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Investigating the effect of waste cooking oil and waste engine oil on aged bitumen

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ABSTRACT

In order to determine if used engine oil and used cooking oil can be used to recycled old asphalt, the impact of these substances on the improvement of the material's physical properties was investigated. Aged asphalt binders with 5 hours ageing were obtained using an indoor test simulation with the Thin Film Oven Test (TFOT) at 163°C. Then, three different dosages of waste engine oil and waste cooking oil were added to investigate performance improvements. The findings clearly demonstrated that waste engine oil and waste cooking oil could effectively soften and recover the workability of aged asphalt. Furthermore, if the content of waste engine oil or waste cooking oil was appropriate, the performance of aged asphalts could be improved to that of virgin asphalt. Overall, the good applicability would provide waste oil with a much broader range of services in the asphalt

pavement recycling field. It also provided a method for creating a new rejuvenating agent using the two waste oils to improve the properties of bitumen. Furthermore, it realized waste recycling and environmental protection.

Keywords: - Bitumen binder, Aged binder, rejuvenating, properties improvement, waste engine oil, waste cooking oil.

1.INTRODUCTION

Waste cooking oil (WCO) and waste engine oil (WEO) have been produced in huge quantities in recent years because of the advancement of automobiles and the improvement of society's living standards. With the increase in the number of vehicles on the road, the amount of WEO being generated around the world is increasing. Continuous engine operation causes the oil's performance to deteriorate over time, making it more challenging to recycle WEO as fresh motor oil. WEOs are by-products of petroleum products, including used motor oil from cars, and they share the majority of bitumen's essential physical and chemical characteristics. Additionally, a growing population has caused a rise in food production, which has increased the quantity of kitchen trash produced. Edible cooking oil is one of the most often-used kitchen essentials. It may be generated from a variety of feed materials, including plant and vegetable oils, animal fats, and a number of other sources. Waste cooking oil (WCO), which is created during the frying and cooking processes when various edible vegetable oils, animal oils, and palm oil are utilized. Due to their ability to damage rivers and other natural resources, WEO and WCO have become significant environmental contaminants.

The appropriate disposal of this waste oil is extremely important since it has the potential to exacerbate local and environmental problems. Since waste oil is not treated before being disposed of, dumping it into landfills or rivers frequently has an adverse impact on the environment. One of the most severe ecological issues that can arise is eutrophication, which occurs when sunlight cannot penetrate the surface of a river because of a thin coating of oil blocking its path. When eutrophication occurs in a river, the oxygen supply for marine life is disrupted over time. As a result, engine oil from automobiles and waste cooking oil are the most significant sources of river contamination.

The responsibility for managing the high construction costs and reducing the waste disposal difficulties has prompted the practice of waste oil recycling as an option and alternative way of preventing these issues from occurring. Treatment or recycling of these waste oils not only helps reduce pollution and save energy, but it is also an example of a new way of reusing waste. According to the International Energy Agency, India uses 23 million tons of edible oil and 102 billion liters of gasoline annually. After use, almost 3 million tons of oil are discarded, this is known as "used cooking oil." When WEO is burned, airborne pollutants are released into the atmosphere, where they can enter people's lungs and have detrimental effects on their health. According to research, WEO and WCO have the potential to be utilized in highway construction to lessen the effect of hardening on recycled flexible pavement materials after being reused since their molecular structures are similar to those of bitumen. As a result, the reuse and recycling of oils in modified asphalt materials can be a source for properly converting waste material qualities into ecologically beneficial products. By using waste oil, the proposed method offers an effective means to restore the usage of old bitumen while also having the potential to enhance its qualities.

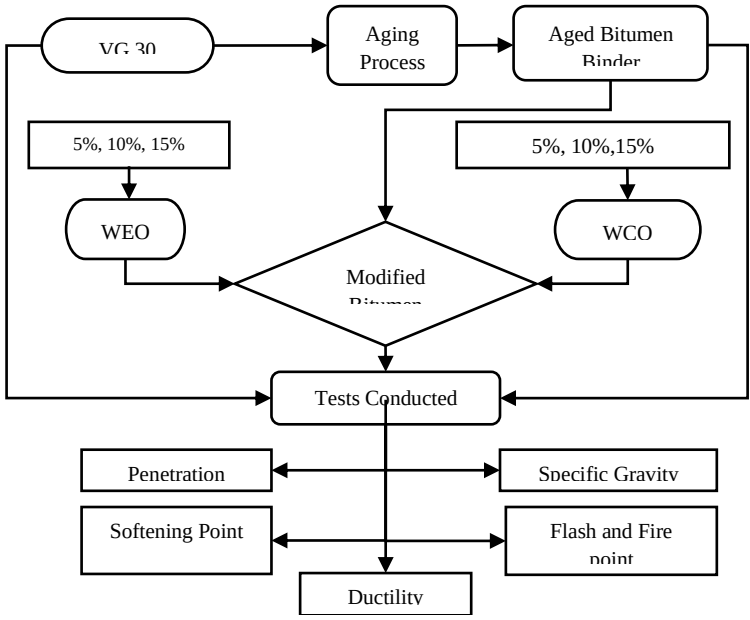

Figure 4.1 Experimental program flow chart

2.Need for study

The purpose of this study is to develop a bitumen that can be used in place of bitumen in flexible pavement. To achieve this goal, it is necessary to integrate bio-based waste products with standard bitumen while simultaneously reducing the percentage of bitumen, according to the adaptability of the paving bitumen, specification by Indian Standard IS 73: 2013.Three different dosages of WCO and WEO are blended with Viscosity Grade VG-30 bitumen under ageing conditions and evaluated for their performance. The thin film oven test (TFOT) was used to age the waste oil treated samples for an artificially short period. To further assess physical performance parameters such as penetration test, softening point test, ductility test, specific gravity test and flash and fire point test were performed on the samples. Based on the physical performance parameters, an optimal type and content of waste oil was suggested.

3. OBJECTIVES AND SCOPE

The aim of this study is to enhance properties of the simulated aged asphalt by adding waste oils to it. To achieve these following objectives are formulated**.**

- To conduct various experiments (e.g., penetration, ductility and etc.) on virgin VG 30 bitumen.
- To prepare aged bitumen of VG30 in laboratory.
- To perform various tests on aged bitumen after adding waste oils.
- To carry-out the detailed project report.

4. METHODOLOGY

In this study, virgin bitumen is aged and modified with waste oils with different proportions and various tests are conducted.

5. Materials used

5.1 BITUMEN

India experiences a hot climate on average, with summer mean temperatures reaching 35–40°C and winter mean temperatures exceeding -10°C. As a result, while keeping this in mind, it is necessary to design pavements that are stable enough during the summer and winter seasons, respectively. This study uses VG 30 (Viscosity Grade) bitumen. Bitumen must meet standard specifications as specified in IS 73:2013 by the Bureau of Indian Standards for Viscosity Grade. The thin film oven test was performed at 163°C for 5 hours as per IS 9382. The effects of heat and air can be determined by comparing the physical properties of the samples measured before and after the oven condition, as well as the change in sample mass. It is possible to estimate the approximate change in bitumen properties. It creates a residue that resembles the asphalt condition similar to that of the one incorporated into the pavement.

5.2 WASTE COOKING OIL

Waste cooking oil used to modify in this study was a sunflower oil that was procured from hostel mess, which was used for frying and it was ensured that there were no particulate matters in it. It was then filtered to remove any dirt or other suspended materials that might have been present.

5.3 WASTE ENGINE OIL

Waste engine oil used in this study was used in its natural form without any special treatment. It was procured from local vehicle garage in Solapur, Maharashtra. It was dark liquid that was then filtered to ensure there are no suspended particles or any dirt.

6. TEST CONDUCTED

6.1 Penetration Test-

The penetration test is used to evaluate the consistency and resistanc is

Conducted according to IS: 1203-1978.The penetration ageing ratio can also be used to determine how ageing would affect modified binder made using waste oils.

6.2 Softening point test:

The softening point test of a material is used to determine

its thermal sensitivity at a higher temperature at which it achieves a specific degree of softening. The softening point test is conducted as per IS: 1205-1978 using the ring and ball apparatus.

6.3 Ductility Test: -

The ductility of bitumen is defined as the distance in centimeters, to which the bitumen filled in a standardized briquette elongates before the thread of bitumen breaks. The ductility test is conducted according to IS: 1208-1978. This test determines the adhesive properties of bitumen as well as its capacity to stretch under certain conditions.

6.4 specific Gravity Test: -

A specific gravity test is used to determine how much bitumen weighs relative to the same volume of water. It is the ratio of the mass of the substance in consideration to the 7mass of an equal volume of water at a specified temperature. This test is conducted according to IS: 1202-1978.

7. Bitumen Ageing using Thin Film Oven (TFO):-

The aging operation was done with the help of thin film oven as per IS 9382. During the test, oven temperature is kept constant at a certain value and dry air is blown to the samples kept in pans. For aging procedure, 50g of bitumen samples were placed in the pans at a temperature of 163C for a time period of 5 hours. This process of ageing simulated the loss of volatiles due effect of heat and air.

8. Preparation of Modified Binder

Three dosages of the oils 5, 10, and 15 percent by weight of the binder were chosen in order to evaluate the impact of waste oils on the aged binder. In order to keep the cost of the overall quantity of rejuvenator used in recycling significantly lower than the cost of a virgin binder, the decision to employ the maximum amount of rejuvenator was made based on economic judgement. To examine the effectiveness of rejuvenator at low, medium, and high doses, a 5% difference between the dosages was used (5, 10, and 15 percent, respectively). For five minutes, the samples were heated and stirred simultaneously within the beaker with the use of a glass rod. For other aged binder samples immediately after recovering the aged binder from the thin film oven plates to avoid reheating and extra aging.

9. Results and Discussions.

9.1 EFFECT OF WCO AND WEO ON PENETRATION VALUE.

Penetration test is one of the most essential test that is performed to examine the physical properties of bituminous materials. Below figures depicts the result of penetration test conducted on bitumen treated with WCO and WEO at different oil percentages (5%, 10% and15%) by the weight of bitumen.

An increase in penetration value was achieved by addition of waste oils, the observed variations in the results indicates the variations in the physical characteristics of modified bitumen with increasing oil concentration. The data obtained reveal that aged bitumen softened when the WEO and WCO doses were increased, adding WCO softens the bitumen more as compared to adding WEO for modifying. As a result, just 5% of waste oil by weight of binder was found to be optimal since the outcomes were within the limit of 50-70mm according to IS: 73–2013

for VG 30 grade.

WCO - waste cooking oil
WEO -waste engine oil

Table-1: Results of penetration with 5% dosage of oil

Sr. no	Virgin Binder	Aged Bitumen	WCO	WEO
1	54.67	38.67	66.00	58.33
2	58.00	44.00	58.00	68.67
3	62.67	31.33	75.33	69.33

Table-2: Results of penetration with 10% dosage of oil.

Sr. no	Virgin Binder	Aged Bitumen	WCO	WEO

1	54.67	38.67	159.67	72.00
2	58.00	44.00	160.00	79.34
3	62.67	31.33	160.33	78.67

Table-3: Results of penetration with 15% dosage of oil.

Sr. no	Virgin Binder	Aged Bitumen	WCO	WEO
1	54.67	38.67	257.67	178.67
2	58.00	44.00	258.33	154.00
3	62.67	31.33	262.00	165.00

9.2 EFFECT OF WCO AND WEO ON SOFTENING POINT.

Bitumen with a higher softening point is preferable because bitumen is considered stiff and provides mixtures that are less susceptible to deformations and fatigue cracking when exposed to high temperatures. Below figures depicts the result of penetration test conducted on bitumen treated with WCO and WEO. It was observed that WCO and WEO modified bitumen decreased the softening point values when compared with the virgin and aged bitumen. As the amount of WEO and WCO dosages were increased, so was the drop in the softening point. Whereas there was not much difference in the values of aged and virgin bitumen. The WCO modified bitumen was softer than WEO modified bitumen. As a result, 5% of waste oil by the weight of binder was found to be optimal dosage as it obtained values within the 47°C limit (Clause 6.2 IS: 73–2013 for VG 30 grade).

Table-4: Results of softening point 5% dosage of oil

Sr. no	Virgin Binder	Aged Bitumen	WCO	WEO
1	52.6	52.75	44.20	50.35
2	51.25	54.20	44.15	46.3
3	53.65	52.15	44.30	47.05

Table-5: Results of softening point 10% dosage of oil

Sr. no	Virgin Binder	Aged Bitumen	WCO	WEO
1	52.6	52.75	39.15	42.40
2	51..25	54.20	34.30	42.90
3	53.65	52.15	34.65	43.70

Table-6: Results of softening point 15% dosage of oil

Sr. no	Virgin Binder	Aged Bitumen	WCO	WEO
1	52.6	52.75	66.00	58.33
2	51.25	54.20	58.00	68.67
3	53.65	52.15	75.33	69.33

9.3 Effect of WCO and WEO on ductility.

Ductility is a property of bitumen that is used to demonstrate its adhesive and cohesiveness. Below are the figures depicting the ductility values of virgin, aged and waste oil treated bitumen. When virgin and aged bitumen was tested the average values were 78cm and 75cm respectively. It was observed that in case of WCO modified bitumen, the ductility values were decreasing with increase in percentage of WCO content. With 5% modification the values obtained were just satisfactory and for 10% modified bitumen the average value was 30cm and for 15% modification the sample was not able to be treated. Whereas in case of WEO modified bitumen the values were almost similar for the three all dosages. For one of the specimens in 5% modification the value was greater than 100 cm and since the ductility machine's maximum ductility limit is just 100 cm, the value could not be recorded. As a result, 5% of waste oil by the weight of binder was found to be optimal dosage as it obtained satisfactory values.

Table-7: Results of ductility with 5% dosage of oil

Sr. no	Virgin Binder	Aged Bitumen	WCO	WEO
1	83.00	75.00	48.00	80.00
2	75.00	70.00	50.00	88.00
3	76.00	80.00	53.00	100.00

Table-8: Results of ductility with 10% dosage of oil

Sr. no	Virgin Binder	Aged Bitumen	WCO	WEO
1	83.00	75.00	32.00	82.00
2	75.00	70.00	36.00	94.00
3	76.00	80.00	34.00	78.00

Table-9: Results ductility with 15% dosage of oil

Sr. no	Virgin Binder	Aged Bitumen	WCO	WEO
1	83.00	75.00	0	80.00
2	75.00	70.00	0	73.00
3	76.00	80.00	0	72.00

9.4 EFFECT OF WCO AND WEO ON SPECIFIC GRAVITY.

As we can see in the results, the addition of waste oils has decreased the specific gravity of the samples as demonstrated in below figures. For virgin bitumen the obtained average value is 0.95 and for aged bitumen is 1.02 as shown in. However, all the obtained results are acceptable, It was observed that for modified bitumen average values are increasing with increase in dosage for both WCO and WEO dosages. After treating aged bitumen with all the three percentages of both the waste oils it was found that from 5% dosages onwards the specific gravity values were satisfying and for 10% and 15% it was slightly more than that of virgin bitumen as shown in Figure **Error! No text of specified style in document.**.11 and Figure **Error! No text of specified style in document.**.12. As a result, dosage of 5% waste oil by weight of bitumen was found to be optimal because it gives the results same as that of the virgin bitumen.

Table-10: Results of specific gravity with 5% dosage of oil

Sr. no	Virgin Binder	Aged Bitumen	WCO	WEO
1	0.90	1.07	1.03	1
2	1.00	1.05	0.82	1.00
3	0.93	0.94	1.05	0.93

Table -11: Results of specific gravity with 10% dosage of oil

Sr. no	Virgin Binder	Aged Bitumen	WCO	WEO
1	0.90	1.07	1.00	1.00
2	1.00	1.05	1.17	1.06
3	0.93	0.94	1.00	1.00

Table -12: Results of specific gravity with1 5% dosage of oil

Sr. no	Virgin Binder	Aged Bitumen	WCO	WEO
1	0.90	1.07	1.03	1.06
2	1.00	1.05	1.05	1.06
3	0.93	0.94	1.05	1.06

10. CONCLUSIONS

The following conclusions were obtained from the result of the present study

1. When compared to VG 30 bitumen in aged circumstances, the modified binders, such as WCO and WEO, showed higher penetration values Addition of WCO softens the bitumen more as compared to adding WEO for modifying.
2. The modified bitumen showed decreasing values of softening point when compared to virgin and aged bitumen.
3. The amount of waste oil is increased, the ductility values were reducing, showing that the WEO and WCO 5% dosages values obtained satisfactory results compared to 10 and 15%.
4. In case of results obtained from the specific gravity and flash and fire point results, it was found that modified bitumen with 5% dosage of oil gave results similar to that of VG30 bitumen.
5. Waste cooking and engine oils can be used to successfully improve the physical qualities of bitumen. This observation indicates that when a higher percentage of waste oil was blended with bitumen, variability was observed, which resulted in a change in the quality of the bitumen that was formed. Overall, modified bitumen samples containing up to 5% waste oil produced the best results.

11. REFERENCES

1. Amira M. El-Shorbagy , Sherif M. El-Badawy and Alaa R. Gabr (2019). "Investigation of waste oils as rejuvenators of aged bitumen for sustainable pavement", Construction and Building Materials 220 (2019) 228–237.

2. Huifang Yang and Ruikun Dong(2019). "Investigating the properties of rejuvenated asphalt with the modified rejuvenator prepared by waste cooking oil and waste tire crumb rubber", Construction and Building Materials 315 (2022) 125692.

3. IRC SP:53 (2010) "Guidelines on use of modified bitumen in road construction", second revision, Indian Road Congress, New Delhi.

4. IS 1201-1220 (1978) " Methods for testing tar and bituminous materials" , first revision, published Bureau of Indian Standards, New Delhi.

5. IS 73 (2013) "Paving bitumen [PCD 6: Petroleum, Coal, and Related Products]", fourth revision, published by Bureau of Indian Standards, New Delhi.

6. IS 9382 (1979): Methods for testing tar and bituminous materials: Determination of effect of heat and air by thin film oven tests [PCD 6: Bitumen Tar and their Products], published by Bureau of Indian Standards, New Delhi.

7. Islam Gokalp and Volkan Emre Uz (2019). "Utilizing of Waste Vegetable Cooking Oil in bitumen: Zero tolerance aging approach", Construction and Building Materials 227 (2019) 116695.

8. Majid Zargar, Esmaeil Ahmadinia, Hallizza Asli and Mohamed Rehan Karim (2012). "Investigation of the possibility of using waste cooking oil as a rejuvenating agent for aged bitumen", Journal of Hazardous Materials 233–234 (2012) 254–258.

9. Tufail Ahmad, Naveed Ahmad, Muhammad Jamal, Gul Badin and Muhammad Suleman (2020), "Investigation into possibility of rejuvenating aged asphalt binder using mustard oil", International Journal of Pavement Engineering, DOI:10.1080/10298436.2020.1823388.

