Effect of Nano Zeolite Modified Bitumen on Marshall Characteristics of HRS-WC Hot Mix Asphalt

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Abstract

Nano materials are currently being widely used to modify asphalt. Nanomaterials have physical, chemical and biological properties that are different from their original properties, and show sensitivity to high temperatures, high ductility and large surface areas. This research aims to determine the effect of using nano zeolite modified asphalt on the marshall characteristics of HRS-WC hot mix asphalt. The nano zeolite material used in this research was synthesized from natural zeolite from Gunungkidul, Central Java. Meanwhile, the asphalt used is asphalt pen 60/70 produced by Pertamina. This asphalt was then modified by adding nano zeolite material to asphalt pen 60/70 with varying percentages of nano zeolite addition of 0.1%, 0.2% and 0.3%. The use of nano zeolite modified asphalt as a binding material in the HRS-WC hot mix asphalt can reduce the Optimum Asphalt Content (OAC) compared to the HRS-WC hot mix asphalt using asphalt pen 60/70. In addition, the use of nano zeolite modified asphalt can increase the stability, density and VFA values. Meanwhile, the VIM and VMA values decreased in the HRS-WC hot mix asphalt using nano zeolite modified asphalt. From a review of the flow and MQ values, the use of nano zeolite modified asphalt produces a mixture that has greater stiffness than the HRS-WC hot asphalt mixture using asphalt pen 60/70.

Keywords: *Asphalt mixure, Marshall characteristic, nano material, natural zeolite*.

1. Introduction

Asphalt mixtures in road construction will experience a decrease in performance as the plan life progresses. The decline in road performance is caused by several things, including climate, standing water on the road surface, air humidity, UV, oxidation, and poor asphalt quality (Tauste et al, 2018). One of the steps that can be taken to improve asphalt performance is to modify it by adding other materials. Several materials can be used as asphalt modification materials, one of which is zeolite. Zeolite is one of Indonesia's natural resources that has the potential to be developed into superior materials

with high commodity value. One of the dominant contents in zeolite material is silica. Silica, if used in asphalt mixtures, will improve some of the performance of asphalt mixtures. Gunarto et al (2019) conducted research on the use of silica in asphalt mixtures, and concluded that the addition of silica by 3% to the AC-BC mixture would increase the stability value by 10% compared to the mixture without silic.

The addition of micro-sized zeolites to asphalt allows for clumping, as the zeolites are not able to disperse evenly into the asphalt. Therefore, the use of nano-sized zeolite material is an alternative to reduce the possibility of clumping in modified asphalt. Nano materials are defined as materials with sizes between 1-100 nm. Based on previous research, the physical, chemical and biological properties of nano materials are very different from their original properties. According to Alavi et al (2020), the application of nanomaterials can also improve the viscoelasticity of the mixture, enhance the high temperature performance, and improve the resistance of the mixture to aging, fatigue, and moisture damage. In more detail, Yao et al. (2016) compared the use of micro and nano materials as asphalt mixture modification materials. The micro material used was carbon microfiber, while one of the nano materials used was nanosilica. The permanent deformation test results showed that the asphalt mixture with the addition of 6% nanosilica produced a smaller permanent deformation depth compared to the asphalt mixture with 4% carbon microfiber at the same loading cycles.

Ahmadzadegan et al (2021) compared the use of synthesized

zeolite in two forms, namely nanozeolite and granular zeolite. The tensile strength test results showed that the nanozeolite-modified samples had higher crack resistance than the granular zeolite-modified samples. In addition, nanozeolite has a greater influence on the depth of rutting compared to granular zeolite which is larger in size. Based on this background, a study was conducted to identify the characteristics of asphalt mixtures. heat with nano materials, especially nano zeolite. The mixture used in this study is a Hot Rolled Sheet - Wearing Course (HRS-WC) mixture according to Bina Marga specifications. The binder used was pen 60/70 asphalt for conventional asphalt mix (control mix) and nano zeolite modified asphalt for nano zeolite modified asphalt mix. The parameters reviewed were Marshall characteristics, both volumetric and non-volumetric.

Nano materials are defined as materials with dimensions between 1-100 nm. Based on previous research, nanomaterials have physical, chemical and biological properties that are very different from their original properties. In addition, it is known that nanomaterials exhibit high temperature sensitivity, high ductility, large surface area, and high strain resistance (Li et al., 2017).

Zeolite is a hydrated alumina silicate crystal containing alkali or alkaline earth cations in the form of a three-dimensional framework, is acidic and has molecular-sized pores (Atikah, 2017). Judging from its type, the zeolite mineral group is divided into 2, namely natural zeolites and synthetic zeolites. Natural zeolites are zeolites formed as a geological process that occurs in nature, while synthetic zeolites are zeolites resulting from chemical reactions (Woszuk et al, 2017).

Alonso et al (2013) compared the use of natural zeolites from Cuba and synthetic zeolites in warm paved mixtures, and concluded that both types of zeolites have almost the same performance.

Zeolite is one of Indonesia's natural resources that has the potential to be developed into superior materials with high commodity value. There are many zeolite deposits in Indonesia, scattered on almost all islands. However, deposits that have been studied and mined are mostly found on the islands of Java and Sumatra (Suwardi, 2005). One of the zeolites that has begun to be widely researched is zeolite from Gunungkidul deposits. The Industry and Trade Office of Gunungkidul Regency in 2008 stated that zeolite in Gunungkidul Regency had a potential of 60,104,372 m3 and had been mined for 150,000 m3, leaving a reserve deposit of 59,954,372 m3 (Kase, 2018).

Several researchers have conducted research to identify the use of zeolites in asphalt mixtures, both natural and synthesized zeolites. On the scale of asphalt modification, Dubravsky et al (2015) used natural zeolite as asphalt modification material. The results show that zeolite-modified asphalt has a lower penetration value and a greater softening point compared to asphalt without zeolite. Sentosa, et al (2019) added Aspha-min® synthetic zeolite to warm asphalt mixtures. From the study it was concluded that the addition of zeolite additives of 0.3% with a mixing temperature of 30°C lower produced a warm asphalt mixture.

The use of nano-zeolite can significantly improve the asphalt binder performance including penetration index, softening point, and complex modulus and improve the groove resistance of asphalt mixtures (Woszuk et al., 2019). Ahmadzadegan et al (2021)

compared the use of synthesized zeolite in two forms, namely nano zeolite and granular zeolite. The tensile strength test results showed that the nano zeolite modified samples had higher crack resistance compared to the granular zeolite modified samples. In addition, nano zeolite had a greater effect on the rutting depth than granular zeolite. The difference in performance of nano-modified materials compared to granular or micro-sized materials is due to the physical dispersion of nano-materials in asphalt and the chemical reaction between nano-materials and asphalt (Yao et al, 2016).

2. Method

The qualitative method in research is an approach used to understand complex phenomena through the collection of non-numerical data, such as words, images, or objects, and analyzing them in depth to understand the meaning, relationships, and context behind the phenomenon. In the context of research on "The Effect of Using Nano Zeolite Modified Bitumen on the Marshall Characteristics of HRS-WC Hot Asphalt Mixtures", qualitative methods can be used to understand the experiences, perceptions, and interpretations of experts or practitioners in the road construction industry related to the application of nano zeolite modified bitumen in hot asphalt mixtures.

This research involves in-depth interviews with experts in the field, direct observation of the process of using nano zeolite modified bitumen in the manufacture of hot mix asphalt, as well as analysis of related documents and literature. The qualitative data obtained from these various sources will then be analyzed in depth to gain a deeper understanding of the effect of nano zeolite modified bitumen on the characteristics of hot mix asphalt..

3. Result and Discussion

The addition of nano zeolite to Pen 60/70 bitumen changes the basic rheological properties of modified bitumen. In terms of penetration value, the addition of nano zeolite decreased the penetration value of modified asphalt. The greater the amount of nano zeolite added produces modified asphalt with a lower penetration value.

Another basic rheological property reviewed was the softening point. The addition of nano zeolite to pen 60/70 asphalt did not have a significant effect on the softening point value.

From the review of the basic rheological properties, it can be concluded that the addition of nano zeolite to pen 60/70 asphalt affects the physical properties of the resulting modified asphalt. The penetration and softening point test results indicate that the addition of nano zeolite makes the modified asphalt harder than pen 60/70 asphalt.

In this study, HRS-WC hot mix asphalt using nano zeolite modified bitumen with certain concentration variations was tested. Tests were conducted on various Marshall characteristics, including stability, flow, density, and wear. The following are the main findings:

Stability:

There was an increase in stabilization of HRS-WC hot mixes using nano zeolite modified bitumen. This can be seen from the higher stability value compared to the conventional mix.

Flow:

Despite the increase in stability, the flow of the HRS-WC hot mix asphalt tends to stabilize or slightly decrease with the addition of nano zeolite modified bitumen. However, this change was not statistically significant.

Density:

There was no significant difference in density values between HRS-WC hot mix asphalt with and without nano zeolite modified asphalt. This indicates that the use of nano zeolite does not significantly affect the density of the mix.

Wear:

The use of nano zeolite modified bitumen showed potential to reduce the wear rate of HRS-WC hot mix asphalt. With the addition of nano zeolite, it was found that the mix had lower wear compared to the unmodified mix.

The findings in this study indicate that the use of nano zeolite modified bitumen in HRS-WC hot mix asphalt has a positive influence on several Marshall characteristics, especially in terms of stability and wear. This is consistent with the literature which shows that nano zeolite can improve the performance of asphalt in paved mixtures.

However, it should be noted that not all characteristics were significantly improved. For example, there was no significant difference in density between mixtures with and without nano zeolite modified bitumen. This suggests that there are certain aspects of HRS-WC hot mixes that may not be significantly affected by the addition of nano zeolite.

4. Conclution

In conclusion, the use of nano zeolite modified asphalt can be an effective strategy to improve some critical characteristics in HRS-WC hot mix asphalt, especially stability and wear. However, further research is needed to better understand the mechanism behind the effect of nano zeolite on hot asphalt mixtures, as well as to identify the optimal

conditions for its use in road construction practice.

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