

Rejuvenation of Aged Bitumen using Natural Rejuvenators

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Abstract - Bitumen is a thermo plastic and viscoelastic material with high thermal sensitivity. Aging of bitumen is known as the change in physical and rheological properties with time. The most important problems presented by the use of bitumen in pavements are due to aging of the bitumen occurring on storage, mixing, transporting and laying on the road, as well as in service life. The aging problem of bitumen leads to pavement failure, such as surface ravelling and cracking. The aging mechanism of bitumen is the loss of volatiles and oxidation. To improve the performance of aged bitumen, rejuvenator shall be added. Rejuvenators mainly include vegetable oil and petroleum based extracted oil. The natural product based rejuvenating agent must have the required technical properties and in use should be safe and easy to handle. Waste Vegetable Oil, Waste Engine Oil, Palm Oil, Castor Oil, Pongamia Oil, Cotton Oil etc., are some of the natural rejuvenators widely accepted. Vegetable oil based rejuvenators have received more and more attention due to their green and regenerative advantages. The effect of natural rejuvenating agents on the performance of aged bitumen is characterized by pavement performance tests included physical tests and a rheological test. This study identifies the most effective natural rejuvenator among Waste Vegetable Oil, Waste Engine Oil and Castor Oil. The aged bitumen is rejuvenated by 1%, 2%, 3%, 4% and 5% of the most effective natural rejuvenator by weight of bitumen to find out the optimum content.

Key Words: Aged Bitumen, Natural Rejuvenators, Waste vegetable oil, Waste engine oil, Castor oil

1. INTRODUCTION

Bitumen aging concerns the physical properties involved in bitumen because as time elapses changes occur in its chemical composition. These changes are produced by the interaction of intrinsic and extrinsic variables associated with short and long term aging. Aging mechanisms consist of volatilization, oxidation and hardening. Bitumen aging is complex and causes functional damage to bitumen. The aging mechanism negatively affects pavement flexibility (performance) after years of service life. The most important damage engendered by aging is cracking and a reduction of bitumen fatigue life due to bitumen binder stiffness. Aging can be understood in terms of two stages short term and long term aging, the former takes place during mixing in a plant, production, storage, and transport. Laying of a bitumen mixture results in volatilization and some degree oxidation during short term aging and making it the more

severe type of aging. Long term ageing is produced throughout bitumen's service life, resulting from oxidation due to UV radiation, humidity and rain, hardening happens during long term aging at room temperature. To improve the performance of aged bitumen, rejuvenator is usually added. Rejuvenating Agent is used to regain the properties of aged bitumen to that of fresh bitumen. Rejuvenator mainly includes vegetable oil and petroleum based extracted oil. A rejuvenating agent that is commonly used is a low viscosity product obtained from crude oil distillation. The present inventors have sought to provide an alternative rejuvenating agent, and have sought to provide an agent wherein at least a proportion of the agent is a natural product of plant origin. Incorporating a plant product instead of a petroleum product offers a potentially more sustainable product, and may lead to price and supply advantages. The natural product based rejuvenating agent must have the required technical properties and in use should be safe and easy to handle. Waste Vegetable Oil, Waste Engine Oil, Palm Oil, Castor Oil, Pongamia Oil, Cotton Oil etc., are some of the natural rejuvenating agents widely accepted. Due to cost and supply advantage Waste Vegetable Oil (WVO), Waste Engine Oil (WEO), and Castor Oil are considered to be used in this study.

2. EXPERIMENTAL INVESTIGATION

2.1 Materials

1. Bitumen

It is obtained naturally or as residue from petroleum distillation. Bitumen used for the study is 60/80 grade. Both the samples of fresh and aged bitumen were collected from the same source. There are 5 different samples of bitumen used in the study. They are Fresh Bitumen, Aged Bitumen, Aged Bitumen blended with WVO, Aged Bitumen blended WEO, Aged Bitumen blended with Castor Oil.

2. Waste Vegetable Oil (W-Oil)

It is a waste product produced within the catering industry. It is rich in unsaturated fatty acid and having better temperature resistance.

3. Waste Engine Oil (WEO)

Engine oil is a petroleum based material, and a similar molecular structure to asphalt. Addition of waste engine oil into bitumen has shown that it can change physical, mechanical and chemical properties.

4. Castor Oil

It is a vegetable oil that is used for a wide range of cosmetics and medical purposes. Castor oil is a colour less to very pale yellow liquid with a distinct taste and odour.

2. 2 Tests

The following IS tests were performed in this study. They are:

1. Penetration test (IS:1203-1978)
2. Softening point test (IS:334-1982)
3. Ductility test (IS:1208-1978)
4. Specific Gravity (IS:1203-1978)
5. Viscosity test (IS:217-1969)

3. RESULTS AND DISCUSSION

3.1 Comparison of Properties of Fresh and Aged Bitumen

200 gm of fresh bitumen and aged bitumen samples are taken, heated at 100-150°C and melted into its viscous form and all the physical tests were performed. Test result of fresh and aged bitumen is illustrated in table 1.

Table -1: Test results of Fresh and Aged Bitumen

Bitumen Tests	Fresh Bitumen	Aged Bitumen
Penetration Value	62	38
Softening Point (°C)	41	53
Ductility (cm)	100	65
Specific Gravity	0.99	0.60
Viscosity (sec)	42	17

200 gm of fresh bitumen and aged bitumen samples are taken, heated at 100-150°C and melted into its viscous form and all the physical tests were performed. Test result of fresh and aged bitumen is illustrated in table 1. By comparing it is proved that there is lot of variation in the properties of bitumen due to aging. Penetration value of 60/80 grade of bitumen has reduced from 62 to 38 after aging. Softening point has increased from 41°C to 53°C because of aging. Ductility value is also affected due to aging. The value has been reduced from 100 cm to 65 cm. The viscosity value falls from 42 sec. to 17 sec. Specific gravity value has been changed from 0.99 to 0.60.

3.2 Comparison of Properties of WVO, WEO and Castor Oil Rejuvenated Aged Bitumen

In order to ascertain the most suitable rejuvenator among WVO, WEO and Castor Oil, 4% of each is added to 200 gm. of aged bitumen and physical tests were carried out. The results are shown in table 2.

Table -2: Comparison of Fresh and Rejuvenated Aged Bitumen

Bitumen Tests	Fresh Bitumen	Rejuve nated Aged Bitumen		
		WVO	WEO	Castor Oil
Penetration Value	62	60	58	56
Softening Point (°C)	41	40	50	46
Ductility (cm)	100	84	83	80
Specific Gravity	0.99	0.96	0.95	0.95
Viscosity (sec)	42	38	36	32

By comparing it is proved that WVO is the best rejuvenating agent than WEO and castor oil. From the test results, it is observed that the properties of aged bitumen after blending with 4% of WVO resembles more close to the properties of fresh bitumen. So WVO is more effective than other rejuvenating agents. Now we would find out the optimum content of WVO in rejuvenating aged bitumen.

3.3 ANALYSIS OF WVO REJUVENATED AGED BITUMEN

From the previous experiments conducted, WVO Rejuvenated Aged Bitumen showed a close resemblance to fresh bitumen. In order to find the optimum content of WVO as a rejuvenator, varying percentages of WVO (By weight of bitumen) was added to the aged bitumen and the following test results were obtained

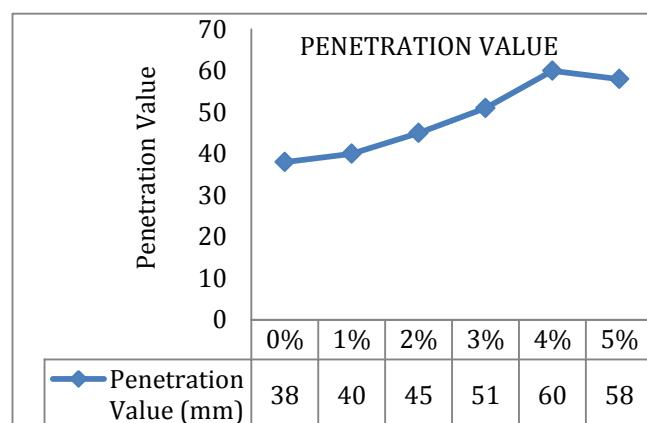


Chart -1: Penetration Value versus Percentage of WVO

Aged bitumen is blended with 1%, 2%, 3%, 4% and 5% of waste vegetable oil by weight of bitumen. As we can see that the penetration value of virgin bitumen reduces due to aging. In contrast, the value of penetration increased with the addition of waste vegetable oil into the aged bitumen especially for bitumen with 4% of WVO. The higher penetration value indicates less temperature susceptibility and more elastic behaviour. Increasing the penetration value for various degree of ageing is caused by changes in chemical groups (asphaltenes and maltenes) of bitumen, due to the addition of waste vegetable oil that lead to having a softer binder. From the test results it is observed that the penetration value of aged bitumen after blending with 4% WVO resembles closer to the penetration value of fresh bitumen which is 62.

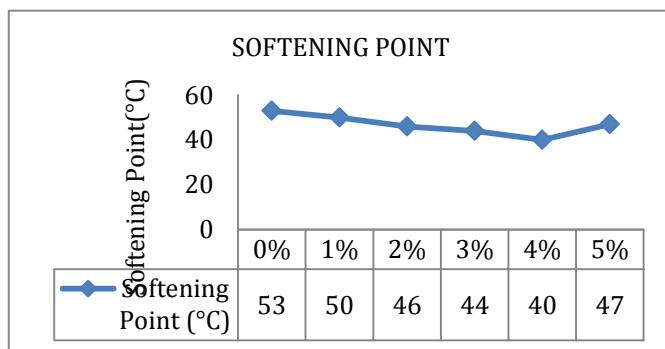


Chart -3: Softening Point versus Percentage of WVO

Softening point value decreases with the addition of waste vegetable oil content in the aged bitumen. In aged bitumen, increase in the asphaltene content with high molecular weight can produce harder bitumen, while the chemical group changes during the mixture of waste vegetable oil can rejuvenate the aged bitumen. There is a gradual decrease in the softening point of bitumen by adding waste vegetable oil to aged bitumen. However an appreciable change can be noted by adding 4% of waste vegetable oil to aged bitumen. From the test results it is observed that the softening point value of aged bitumen after blending with 4% WVO resembles more close to the softening point value of fresh bitumen.

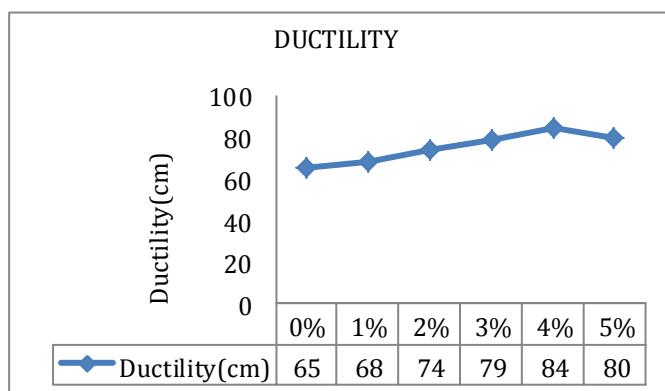


Chart -3: Ductility versus Percentage of WVO

It is clear that after the addition of waste Vegetable oil, the ductility of aged bitumen has increased. By adding 4 % of WVO the ductility of aged bitumen resembles close to that of virgin bitumen. So it proves that by addition of WVO to aged bitumen the adhesive property of aged bitumen is increased and the value is coming closer to that of virgin bitumen whose ductility value is 100 cm.

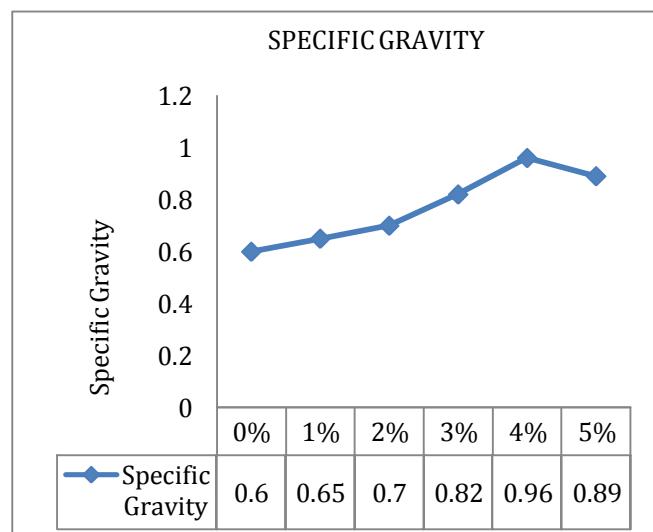


Chart -4: Specific Gravity versus Percentage of WVO

The specific gravity value of bitumen reduces due to aging caused by the oxidation of bitumen. Specific gravity determines the strength of bitumen. By the addition of various percentage of waste Vegetable oil to aged bitumen the specific gravity value of bitumen is increased. This proves that waste Vegetable oil can increase the strength of aged bitumen and it can be again used for road construction works. From the test results, it is observed that the specific gravity value of aged bitumen after blending with 4% WVO resembles closer to the specific gravity value of fresh bitumen.

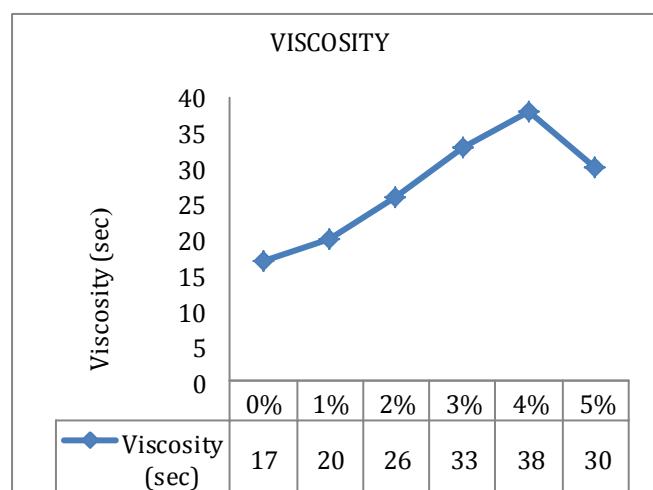


Chart -5: Viscosity versus Percentage of WVO

As the graph shows, the aged bitumen has a highest viscosity value, while the addition of 4% waste vegetable oil into the aged bitumen achieves almost the same viscosity as that of original bitumen. The viscosity value of fresh bitumen is 42 seconds.

4. CONCLUSION

Due to aging, bitumen loses its properties. As the result of aging, bitumen hardens, change in chemical composition occurs, softening point increases, ductility, penetration value, specific gravity and viscosity values get decreases. The use of waste vegetable oil as rejuvenating agent in aged bitumen showed a very promising result compared to the other two rejuvenating agents. The aged bitumen was rejuvenated by 1%, 2%, 3%, 4% and 5% of waste vegetable oil by the total weight of bitumen. From the study it proved that 4% of WVO content is the optimum. This result proved that penetration value of aged bitumen increases with increasing percentage of waste vegetable oil, Softening point decreases with increase in percentage of waste vegetable oil, ductility of aged bitumen increases with increase in percentage of waste vegetable oil. Specific gravity determines the strength of bitumen. By adding various percentages of WVO to aged bitumen the specific gravity value of aged bitumen is increased thereby increasing the strength of aged bitumen. We investigated the possibility of using Waste Vegetable Oil (WVO), which is a waste material that pollutes landfills and rivers, as an alternative natural rejuvenating agent for aged bitumen to enhance the properties to that of original bitumen. The WVO can act as an effective rejuvenating agent, but only when used in appropriate proportion.

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