

Marshall immersion test of warm mix asphalt polymer using Bayat natural zeolite

By Hita Pandita

17

IOP Conference Series: Materials Science and Engineering

PAPER • OPEN ACCESS

6

Marshall immersion test of warm mix asphalt polymer using Bayat natural zeolite

To cite this article: A T Handayani *et al* 2019 *IOP Conf. Ser.: Mater. Sci. Eng.* **602** 012106

10

View the [article online](#) for updates and enhancements.

239th ECS Meeting

with the 18th International Meeting on Chemical Sensors (IMCS)

ABSTRACT DEADLINE: DECEMBER 4, 2020



May 30-June 3, 2021

SUBMIT NOW →

This content was downloaded from IP address 103.145.97.38 on 23/11/2020 at 03:50

6

Marshall immersion test of warm mix asphalt polymer using Bayat natural zeolite

A T Handayani^{1*}, S N Peni², H Pandita³

¹Department of Civil Engineering, STTNAS, Yogyakarta, Indonesia

²Department of Geology, STTNAS, Yogyakarta, Indonesia

³Department of Geology, STTNAS, Yogyakarta, Indonesia

E-mail: ani.tjitra@sttnas.ac.id

Abstract. The development of increasingly dense traffic and weather changes greatly affect the quality of the pavement which could cause premature damage. Elastomeric polymer modified asphalt is used to reduce the early damage and increase the durability of pavement to various damage such as fatigue, cracking due to temperature changes. All this time polymer asphalt mixing is using hot mix asphalt method. According to the name the hot mixing asphalt requires heating at a certain temperature which is quite high on the Asphalt Mixing Plant (AMP), also requires a certain density. Some countries have developed asphalt mixture known as Warm Mix Asphalt by mix temperatures and compaction temperatures lower than hot asphalt mixtures using the added material. Research using experimental methods with elastomeric polymer bitumen as a binder in the warm mix asphalt with the added material of natural zeolite, thus obtained mixture quality hot asphalt mixture equivalent but processed by low mixing and compaction temperatures. Based on Marshall test asphalt polymer with zeolite content of 1.5% of natural zeolite sieve no. 400, has the highest stability values 1627,7 kg, has the residual stability value of 93,36%. The value of residual stability meet the specifications Department of Public Works of Highways, 2010, indicating that the residual stability the warm mix asphalt with 1.5% Bayat natural zeolite is high and the water resistance is very good.

1. Introduction

1.1. Background

Polymer modified asphalt is used to improve the durability of pavement to various damage such as fatigue, permanent deformation, cracking due to temperature changes. But unfortunately polymer modified asphalt mixing process, this time using the method of Hot Mix Asphalt. Hot asphalt mixture using a polymer modified asphalt intended to increase resistance to a variety of damages require the mixing temperature in Asphalt Mixing Plant, which is higher around 175°C. Mixing temperature is the temperature where the bitumen has a viscosity of 170 ± 20 cSt viscosity whereas for asphalt compaction temperatures between 280 ± 30 cSt [1]. The high temperature of mixing and compaction in the process of making asphalt mixture resulted in a lot of fuel, exhaust emissions are large and high costs [2].

Some countries have developed asphalt mixture with mixing and compaction temperatures lower than hot asphalt mixture known as Warm Mix Asphalt. Warm mix asphalt (WMA) is a new kind of energy saving and environmental protection material, which has broad application prospects. Warm mix asphalt technology has become the main method in the use of road construction in the United States and the world. It is because of the fuel savings, environmentally friendly [3]. Warm Mix



Asphalt, produced in AMP and compacted in the field while maintaining the required workability so it can be spread and compacted well [4]. Classification of warm mix asphalt based on the technology can be classified into three types; based on chemical uses, water uses and process using water and additive [4]. Most research warm mix asphalt using pure asphalt binder with the added ingredient of synthetic zeolite. In this research, the material used is asphalt binder polymer elastomer types E-55 and the added materials used are natural zeolite Bayat. Natural zeolite serves as a material added by utilizing the water it contains, can increase the volume of bitumen/asphalt during mixing and compaction [5]. Using elastomeric polymer bitumen as the bonding material, While the bonding material using asphalt elastomeric polymer, with expectations of getting a mixture that has a great fatigue resistance that can be mixed and compacted with a bunch of lower temperature than the hot mix asphalt with pure asphalt binder that is often used in Indonesia.

8 1.2. Objectives

The main objectives of this research include: (1) examine the effect of zeolite as an added material to develop warm mix asphalt using asphalt polymer with the added material of natural zeolite (2) assess the optimum zeolite content that meets the specifications Marshall (3) assess the Marshall Stability of asphalt hot mix asphalt with polymer binder at the mixing temperature and compaction temperatures lower than hot mix asphalt binder pure asphalt penetration 60/70.

8 2. Experimental Work

2.1. Materials and Mix Proportion.

24
This warm mix asphalt research using materials added natural zeolite, types of mineral mordenite sourced from Bayat, Central Java, Indonesia, in powder form through sieve no.400. Natural zeolites are used because they are cheap and Indonesia is one of the countries with the largest deposits of natural zeolites. Before use the Bayat natural zeolite first processed by chemical activation methods to clean the surface of the pore, to dispose impurity compounds, and re-measure the location of the atoms that are exchanged, so that the zeolite pores can be cleaned to increase the water content to be used. In this research, the polymer modified asphalt was an elastomeric polymeric bitumen. Based on the ability of elastomeric polymer bitumen are more resistant to deformation after receiving a load on its surface, will stretch the surface and return to its original shape after the load is lost. In this research, elastomeric polymer bitumen used was asphalt polymer. To get a compactable mix of warm asphalt mixture using elastomeric polymer bitumen without natural zeolite [6]. The aggregate was from Subang, West Java, with the combined aggregate gradation to wear layers.

2.1.1. The Details of Experimental Tests. The first thing to do is to test the materials to be used, the aggregate, Elastomeric polymer bitumen, and Bayat natural zeolite. Asphalt testing performed on elastomeric polymer bitumen. Tests conducted on two kinds of aggregate, the coarse aggregate and fine aggregate, which are both taken from Subang, West Java. Before making an asphalt mixture, natural zeolite as an ingredient added, activated in advance using chemical activation. Then Marshall experiments conducted to obtain the optimum bitumen content in asphalt content between 5% to 7%, with increases of 0.5% each on any mixture containing zeolite content of 0%, 0.5%, 1%, 1.5%, 2%, and 2.5% were mixed at temperatures of mixing and compaction temperatures, according to the results of testing of elastomeric polymer bitumen 0% zeolite is between 173°C - 179°C, whereas, the compaction temperature between 159°C - 165°C. Elastomeric polymer asphalt mixture characteristics were evaluated using Marshall [10] on each mix asphalt with levels of natural zeolite (0%, 0.5%, 1%, 1.5%, 2%, 2.5%). Based on the experiment Marshall obtained the optimum bitumen content of 5.8% (0%, 0.5%, 1%, 1.5%, 2% and 2.5% natural zeolite content).

Blend asphalt mixture elastomeric polymer asphalt, with the Bayat natural zeolite content variation tested with Marshall. Then obtained mixture that produces values that meet the specifications. The connection of viscosity and temperature of the elastomeric polymer bitumen with material added Bayat natural zeolite could not be done, because of the process of mixing zeolite done

by the dry method. Aggregate heated first, then the natural zeolite and asphalt poured simultaneously. Seen by viscosity and is associated only with the mixing and compaction temperatures, as if the addition of natural zeolite as material added cannot reduce the temperature of mixing and compaction. This is in accordance with research which states that viscosity measurements and conditions in this way only suitable for conventional asphalt, but not suitable for warm mix asphalt testing. To find out the Immersion Marshall test of warm mixed asphalt using an elastomeric polymer-asphalt binder, which combined natural zeolite as an added ingredient, testing the mixture with mixing and compaction temperatures lower than normal temperature (146°C/132°C).

The analysis will be conducted on the experimental results, which include the testing of all the properties of the mixture are planned. The nature of the mixture and volumetric done by testing on a variety of mixing and compaction temperatures, with several levels of zeolite materials, added, and compare the properties of each of the pure asphalt binder and asphalt mixture with a polymer binder.

3. Results of the laboratory experiment

The results of experimental activities in the laboratory that included a preliminary test of mixture material, Marshall testing dan Marshall immersion test.

3.1. Aggregates properties

Aggregate tests performed on coarse aggregate, fine aggregate, and gradation, the results can be seen in table 1, table 2 and figure 1.

Table 1. Test results of coarse aggregate properties

No	Characteristics	Testing Methods	Result	Specification	Unit
1.	Abrasion	SNI 03-2417-2008	17,5	≤ 40	%
2.	Weight Type				
	Bulk	SNI 03-1969-2008	2,647	> 2,5	-
	SSD	&	2,688	2,5	-
	Apparent	SNI 03-1970-2008	2,760	< 3	-
3.	Absorption	SNI 03-1969 -2008	1,543	≤ 3	%
4.	Angularitas Coarse Aggregate	ASTM D 4791-2005	99,9/99,6	≥ 95/90	%
5.	Particles Flat and Oval	ASTM D4791-2005	1,0	≤ 10	%
6.	Weathering	SNI 03-3407-1994	0,3	≤ 12	%
7.	Sieve Qualify No. 200	SNI 03-4142-1996	0,47	≤ 1	%

Table 2. Test results of fine aggregate properties

No	Characteristics	Testing Methods	Result	Specification	Unit
1.	Sand Equivalent	SNI 03-4428-1997	61,0	≥ 60	%
2.	Weight Type				
	Bulk	SNI 03-1969-2008	2,658	> 2,5	-
	SSD	&	2,691	2,5	-
	Apparent	SNI 03-1970-2008	2,748	< 3	-
3.	Absorption	SNI 03-1969 -2008	1,235	≤ 3	%
4.	Fine Aggregate Angularitas	SNI 03-6877-2002	48,50	≥ 45	%
5.	Weathering	SNI 03-3407-1994	1,8	≤ 12	%
6.	Clumps of clay	SNI 03-4141-1996	0,40	≤ 1	%

Table 3. Test results of filler properties

Sieve size	Slip Percentage
No.30	100
No. 50	95 – 100
No. 100	90 – 100
No. 200	65 - 100

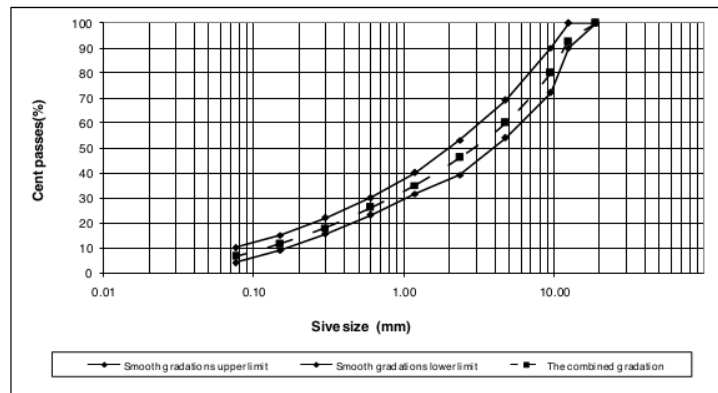


Figure 1. Gradation combined mixed graph

3.2. Bitumen properties 7

Asphalt test performed can be seen in table 4.

Table 4. Test results of asphalt modified properties

No.	Testing Type	Testing Methods	Result	Specification	Unit
1.	Penetration at 25 ° C, 100 g, 5 seconds	SNI 2456: 2011	65	60 – 70	0,1 mm
2.	Viscosity at 135oC	SNI 06-6441-2000	420	≤300	cSt
3.	Softening point	SNI 2434: 2011	49,5	>48	°C
4.	Ductility at 25 ° C, 5 cm / min	SNI 2432: 2011	> 140	≥100	Cm
5.	Flash point (COC)	SNI 2433 : 2011	312	≥232	°C
6.	Solubility in C2HCl3	SNI 06-2438-1991	99,8876	Min. 99	%
No.	Testing Type	Testing Methods	Result	Specification	Unit
7.	Density	SNI 2441: 2011	1,039	≥1,0	-
8.	Losing weight (TFOT)	SNI 06-2440-1991	0,0026	≤2,2	%
9.	The difference in softening point	ASTM D5976 part. 6.1	0,2	≤0,8	°C
10.	Penetration after TFOT	SNI 2456: 2011	81,5	≥54	%
11.	Ductility after TFOT	SNI 2432: 2011	> 140	≥100	Cm
12.	Estimated mixing temperature	ASSHTO-72-1990	173 – 179		°C
13.	Approximate compaction temperature	ASSHTO-72-1990	159 - 165		°C

14 The results of testing of coarse aggregate [refer Table.1] and the results of testing of fine aggregate [refer Table.2], and the results of gradation combined mixed [refer Figure.1], the results showed that all three test materials that will be used to make the mixtures according to the specifications. Zeolite using chemical activation method test result produces a moisture content of 18.99%. The results of testing asphalt polymer, so that the material consists of aggregates, asphalt and zeolites can be used to make asphalt mixture [refer Table.4].

19 3.3. Characteristic marshall on warm mix asphalt
 12 In this study, the effect of the use of warm mix asphalt to be analyzed based on the results of the Marshall test. Mix asphalt, used as a benchmark mix from warm mix asphalt with asphalt binder polymer and additive materials natural zeolite levels 0,5% which used to reduce the temperature. Effect of natural zeolite levels on asphalt polymer can be seen from table 5.

Table 5. Test results of bayat natural zeolite on asphalt mixture

Characteristic of Mixture	Test Results						Specification
	0%	0,5%	1%	1,5%	2%	2,5%	
Levels of Asphalt	5,8	5,8	5,8	5,8	5,8	5,8	%
Density	2,383	2,353	2,372	2,35	2,358	2,34	ton/m ³
VMA	15,5	16,53	15,7	16,41	16,1	16,94	min. 15%
VFB	79,87	76,47	76,73	77,15	74,12	74,26	min. 65%
VIM Marshall	3,1	3,89	3,7	3,75	4,2	4,16	3,0 - 5,0%
Stability	1551,2	1597,6	1555,3	1627,7	1500,6	1653,2	min. 1000 kg
Flow	4,74	4,10	4,20	4,00	4,23	4,03	min.3 mm
Marshall Quotient	331,2	390	300,9	321,5	358,1	413,2	min. 300kg/mm
Asphalt Effective	5,37	5,4	5,4	5,4	5,5	5,4	min. 4,3%

22 From Table 5, it seems in general that, with the use of asphalt polymer as a binder in hot mix asphalt material zeolite is added as a medium to reduce the temperature, making the value of stability is increased because of the water vapor produced from heating the zeolite causing the air cavity between the grains of aggregate encased in asphalt increased, while the value of stability increased by 1627.7 kg in mixed conditions with the zeolite content of 1.5% for grain size through sieve no. 400.

3.4. Immersion Marshall

Table 6. The test result of immersion Marshall

Soak time	AC-WC mixture	
	Modified asphalt mixtures without natural zeolite	Modified asphalt mixtures with 1,5% natural zeolite
	176 °C/162 °C	146 °C/132 °C
Bitumen content, %	5,8	5,86
Immersion Stability (30 menit), kg	1692,8	1324,0
Immersion Stability (24 menit), kg	1629,4	1236,1
IKS	96,2547	93,36

Table 5 shows the residual stability value of 93,36% in a warm asphalt with 1.5% natural zeolite still complying the provisions meet the specifications Department of Public Works of Highways, 2010, indicating that the residual stability the warm mix asphalt with 1.5% bayat natural zeolite is high and the water resistance is very good.

4. Conclusions

- The results of testing asphalt polymer, so that the material consists of aggregates, asphalt and zeolites can be used to make asphalt mixture.
- Warm mix asphalt modified with 1.5% bayat natural zeolite having the greatest stability value of 3)27,7 kg.
- Based on Marshall test asphalt polymer with zeolite content of 1.5% of bayat natura)3 zeolite sieve no. 400, has the residual stability value of 93,36%. The value of residual stability meet the specifications Department of Public Works of Highways, 2010, indicating that the residual stability the warm mix asphalt with 1.5% bayat natural zeolite is high and the water resistance is very good

Acknowledgments

We want to express our gratitude and appreciation for grant from the Ministry of Research and Technology of Higher Education, Indonesia.

References

- [1] Asphalt Institute. Mix Design Methods for Asphalt Concrete and Other Hot-Mix Types. MS-2 Sixth Edition Lexington: Asphalt Institute, 1993.
- [2] D'Angelo, J., Harm, E., Bartoszek, J., Baumgardner, G., Corrigan, M., Cowsert, J., Harman, T., Jamshidi, M., Jones, W., Newcomb, D., Prowell, B., Sines, R., dan Yeaton, B. 2008, 'Warm Mix Asphalt: European Practice', *Publication FHWA-PL-08-007*. FHWA, U.S Department of Transportation, February 2008.
- [3] Hurley, G. dan Prowell, B.D. Evaluation of Potential Processes for Use in Warm Mix Asphalt, *Journal of the Association of Asphalt Paving Technologists*. Proceedings of the Technical Sessions, 2006 Annual Meeting. Vol.75, pp. 41-90, 2006.
- [4] Gierhart, D. Warm Mix Asphalt-what is it and how can we benefit?. In SE States Pavement Association Management and Design Conference Southeast Pavement Preservation Partnership Meeting. Lexington, 2009.
- [5] Prowell, B.D, Hurley, G.C and B. Frank. Warm Mix Asphalt. Best Practices, National Asphalt Pavement Association, Lanham: NAPA, 2011.
- [6] American Association of State Highway and Transportation Officials 2012. Resistance to plastic flow of Bituminous Mixtures Using Marshall Apparatus. AASHTO 2008. Standard Specifications for Transportation Materials and Methods of Sampling and Testing, Washington, DC.

Marshall immersion test of warm mix asphalt polymer using Bayat natural zeolite

ORIGINALITY REPORT

24%

SIMILARITY INDEX

PRIMARY SOURCES

- | | | |
|---|---|----------------|
| 1 | N Rohadi. "Performance of impedance measurement algorithm applied in line with a compensation circuit", IOP Conference Series: Materials Science and Engineering, 2019
<small>Crossref</small> | 197 words — 7% |
| 2 | fstpt.unila.ac.id
<small>Internet</small> | 87 words — 3% |
| 3 | conference.ft.unand.ac.id
<small>Internet</small> | 59 words — 2% |
| 4 | adoc.pub
<small>Internet</small> | 44 words — 2% |
| 5 | Henry Prastanto, Yusep Firdaus, Santi Puspitasari, Arief Ramadhan, Asron Ferdian Falaah. "Study of physical characteristic of rubberized hot mix asphalt based on various dosage of natural rubber latex and solid rubber", IOP Conference Series: Materials Science and Engineering, 2019
<small>Crossref</small> | 32 words — 1% |
| 6 | sinta3.ristekdikti.go.id
<small>Internet</small> | 24 words — 1% |
| 7 | files.eric.ed.gov
<small>Internet</small> | 21 words — 1% |

-
- 8 www.thefreelibrary.com 21 words — 1%
Internet
-
- 9 Changfa Ai, Qiang Joshua Li, Yanjun Qiu. "Testing and assessing the performance of a new warm mix asphalt with SMC", Journal of Traffic and Transportation Engineering (English Edition), 2015 20 words — 1%
Crossref
-
- 10 repository.unmuhjember.ac.id 20 words — 1%
Internet
-
- 11 Abdul Muhaimin Memon, Nur Hazwani, Muslich Hartadi Sutanto, Nura Bala. "Rheological Properties of Bitumen Containing Organic Foaming Agent for Warm Mix Asphalt", IOP Conference Series: Earth and Environmental Science, 2020 16 words — 1%
Crossref
-
- 12 "7th RILEM International Conference on Cracking in Pavements", Springer Science and Business Media LLC, 2012 13 words — < 1%
Crossref
-
- 13 Li Ming Wang, Yi Qiu Tan, Zhen Wu Shi. "Characteristics of Different Warm Mix Asphalt Compacted at Low Temperature", Advanced Materials Research, 2011 12 words — < 1%
Crossref
-
- 14 S. A. Zhdanok, E. N. Polonina, S. N. Leonovich, B. M. Khroustalev, E. A. Koleda. "Physicomechanical Characteristics of Concrete Modified by a Nanostructured-Carbon-Based Plasticizing Admixture", Journal of Engineering Physics and Thermophysics, 2019 12 words — < 1%
Crossref

15	pertambangan.fst.uinjkt.ac.id Internet	11 words — < 1%
16	www.oncotarget.com Internet	11 words — < 1%
17	repository.uin-malang.ac.id Internet	10 words — < 1%
18	Arief Ramadhan, Santi Puspitasari, Henry Prastanto, Asron Ferdian Falaah et al. "Development of Rubberized Asphalt Technology Based on Asphalt Cement (AC Pen 60) and Fresh Natural Rubber in Indonesia", Macromolecular Symposia, 2020 Crossref	9 words — < 1%
19	www.3dpainting.be Internet	9 words — < 1%
20	www.highways.gov.sk.ca Internet	9 words — < 1%
21	On Tam, Weng. "Highway Materials", The Handbook of Highway Engineering, 2005. Crossref	8 words — < 1%
22	lib.dr.iastate.edu Internet	8 words — < 1%
23	www.jourlib.org Internet	8 words — < 1%
24	www.scientific.net Internet	8 words — < 1%

EXCLUDE QUOTES ON

EXCLUDE MATCHES OFF

EXCLUDE BIBLIOGRAPHY ON