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Study on Properties of Modified Bitumen for Flexible Pavement Construction using Plastic Scrap and Bakelite

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ABSTRACT

The bituminous mix design aims to determine the proportion of bitumen, filler, fine aggregates, and coarse aggregates to produce a mix which is workable, strong, durable and economical. In India, majority of road comprise of bituminous surfaced flexible pavements. Distress symptoms, such as cracking, rutting, etc., are being increasingly caused at earlier stages due to high traffic intensity, over loading of vehicles and significant variations in daily and seasonal temperature of the pavement.

Use of fiber waste plastic scrap material with Bakelite in the construction of flexible pavement is gaining importance. The modified bitumen shows better properties desired for road construction like ductility, fire and flash point, penetration, specific gravity.

The fiber waste plastic scrap material with Bakelite were heated at 160-180oC and added to the aggregate, was added to bitumen (60/70) at 120-140oC. The fiber waste plastic scrap material with Bakelite aggregate mix were then combined to get the sample for dense bituminous concrete (DBC). In fiber waste plastic scrap material with Bakelite modified bitumen the higher marshal stability value is obtained when 4% fiber waste plastic scrap material with 4% Bakelite is added to the mix. We get marshal stability value of 1448 kg for fiber waste plastic scrap material with Bakelite mix and 1186 kg for without fiber waste plastic scrap material with Bakelite mix

Optimum binder content reduces When 6% fiber waste plastic scrap material with Bakelite is added (5%) in comparison of ordinary bituminous mix(5.5%). Reduce the cost to around Rs. 5000/Km. of single lane road Carry the process in situ

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INRODUCTION

Investigations have revealed that modifiers can be used to improve rheological properties of bitumen and bituminous mixes to make it more suitable for road construction.

- Bakelite: The bakelite wastes are produced from the various components such as cars, telecommunication workshops, industrial manufacturing units, etc… from various areas.
- Properties: Strong, rigid and dimensionally stable; heat resistant, chemical resistant; less weight and it is resistant towards electricity.
- Waste plastics: The waste plastics includes plastic bottles, containers, film, thermo-cole, blister packs, toys, trays, carry bags, cups, household articles, pipes, etc. These plastics are subjected to heat and pressure and remolded.
- Properties: Low water and moisture absorption, excellent fatigue and wear resistance, excellent impact resistance.

OBJECTIVES

To study the effect of plastic fiber scrap material with Bakelite on the strength of bituminous mix.

METHODOLOGY

Laboratory experiments were conducted on the conventional bitumen (60/70 GRADE) and modified bitumen samples. Individual properties (Penetration, Softening Point, Ductility, Flash and Fire, and Specific Gravity) of the sample were determined. Using the Marshal Mix design characterization of conventional bituminous mix (60/70 GRADE) for dense bituminous mix (DBC) were carried out and comparison was made for conventional bitumen mix properties with modified bitumen. After determining factors to be considered for modeling modified bitumen in bituminous mix, a detailed plan for the experimental program (sample preparation and lists of tests) was developed.

Following tests were conducted:

1. Penetration test
2. Ductility test
3. Softening point test
4. Specific gravity test
5. Flash and fire point test
6. Marshal stability test

The above listed tests were conducted on the following conventional/modified bituminous samples, given in Table 60/70Grade bitumen, Bitumen and PLASTIC SCRAP AND BAKELITE. The details of the materials used and the preparation of the samples are given in the subsequent sections. The experimental procedure is described in next section.

EXPERIMENTAL PROCEDURE

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. 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 $^{\circ}$ 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 60/70 bitumen means the penetration value is in the range 60 to 70 at standard test conditions. In hot climates, a lower penetration grade is preferred.

Figure: Penetration Test Set-up

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. These samples with moulds are cooled in the air and then in water bath at 27 $^{\circ}$ C temperature. The excess bitumen is cut and the surface is leveled using a hot knife. Then the mould with assembly containing sample is kept in water bath of the ductility machine for about 90 minutes. The sides of the moulds are removed, the clips are hooked on the machine and the machine is operated. The distance up to the point of breaking of thread is the ductility value which is reported in cm. The ductility value gets affected by factors such as pouring temperature, test temperature, rate of pulling etc. A minimum ductility value of 75 cm has been specified by the BIS.

Figure: Ductility Test

FLASH AND FIRE POINT TEST

1. **Flash Point** – The flash point of a material is the lowest temperature at which the application of test flame causes the vapors from the material to momentarily catch fire in the form of a flash under specified conditions of the test.
2. **Fire Point** – The fire point is the lowest temperature at which the application of test flame causes the material to ignite and burn at least for 5 seconds under specified conditions of the test.

Figure: Flash and Fire point Test

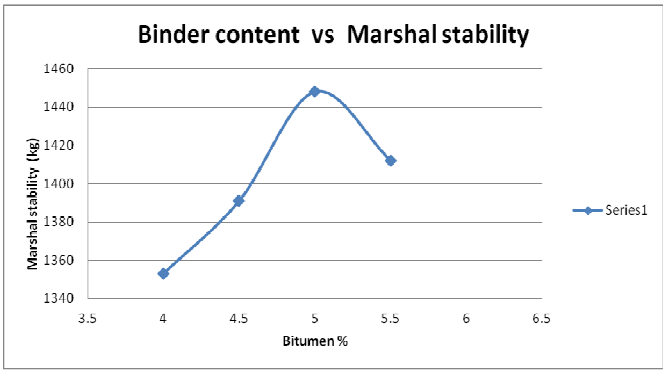
RESULTS

Properties of DBM with 4% FIBER WASTE PLASTIC SCRAP MATERIAL + 4% BAKELITE modified bitumen and varying percentage of bitumen binder

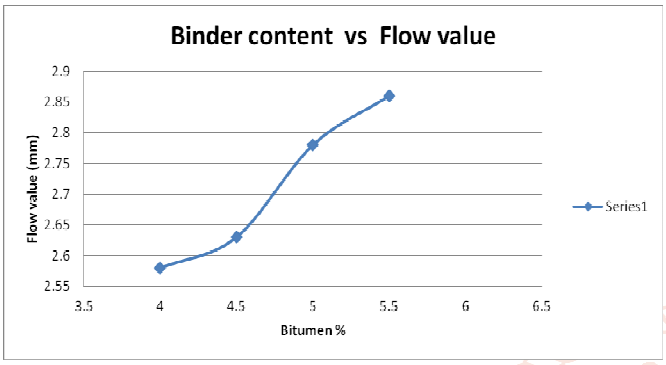
Following graphs have been plotted to find the optimum binder content

It is observed from graphs, that maximum marshal value is obtained with 5% modified bitumen compared 5.5% ordinary bitumen in DBM.

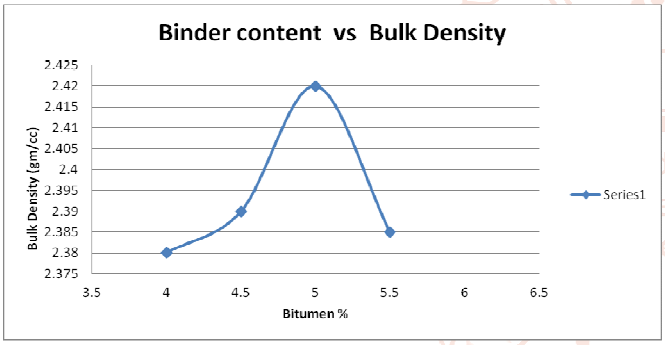
It is therefore inferred that 4% FIBER WASTE PLASTIC SCRAP MATERIAL + 4% BAKELITE admixture saves bitumen content, without adversely affecting Marshal Stability Value.



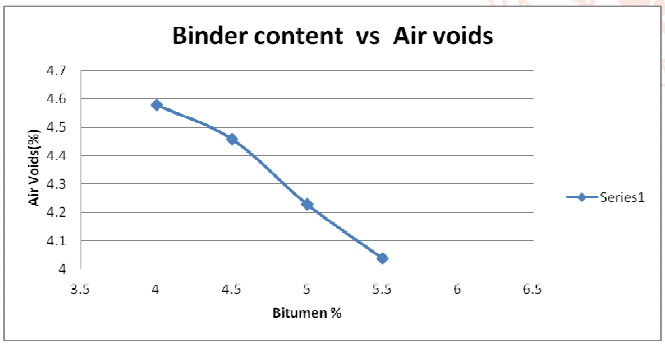
Bitumen % Vs Marshal Stability Value



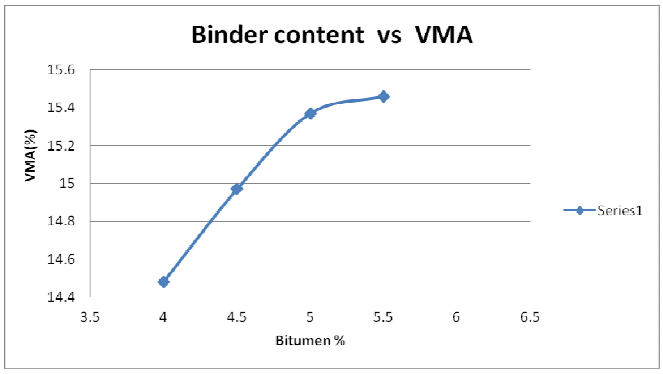
Bitumen % Vs Flow value



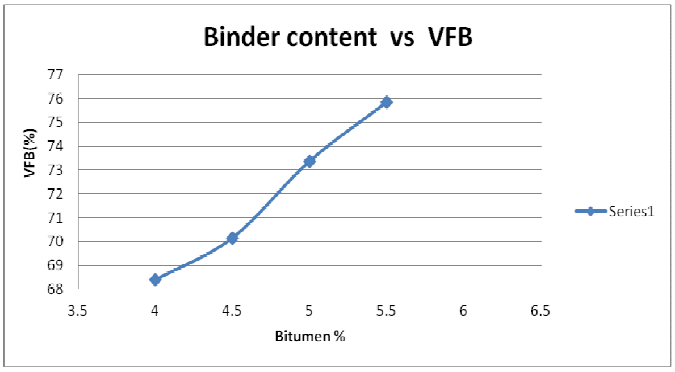
Bitumen % Vs Bulk Density



Bitumen % Vs Air voids %



Bitumen % Vs VMA %



Bitumen % Vs Voids filled with bitumen %(VFB)

CONCLUSIONS

It has been observed that when the Plastic Scrap and Bakelite is mixed with bitumen with varying % (0, 2, 4, and 6), is mixed with 60/70 Grade bitumen with varying properties of bitumen like penetration value, ductility, flash and fire point, specific gravity and softening point change. As discussed earlier in chapter 5 it is observed experimentally that the penetration, ductility decreased and While then decreases at 6% +6% waste plastic scrap material with Bakelite. Significant change in properties of DBM was observed as per follows.

Based on this study the following conclusions are arrived:

- Marshal Stability values and flow value of bituminous mix are increased due to addition of Plastic Scrap and Bakelite.
- In Plastic Scrap and Bakelite modified bitumen the higher marshal stability value is obtained when 4% fiber waste plastic scrap material with 4% Bakelite is added to the mix.
- We get marshal stability value of 1448 kg for Plastic Scrap and Bakelite mix and 1186 kg for without Plastic Scrap and Bakelite mix
- Optimum binder content reduces When 6% Plastic Scrap and Bakelite is added (5%) in comparison of ordinary bituminous mix(5.5%).
- Marshall's mix design conducted on DBM using Plastic Scrap and Bakelite gives results as per MORTH recommendations, which indicates the acceptability of the Plastic Scrap and Bakelite in Bituminous Concrete mix.
- Develop a technology, which is eco-friendly and cost saving for road construction.

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