Creating a New Type of Asphalt Using Oil Waste, Resin Stone and Plant Branches

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Abstract— Road construction as a transportation infrastructure is a priority in Indonesia. Road construction consists of rigid pavement and flexible pavement. Flexible pavement using asphalt is still an option because of its flexible characteristics, but the amount of asphalt needs in Indonesia is not proportional to the availability of asphalt, even half the asphalt needs are still imported. Besides this, in Indonesia there are many wastes that are harmful to living things and the environment, namely oil waste. Lack of asphalt material and the abundance of oil waste that endanger living things and the environment becomes a very serious problem and must be addressed therefore how to overcome the shortage of asphalt and overcome the abundant oil waste. The solution is engineering the waste oil into asphalt. This engineered asphalt is a new type of asphalt, and the materials used consist entirely of waste material, namely oil waste, coal mine waste (resin stone) and plant branches. To produce this new type of asphalt, conducted research using pure experimental methods. The experimental procedure to make asphalt is to process and cook ingredients with different compositions and repeatedly. Based on the experimental results it was proven that oil waste, coal mine waste (resin stone) and ash from plant branches, namely bamboo stems, avocado branches, gardenias branches (*gardenia augusta merr*) and *kejibeling branches* (*S. crispa*) can be engineered into asphalt. This new type of asphalt has shortcomings in ductility and specific gravity when compared to the Indonesian National Standard (SNI) asphalt but has equal penetration and softening point with penetration asphalt 120 and flash point equivalent to penetration asphalt 80. This asphalt has been tested as a leak-proof coating in high rise building bathrooms and the results are proven to be good, visually meeting the characteristics of asphalt in general. It is expected that in the future, this new type of asphalt can be used for flexible pavement on highway construction.

Index Terms— new type of asphalt, asphalt from oil waste, asphalt from resin stone, asphalt waste, asphalt from twigs.

1 Introduction

Transportation facilities and infrastructure are priority projects in Indonesia. The project is a highway and toll road construction project. Road construction generally consists of rigid pavement and flexible pavement [13]. Rigid pavement uses concrete material while flexible pavement uses asphalt material. Flexible pavement is still an option because of its flexible characteristics [13], [16] but the asphalt needs to date are still not comparable to the availability of asphalt. In Indonesia there are only 50% while the other 50% are still imported [16], [18]. Asphalt needs are increasing so that the price becomes expensive. In addition to lack of asphalt, in Indonesia there are very serious problems, namely the large number of B3 waste which is harmful to living things and the environment [8], [11], [23] and oil waste including the category of waste that is endangering to living things and the environment.

Based on these problems, it is necessary to find a solution to anticipate the shortage of asphalt and overcome the abundant oil waste so as not to endanger the living things and the environment.

Scientists have conducted research to anticipate asphalt shortages, as well as improve the quality of asphalt. The resulting solution is mostly to modify asphalt by mixing other materials, including recycling asphalt pavement or Reclaimed Asphalt Pavement (RAP) [3], [9], [10], [14], [18], [19], added plastic [15], [20], added mineral powder dolomite [1], [2], added rubber [22], modified with asphalt buton [5], [6], [18], added pine sap [17] etc. The findings in the research and the solutions of the previous researchers are very good, but still have not solved the problem that the authors convey, namely how to anticipate the shortage of asphalt in Indonesia and utilize oil waste so as not to endanger living things and the environment.

Can oil waste be used, engineered by mixing other materials such as stone resin and plant branches into asphalt. If the waste oil, resin stone and twigs of plants can be engineered into asphalt, it can increase the production of asphalt while utilizing oil waste into a product that is beneficial to the environment and survival.

Based on this description, this research is very important, in order to find new types of asphalt using oil waste materials, coal mine waste or resin stone, as well as several types of leaves and twigs of plants. Previous research has modified the asphalt by adding oil, stone resin powder and others, so the authors hypothesize that if the stone resin is boiled using oil waste by adding formula ash from several types of leaves and twigs of plants can become asphalt, therefore the problems in this study are formulated as follows:

Can oil waste, coal mine waste (resin stone) and twigs and leaves of plants be engineered into new types of asphalt.

2 Literature Review

2.1 Related Work

Trautvain et al [1] in Russia, consumers of road transportation more than 82.4% are industrial metered cargo, so increasing the volume of roads and improving the quality of roads is very important. The study was conducted to determine the quality of the road by adding dolomite mineral

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powder to asphalt. And it is known that by adding dolomite mineral powder, it significantly improves the quality of the asphalt road.

Colbert et al [3] Integrate the latest innovations from recycled asphalt materials used in designing and building roads, through measures such as construction guarantees and the aim of reducing air pollution. The aim is to develop a systematic approach towards choosing the optimal combination of sustainable materials for asphalt road construction. The selected ingredients are warm mix asphalt (WMA), recycled asphalt shingles (RAS), and reclaimed asphalt pavement (RAP).

Suparma [7] Conducting research to determine the nature of ethylene vinyl acetate modification (EVA modified asphalt - EVA-MA), its effect on the mixture of Asphalt Concrete - Wearing Course (AC-WC) and Asphalt Concrete - Binder Course (AC-BC). The research was carried out by making EVA modified asphalt, then the mix design was carried out using a mixture of AC-WC and AC-BC types and mixed characterization was carried out at optimum asphalt content (KAO). The results of his research show that the greater the level of EVA in asphalt will reduce the penetration value and increase the softening point, and the higher the level of EVA, the optimum asphalt mixture will be higher. AC-WC and AC-BC asphalt mixture using EVA-MA shows good resistance to the influence of water.

Noferini et al [9] In Europe produced 265 mil tons of asphalt in 2014, and Reclaimed Asphalt Pavement (RAP) of 50 mil tons. Related agencies limit the use of RAP because it is considered uncertain performance. The focus of his research is on the interaction of asphalt with a mixture of reclaimed asphalt pavement (RAP). In mixed compositions of 10%, 20% and 30%.

Ogundipe [13] The purpose of toll road pavement is to provide a smooth surface where vehicles can move safely. Therefore, it is important to modify asphalt concrete so that it is more resistant to rutting and fatigue failure. Lime modified asphalt has been observed to have better resistance to rutting, cracking and stripping, as well as having an improved aging behavior.

Cong et al [14] Recycling asphalt roads creates a cycle of reuse of materials that optimize the use of natural resources, two experimental methods are carried out for research in rejuvenating venues at the age of asphalt. The two types of asphalt in China studied were asphalt A7 (60/80 pen) and asphalt A11 (100/120 pen) and two RA rejuvenators (containing 90% alkyl aromatic oil and 10% saturate oil), and RS (containing alkyl aromatic oils) 10% and 90% saturating oil). It is known, the effect of temperature on diffusion coefficient is large, and the effect of rejuvenator layer thickness on diffusion is not clear. Rejuvenator RA has a high level of absorption at various temperatures. In addition, the coefficient of occupancy of the rejuvenator on asphalt A11 is greater than that of asphalt A7. Test data suggest that the use of rejuvenators at high levels is a viable option for recycled asphalt.

Suhardi et al [20] Addition with plastic bottle waste gives an effect on the characteristics of marshal on asphalt concrete mixture (AC-BC (Asphalt Concrete - Binder Coarse) with the type of mixture used is Asphalt Concrete - Binder Coarse (AC-BC) with fine gradation using specifications general Bina Marga 2010. Levels of variations in the addition of PET used are 0%, 1.5%, 2.5%, 3.5%, 4.5%, 5.5%, 6.5% in the upper boundary gradation and middle with a tolerance value of ± 0.5%. It is known, for a rough graded AC-BC laston mixture does not meet the 2010 *Bina Marga* standards. While for fine grading meets the 2010 *Bina marga* standards. The optimum asphalt content (KAO) results for the upper and middle limit are 6.44%. Marshall parameters for finely graded laston AC-BC mix on average meet the 2010 *Bina Marga* specifications.

Ritonga and Irfandi [22] Conducted research to determine the effect of cyclic natural rubber on modified asphalt cavities. The stages of the research include making modified asphalt by mixing pure asphalt and cyclic natural rubber. Testing uses the Marshall method to determine asphalt cavities including VIM, VMA and VFA. It is known that cyclic natural rubber can be used as material for modifying asphalt, and cyclic natural rubber affects asphalt cavity. In general, asphalt modifications using pure asphalt and cyclic natural rubber meet the physical requirements of asphalt.

Previous research has revealed the problem of asphalt and the solutions it offers, but it does not solve the problem presented by the author in this paper, therefore this research is necessary and important. Based on previous research studies, making asphalt using oil waste, resin stone and formula ash from several kinds of leaves and twigs allows the plant to be asphalt.

2.2 Basic Theory

Asphalt is a material that is black or dark brown. At room temperature in the form of solid to slightly dense, if heated to a certain temperature can be soft, so that it can wrap aggregate particles at the time of making concrete asphalt mixture. If the temperature begins to fall, asphalt will harden and bind the aggregate in place or is thermoplastic. Hydrocarbons are the main basic ingredient of bitumen. Asphalt is one of the flexible pavement construction materials [4]. The nature of asphalt properties required must meet Indonesian National Standards (SNI 6749: 2008).

3 METHODOLOGY

3.1 Method

To produce new types of asphalt, this study uses pure experimental methods. Experiments on making this new type of asphalt are carried out repeatedly, including trying to make asphalt using 2 types of materials, namely oil waste and coal mine waste (resin stone), then try adding other ingredients, namely formula ash. Ash formula is made from bamboo sticks, avocado branches, gardenias branches (*gardenia augusta merr*) and *kejibeling branches* (*S. crispa*). Ash formulas are made using different mixture compositions. Asphalt made from waste materials is then tested in a laboratory to determine the characteristics of asphalt.

3.2 Equipments

The equipment for making asphalt experiments consists of the main tools, namely furnaces and frying pans, other complementary equipment namely stirring wood, large wooden spoons, and packaging cans for storing asphalt. The cooking stove is made of masonry and the cooking pot is made from used oil drums with a capacity of 155 kg. Cooker stoves and cooker pans like in Figure 1.

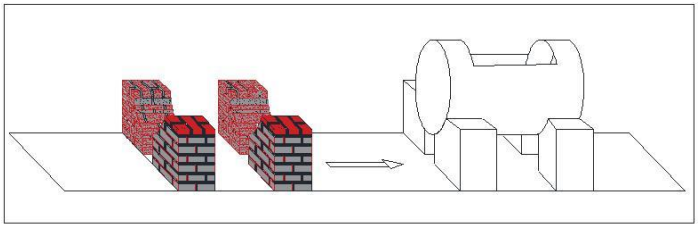

Figure 1. Cooker stoves and pans.

3.3 Asphalt Ingredients

The purpose of this new asphalt manufacturing experiment is to increase the production of asphalt and utilize abundant oil waste, therefore the material for making asphalt consists of oil waste, coal mine waste (resin stone) and formula ash made from plant twigs. Coal mine waste (resin stone) referred to as shown in Figure 2.

Figure 2. Coal mine waste (resin stone)

3.4 Formula Ash

Ash formula as a formula to make a new type of asphalt in this study is made from bamboo stems, avocado branches, gardenias branches (*gardenia augusta merr*) and *kejibeling branches* (*S. crispa*). Ash formula is made by inserting ingredients into the oven, heated to ash. Ash formula is made from materials with 2 different compositions, namely:

- Composition 1; 0.25 kg of bamboo sticks, 0.25 kg of avocado leaves, 0.25 kg of gardenia twigs and 0.25 kg of S. crispa.
- Composition 2; 0.25 kg of bamboo, 0.15 kg of avocado leaves, 0.15 kg of gardenia twigs and 0.15 kg of S. crispa

3.5 Asphalt Manufacturing Experiments

Asphalt manufacturing experiments are carried out repeatedly using different material compositions, namely:

1) Experiment 1 with ingredients; 50% oil waste and 50% resin stone, without using formula ash.
2) Experiment 2 with ingredients; 55.40% oil waste, 44.32% resin stone, and add 0.28% ash mixture composition formula 1.
3) Experiment 3 used a mixture of ingredients; 62.31% oil waste, 37.38% resin stone, and add 0.31% formula ash from mixture composition 2.
4) Experiment 4 used a mixture of ingredients; 62.31% oil waste, 37.41% resin stone, and add 0.25% formula ash from mixed composition 1.
5) Experiment 5 used a mixture of ingredients; 62.31% oil waste, 37.41% resin stone, and add 0.25% formula ash from mixed composition 2.
6) Experiment 6 used a mixture of ingredients; 62.38% oil waste, 37.43% resin stone, and add 0.19% formula ash from mixed composition 1.
7) Experiment 7 used a mixture of ingredients; 62.38% oil waste, 37.43% resin stone, and add 0.19% formula ash from mixed composition 2.
8) Experiment 8 used a mixture of ingredients; 62.42% oil waste, 37.45% resin stone, and adding 0.12% formula ash from mixed composition 1.
9) Experiment 9 uses a mixture of ingredients; 62.42% oil waste, 37.45% resin stone, and add 0.12% formula ash from mixed composition 2.

3.6 Laboratory Test

The discovery of asphalt from pure experimental results, then carried out laboratory tests to determine the characteristics of asphalt. The characteristics of asphalt to be tested in this study are; penetration, softening point, flash point, ductility, specific gravity, and bitumen attachment to rocks. The test methods used are as described in Table 1.

TABLE 1. TEST METHOD

N	Type of Testing	Unit	Method
1	Penetration testing	dmm	SNI 06-2456-1991
2	Softening point testing	°C	SNI 06-2434-1991
3	Ductility testing	Cm	SNI 06-2433-1991
4	Flash point testing	°C	SNI 06-2432-1991
5	Burn point testing	°C	SNI 06-2441-1991
6	Specific gravity testing	gr/cm^3	RSNI M -04-2004
7	Bitumen sticky testing on rocks	%	SNI 06-2432-1991

3.7 Research Flow Chart

The research to find new types of asphalt, using this pure experimental method, is briefly described in the research flowchart as in Figure 3.

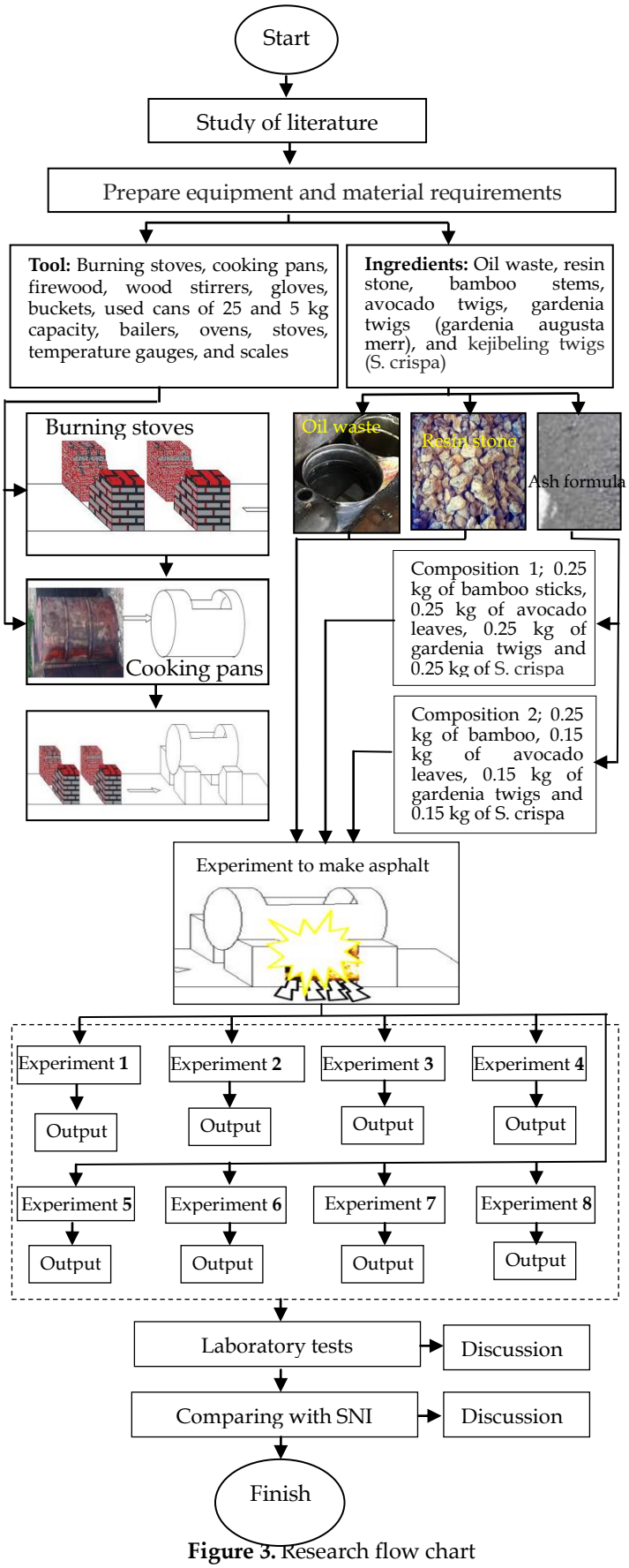

Figure 3. Research flow chart

4 Results And Discussion

4.1 Oil Waste

Oil waste is the residual use of engine oil. The large number of motor vehicles and industries that use oil lubricants causes the amount of oil waste is very high. In Indonesia oil waste reaches around 465 million liters per year. Not only in Indonesia, there are also around 150 million liters of oil waste per year in Malaysia [23]. In this research, oil waste is used to produce asphalt. Because oil waste is plentiful and easily available, it is not volatile, has a high boiling point and good viscosity. The function of oil waste in making asphalt as a solvent, diluent, maintaining the elasticity of stone resin during cold temperatures, overcoming flash points and burn points [4].

4.2 Coal Mining Waste (Resin Stone)

Resin stone in Indonesia is often found in coal mining areas, therefore damar batu is a coal mining waste. Stone resin in addition to containing stones also contains natural resins so that they have elastic properties, can be soluble in oil, can dissolve in nonpolar organic solvents, slightly soluble in polar organic solvents, insoluble in water, not heat resistant, flammable.

4.3 Branches of Plants and Leaves

The leaves and twigs of plants used to make this asphalt, is a pure experiment because there has been no prior research. In general, the characteristics of these ingredients according to previous research are as follows:

- Bamboo stems are very abundant in Indonesia, in addition to the many benefits of bamboo, bamboo also has chemical properties including; cellulose, lignin, pentosan, ash, silica, solubility in cold water, solubility in hot water and solubility in alcohol benzene [24].
- Avocado leaves (*Persea americana miller*) can inhibit the growth of some bacteria such as *Staphylococcus sp*, *Pseudomonas sp*, *Proteus sp*, *Escherichea sp*, and *Bacillus sp*. Avocado leaves contain active ingredients flavonoids, *quersetins* and polyphenols. Benefits of flavonoids include preventing bone loss, and as an antibiotic.
- Gardenia twigs. Gardenia plants have a chemical content on the leaves, namely saponins, flavonoids, polyphenols, essential oils, tannins error, and steroids / triterpenoids. In leaf ash there are sodium, calcium, potassium, magnesium, iron, copper, and lead.
- *Kejibeling leaves (S. crispa)* contain carbonate elements and minerals such as potassium, sodium, calcium, *ferum*, phosphorus, silicic acid, caffeic acid, *vanillic* acid, gentinic acid and citric acid.

The materials from the leaves and twigs of this plant are used as formula ash to make a new type of asphalt from waste oil and stone resin. This formula ash is made in the following way:

- First, dry 0.25 kg of bamboo stalks, 0.25 kg of avocado branches, 0.25 kg of gardenia twigs and 0.25 kg of *kejibeling branches* (*S. crispa*).
- After drying, put it in the oven then heat it until it becomes ash.

- After becoming the ashes, stir until evenly distributed and place in a closed place, for example the jar.

This formula ash is made with two different compositions, the composition of which is:

- Composition 1; 0.25 kg of bamboo stems, 0.25 kg of avocado bark, 0.25 kg of gardenia twigs and 0.25 kg of *kejibeling branches* (*S. crispa*).
- Composition 2; 0.25 kg of bamboo stems, 0.15 kg of avocado bark, 0.15 kg of gardenia twigs and 0.15 kg of *kejibeling branches* (*S. crispa*).

This formula ash is expected to function to melt stone resin during the process of making asphalt, and to harden asphalt when used as an aggregate binder in road construction.

4.4 Asphalt Manufacturing Experiments

The process of making a new type of asphalt made from this waste, through several stages as follows:

1) Prepare a furnace made of masonry, as well as a cooking pot made from used oil drums with a capacity of 155 kg.
2) Pour the oil waste into a cooking pan and heat it using firewood until it boils, or for about 60 minutes in a temperature of 450 ° C.
3) Put the resin stone into the oil waste that has boiled, boil it in a temperature of 450 ° C - 750 ° C for 120 minutes while stirring.
4) Sprinkle the formula ash after the resin stones have been boiled for 120 minutes while stirring. Ash formula is done 4 times sprinkling. The first sprinkling after the resin stone has been boiled for 120 minutes at 650 ° C, the second sprinkling at 180 minutes at 650 ° C, the third sprinkling at 240 minutes at 650 ° C, the fourth sprinkling at 300 minutes and begins to lower the combustion temperature to 450 ° C.
5) Make a continuous stirring until 420 minutes and reduce the combustion temperature little by little from the temperature at 300 minutes to 450 ° C to 180 ° C dimenit to 420.
6) Visually examine the produced asphalt by taking a little, cooled, then check the thickness of the asphalt, by forming asphalt like a small ball, then pull like pulling rubber. If the asphalt is stretched elastic, or stretched for 20 - 30 cm, it is not broken, then it is stated that the asphalt making is ripe, and then pour it into the space provided.

The combustion temperature of asphalt manufacture based on asphalt processing time in detail can be seen in Figure 4.

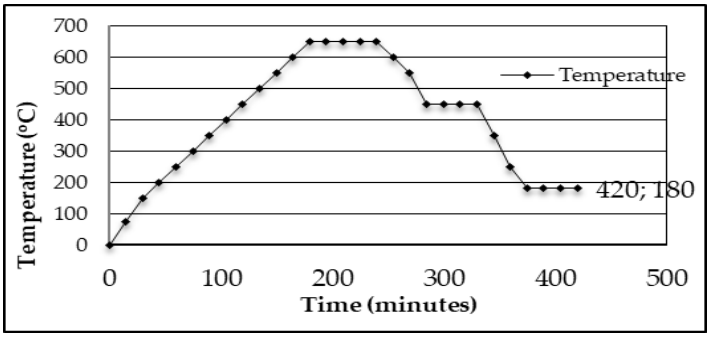

Figure 4. Time and temperature relationship graph

4.5 Asphalt Manufacturing Results Based on Material Composition

Experiments for making asphalt made from waste oil, resin stone and formula ash, conducted 9 times with a mixture of different ingredients. The results of 9 experiments based on visual inspection are known, the best results are the composition of the mixture of ingredients; 62.42% oil waste, 37.45% resin stone, and add 0.12% formula ash from mixed composition 2. In general, changes in materials at the combustion temperature in the asphalt manufacturing process as described in Figure 5.

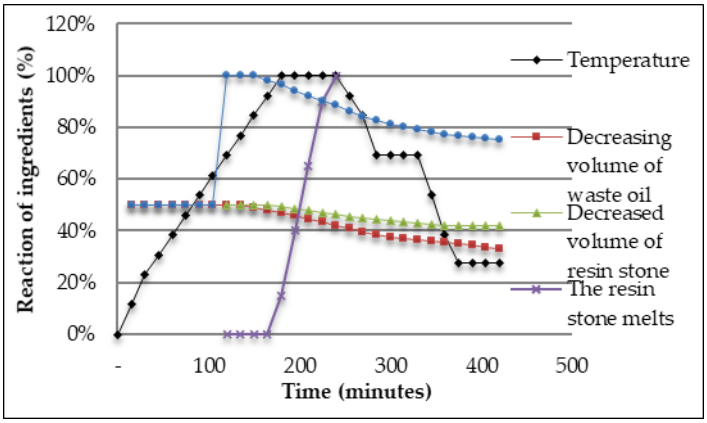

Figure 5. Graph of behavior change in asphalt material

4.6 Asphalt Laboratory Test

The asphalt criteria required are based on the Indonesian National Standard (SNI 6749: 2008) as described in Table 2.

TABLE 2. REQUIREMENTS FOR MULTIGRADE ASPHALT (60/70 PENETRATION ASPHALT BASE MATERIAL)

N	Type of Testing	Method	Requirements	
			Min.	Max.
1	Penetration; 25 °C, 100 g; 5 seconds; 0.1 mm	SNI 06-2456-1991	50	70
2	Softening point, °C	SNI 06-2434-1991	55	-
3	Flash point, °C	SNI 06-2433-1991	225	-
4	Ductility; 25 °C; cm	SNI 06-2432-1991	100	-
5	Specific gravity	SNI 06-2432-1991	1.00	-
6	Solubility in trichlorethylene; % by weight	ASTM D 5546-94a	99	-
7	Weight loss (TFOT), % by weight	SNI 06-2440-1991	-	0.8
8	Penetration after weight loss, original%	SNI 06-2456-1991	60	-
9	Ductility after weight loss, cm	SNI 06-2432-1991	50	-

Based on the provisions of multi grade asphalt requirements (base material asphalt penetration 60/70) as in Table 2, it then becomes an evaluation parameter for the characteristics of a new type of asphalt made from waste oil, resin stones and formula ash from plant twigs. Visually the asphalt results from this study resemble asphalt in general, but the aroma of this new type of asphalt is very different from the common oil asphalt. This new type of asphalt when heated emits an aroma

like the smell of incense burned. Based on asphalt laboratory tests the findings in this study are shown in Table 3.

TABLE 3. PROPERTIES OF ASPHALT FROM THIS STUDY

N	Type of Testing	Method	New asphalt from waste	
			Samp. 1	Samp.2
1	Penetration testing	SNI 06-2456-1991	170.6	170.02
2	Softening point testing	SNI 06-2434-1991	56	57
3	Ductility testing	SNI 06-2433-1991	14	15
4	Flash point testing	SNI 06-2432-1991	204	200
5	Burn point testing	SNI 06-2441-1991	216	210
6	Specific gravity testing	RSNI M -04-2004	0.997	0.992
7	Bitumen sticky testing on rocks	SNI 06-2432-1991	99	99

Asphalt penetration requirements 60/70 Indonesian National Standard (SNI 6749: 2008) minimum penetration of 50 - 70 dmm, while the penetration of the asphalt of this research reaches 170.6 dmm, which means the asphalt from this research is equivalent to asphalt penetration of 120. The softening point of asphalt penetration 60/70 requires 55 ° C while the asphalt softening point of this study reaches 57 ° C, meaning that the asphalt results of this study have equality with penetration asphalt 120. The flash point of asphalt 60/70 is required 225 ° C while the asphalt flash point of this study reaches 204 ° C, meaning that the asphalt from this study, has an equivalence with asphalt penetration of 80. The ductility of asphalt from this study only reached 15 cm, this means it is below the 60/70 penetration asphalt standard. The asphalt of this research, having a specific gravity of 0.997, is below the penetration standard of asphalt 60/70, which requires a specific gravity of 1.00.

5 CONCLUSION

This research has found a solution to the problem of asphalt deficiency, as well as an abundance of oil waste, which is harmful to living things and the environment. At present it has been found that oil waste can be used to make asphalt. The new discovery in this study is that waste oil, stone resin, and formula ash made from plant twigs can be engineered into asphalt. This asphalt has been tested as a leak-proof coating in high rise building bathrooms, the results are proven to be good, visually meeting the characteristics of asphalt in general. This asphalt has been laboratory tested and has ductility and specific gravity below the asphalt penetration standard of 60 but has better penetration and softening points. Asphalt as a result of this research has penetration and softening point which is equivalent to penetration asphalt 120 and flash point is equivalent to penetration asphalt 80. This asphalt can then be used for flexible pavement in road construction.

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