

**PROPERTIES OF MODIFIED BITUMEN IN
HOT MIX ASPHALT USING CRUMB RUBBER**

HASHIMAH BINTI MOHD HADZRI

B. ENG(HONS.) CIVIL ENGINEERING

UNIVERSITI MALAYSIA PAHANG



SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Bachelor of Civil Engineering

(Supervisor's Signature)

Full Name : DR. FADZIL BIN MAT YAHAYA

Position : SUPERVISOR

Date : 19 June 2017



STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

(Student's Signature)

Full Name : HASHIMAH BINTI MOHD HADZRI

ID Number : AA13037

Date : 19 June 2017

PROPERTIES OF MODIFIED BITUMEN IN HOT MIX ASPHALT USING
CRUMB RUBBER

HASHIMAH BINTI MOHD HADZRI

Thesis submitted in fulfillment of the requirements
for the award of the
Bachelor Degree in Civil Engineering

Faculty of Civil Engineering and Earth Resources

UNIVERSITI MALAYSIA PAHANG

JUNE 2017

ACKNOWLEDGEMENTS

Alhamdulillah, a very thankful to Allah S.W.T with His help, I have been able to complete this final year project. Many of my colleagues in my university and my lecturers have made constructive criticisms that have helped in the development of this final year project.

I personally would like to thank my supervisor, Dr. Fadzil bin Mat Yahaya for his guides, encouragement and advices during my final year project development. My utmost gratitude goes to the Faculty of Civil Engineering and Earth Resources, Universiti Malaysia Pahang (UMP) and their staff for giving me an opportunity to accomplish my studies. Thousands of thanks to Highway and Traffic Laboratory lab technicians for their helps in physical aspect and brilliant ideas during my research in final year project.

Finally, I would like to acknowledge the help I received from my parents, families and friends, who has always been very supportive and helpful in my life. Last but not least, to all the parties involved not only in my final year project but also giving the best memories throughout these four years in UMP.

.

TABLE OF CONTENT

DECLARATION	
TITLE PAGE	
ACKNOWLEDGEMENTS	ii
ABSTRAK	iii
ABSTRACT	iv
TABLE OF CONTENT	v
LIST OF TABLES	ix
LIST OF FIGURES	x
LIST OF SYMBOLS	xi
LIST OF ABBREVIATIONS	xii
CHAPTER 1 INTRODUCTION	1
1.1 Background of Study	1
1.2 Problem Statement	2
1.3 Objective of the Study	3
1.4 Problem Statement	3
1.3 Importance of the Study	4
CHAPTER 2 LITERATURE REVIEW	5
2.1 Introduction	5
2.2 Crumb Rubber	6
2.3 Crumb Rubber Grinding Process	6
2.4 Benefits Using of Crumb Rubber	7

2.4.1	Reduced the Demand for Aggregates	7
2.4.2	Reduced the Demand For Bituminous Binders	7
2.4.3	Reduced Waste	7
2.4.4	Cost Effective	8
2.5	Crumb Rubber Modified Bitumen	8
2.6	Modification of Crumb Rubber	8
2.7	Wet Process	10
2.8	Volumetric Properties	11
2.9	Summary	11
CHAPTER 3 METHODOLOGY		12
3.1	Introduction	12
3.2	Research Flow Chart	13
3.3	Sample Preparation of Crumb Rubber Modified Bitumen	14
3.4	Softening Point of Bitumen	15
3.4.1	Apparatus	15
3.4.2	Procedure	15
3.5	Penetration of Bituminous Materials	17
3.5.1	Apparatus	17
3.5.2	Procedure	17
3.6	Sieve Analysis	19
3.6.1	Apparatus	19
3.6.2	Procedure	19
3.7	Aggregate Gradation	20
3.8	Marshall Mix Design (ASTM or BS)	21

3.8.1	Apparatus	21
3.8.2	Procedure	21
3.9	Testing	24
3.9.1	Density and Void Analysis	24
3.9.2	Marshall Stability & Flow Test	26
3.9.2.1	Procedure	26
3.10	Optimum Bitumen Content (OBC)	28
CHAPTER 4 RESULTS AND DISCUSSION		29
4.1	Introduction	29
4.2	Bitumen Properties	29
4.2.1	Penetration of Bituminous Materials	29
4.2.2	Softening Point of Bitumen	32
4.3	Sample Preparation of Marshall Test	33
4.4	Marshall Test	34
4.5	JKR Specification	34
4.6	Results of Volumetric Properties	34
4.6.1	Air Void- Bitumen Content Relationship	36
4.6.2	Stability- Bitumen Content Relationship	38
4.6.3	Flow- Bitumen Content Relationship	40
4.6.4	Void in Filled Bitumen (VFB) - Bitumen Content Relationship	42
4.6.5	Stiffness- Bitumen Content Relationship	43
4.6.6	Bulk Density- Bitumen Content Relationship	45
CHAPTER 5 CONCLUSION		47
5.1	Introduction	47

5.2	Conclusion	47
5.3	Recommendations	48
	REFERENCES	49
	APPENDIX A MARSHALL MIX DESIGN	51
	APPENDIX B SOFTENING POINT OF BITUMEN	59
	APPENDIX C PENETRATION OF BITUMINOUS MATERIALS	63

LIST OF TABLES

Table 3.1	Design bitumen contents	17
Table 3.2	Gradation of aggregate	20
Table 4.1	Penetration for unmodified	30
Table 4.2	Penetration for modified 1% of crumb rubber	30
Table 4.3	Penetration for modified 2% of crumb rubber	30
Table 4.4	Penetration for modified 3% of crumb rubber	31
Table 4.5	Softening Point for unmodified and modified bitumen	32
Table 4.6	JKR specification	34
Table 4.7	Summary of Marshall Test results for 0% crumb rubber	35
Table 4.8	Summary of Marshall Test results for 1% crumb rubber	35
Table 4.9	Summary of Marshall Test results for 2% crumb rubber	35
Table 4.10	Summary of Marshall Test results for 3% crumb rubber	36

LIST OF FIGURES

Figure 2.1	Dry Process	9
Figure 2.2	Wet Process	10
Figure 3.1	Methodology Flow Chart	13
Figure 3.2	Weighed of Crumb Rubber	14
Figure 3.3	Mix Crumb Rubber with Bitumen	14
Figure 3.4	Crumb Rubber Modified Bitumen	15
Figure 3.5	Softening Point Preparation	16
Figure 3.6	Softening Point Test	16
Figure 3.7	Unmodified and Modified Bitumen for Penetration	18
Figure 3.8	Penetration Test	18
Figure 3.9	Mechanical Sieve Shaker	20
Figure 3.10	Modified Bitumen Mix	22
Figure 3.11	Placed Mix into Mould	23
Figure 3.12	Placed Specimen into Marshall Compactor	23
Figure 3.13	Measurement of Specimen	24
Figure 3.14	Placed the Specimen in Water Bath	27
Figure 3.15	Crumb Rubber Modified Bitumen	27
Figure 4.1	Summary of Penetration Test	32
Figure 4.2	Summary of Softening Point Test	33
Figure 4.3	Air void vs Binder Content for Unmodified	37
Figure 4.4	Air void vs binder content for modified	37
Figure 4.6	Marshall Stability vs Binder Content for Unmodified	39
Figure 4.6	Marshall Stability vs Binder Content for Modified	39
Figure 4.7	Flow vs Binder Content for Unmodified	41
Figure 4.8	Flow vs Binder Content for Modified	41
Figure 4.9	VFB vs Binder Content for Unmodified	42
Figure 4.10	VFB vs Binder Content for Modified	43
Figure 4.11	Stiffness vs Binder Content for Unmodified	44
Figure 4.12	Stiffness vs Binder Content for Modified	44
Figure 4.13	Bulk density vs Binder Content for Modified	45
Figure 4.14	Bulk density vs Binder Content for Modified	46

LIST OF SYMBOLS

mm	Millimeter
dmm	Deci-millimeter
g/cm ³	Gram per centimeter square
g	Gram
kg	Kilogram
s	Second
°C	Degree Celsius
N	Newton
kN	Kilo Newton

LIST OF ABBREVIATIONS

ASTM	American Society Testing for Materials
BS	British Standard
HMA	Hot mix Asphalt
JKR	Jabatan Kerja Raya
CR	Crumb rubber
PEN	Penetration
CRM	Rubberized Modified Bitumen
RMB	Rubberized Modified Bitumen
CRM	Crumb rubber modifier
OBC	Optimum Bitumen Content