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Effect of Lapindo Hot Mud Extraction Addition to Asphalt Pen-60 Characteristics

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ABSTRACT
Asphalt modification with nanotechnology materials can be in the form of nanoclay, carbon nanotubes and nanosilica. Recent research found that nanosilica has been proven to improve rutting performance and fatigue resistance in asphalt mixtures. Nanosilica that will be used in this research is nanosilica from Lapindo hot mud, Sidoarjo. One effort to reduce the impact of losses is to use Lapindo mud that has a large enough potential to be used as a source of silica in Indonesia. With the advancement of nanotechnology that already exists and proving that nanosilica can increase the performance of asphalt, this research on the characteristics of pen 60 modified asphalt nanosilica will be conducted with a percentage of 2%, 4%, 6%, and 8%. The research was based on laboratory works. The modified asphalt showed increasing 40,35% in penetration, 112,3% in penetration index and 13,586% in viscosity, 39,96% in flashpoint, and 2,9% specific gravity. The increasing characteristic also indicates that asphalt would be more resistant to rutting and fatigue. From the results of laboratory testing, the NaCl content affects the characteristics of asphalt more than the silica contained in Lapindo mud extraction. Because of the NaCl, asphalt modified indicates the lack of pavement resistance to rutting.

Keywords: *Nanosilica, Lapindo Hot Mud, Asphalt Pen 60*

1. INTRODUCTION

Asphalt modification with nanotechnology materials can be in the form of nanoclay, carbon nanotubes and nanosilica. In the utilization of sludge waste, the nanotechnology used is nanosilica material. Nanosilica is taken from sodium silicate, which is a silicate mineral that has quite extensive benefits in the industrial world. Galooyak (2015) explains that nanosilica 6% can significantly improve the rutting performance of the base binder.[1] Furthermore, Ezzat (2016) explains that asphalt modified with nanosilica. Asphalt modified with nanosilica can improve the performance of binder and rutting parameters in asphalt mixtures using the Superpave method. The optimum condition that increases the performance of the rutting parameter is asphalt modification with 7% nanosilica content.[2] Another research found that the addition of nanosilica up to 8% can increase fatigue resistance (Hasaninia, 2018).[3]

In this research, Sidoarjo mud will be used as nanomaterials. Lapindo mud is used in this study because based on research by Adzima (2013) it proves that Lapindo mud has a high silica content.[4] Nanosilica will be mixed with asphalt pen with a variation of 2%, 4%, 6%, and 8%. With the addition of nanosilica, asphalt characteristics from modified asphalt are expected to be more resistant to rutting

2. OBJECTIVES

The objective of this study was to determine the effects of nanosilica from Lapindo Sidoarjo mud on asphalt pen-60. Those effects could be seen from asphalt modification characteristics.

3. METHODOLOGY

The methodology in this study can be seen in Figure 1.

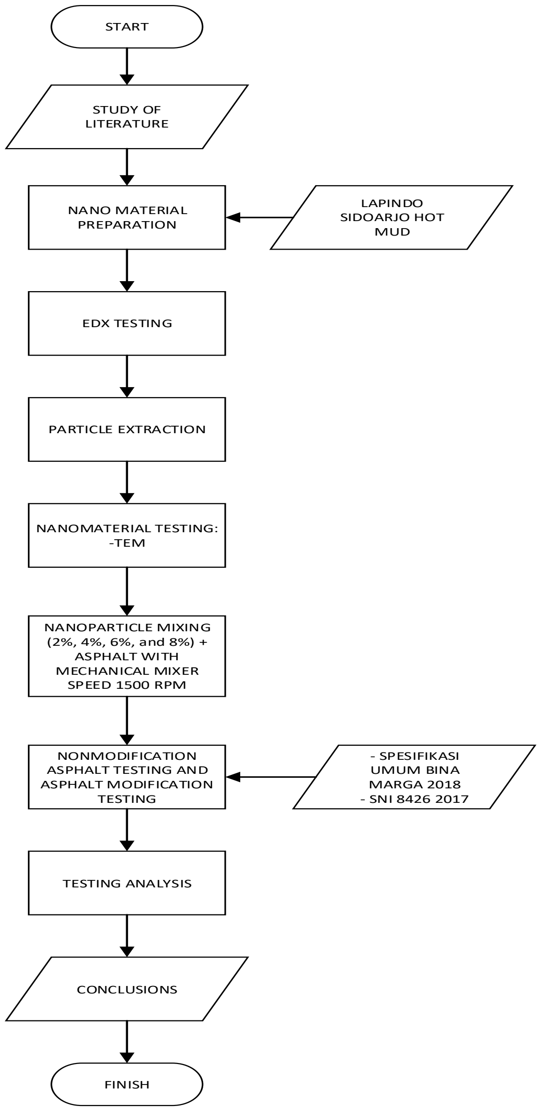

Figure 1 Flow Chart

3.1 Study of Literature

Literature studies are carried out by reading research references related to the preparation of this journal.

3.2 Nano Material Preparation

The material to be used is silica from Lapindo mud. Based on Agus Farid Fadli (2013) in Silica Extraction in Lapindo Mud Using the Continuous Method, silica is one of the elements in Lapindo mud so it can be used as a source of silica.[5]

3.3 EDX Testing

Energy Dispersive X-ray (EDX) enables qualitative and semi-quantitative microanalysis of elements ranging from lithium (Li) to uranium (U). From this test, it will be known what elements are in the Lapindo mud.

3.4 Particle Extraction

Particle extraction is carried out to remove silica from other elements contained in the Lapindo mud.

3.5 Nano Material Testing: TEM

TEM is a microscopic technique in which several electrons are transmitted through a thin specimen and interact with the specimen. The image is formed from the interaction of electrons transmitted through the specimen. From this test, it can be seen the size of the particles that have been previously extracted.

3.6 Mixing of NanoParticle + Asphalt

The particles to be mixed with asphalt are particle extraction with a concentration of 2%, 4%, 6%, and 8%. In order for the mixture to be homogeneous, the particle and asphalt extractions were mixed using a mechanical mixer at a speed of 1500 rpm.

3.7 Nonmodification Asphalt Testing and Asphalt Modification Testing

Testing of nonmodified asphalt and modified asphalt was carried out to see the quality of asphalt based on the General Specifications of Bina Marga 2018.

3.8 Testing Analysis

Test analysis is carried out to see whether the modified asphalt qualifies the General Specifications of Bina Marga 2018.

4. RESULTS

EDX is used to determine the elemental composition of Lapindo mud.

4.1 EDX Testing

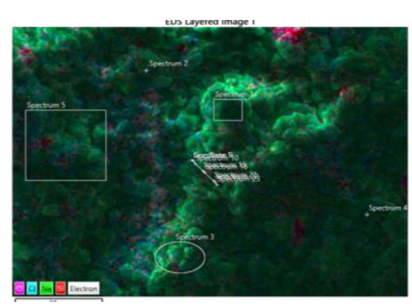

Figure 2 Image of EDX Tested Layer

Table 1 Table of Lapindo Mud Element Content Before Extracted

7Spectrum 1				
Element	**Line Type**	**Weight %**	**Weight % Sigma**	**Atomic %**
Si	K series	4.87	0.09	5.37
Na	K series	33.74	0.21	45.52
Cl	K series	51.33	0.26	44.90
Au	M series	6.48	0.30	1.02
Ca	K series	0.86	0.08	0.67
Fe	K series	1.01	0.16	0.56
Al	K series	1.71	0.07	1.96
Total		100.0		100.00

From the EDX test results, it can be seen that the Lapindo mud still contains other elements besides silica (Si), such as sodium chloride (NaCl), aurum (Au), calcium (Ca), ferrum (Fe), and aluminum (Al), which can affect the asphalt binder. Therefore, extraction is needed to extract silica in Lapindo mud.

4.2 Particle Extraction

Particle extraction was carried out using the help of 2M HCl solution and 7M NaOH. Particle extraction was carried with a sample of 1 kg of Lapindo mud that had been dried and crushed and then divided into ten times extraction with a weight of 100 grams per extraction. One hundred grams of mud was soaked using 2M HCl for 24 hours. After 24 hours of soaking, the mud reacted with 7M NaOH then stirred using a magnetic stirrer for 1 hour at 80oC with a two mod rotational speed to get the filtered filtrate solution. The filter solution is titrated with 3M HCl by rotating using a magnetic stirrer at 40^{o}C with a rotation speed of 2 mod until the pH approaches seven and a silica white precipitate is formed. The resulting silica precipitate is filtered using filter paper and then dried. Of all 1 kg of Lapindo mud, 100 grams of nanosilica is produced.[6]

4.3 TEM Testing

TEM testing is carried to ascertain the size of the Lapindo mud that has been extracted. Figure 3 shows the particles in Lapindo mud extraction with a magnification of 50000X. Figure 3 shows the EDX results from Lapindo mud particle extraction.

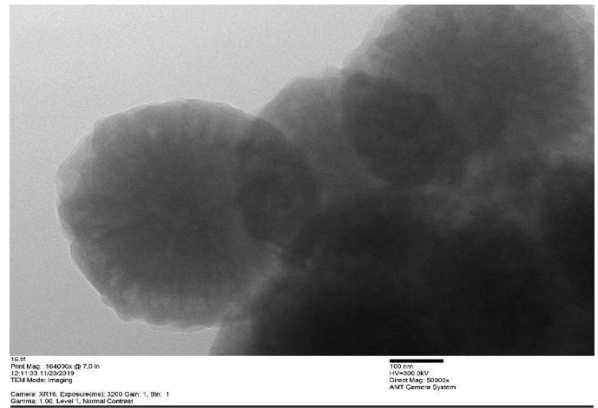

Figure 3 TEM Test Result at 50000X Magnification

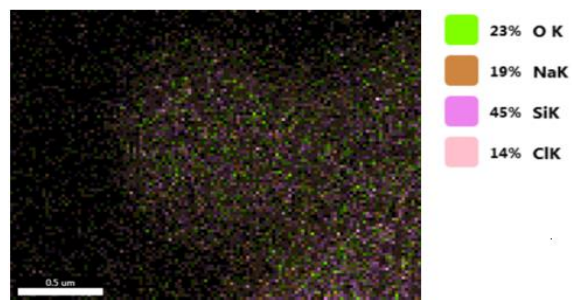

Figure 4 Image of EDX Tested Layer

Based on Figure 4, the highest elements present in nanosilica extraction are the elements Si and O. These Si and O components can react to become Si_2O_3 or silica components. This result showed that there were enough silica components to bond with the asphalt.

4.4 Non-Modified Asphalt Testing

Asphalt testing is carried out based on General Specifications of Bina Marga Tahun 2018. The results of the tests that have been carried out are as seen in Table 2.

Table 2 Table of Asphalt Characteristic Based on Laboratory Test

Type of Testing	**Nonmodified Asphalt**	**Modified Asphalt 2% Lapindo Mud Extraction**	**Modified Asphalt 4% Lapindo Mud Extraction**	**Modified Asphalt 6% Lapindo Mud Extraction**	**Modified Asphalt 8% Lapindo Mud Extraction**
Penetration at 25^{o}C	62.7	70.835	75.665	75.335	88
Kinematic Viscosity	303.736	307.5	345	336.4	312.7

135ºC (cSt)					
Softening Point (ºC)	49	48.3	48.5	48.2	48.2
Ductility at 25ºC (cm)	>100	>90.5	>57.5	>55.5	>40
Flash Point (ºC)	241.5	338	336	327	323
Solubility in Trichloroethylene (%)	99.25	99.99	99.655	99.65	99.923
Specific Gravity	1.032	1.032	1.036	1.042	1.062
Storage Stability: Softening Point Difference (ºC)	0.6	0.55	0.3	0.6	0.6
Wax Parafin Level (%)	0.191	0.103	0.056	0.09	0.022
Plasticity Index	-0.92	0.131	0.056	0.09	0.022
TFOT Residue Testing Result					
Lost Weight (%)	0.006	0.008	0.02	0.019	0.019
Penetration at 25ºC (% Beginning)	54	0.706	1.54	32.903	17.046
Ductility at 25 ºC (cm)	>100	>100	>100	>100	>100

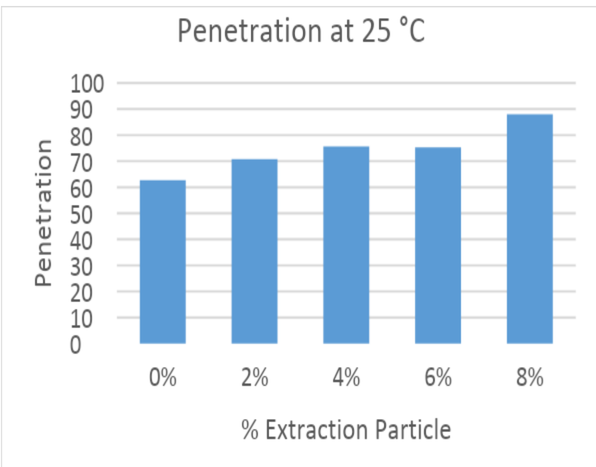

Figure 5 Penetration Test Result

As seen from Figure 5, the influence of extraction particles from Lapindo mud on the asphalt penetration increased by 40.35% and made the asphalt not qualify standard based on General Specifications of Bina Marga 2018. The increase in penetration value happens because of the presence of NaCl in the Lapindo mud extraction content. Md. Shahin (2015) and Md. Shariful Islam (2019) proves that NaCl increases the value of asphalt penetration.[6][7] Asphalt with high penetration value is used for pavements in cold areas or roads with low traffic volume. Therefore, the penetration with a high value indicates the lack of durability of rutting.

Asphalt with low viscosity will help the process of mixing asphalt with other materials (high workability). From Figure 6, we can see the results of the asphalt viscosity test modified by extraction from Lapindo mud can increase asphalt viscosity by up to 13,586%. The increase of asphalt viscosity happens because of silica in the Lapindo mud extraction content. Nader Abutalib (2015) and Hussein H. Zghair (2018), proved that silica could increase the value of asphalt viscosity.[8][9] The modified asphalt viscosity qualifies the standard based on General Specifications of Bina Marga 2018.

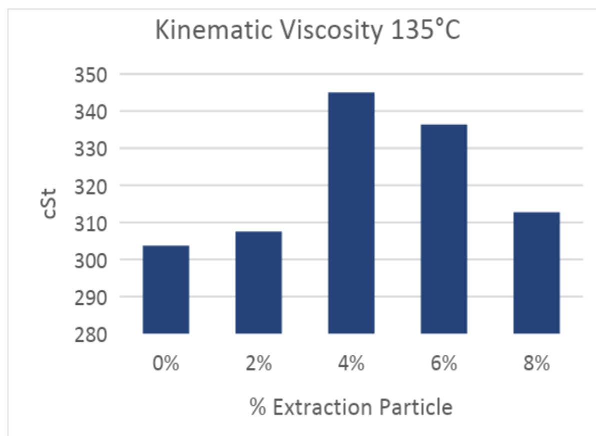

Figure 6 Kinematic Viscosity Test Result

As with asphalt penetration, asphalt softening point temperature decreases also occur due to the presence of NaCl in the Lapindo mud extraction content. As seen from Figure 7, the asphalt softening point modified asphalt decreased to 1.633%. Md. Shahin (2015) and Md. Shariful Islam (2019) proves that NaCl decreases the value of asphalt softening point.[6][7] Asphalt with a softening point temperature is used for pavement in cold areas or roads with low traffic volume. So with a low softening point temperature indicates the inability of hardening against rutting. Asphalt with an 8% extraction particle does not qualify the standard based on General Specifications of Bina Marga 2018.

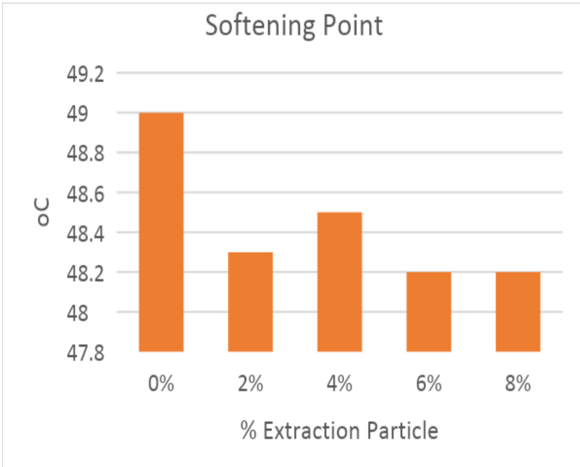

Figure 7 Softening Point Test Result

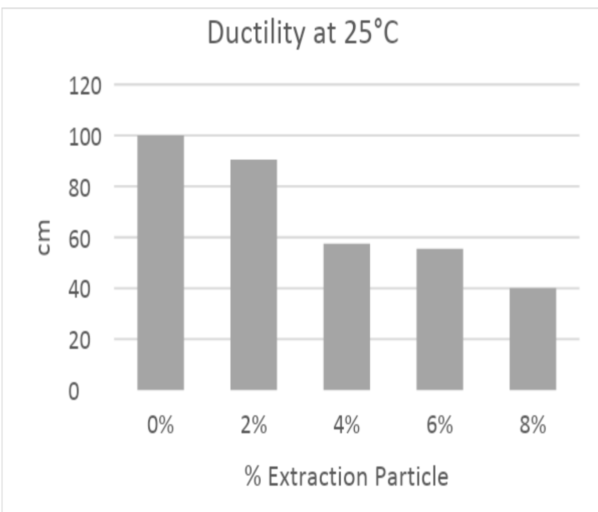

Figure 8 Ductility at 25°C Test Result

From Figure 8, we can see that modified asphalt reduces 60% asphalt ductility. The addition of silica and NaCl decreased the ductility of asphalt. Zghair (2018) proves that the addition of silica results in decreased asphalt ductility. Besides silica, according to Md. Shahin (2015) proves that NaCl reduced ductility in asphalt.[9][6] With the addition of mud extraction, the asphalt becomes more brittle.

From the result of the asphalt flashpoint test in Figure 9, modified asphalt with 2% extraction from Lapindo mud increased 39.96% asphalt flash point temperature, but when added again the concentration of the mud extraction made the asphalt flash point drop 4.44%. In this test, NaCl affects the decrease of asphalt flash point temperature. Md. Shahin (2015) and Md. Shariful Islam (2019) proves that NaCl decreases the value of the asphalt flashpoint.[6][7] Although the flashpoint temperature decreases, all modified asphalt still qualify the standard based on General Specifications of Bina Marga 2018.

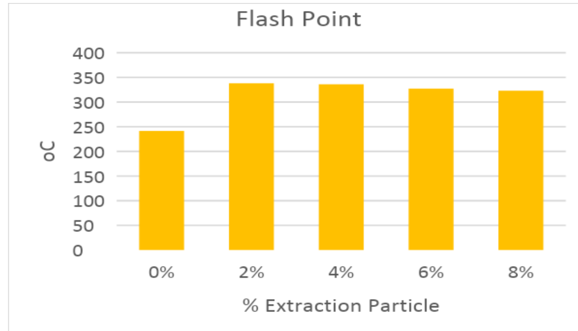

Figure 9 Flash Point Test Result

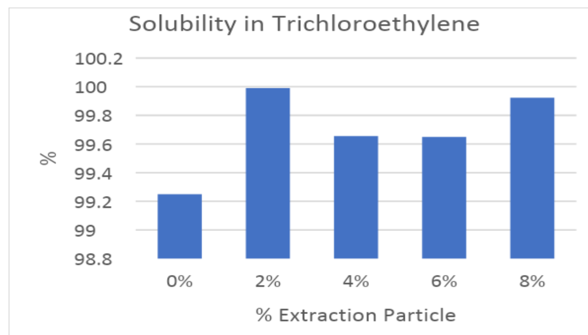

Figure 10 Solubility in Trichloroethylene Test Result

From Figure 10, we know that modified asphalt still meets the requirements in the testing of solubility in trichloroethylene. From this test, it was concluded that both nonmodified asphalt and modified asphalt had a purity of > 99% which qualify the standard based on General Specifications of Bina Marga 2018.

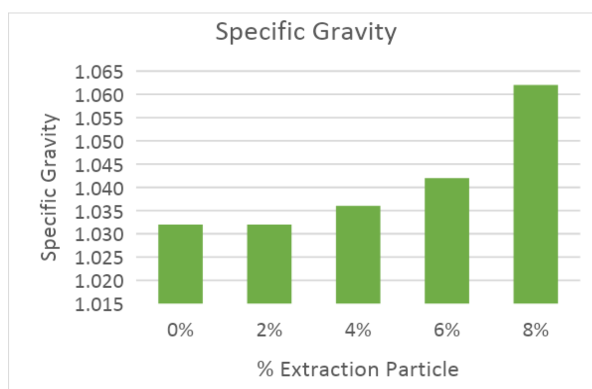

Figure 11 Specific Gravity Test Result

As seen from Figure 11, with increasing levels of Lapindo mud extraction, the asphalt density is also increasing. The increase of asphalt density proves that the extraction particles from Lapindo mud that are small can fill the cavity in the asphalt.

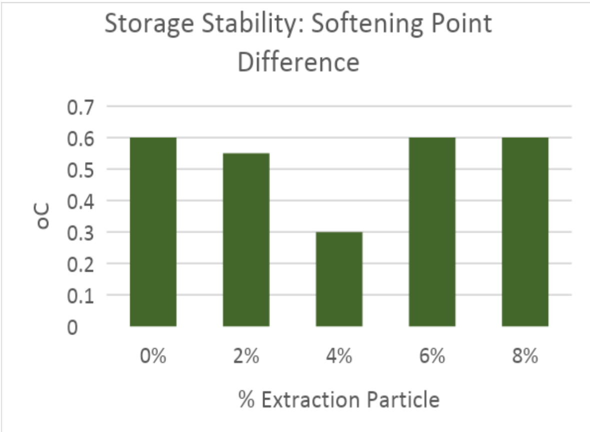

Figure 12 Storage Stability: Softening Point Difference Test Result

The storage stability test is used to know the stability or deposition of asphalt during storage for a short time. From Figure 12, we know the addition of Lapindo mud extraction by 2% and 4% decreases the value of softening point asphalt difference up to 50%. However, when added 6% and 8% difference in asphalt softening point back to 0.3ºC the same as unmodified asphalt. All the modified asphalt qualifies the standard based on General Specifications of Bina Marga 2018.

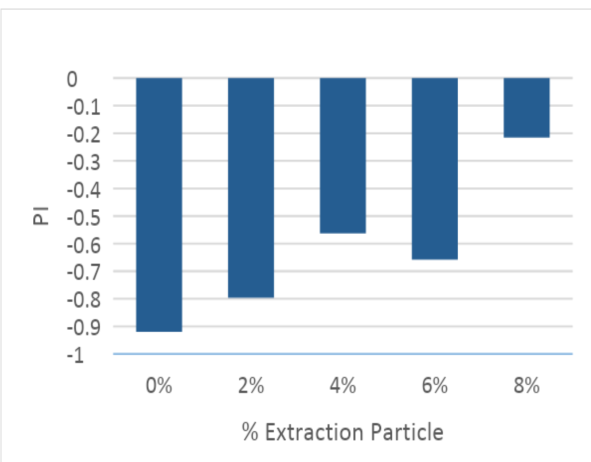

Figure 13 Plasticity Index Non-Modified Asphalt and Modified Asphalt

As seen from Figure 13, the addition of Lapindo mud extraction by 2% and 4% increases the Plasticity Index (PI) value by 112.35%, making the asphalt less sensitive to temperature compared to nonmodified asphalt. However, when the asphalt is modified with 6% and 8% Lapindo mud extraction, the PI value decreases by 939.317%, making asphalt more sensitive to temperature changes.

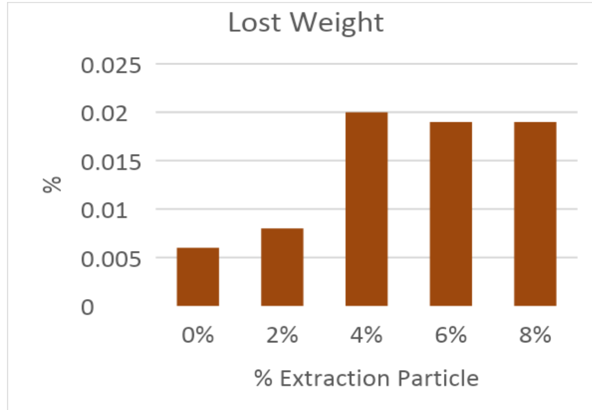

Figure 14 Lost Weight after TFOT Test Result

As seen from Figure 14, asphalt modified with Lapindo mud extraction makes higher weight loss 233.33%. High weight loss results are due to the relatively strong influence of NaCl (Md. Shahin,2015).[6] However, all the modified asphalt qualifies the standard based on General Specifications of Bina Marga 2018.

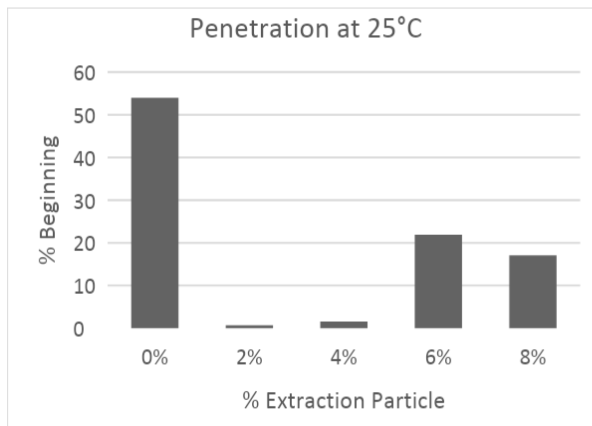

Figure 15 Lost Penetration after TFOT Test Result

Test results lost penetration after TFOT as seen in Figure 15 that asphalt modified with 2% Lapindo mud extraction can reduce 98.69% loss of penetration on asphalt. However, asphalt modified with Lapindo mud extraction 6% can only reduce 59.44% loss of penetration on asphalt. All asphalt with particle extraction does not qualify the standard based on General Specifications of Bina Marga 2018.

Moreover, from the test results of ductility loss after TFOT, when compared with modified asphalt before TFOT asphalt modified with Lapindo mud extraction is more ductile. However, modified all modified asphalt qualify the standard based on General Specifications of Bina Marga 2018.

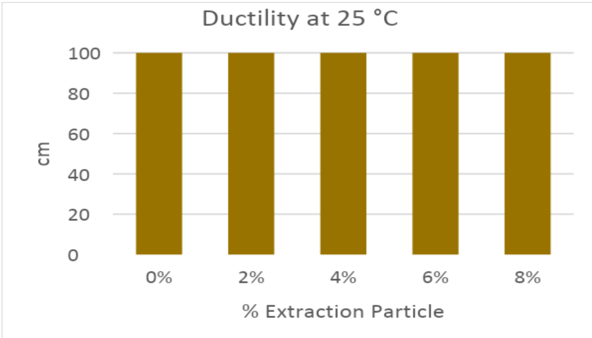

Figure 16 Ductility at 25ºC after TFOT Test Result

5. CONCLUSIONS

The modified asphalt showed increasing 40,35% in penetration, 112,3% in penetration index and 13,586% in viscosity, 39,96% in flashpoint, and 2,9% specific gravity. Meanwhile, other characteristics are decreasing; softening point decreased 1,63%, ductility decreased 1,635%. Most of the asphalt characteristics are affected by NaCl element presence in extraction material. Silica in extraction particles also affects the characteristics of asphalt but not as significant as the element NaCl. Silica only affects asphalt viscosity and asphalt flashpoint. Asphalt viscosity with 4% Lapindo hot mud extraction increases up to 13,586%, but then decreases when the asphalt is added with 6% and 8% Lapindo hot mud extraction. The asphalt flashpoint is increased when asphalt added by 2% of Lapindo hot mud extraction, then decreases to 4,44% when the Lapindo hot mud extraction concentration is added. Because of the effect of NaCl, asphalt modified indicates the lack of pavement resistance to rutting and fatigue.

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