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International
Journal
Of Modern Engineering Research (IJMER)

Effect of Partial Substitution of Candle Wax in Bitumen

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ABSTRACT: *This study was conducted to find the effects of uses of pieces of candle as a partial substitute in bitumen. Objective of this study is to reduce the quantity of bitumen used and replaced with pieces of candle. Therefore, many efforts have been undertaken to improve the quality of the existing bitumen. In this study, bitumen grade is modified with the addition of various pieces of candle per cent content. Percentage of candle used is 0%, 5%, 10 %, 15%, 20% and 25% of the total amount of bitumen used. Overall analysis shows that, the addition of pieces of candle in the mixture can enhance the capability of the mixture pavement as flexible.*

Keywords: *Bitumen, Candle wax, flexible, modified grade, pavement*

I. INTRODUCTION

The greater proportion of bitumen used in road construction today, is obtain from crude petroleum. According to Indian standards institution, "Bitumen can be defined as a non crystalline solid or viscous material having adhesive properties. It is derived from crude petroleum, either by natural or refinery processes. Bitumen can be described as a viscous liquid or solid consisting essentially of mineral oil (having a variety of hydrocarbons with high molecular weight, which are asphaltic in nature and having small proportions of oxygen, nitrogen and sulphur), hydrocarbon derivatives (such as asphaltenes, maltenes), which are soluble in carbon disulphide and is substantially non-volatile and softens gradually when heated. In usual commercial practice, bitumen is restricted to semi-solid or solid bitumen, which includes asphalts, tars and pitches. However, due to its binding and cementing property, it is used in road construction for paving road surfaces and also for a variety of uses such as in water-proofing to prevent leakages. It is also used for filling joints in construction works to prevent contractions and expansions. Furthermore, it is used for the reduction of the heat of hydration in Portland-cement concrete constructions

Othmer (1963) observes that the limitations of bitumen as a road-paving material are associated with the problems of oxidation, which results in the cracking of the pavement and its instability with respect to temperature variations. Due to these problems, various forms of modifications of the physical properties of bitumen have evolved over the years using different materials like natural rubber, recycled polyethylene from grocery bags; recycled plastics composed predominantly of polypropylene and low density polyethylene and processed plastic bags. However, there is a dearth of information on the use of candle wax as a modifier for bitumen which this study sought to investigate. In addition, it will compare the rates of changes that will occur in the physical properties of bitumen using polythene and candle wax of the same grade of bitumen

1.1 Chemical Composition of Bitumen

Molecular weight wise, bitumen is a mixture of about 300-2000 chemical components with an average of around 50-700. Elementally it is around 95% carbon and hydrogen (±87% carbon and ±8% hydrogen) and up to 5% sulfur, 1% nitrogen, 1% oxygen and 2000 ppm metals. Bitumen is composed mainly of highly condensed polycyclic aromatic hydrocarbons. The main properties of bitumen are

- Adhesion: Bitumen has the ability to adhere to a solid surface in a fluid state depending on the nature of the surface. The presence of water on the surface will prevent adhesion.
- Resistance to water: Bitumen is water resistant. Under some condition water may be absorbed by minute quantities of inorganic salts in the bitumen or filler in it.
- Hardness: To measure the hardness of bitumen, the penetration test is conducted, which measure the depth of penetration in tenths of mm of a weighted needle in bitumen after. A given time at a known temperature. Commonly a weight of 100gm is applied for 5sec at a temperature of 77˚ F. The penetration is a measure of

hardness. Typical results are 10 for hard coating asphalt, 15 to 40 for roofing asphalt and up to 100 or more for water proofing bitumen.

- Viscosity and flow: The viscous or flow properties of bitumen are of importance both at high temperature during processing and application and at low temperature to which bitumen is subjected during service. The flow properties of bitumen vary considerably with temperature and stress conditions. Deterioration, or loss of the desirable properties of bitumen, takes the form of hardening. Resultantly, decrease in adhesive and flow properties and an increase in the softening point temperature and coefficient of thermal expansion.

1.2 Objective of the modification of bitumen

A lot of efforts have been made for the modification of bitumen. But the cost of the modified binder is high because of the high price of the polymers. Considering this problem our endeavor was to use reclaimed polyethylene to fulfill the following objectives:

- To get high strength bituminous mix.
- To achieve economic goal by saving some portion of bitumen.
- To find out the changing properties of bitumen after mixing of polyethylene and kerosene.
- To sure the bituminous admixture is suitable or not for construction.
- To measure benefit from the project. To save the environment from pollution by using waste polyethylene.

II. THEORETICAL STUDY

Theoretical studies have been conducted for calculating different properties of bitumen. The major studies such as ductility, penetration and viscosity were studied.

2.1 Ductility test

Ductility is defined as the distance in mm, to which a standard sample or briquette of the material will be elongated without breaking.

2.1.1 Apparatus Required

- Briquette mould: Length = 75mm
  Distance between clips = 30mm
  Width of mount clip = 20mm
  Cross section at minimum width = 10x10mm
- Ductility machine

2.1.2 Procedure

The bitumen sample is melted to a temperature of 750^{C} to 100^{0}C.The molten bitumen is poured in the mould assembly and placed on a brass plate after a solution of glycerin is applied at all surfaces of the mould exposed to bitumen. Bitumen is poured into the moulds into the moulds and specimen is then placed in water bath maintained at 27^{0} C for 30 minutes. The sample and mould assembly is removed from the water bath and excess bitumen material cut off by leveling the surface using the hot knife. The sides of the mould are now removed and the clips are carefully booked on the machine without causing any initial strain. The pointer is set to read zero or the initial reading of the pointer is noted. The machines started and the two clips are thus pilled apart horizontally. The distance at which the bitumen thread of each specimen breaks, is recorded to report as ductility value.

2.2 Penetration test

Penetration of a bituminous material is the distance in tenths of millimeter that standard needle will penetrate vertically into a sample under standard conditions of temperature, load and time 2.5 Apparatus Required

- Penetrometer
- Container
- Needle
- Water bath
- Transfer tray

2.2. 1 Procedure

The bitumen is softened to a pouring consistency above the approximate temperature at which bitumen softens. The sample material is then poured into the container to a depth of at least 15 mm more than the

expected penetration. The sample container is cooled in atmospheric temperature not lower than 130 c for one hour. Then they are placed in temperature controlled water bath at a temperature of 250 c for a period of one hour. The sample container is placed under is placed in the transfer tray with water from the water bath and placed under the needle of the penetrometer. The needle assembly is lowered using the adjusting screw to touch the top surface of the bitumen sample and the needle assembly is clamped in this position. The initial reading of the penetrometer dial is either adjusted to zero or the initial reading is taken before releasing the needle. The needle is released exactly for a period of 5 second by pressing the knob and the final reading is taken on the dial. At least three measurements are made on this sample by testing at distance of not less than 10 mm apart. The test is repeated with sample in the other container

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2.3 Viscosity test

Viscosity is defined as inverse of fluidity. Viscosity thus defines the fluid property of bituminous material. The degree of fluidity at the application temperature greatly influences the ability of bituminous material to spread, penetrate into the voids and also coat the aggregates and hence affects the strength characteristics of resulting paving

2.3.1 Apparatus Required

- Watch
- Collector (beaker)
- Sample container
- Thermometer
- Viscometer consisting of cylindrical cup with 10 mm orifice
- Water bath
- Stirrer
- Receiver

2.3.2 Procedure

The tar cup is properly leveled and water in the bath is heated to the temperature specified for the test and is maintained throughout the test. Stirring is continued. The sample a material is hearted at the temperature 2000c above the specified test temperature and the materials is allowed to cool. During this is the material is continuously stirred. In the graduated received (cylinder) 20 ml of or one percent by weight solution of soft soap is poured. This receiver is placed under the orifice. When the sample material reaches the specified testing temperature within 0.1 c and is maintained for 5 minute, the valve is opened.

III. EXPERIMENTAL STUDIES

The experiments such as ductility, penetration and viscosity were conducted on test sample of bitumen. The tests were conducted without adding candle waste to the sample. The same experiments were repeated by adding candle waste to the sample. The candle waste was added in to the sample at a percentage of 5,10,15,20 and 25%. Compare the results of 0% candle waste bitumen with the modified bitumen sample with different percentage of candle waste. The results of each test are given below.

Results Of Unmodified And Modified Properties Of Bitumen Of 0% To 25% Of Candle Waste Content

S.NO	Test	Unmodified Bitumen 0% Candle	Modified Bitumen with Candle				
			5%	10%	15%	20%	25%
1.	Ductility	93	81	61	40	32	24

From the table it is clear that ductility values of modified bitumen in higher percentage reduces. The variations in ductility with modified bitumen are as shown in Fig 1.

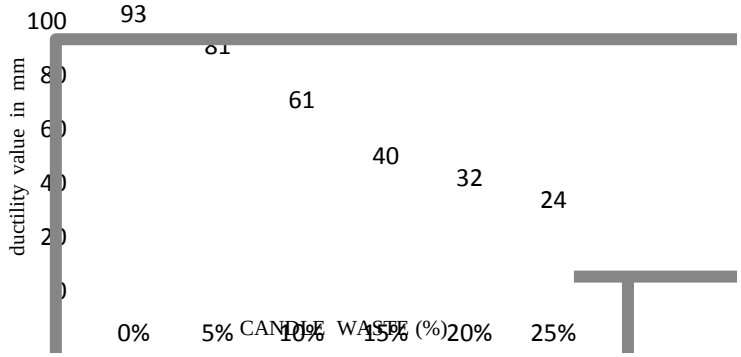

Fig. 1. Variation of ductility with modified candle waste content

Penetration test was conducted with the same percentage of increase in candle wax waste with bitumen. The results of modified bitumen was shown in Table 2 .

Results Of Unmodified And Modified Properties Of Bitumen Of 0% To 25% Of Candle Waste Content

S.NO	Test	Unmodified Bitumen 0% Candle	Modified Bitumen with Candle				
			5%	10%	15%	20%	25%
1.	Penetration	85	47	38.5	25	18	13.5

From the table it is clear that penetration values of modified bitumen in higher percentage also reduces. The variations in penetration value with modified bitumen are as shown in Fig 2.

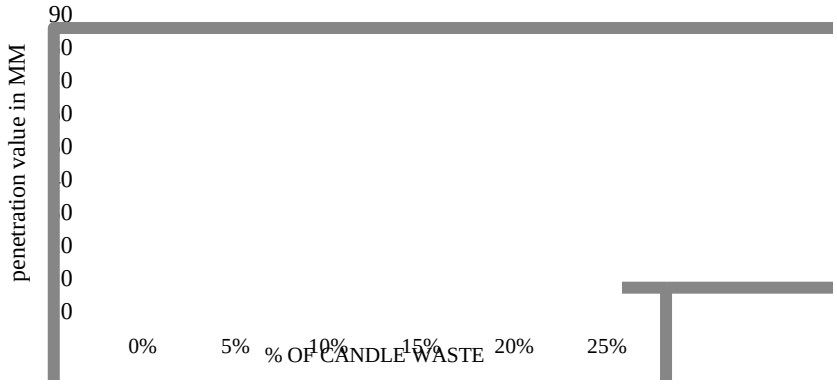

Fig. 2. Variation of penetration with modified candle waste content

Viscosity test was conducted with the same percentage of increase in candle wax waste with bitumen. The results of modified bitumen for viscosity test in sec are shown in Table 3.

Results Of Unmodified And Modified Properties Of Bitumen Of 0% To 25% Of Candle Waste Content

S.NO	Test	Unmodified Bitumen 0% Candle	Modified Bitumen with Candle				
			5%	10%	15%	20%	25%
1.	viscosity	2	15	18.5	21	27	35

From the table it is clear that viscosity values of modified bitumen in higher percentage increases. The variations in viscosity value with modified bitumen are as shown in Fig 3.

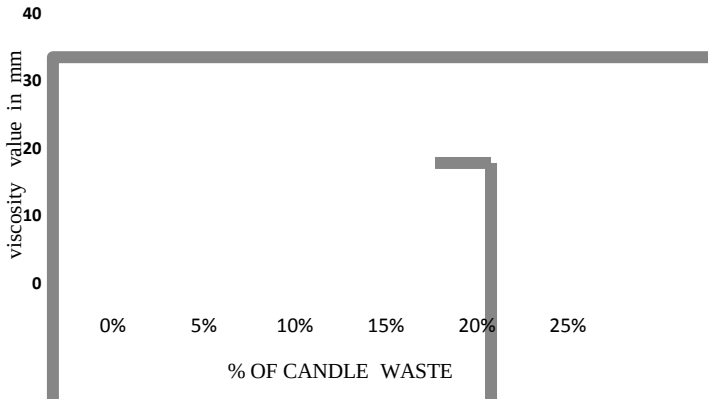

Fig. 3. Variation of viscosity with modified candle waste content

IV. RESULTS AND DISCUSSION

From the results obtained in figure 1 it was observed that ductility of the bitumen at 0% candle wax content was 93mm. However, the addition of varying amounts of candle wax between 5-25% revealed that ductility decreased linearly to a value of 24mm at 25% candle wax content Although the bitumen at 0% candle wax content (i.e. having ductility of 93 mm) can be said to be more ductile, however higher ductility does not necessarily imply a binder with better quality. a ductility of100mm is obtained at 4.1% candle wax content which becomes our limiting value of modifier, and less than this value will result in a pavement subject to flushing or bleeding

From the results obtained in figure 2 it was observed that the value of penetration at 0% candle wax content was 85mm implying a grade 80/100 bitumen. However, the addition of varying amounts of candle wax between 5-25% revealed that penetration decreased linearly to a value of 13.5mm at 25% candle wax content. The implication of their findings is that there is both upper and lower limit of cracking associated with bitumen in terms of penetration. That is, the limit of cracking is between 20-85mm. From figure 2 corresponding values of penetration at 20mm and 85mm occurs at 18.85% and 0.54% candle wax contents, thus modifying bitumen with candle wax between these values produce bitumen with penetrations having higher resistance to cracking of road surface pavement for grade 80/100 bitumen

It is also intended that bitumen should resist flow under the influence of external load particularly traffic loads during use; therefore the need to increase that property that inhibits movement or flow of bitumen which is viscosity From figure 3 it was observed that the value of the unmodified bitumen at 0% candle wax content was 2seconds. However, addition of varying amounts of candle wax resulted in linear increase of viscosity up to 35seconds. Therefore, it is concluded that the addition of candle wax to bitumen increases its resistance to flow or movement during use of pavement.

V. CONCLUSION

This study experiment the use of candle wax as a modifier for bitumen. In addition, it compared the rates of changes that occur in the physical properties of bitumen using candle wax for the same grade of bitumen From the findings based on the laboratory tests carried out, it is concluded that the addition of candle wax between 18.85% to 0.54% produce bitumen better than the unmodified bitumen in terms of penetration; that is a material that will not distort under external traffic loads. The addition of candle wax up to 4.1% and above will produce ductility in bitumen that will not flush or bleed when subjected to incremental changes in temperature, thus performing better than the unmodified bitumen. The addition of candle wax between 5-25% produce bitumen that is more resistant to boiling than the unmodified bitumen when both are subjected to incremental changes in temperature. The resistance to flow or movement of the modified bitumen under external loads of traffic was better than that of the unmodified bitumen due to the addition of candle wax.

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