

# **PROPERTY CHANGE OF ROAD AGGREGATE WITH BLASTING EFFECTS**

A.L.N.U. Abeysinghe

108602



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

M. Eng. in Highway and Traffic Engineering

Department of Highway and Traffic Engineering

University of Moratuwa

Sri Lanka

November 2013

## **Declaration of the Candidate and Supervisor**

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 the 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 also retain the right to use this content in whole or part in future works (such as articles or books).

Signature:

Date:

The above candidate has carried out research for the Master/MPhil/PhD thesis/  
Dissertation under my supervision.



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

Signature of the supervisor:

Date:

## ACKNOWLEDGEMENT

First and foremost, I wish to express my sincere gratitude to University of Moratuwa, Sri Lanka, for giving me the opportunity to follow my post graduate programme at department of civil engineering, University of Moratuwa. I would also like to thank Dr. W.K. Mampearachchi for giving me a chance to complete my study under his supervision. This dissertation would not have been a reality if not for his friendly guidance and shared knowledge.

I wish to thank Professor Manjriker Gunarathne, Chairman, Department of Civil Environment Engineering, University of South Florida, for his generous and valuable comments for the successful completion of this research.

I am thankful to Professor J.M.S.J. Bandara and other staff members of Transportation Engineering Division, University of Moratuwa, for imparting their experience and knowledge to complete my dissertation.

I would like to express my sincere thank to Maga Engineering (Pvt.) Ltd, for granting me leave and providing financial support to complete my studies at university of Moratuwa.

I am grateful to my friends and the staff working with me in the projects. Special thanks go to Mr. Chaminda Wijesinghe, Mr. Indika Samarakkody, Mr. Shashika Gayan and Miss. Piyumi Niroshini for supporting me to complete this research despite their busy schedules.

Last but not least I extend my gratitude and appreciation to my family for their support and motivation. My thanks and blessings go to everyone who supported me to complete this study, successfully.

## ABSTRACT

Road aggregate is the largest component contributing to road construction. In Sri Lanka, naturally occurring sources that suits construction work are not available. Therefore, this requirement is most commonly fulfilled by excavating rocks and crushing them to suitable sizes.

Demand for road aggregate has increased due to the current development of highway sector in Sri Lanka, and it is difficult to satisfy the requirement. In some areas of the country, especially in the Northern region, it is hard to fulfill these requirements due to several reasons such as archeological sites and environmental-sensitive forest areas. Therefore, quality control and fulfillment of the requirement with the available limited sources is a challenge.

Considering the use of crushed rock for road construction, it is important to select materials in an acceptable quality. Especially when crushed rock is used for the road bases and surfacing, these properties play a vital role in ensuring durability. To ensure the quality, various tests have been introduced by relevant authorities.

When selecting a source to produce crushed rock as road construction material, production from the selected source have to satisfy certain requirements. The los angeles abrasion value (LAAV) and aggregate impact value (AIV) is the two important tests which ensure the strength requirement of road aggregate.

With the blasting operation, a considerable variation of rock fragmentation is noted. This is mainly due to the explosive quantity used for blasting operation. Types and features of explosives and blasting design also play an important role of rock mass fragmentation.


In Sri Lanka, blasting design patterns and the explosives used do not vary considerably. But usage of explosives changes in continuous operation even the place is unchanged. These changes may be due to environmental conditions such as rainy seasons or due to some significant change of nature and properties of rock mass.

The objective of this study was to identify the changes of AIV and LAAV with the use of explosive percentage used for the blasting operation and improve the strength of road aggregate by controlling the explosive usage for aggregate production.

There was not found a relationship between explosive usage for blasting and the aggregate strength properties. But the significant relationship was found between the LAAV and AIV of the aggregate.

**Key words:** Los Angeles Abrasion Value, Aggregate Impact Value, Explosive Percentage

## TABLE OF CONTENTS

Declaration of the Candidate and Supervisor	i
Acknowledgement	ii
Abstract	iii
Table of contents	iv
List of Figures	viii
List of Tables	x
List of Abbreviations	xi
List of Appendices	xii
Chapter 1: Introduction	
 1.1 Introduction	1
1.2 Problem Statement	3
1.3 Objective	3
Chapter 2: Literature Survey	
2.1 Introduction	4
2.2 Related Findings	4
Chapter 3: Quarry Blasting Practices in Sri Lanka	
3.1 Introduction	10
3.2 Explosives	10
3.2.1 Ammonium Nitrate and Fuel Oil (ANFO)	11

3.2.2	Dynamite	12
3.2.3	Water Gel (Slurry)	13
3.3	Types of Blasts	14
3.3.1	Production Blasting	14
3.3.2	Controlled Blasting	15
3.4	Drilling Patterns	16
3.4.1	Squire Type Drilling	16
3.4.2	V-Cut Type Drilling	17
3.4.3	Zigzag Type Drilling	17
3.5	Blast Design	18
3.5.1	Face	19
3.5.2	Bench Height	19
3.5.3	Burden Distance	19
3.5.4	Spacing	19
3.5.5	Blast hole depth	20
3.5.6	Stemming	20
3.5.7	Sub Drilling	20
3.5.8	Blast hole Diameter	20
3.5.9	Stiffness Ratio	20
3.6	Sri Lankan practice of Quarry Blasting	21



Chapter 4: Strength Test Used For Crushed Aggregates		
4.1	Introduction	23
4.2	Aggregate Impact Value	24
4.3	Los Angeles Abrasion Value	27
4.4	Aggregate Crushing Value	29
4.5	Ten Percent Fines Value	31
4.6	Water Absorption Test	32
Chapter 5: Methodology		
5.1	Introduction	34
5.2	Methodology and data collection	35
5.3	Geology of selected quarry sites	41
Chapter 6: Data analysis		
6.1	Specification Requirements	42
6.1.1	Aggregate for cement concrete	42
6.1.2	Aggregate for the construction and maintenance of bases and surfacing of flexible pavements	43
6.2	Effect of explosive amount on aggregate properties	43
6.3	Evaluation of results	49
Chapter 7: Conclusions and Recommendations		51
Reference List		52



Appendix: A - Data Analysis	53
Appendix: B - Data Sheets	85
Appendix: C - Sample Questionnaire Form	94



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



## LIST OF FIGURES

	Page	
Figure 2.1	Correlation of block fragmentation and tensile strength	5
Figure 2.2	Correlation of Feldspar (%) and Impact Value (%)	6
Figure 2.3	Correlation of Mica (%) and Impact Value (%)	7
Figure 2.4	Correlation of Feldspar (%) and Abrasion Value (%)	7
Figure 2.5	Correlation of Quartz (%) and Abrasion Value (%)	8
Figure 2.6	Correlation of number of micro cracks and Flakiness	8
Figure 2.7	Correlation of number of micro cracks and Abrasion Value	9
Figure 3.1	Preparation of ANFO to use for blasting in wet and dry condition	11
Figure 3.2	A dynamite cartridge	13
Figure 3.3	Water gel	14
Figure 3.4	Squire Type drilling pattern	16
Figure 3.5	V-Cut drilling pattern	17
Figure 3.6	Zigzag drilling pattern	17
Figure 3.7	Effective parameters for blasting and drilling	19
Figure 3.8	Drilling equipment	22
Figure 4.1	Aggregate Impact Value Testing Machine	26
Figure 4.2	LAAV testing machine	27
Figure 5.1	Flow chart	34

Figure 5.2	Spacing of drilled holes	36
Figure 5.3	Burden Distance	36
Figure 5.4	Bore hole diameter and depth	37
Figure 5.5	Charging of bore hole with water gel, electric detonators and ANFO	38
Figure 5.6	Dynamite cartridge and electric detonator	38
Figure 5.7	Stemming height and sealing of bore hole	39
Figure 5.8	Sample collection	39
Figure 6.1	Comparison of AIV, LAAV and ANFO usage per unit volume at Mirijjawila Quarry	44
Figure 6.2	Comparison of AIV, LAAV & Water gel usage per unit volume at Mirijjawila Quarry	44
Figure 6.3	AIV and LAAV with Explosive usage at Komari Quarry	45
Figure 6.4	Comparison of AIV, LAAV & Explosive usage per unit volume at Haggala Quarry	45
Figure 6.5	Correlation of AIV and LAAV for Crusher Samples	46
Figure 6.6	Correlation of AIV and LAAV for all samples	46
Figure 6.7	Correlation of LAAV and Water Absorption percentage	47
Figure 6.8	Correlation of AIV and Water Absorption percentage	47
Figure 6.9	Correlation of AIV and LAAV/AIV for Crusher samples	48
Figure 6.10	Correlation of AIV and LAAV/AIV for all samples	48
Figure 6.11:	Correlation of Log (AIV) and Log (AIV) / Log (LAAV)	49

## LIST OF TABLES

		Page
Table 3.1	Stiffness ratio's effect on blasting factors	21
Table 4.1	Specification limits of course aggregates in various applications in road construction	23
Table 4.2	Particulars of test sieves for testing in size fraction of aggregates	25
Table 4.3	Guide to minimum mass of test portion required to a suitable mass of material to determine the AIV	25
Table 4.4	The charge depending on the grading of test sample	28
Table 4.5	Grading of aggregate relevant to the work	28
Table 4.6	Selection of sample size	29
Table 4.7	Minimum mass for test	30
Table 4.8	Selection of test sieve for ACV	31
Table 4.9	Selection criteria of minimum weight for test samples	33
Table 5.1	Drillers norms to assume the AIV of rock according to experience	40

## LIST OF ABBREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials
ACV	Aggregate Crushing Value
AIV	Aggregate Impact Value
ANFO	Ammonium Nitrate and Fuel Oil
ASTM	American Society for Testing and Materials
DBA	Dense Blasting Agent
GSMB	Geological Survey and Mines Bureau
ICTAD	Institute for Construction Training and Development
LAAB	Los Angeles Abrasion Value
RDA	Road Development Authority
SR	Stiffness Ratio
SSCM	Standard Specification for Construction and Maintenance of Highways and Bridges
TFV	Ten percent Fines Value
TNT	Trinitrotoluene



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

## LIST OF APPENDICES

Appendix - A	Data Analysis
Appendix - B	Data Sheets
Appendix - C	Sample Questionnaire Form



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