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Waste Cooking Oil as a Rejuvenating Agent in Aged Bitumen

Ravi Datt Sharma^a Amit Kumar Yadav^b and Ashish Kumar^c

^aM.Tech Student, Department of Civil Engineering, Lovely Professional University Phagwara, India

^bAssistant Professor, Department of Civil Engineering, Lovely Professional University Phagwara, India

^cAssociate Professor, Department of Chemistry, School of Civil Engineering, Lovely Professional University Phagwara, India

E-mail: ashish.16464@lpu.co.in

Abstract: As we know that, after years of service, bitumen binder of bituminous concrete has become aged. So this research paper will observe the effect of using waste cooking oil (WCO) as a rejuvenating agent in aged bitumen which is a waste product and causes pollution in seas and land. This research paper also explains the properties of aged bitumen and fresh bitumen. So the objective of this research paper is to know the physical and chemical properties of untreated fresh bitumen, aged bitumen and rejuvenated bitumen by various tests like penetration test, viscosity test, softening point test, acid test, water content test. A property of aged bitumen and untreated fresh bitumen is also compared by these tests. In general this research shows that 3-4% of WCO can rejuvenate the bitumen of 30/40 group and resembles the properties of 60/70 group of bitumen.

Keywords: Aged bitumen, Physical properties, Reclaimed Asphalt Pavement, Rejuvenating agent, Waste cooking oil.

1. INTRODUCTION

Since past many years, paving of flexible roads is being done by the use of most known petroleum based product which is bitumen. Bitumen's modified form known as asphalt is a best binder for flexible pavement. But after many years of service, binder material of road becomes aged and starts losing its properties. Aging causes increase in stiffness of bitumen and also affects its physiochemical properties. Therefore as a conclusion, aged bitumen becomes more brittle and reduces the pavement strength and decrease the service life of road. So as we know that rapid depletion of crude oil resources is leading to continuous increase in crude oil prices. Therefore, by recycling old bitumen layer, the overall service life of pavement can be extended as well as the use of new bitumen is reduced. A well designed reclaimed bitumen mixture can meet the properties of fresh bitumen. In order to minimize the effect of aging from aged bitumen some rejuvenator should be included in the reclaimed mixture. So in past mainly two types of rejuvenating agent were used as a rejuvenator. Softening agent and rejuvenating agent. Softening agents are mostly used to lowering the viscosity of aged bitumen on other hand rejuvenating agent are added for regaining the physical and chemical properties of aged bitumen. So rejuvenator used in this research paper is waste cooking oil as a rejuvenating agent. The result of waste motor oil report that material in which motor oil used as rejuvenator can compete with the new material. Therefore successful uses of WMO also encourage the application of waste oils as a rejuvenator in the pavement. So this paper studies the use of waste cooking oil in bitumen.

2. MATERIAL AND EXPERIMENTAL PROCEDURE

2.1. Material

The applied fresh 60/70 bitumen was collected from near trader and tested. Its properties is illustrated in table1. furthermore aged bitumen of same penetration grade was collected from the stockpile of same trader. Its properties is illustrated in table 2. Waste cooking oil was collected from nearer restaurant.

2.2. Experimental Procedure

Initially, untreated bitumen of 300gm is heated at 100-150 degree Celsius and melted into its viscous form. Then this viscous form is considered as sample 1 and subjected to all physical tests. Later, aged bitumen of 900 gm is heated at 100-150 degree Celsius and melted into its viscous form. This viscous form is considered to be sample 2 and subjected to all physical tests. Then Waste cooking oil is blended in the aged bitumen in the proportion of 1%, 2%, 3%, 4%, 5% for 1 hour with the rpm of 100 at the temperature of 150 degree. This WCO mixed aged bitumen is considered as sample 3. Then that sample is poured in the container for further physical testing. To determine the chemical properties of waste cooking oil acid value and viscosity test were conducted.

3. RESULT AND DISCUSSION

3.1. Sample 1

Untreated bitumen of 300gm is heated at 100-150 degree Celsius and melted into its viscous form. Sample 1 is pure sample of untreated fresh bitumen. So result for sample1 is described here.

Table 1
Testing on fresh bitumen (Source- Primary Source)

<i>Bitumen tests</i>	<i>Value</i>
Penetration value(in cm)	65
Softening point(in degree Celsius)	50
Ductility(in cm)	75

3.2. Sample 2

Aged bitumen of 900 gm is heated at 100-150 degree Celsius and melted into its viscous form. Then the applied aged bitumen is tested and properties are illustrated.

Table 2
Testing on aged bitumen

<i>Bitumen test</i>	<i>Values</i>
Penetration test(in cm)	39
Softening point(in degree Celsius)	58
Ductility(in cm)	42

3.3. Comparison by Graph

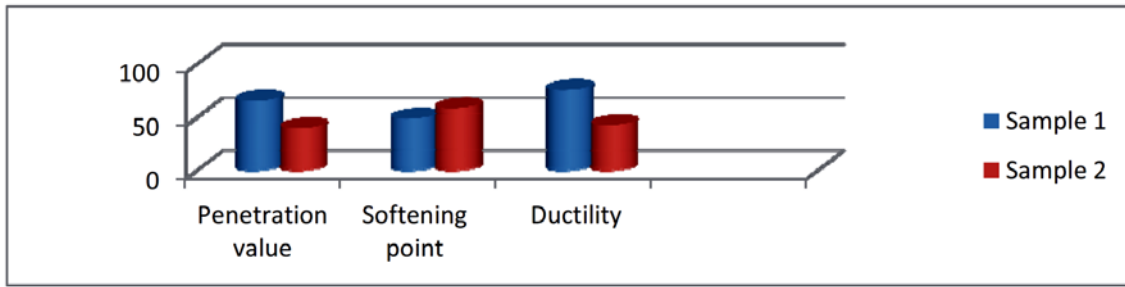


Figure 1: Comparisons of Sample 1 and Sample 2

So by comparison it is proved that there is lot of variation in the properties of bitumen after aging. Penetration value of 60/70 grade of bitumen is reduced from 65 to 39 after aging. Softening point is increased from 50 to 58 because of aging. Ductility value also affected because of aging.

3.4. Analysis of WCO incorporated sample (Sample 3)

3.4.1. Penetration Value

The penetration test determines the hardness or softness of bitumen by measuring the depth in tenths of a millimetre to which a standard load needle will penetrate vertically in five seconds. The sample is maintained in a temperature of 25 degree Celsius. The apparatus used for this test is penetrometer

Table 3
Value of Penetration Test. (Source- primary source)

WCO blended with aged bitumen by weight in different proportion	Penetration value(0.1mm)
1%	46
2%	54
3%	64
4%	78
5%	89

3.4.2. Analysis by graph

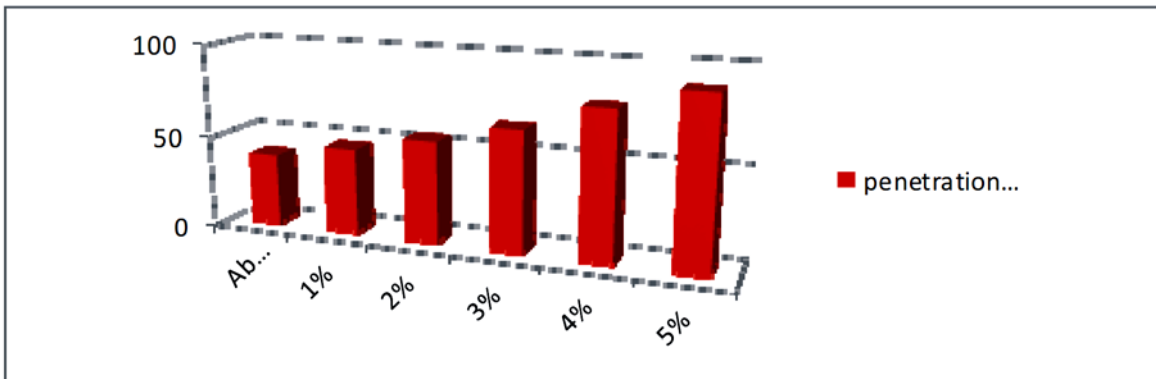


Figure 2: Analysis of Penetration Value (Ab = aged bitumen)

By analysis it is proved that adding of WCO increase the penetration value of aged bitumen. WCO softens the aged bitumen and increase its penetration value.

3.4.3. Comparison between fresh bitumen(sample 1), aged bitumen(sample 2) and 3%WCO blended bitumen

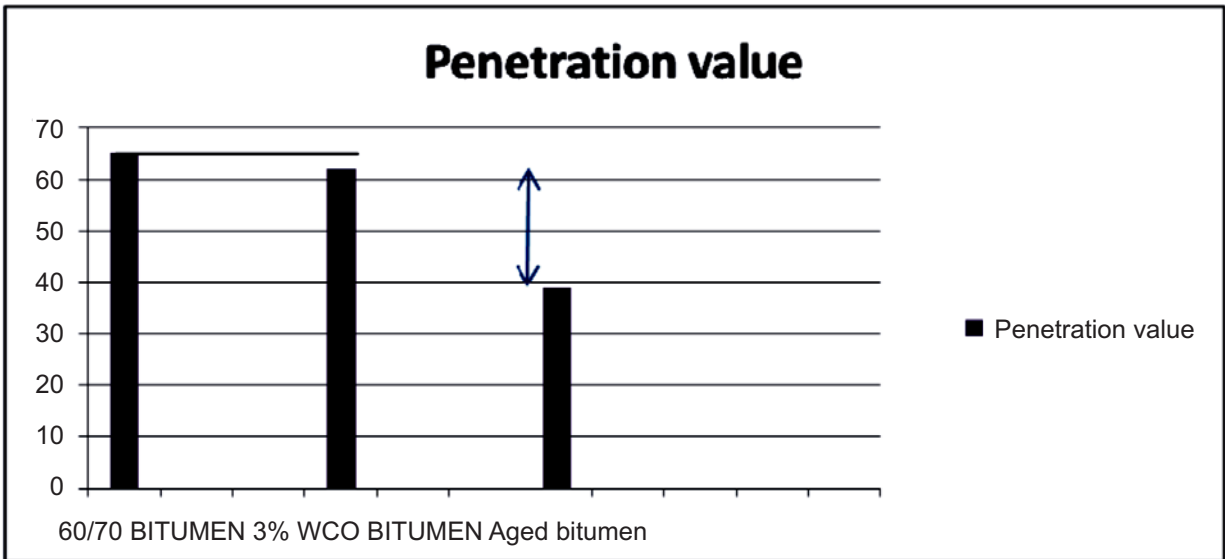


Figure 3: Comparison of Penetration Values (WCO = waste cooking oil)

Dark lines show that 3% of WCO in aged bitumen can enhance its properties which resemble the penetration value of aged bitumen near about 60/70 grade bitumen.

3.4.2. Softening point value

The softening point is the temperature at which the substances attain a particular degree of softening under specified condition of test. The apparatus used for determine the softening point is ring and ball apparatus. The relationship between softening point value and 30/ 40 group bitumen which is mixed with different percentage of WCO is given in table below

**Table 4
Values of Softening Point**

WCO blended with aged bitumen by weight in different proportion	Softening point value(in degree Celsius)
1%	50
2%	45
3%	42
4%	39
5%	35

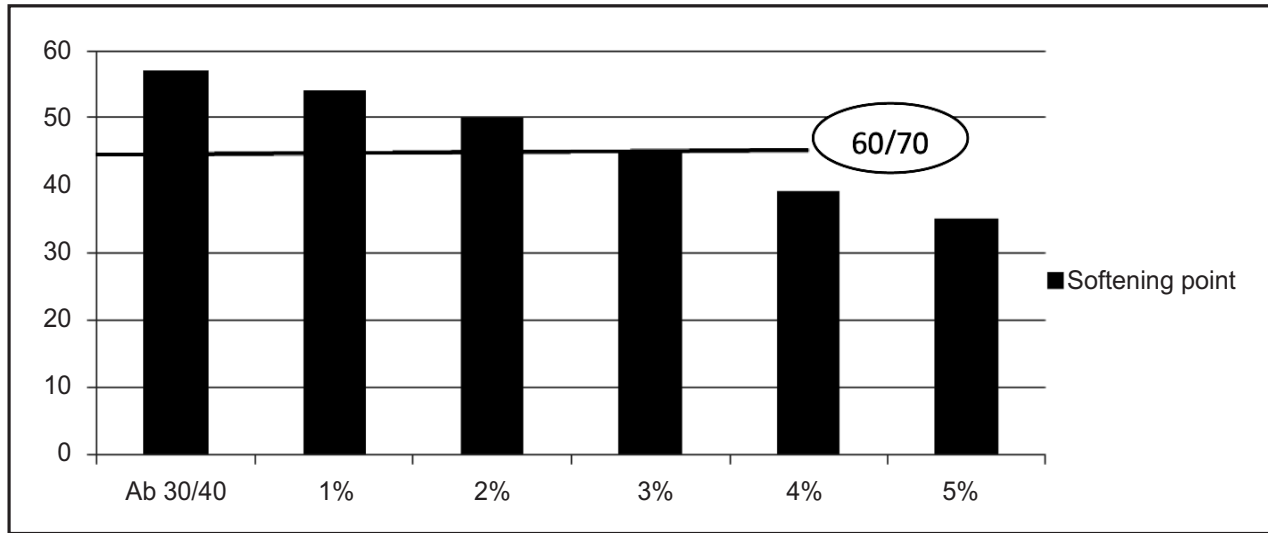


Figure 4: Analysis of Softening Point

So by comparing it is proved that by adding 3% of WCO in aged bitumen softening point of 30/40 grade aged bitumen become equals to the softening point of the 60/70 grade bitumen.

3.4.3 Analysis for Ductility

Ductility is a solid material's ability to deform under tensile stress; this is often characterized by the material's ability to be stretched into a wire. The ductility for sample of aged bitumen and other incorporated WCO is different. The relationship between ductility value and 30/ 40 group bitumen which is mixed with different percentage of WCO is given in table below-

Table 5
Values of Ductility Test

WCO blended with aged bitumen by weight in different proportion	Ductility value(in cm)
1%	48
2%	58
3%	65
4%	75

WCO = waste cooking oil

As content of WCO increases in aged bitumen its ductility is tends to increase. At 4% of WCO ductility value of 30/40 aged bitumen reach nearer to ductility value of 60/70 bitumen.

3.4.4. Analysis for viscosity

Viscosity is the measurement of the internal friction of the bitumen. Viscosity is defined as inverse of fluidity, viscosity thus defines the fluid property of bituminous material, viscosity is the general term for consistency and it measures the resistance to flow. The instrument used to conduct the test was Brookfield Viscometer.

Table 6
Values of viscosity Test

WCO blended with aged bitumen by weight in different proportion	Viscosity(centipoises)
1%	525
2%	495
3%	400
4%	353
5%	305

3.4.5. Analysis by Graph

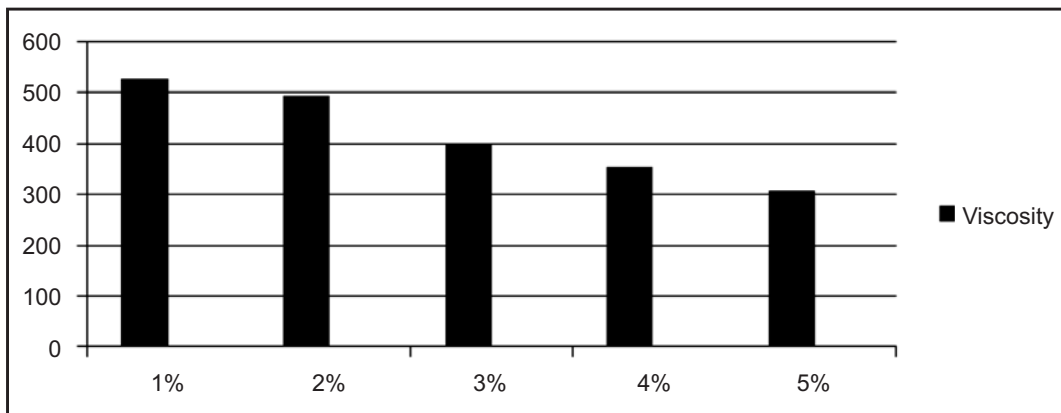


Figure 5: Analysis of viscosity by graph

3.4.6. Comparison between Sample 1, Sample 2 and 4%WCO blended bitumen

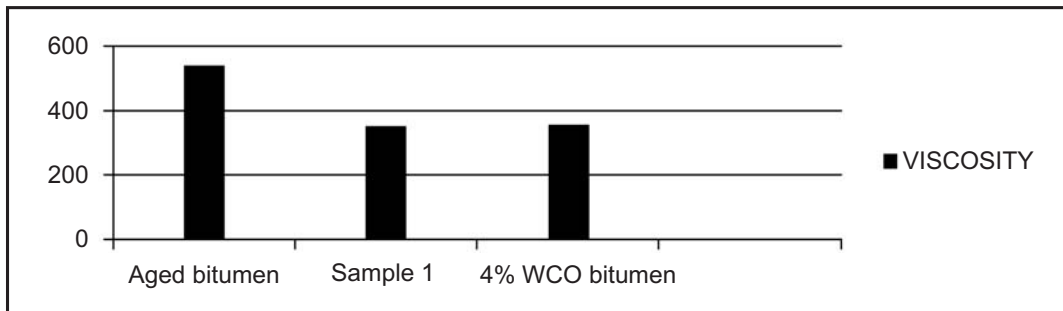


Figure 6: Comparison of Viscosity

This comparison reflects that when 4% of waste cooking oil is added into aged bitumen then, the obtained viscosity becomes equals to the standard viscosity of 60-70 grade of bitumen.

4. CONCLUSION

As mentioned earlier, the main purpose of this research is to investigate the effect of WCO in aged bitumen. So from various physical and chemical tests, Researcher gets various results

4.1. For aged bitumen

1. Due to gradual aging, bitumen loses its properties.
2. As the result of aging, bitumen hardens.
3. Due to aging the softening point increases.
4. Due to aging Ductility decreases.
5. Due to aging viscosity decreases

4.2. For waste cooking oil

1. This research proves that Acid Value depends upon the frying action.
2. This research proves that waste cooking oil can be used as rejuvenator.

4.3. Aged Bitumen Blended with waste cooking oil

1. This research proves that 3-4% WCO content can rejuvenate the 30-40 penetration grade of aged bitumen to meet the properties of bitumen of 60-70 grade.
2. This research proves that penetration value of aged bitumen increases with increasing percentage of waste cooking oil.
3. This research proves that the softening point decreases with increase in percentage of waste cooking oil.
4. This research proves that the ductility of aged bitumen increases with increase in percentage of waste cooking oil
5. This research proves that WCO can act as a best rejuvenating agent but only when used in appropriate proportion.

5. RECOMMENDATION

1. Waste cooking oil can be used as a rejuvenating agent in aged bitumen.
2. Waste cooking oil can be used as a rejuvenator in RAP material.
3. This waste cooking oil incorporated aged bitumen can be used in surface layer as well as in base course of flexible pavement.

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