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IMPROVING QUALITY AND DURABILITY OF BITUMEN BY MODIFICATION USING PLASTIC WASTE AND USED ENGINE OIL

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Abstract. Today we need sustainable development for protection of environment so we used construction technologies that not damage environment. Road construction is spinal cord of development and base material for construction is bitumen. Cost of bitumen rises in last few years so I was used engine oil and plastic waste as a bitumen rejuvenator to increase the recyclability of a pavements and reduce manufacturing cost of bitumen. Plastic waste and used oil both are pollutant which cause air pollution, water pollution, land pollution and contaminate ground water. So utilize waste to reduce disposal cost and modify bitumen properties to increase life span of pavement. The possibility of reducing the cost of bitumen modified by partial replacement of expensive polymer modifier with cheap recycled polyethylene and used engine oil without impairing quality of binder is proved. The best results were obtained when compositions of plastic waste and used engine oil are 15% and 6% respectively.

1. Introduction

Stabilization 21st century is new era in construction technologies. Today we need sustainable development for protection of environment so we used construction technologies that not damage environment. Road construction is spinal cord of development of village, town, city, states and country. India is developing country and various types of national highway, state highways and expressways are constructing every year and aim of Indian government to take average construction of road to 30 km per day.

India has the second largest road network across the world at 4.7 million km. This road network transports more than 60 per cent of all goods in the country and 85 per cent of India's total passenger traffic. Road transportation has gradually increased over the years with the improvement in connectivity between cities, towns and villages in the country.

The Indian roads carry almost 90 per cent of the country's passenger traffic and around 65 per cent of its freight. In India sales of automobiles and movement of freight by roads is growing at a rapid rate. Cognizant of the need to create an adequate road network to cater to the increased traffic and movement of goods, Government of India has set earmarked 20 per cent of the investment of US$ 1 trillion reserved for infrastructure during the 12th Five-Year Plan (2012–17) to develop the country's roads.

The road construction has a number of implications for the environment, consuming large amount of materials and energy. Also, the price of crude oil, which is the major source of bituminous binder, has significantly increased in recent years (the most noticeably in 2001–20015). This has led to an increase in the total price of asphalt mixtures. In order to promote sustainable practices and to combat price increase, measures with sound sustainability credentials need to be widely implemented. Developing novel materials and technologies to integrate greener material, waste and recycled materials into the production cycle of asphalt mixtures is a solution that improves both sustainability and cost-efficiency of the asphalt pavement industry. Thus we use plastic waste and used engine oil with bitumen to modify its strength, reduces cost of road construction and save environment from plastic waste and used engine oil. Plastic waste is most hazardous waste in 21st century. Currently, the common waste disposal methods employed are land filling, incineration and haphazard littering in the cities, municipalities and the countryside. These disposal methods have a negative impact on human health and the environment; consequently, rivers, gutters and roadsides are choked and filled with waste plastics. Polyethylene e Terephthalate (PET) and High density Polyethylene (HDPE) are used

in most bottling applications of water, yoghurt and soft drinks, but in terms of littering, however, one of the worst culprits is polyethylene (or "polythene") bags, for food packaging and sachet water bags. Every day, a multitude of items that are either partly or completely made of plastic are used and these plastics eventually end up in the landfills. Depending on the quality of the plastic, it may take anywhere from a few days to several years to break down in landfills, but it never breaks down completely into particles that can be used in nature. As such, plastic is one of the worst offenders when it comes to environmental pollution.

2. Materials and Test methods

2.1 Penetration Test:

It measures the hardness or softness of bitumen by measuring the depth in tenths of a millimeter to which a standard loaded needle will penetrate vertically in 5 seconds. BIS had standardized the equipment and test procedure. The penetrometer consists of a needle assembly with a total weight of 100g and a device for releasing and locking in any position. The bitumen is softened to a pouring consistency, stirred thoroughly and poured into containers at a depth at least 15 mm in excess of the expected penetration. The test should be conducted at a specified temperature of 25 ^{o}C. It may be noted that penetration value is largely influenced by any inaccuracy with regards to pouring temperature, size of the needle, weight placed on the needle and the test temperature. A grade of 40/50 bitumen means the penetration value is in the range 40 to 50 at standard test conditions. In hot climates, a lower penetration grade is preferred. The Figure 1 shows a schematic Penetration Test setup.

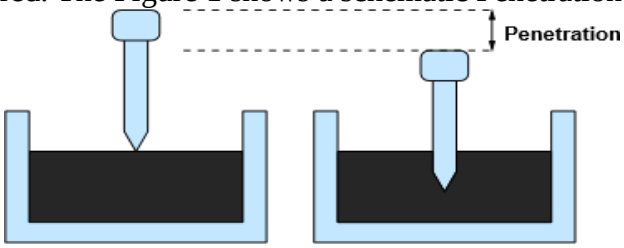


Figure 1: Schematics of penetration test

2.2 Softening Point Test

Softening point denotes the temperature at which the bitumen attains a particular degree of softening under the specifications of test. The test is conducted by using Ring and Ball apparatus. A brass ring containing test sample of bitumen is suspended in liquid like water or glycerin at a given temperature. A steel ball is placed upon the bitumen sample and the liquid medium is heated at a rate of 5^{o}C per minute. Temperature is noted when the softened bitumen touches the metal plate which is at a specified distance below. Generally, higher softening point indicates lower temperature susceptibility and is preferred in hot climates.

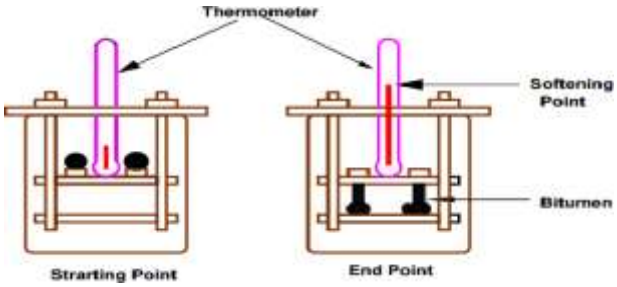


Figure No 2: Softening Test

2.3 Ductility Test

Ductility is the property of bitumen that permits it to undergo great deformation or elongation. Ductility is defined as the distance in cm, to which a standard sample or briquette of the material will be elongated without breaking. Dimension of the briquette thus formed is exactly 1 cm square. The bitumen sample is heated and poured in the mould assembly placed on a plate.

2.4 Float Test

Normally the consistency of bituminous material can be measured either by penetration test or viscosity test. But for certain range of consistencies, these tests are not applicable and Float test is used. The apparatus consists of an aluminum float and a brass collar filled with bitumen to be tested. The specimen in the mould is cooled to a temperature of 5^{o}C and screwed in to float. The total test assembly is floated in the water bath at 50^{o}C and the time required for water to pass its way through the specimen plug is noted in seconds and is expressed as the float value.

2.5 Flash and Fire point test

At high temperatures depending upon the grades of bitumen materials leave out volatiles. And these volatiles catch fire which is very hazardous and therefore it is essential to qualify this temperature for each bitumen grade. BIS defined flash point as the temperature at which the vapour of bitumen momentarily catches fire in the form of flash under specified test conditions. The fire point is defined as the lowest temperature under specified test conditions at which the bituminous material gets ignited and burns.

2.6 Water Content Test

It is desirable that the bitumen contains minimum water content to prevent foaming of the bitumen when it is heated above the boiling point of water. The water in a bitumen is determined by mixing known weight of specimen in a pure petroleum distillate free from water, heating and distilling of the water. The weight of the water condensed and collected is expressed as percentage by weight of the original sample. The allowable maximum water content should not be more than 0.2% by weight.

2.7 specific gravity test for Bitumen

To determine the specific gravity of given Bituminous material. And apparatus required is specific gravity bottle, balance and distilled water.

2.8 Viscosity Test

Viscosity denotes the fluid property of bituminous material and it is a measure of resistance to flow. At the application temperature, this characteristic greatly influences the strength of resulting paving mixes. Low or high viscosity during compaction or mixing has been observed to result in lower stability values. At high viscosity, it resists the compactive effort and thereby resulting mix is heterogeneous, hence low stability values. And at low viscosity instead of providing a uniform film over aggregates, it will lubricate the aggregate particles. Orifice type viscometers are used to indirectly find the viscosity of liquid binders like cutbacks and emulsions. The viscosity expressed in seconds is the time taken by the 50 ml bitumen material to pass through the orifice of a cup, under standard test conditions and specified temperature. Viscosity of a cutback can be measured with either 4.0 mm orifice at 25^{o} C or 10 mm orifice at 25 or 40^{o} C.

3. Testing methodology

3.1 Modification is achieved by two main procedures Dry process and Wet process. Dry process involves direct incorporation of waste plastic, which is blended with aggregate before adding in bitumen, to prepare a plastic modified bituminous concrete mix and the Wet process which involves, simultaneous blending of bitumen and waste plastic. The use of polymer modified bitumen to achieve better asphalt pavement performance has been observed for a long time.

Use Bitumen of AC-20 grade. Physical properties of this bitumen are presented in Table No 1.

The plastic we use is waste plastic bottles, bags, wrappers, etc For Modified bitumen preparation the wet process was is adopted. Samples are prepare, using melt-blending technique.

Bitumen (400 g) was heated in oven till fluid condition and polymer was slowly added. The speed of the mixer was kept above 120 rpm and temperature, between 160 ^{o}C and 170 ^{o}C.

The concentration of Plastic waste i.e. polythene can be ranged from 0.5% to 15% by weight of blend and The concentration of used engine oil can be ranged from 0.5% to 5% by weight of blend. Mixing was continued for 30mins-1hr to produce homogenous mixtures. Then sealed in containers and stored for further testing.

Empirical test such as penetration, softening point and viscosity were then conducted on the prepared samples.

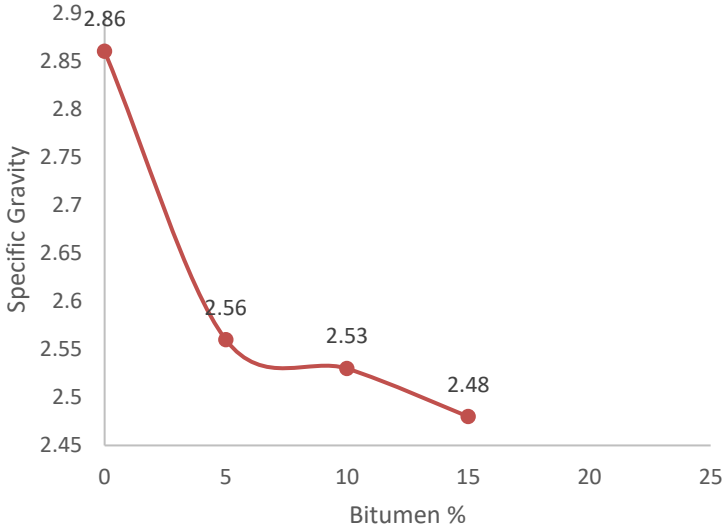
3.1 Experiment Procedure:

All parts of the cup are cleaned and dried thoroughly before the test is started.

The material is filled in the cup upto a mark. The lid is placed to close the cup in a closed system. All accessories including thermometer of the specified range are suitably fixed.

The bitumen sample is then heated. The test flame is lit and adjusted in such a way that the size of a bed is of 4mm diameter. The heating of sample is done at a rate of 5ºC to 6ºC per minute. During heating the sample the stirring is done at a rate of approximately 60 revolutions per minute.

The test flame is applied at intervals depending upon the expected flash and fire points and corresponding temperatures at which the material shows the sign of flash and fire are noted.



Results and Discussion:

- Experiment is carried out at various compositions of plastic waste and used engine oil. But that result is acceptable that output must be come within specified limit set by national highway authority of India and IS 73 :2013 or nearby experimental values of unmodified Bitumen VG-20 grade.
- Experiment is carried out on following compositions:
- For Normal Bitumen
- For Modified Bitumen having 5% Polythene and 2% Used Engine oil.
- For Modified Bitumen having 10% Polythene and 4% Used Engine oil.
- For Modified Bitumen having 15% Polythene and 6% Used Engine oil.
- For Modified Bitumen having 20% Polythene and 8% Used Engine oil.

Table 1: Bitumen Specification of VG 20 grade according to IS 73:2013

TEST	RESULT
Penetration Test (dmm) at 25ºC, 100g,5s	60
Softening Point,ºC	45
Kinematic Viscosity at 135ºC, cSt.	300
Viscosity at 60ºC, Poises	600-2400
Specific Gravity	1.01
Ductility at 25ºC , cm	50

Table 2: Experimental Results of Normal Bitumen.

TEST	RESULT
Penetration Test (dmm) at 25ºC, 100g,5s	60
Softening Point,ºC	45

Kinematic Viscosity at 135ºC, cSt.	300
Specific Gravity	1.21
Ductility at 25ºC , cm	50

For Modified Bitumen having 5% Polythene and 2% Used Engine oil.

Table 4.3: Experimental Results of Modified Bitumen having 5% Polythene and 2% Used Engine oil.

TEST	RESULT
Penetration Test (dmm) at 25ºC, 100g,5s	63
Softening Point,ºC	45
Kinematic Viscosity at 135ºC, cSt.	305
Specific Gravity	1.3
Ductility at 25ºC , cm	52

For Modified Bitumen having 10% Polythene and 4% Used Engine oil.

Table 4: Experimental Results of Modified Bitumen having 10% Polythene and 4% Used Engine

TEST	RESULT
Penetration Test (dmm) at 25ºC, 100g,5s	68
Softening Point,ºC	47
Kinematic Viscosity at 135ºC, cSt.	305
Specific Gravity	1.35
Ductility at 25ºC , cm	54

For Modified Bitumen having 15% Polythene and 6% Used Engine oil.

Table 5: Experimental Results of Modified Bitumen having 15% Polythene and 6% Used Engine.

TEST	RESULT
Penetration Test (dmm) at 25ºC, 100g,5s	66
Softening Point,ºC	48
Kinematic Viscosity at 135ºC, cSt.	310
Specific Gravity	1.33
Ductility	52

For Modified Bitumen having 20% Polythene and 8% Used Engine oil.

Table 6: Experimental Results of Modified Bitumen having 20% Polythene and 8% Used Engine.

TEST	RESULT
Penetration Test (dmm) at 25ºC, 100g,5s	70
Softening Point,ºC	48
Kinematic Viscosity at 135ºC, cSt.	310

5. Conclusions

The possibility of reducing the cost of bitumen modified by partial replacement of expensive polymer modifier with cheap recycled polyethylene and used engine oil without impairing quality of binder is proved.

The best results were obtained when compositions of plastic waste and used engine oil are 15% and 6% respectively.

We can replace about 21% of bitumen and use plastic waste and used engine oil for sustainable development because these wastes are non-degradable which pollute the environment.

So addition of plastic waste and used engine oil leads to:

1. Higher resistance to deformation.
2. Higher resistance to water induced damages.
3. Increased durability and improved fatigue life.
4. Improved stability and strength.

5. Disposal of waste plastic and thereby environment friendly.

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