

[www.lib.mrt.ac.lk](http://www.lib.mrt.ac.lk)

The above candidate has carried out research for the Masters under my supervision.

Signature:.....

Date:.....

Dr.Mrs. D. Nanayakkara

Supervisor

## ABSTRACT

Rapid infrastructure development and urbanization of many rural areas can be seen in Sri Lanka recently. Concrete is widely used in construction of roads, sidewalks, embankments, parking areas and drainage systems due to its fast, easiness in construction and low maintenance cost. Unless well designed drainage systems are provided and regularly maintained, concrete paved impervious areas could cause serious environmental problems such as reduced ground water infiltration, frequent flooding during rainy seasons, need of larger drainage systems to cater for higher storm water run-offs, and risk of epidemics due to mosquito breeding in poorly constructed concrete drains. Pervious concrete is developed and widely used today in most of the developed countries to address most of these problems.

However in Sri Lanka, it is not widely used due to lack of knowledge of its applications, properties, and also due to non-availability of proper mix design method to produce pervious concrete to achieve required properties. Therefore, a research study has been carried out to investigate the properties of pervious concrete to develop a simple mix design method. This report describes all details of the research study including the findings of the experimental study and the proposed mix design procedure to achieve the required compressive strength and permeability of concrete.

Keywords - infiltration, porosity, permeability, gap graded concrete

## ACKNOWLEDGEMENT

The completion of this thesis was made possible by the help of many individuals. I take this opportunity to express my gratitude and indebtedness to my supervisor Dr. Mrs. Dhammika Nanayakkara, for her scholarly guidance, enthusiasm, proactive attitude and advice at every stage of the research study to complete it successfully. Without her direction, this thesis could not possibly have been completed in such an organized and timely manner.

I am grateful to the National Water Supply & Drainage Board for giving this opportunity with financial support and the duty leave required to carry out this research study.

Also I am extending my gratitude to University of Moratuwa, staff of Building Materials laboratory, Soil Mechanics laboratory, Hydraulic Engineering laboratory and Workshop for their great assistance extended to me.

I would like to thank my mother, wife and sons for bearing with me and supporting me to do this research study during weekends and nights and sacrificing limited time available for family get-together.



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


Finally, I offer my appreciation to all officers in National Water Supply & Drainage Board who helped me to complete this research successfully.

# TABLE OF CONTENTS

	Page
Declaration	i
Abstract	ii
Acknowledgement	iii
Table of contents	iv
List of Figures	vii
List of Tables	viii
List of Appendices	ix
Chapter 01: Introduction	01
1.1 General	01
1.2 Need for the research	02
1.3 Objectives of the research study	03
1.4 Scope of the research	03
1.5 Methodology	04
1.6 Arrangement of the thesis report	05
Chapter 02: Literature Review	06
2.1 Main applications and benefits of pervious concrete	06
2.2 Materials used for pervious concrete	07
2.2.1 General	07
2.2.2 Aggregate	08
2.2.3 Water	09
2.2.4 Cementitious materials	10
2.2.5 Admixtures	10



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

2.3	Properties of pervious concrete	11
2.3.1	General	11
2.3.2	Strength	11
2.3.3	Porosity and permeability	12
2.3.4	Workability (Consistency)	13
2.3.5	Durability	14
2.4	Available mix design methods	14
2.5	Disadvantages of pervious concrete	16
2.6	Clogging of pervious concrete	16
Chapter 03:	Experimental Study	18
3.1	General	18
 3.2	Selection of Materials	18
3.3	Material proportioning and test parameters	19
3.4	Mixing procedure	20
3.5	Compaction of specimens	21
3.6	Specimen preparation	22
Chapter 04:	Testing Procedure	24
4.1	General	24
4.2	Determination of coefficient of permeability	24
4.3	Determination of compressive strength	30
4.4	Determination of flexural strength	30
4.5	Determination of effective porosity	32
Chapter 05:	Analysis of Test Results and Discussion	35
5.1	General	35



5.2	Test results for compressive strength	35
5.2.1	Variation of compressive strength with w/c ratio	36
5.2.2	Variation of compressive strength with paste content	37
5.3	Test results for effective porosity and permeability	38
5.3.1	Variation of effective porosity with paste content	40
5.3.2	Variation of permeability with paste content	41
5.3.3	Variation of permeability with effective porosity	41
5.4	Variation of flexural strength	42
5.5	Discussion on test results	45
5.5.1	Compressive strength	45
5.5.2	Porosity and permeability	46
5.5.3	Workability	47
5.5.4	Determination of $b/b_0$ ratio	49
Chapter 06:	Conclusions and Recommendations for Further Research	51
6.1	Development of mix design method for pervious concrete	51
6.2	Conclusions and recommendations	54
6.3	Further Studies	54
	Reference List	56
Appendix A	Pictures of consistency test	58
Appendix B	Test results and calculations	60
Appendix C	Sample calculation using proposed mix design method	132



## LIST OF FIGURES

		Page
Figure 1	Water flow through pervious concrete	02
Figure 2	Surface textures of pervious concrete samples with different aggregate sizes	09
Figure 4.1	Constant head permeability arrangement	25
Figure 4.2	Apparatus used to determine the constant head permeability of pervious concrete	27
Figure 4.3	Constant head permeability test setup	28
Figure 4.4	Loading arrangement for flexural strength test	31
Figure 4.5	Arrangement of effective porosity test	32
Figure 5.1	Compressive strength vs water/cement ratio	36
Figure 5.2	Compressive strength vs paste content	37
Figure 5.3	Effective porosity vs paste content	40
Figure 5.4	Permeability vs paste content	41
Figure 5.5	Permeability vs effective porosity	42
Figure 5.6	Flexural strength vs paste content	43
Figure 5.7	Compressive strength vs flexural strength	44
Figure 5.8	Consistency having paste content 0.20 and w/c ratio 0.30	48
Figure 5.9	Consistency having paste content 0.22 and w/c ratio 0.30	48
Figure 5.10	Consistency having paste content 0.24 and w/c ratio 0.27	49
Figure 6.1	Permeability vs effective porosity	52
Figure 6.2	Effective porosity vs paste content	52
Figure 6.3	Compressive strength vs paste content	53

## LIST OF TABLES

	Page
Table 2.1	15
Material proportions given by National Ready Mix Concrete Association	
Table 3.1	20
Selected test parameters for the research study	
Table 5.1	35
Compressive strength of different pervious concrete mixes	
Table 5.2	39
Test results of effective porosity and permeability	
Table 5.3	43
Test results of flexural strength	
Table 5.4	50
Calculated values for $b/b_0$ ratio	



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

## LIST OF APPENDICES

Appendix	Description	Page
Appendix – A	Pictures of consistency test	58
Appendix – B	Test results and calculations	60
Appendix – C	Sample calculation using proposed mix design method	132



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