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Research Paper

Study on Effect of Coir Fibres on SDBC Grade- 2 Mix

Engineering

KEYWORDS : SDBC Grade- 2 mix, Optimum Bitumen Content, Optimum Fibre Content, Optimum Fibre Length

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ABSTRACT

The development of transportation plays an important role in the development of nation. With flexible pavements being widely used in India, steps must be taken to increase the life of these pavements. Flexible pavements are often plagued with problems of cracking and rutting due to repeated traffic loads. Hence one needs to address these problems in order to improve the performance of flexible pavements. This project studies the suitability of coir as a reinforcing material in SDBC grade-2 mix. Marshall Method of mix design was adopted and the optimum bitumen content and fibre content are determined for coir fibre reinforced bituminous mixes and their performance is analyzed. An optimum bitumen content of 5.5%, optimum fibre content of 0.4% and fibre length of 15 mm was obtained after analysis. On studying the parameters, it is found that the addition of coir fibre to SDBC grade-2 mix improves its strength and physical properties.

I. INTRODUCTION

A typical pavement can be designed either as a flexible pavement or as a rigid pavement based on its importance and area of requirement. In India flexible pavements are widely preferred due to various advantages and economical construction of flexible pavements over rigid pavements.

Flexible pavements have negligible flexural strength and are flexible under the action of loads. These pavements consists of various layers, they are;

Soil subgrade
Sub base course
Base course
Surface course

The transmission of compressive stresses from the surface layer to lower layers is by grain to grain action. As the stresses are transmitted from the surface layer to lower layers it gets distributed over a wider area and hence the surface layer must be strong and resist wear and tear. Thus bituminous mixes are generally considered as a surface course and wearing course in flexible pavements. Due to repetition of loads the pavement structure may undergo various distresses such as cracking and rutting. Undulations can also be seen due to elastic deformation causing discomfort to the road users. Hence it is necessary to take remedial measures to overcome the difficulties in use and maintenance of flexible pavements. It is also required to take necessary steps to keep elastic deformations within the permissible limits and minimize the undulations on flexible pavements.

II. OBJECTIVE

This study aimed at determining the effect of addition of coir fibres on SDBC mix in terms of physical and strength properties. Marshall tests were conducted on the mixes with varying amount of coir fibres ranging from 0% to 0.8% by weight of total mix with an increment of 0.2% and various changes in properties such as Marshall stability, Bulk Density(G_b), Volume of Voids in total mix (V_v), Volume of bitumen (V_b) Voids in Mineral Aggregate (VMA), Voids filled with bitumen (VFB) and Marshall Flow were determined and compared with different mixes and optimum bitumen content (OBC) for a mix with maximum stability was decided. Here 2% by weight of total mix of cement was used as filler for various mixes.

III. MATERIAL CHARACTERISATION

Test on Aggregates

Normal weight aggregate with a maximum size of 9.5mm was used as coarse aggregate and stone dust was used as fine aggregate. The various properties and their specified and determined values are as follows:-

Property	Size of aggregates	Values	Limits specified by MoRTH 4TH Revision
Specific gravity	9.5mm aggregate	2.60	-----
	4.75mm aggregate	2.63	
	Stone dust	2.90	
Water absorption (%)	9.5mm aggregate	1.01%	Max 2%
	4.75mm aggregate	1.00%	Max 2%
	Stone dust	0.80%	Max 2%
Impact value (%)	9.5mm aggregate	25%	Max 27%
Combined index (%)	9.5mm aggregate	20.83	Max 30%

Tests on Bitumen

60/70 grade bitumen was used as binder and it specified and desired properties are as follows

Property	Test Results	Limits specified for bitumen
Specific gravity	1.01	0.97-1.02
Penetration (mm)	64	60-70
Softening point (°C)	46	45-48
Flash point (°C)	240	Min 220

Tests on Coir Fibre

For the study unretted coir was used as it is easily available. As per literature review the length of the coir fibre was taken as 15mm and various other properties are as follows:-

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Property	Value of Specified limits	Determined value
Diameter (mm)	0.1-0.4	0.15-0.3
Density (g/cm^3)	0.67-1.0	0.96
Natural moisture content (%)	11.44-15.85	----
Water absorption (%)	Max 135	53.06

IV. PROPORTIONING OF AGGREGATES

To study the properties of coir fibre reinforced concrete, Semi Dense Bituminous Concrete(SDBC) of grade II mix as prescribed by Ministry of Road Transport and Highways (MoRTH) in Specifications for Road and Bridge Works (fourth revision) was chosen as the bituminous mix. The gradation of SDBC grade II mix is as follows:-

IS Sieve (mm)	Required % passing	Average value of % passing
13.2	100	100
9.5	90-100	95
4.75	35-51	43
2.36	24-39	31.5
1.18	15-30	22.5
0.6	-----	-----
0.3	9-19	14
0.15	-----	-----
0.075	3-8	5.5

On proportioning the aggregates for semi dense bituminous concrete mix as per MoRTH specifications, the following mix proportion was obtained.

- 9.5 mm aggregate: 5%
- 4.75 mm aggregate: 52%
- Fine aggregates: 37.5%
- Cement: 2%
- Stone dust: 3.5%

V. MARSHALL METHOD OF MIX DESIGN

Principle of Marshall Method

Marshall Test is an unconfined compression test where load is applied to a cylindrical specimen of bituminous mix and the sample is observed till its failure. The resistance to plastic deformation of the cylindrical specimen of bituminous mix is measured when loaded at the periphery at 5 cm per minute. Stability and flow, together with density, voids and percentage of voids filled with binder are determined at varying binder contents to obtain optimum bitumen content for stability, durability, flexibility etc. The Marshall method of mix design consists of the following three stages.

1. Bulk Density determination
2. Stability and Flow test
3. Density and Voids analysis

Marshall Apparatus

The Marshall Test apparatus essentially consists of the following equipments,

(a) Mould Assembly
(b) Specimen Extractor
(c) Testing Head
(d) Loading Machine
(e) Flow meter (dial gauge)

Preparation of Marshall Compaction Specimens

The specimens are casted in triplicate and the average of the three specimens for each mix is considered during the analysis of data. The preparation of the specimen is as follows:-

(a) The materials for the sample i.e 1200grams of aggregates of three different sizes (coarse aggregates, fine aggregates, stone dust and cement), 60/70 grade bitumen and coir fibre of 15mm length were weighed according to the proportioned values for the various mixes.
(b) The aggregates of the required gradation were mixed in a pan. The coir fibre was also added to the aggregates and mixed well uniform distribution of fibre ensured. The entire mixture was heated to a temperature of 150°C.
(c) The weighed bitumen for a sample was heated to 145°C and was added to the heated aggregate and coir fibre mix. Bitumen was mixed well with the aggregates to get a homogenous mixture at 160°C.
(d) The homogenous bituminous mix was poured into the mould for compaction at 160°C to ensure compaction was done at 150°C. The cylindrical moulds with an inside diameter of 101.7 mm and a height of 63.5 mm, base plates, and collars are used for compaction.
(e) The specimen was compacted with 75 blows to each side of the cylindrical sample mounted on a standard mould assembly with a standard Marshall hammer that has a circular tamping face and a weight of 4.536 kg with a free fall of 45.7 cm to get the Marshall Compaction Specimen. The compacted specimen was allowed to cool down to room temperature before extraction of the sample.
(f) A steel disc with a diameter not less than 100 mm and a minimum thickness of 13 mm was used for extracting the compacted specimen from the mould by applying a slow gradual force using a hydraulic jack to the face of the specimen.

Bulk Density Determination

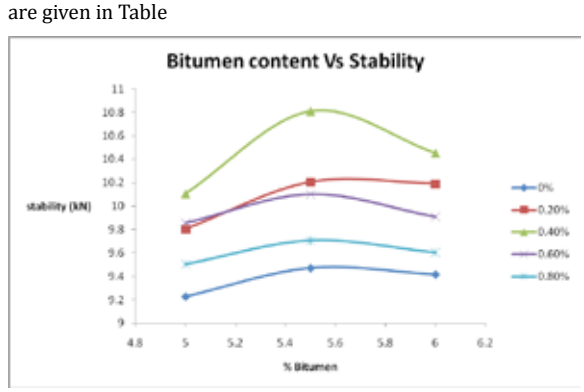
It is required to determine the various density parameters for the sample like theoretical density, bulk density and specific gravity before testing for stability and flow. For this purpose the weight of the extracted sample was measured in air and in water. The bituminous sample being porous may absorb water into the voids and hence it is necessary to coat the samples with oil to prevent the entry of water. Before coating the samples with oil, the dimensions of the extracted sample were noted down at room temperature.

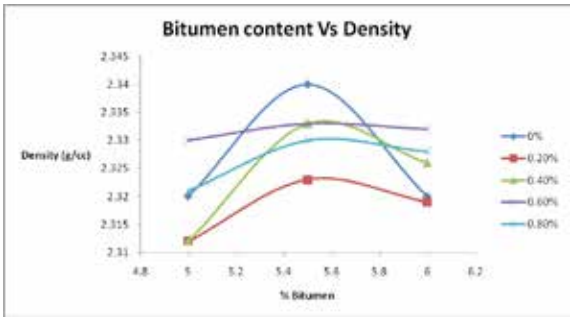
Stability and Flow Value Test

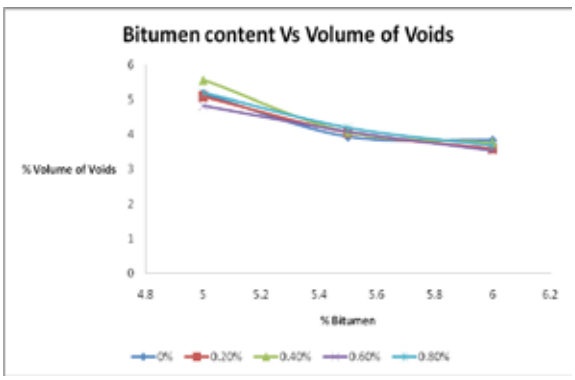
The bituminous mixes must be tested at 60±1°C. To facilitate this, after bulk density determination the oil coated samples were kept in a water bath maintained at 60°C for 30-40 minutes. The entire breaking head setup were cleaned and lubricated. The specimen was removed from the water bath and was placed with its axis horizontal to the test heads. The complete assembly was quickly placed on the base plate of the Marshall Compression machine. The flow dial gauge was placed over the guide rod and the dial gauges of proving ring and flow meter were adjusted to zero. The machine was set to operate to apply the load until the maximum value was reached. The values of maximum load and the flow dial gauges were recorded and the machine was reversed and the failed specimen removed from the test head.

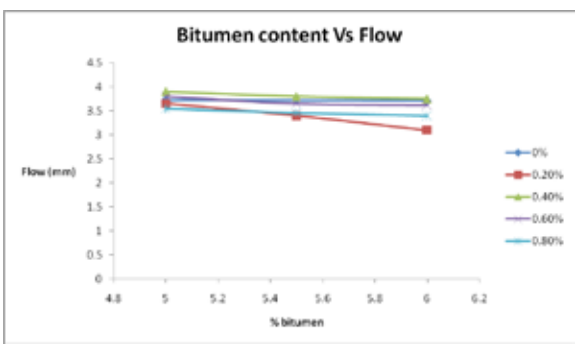
MARSHALL TEST RESULTS

The results of the Marshall Test i.e. Marshall Stability and flow values, density and void parameters for the bituminous mixes are given in Table









VI. DETERMINATION OF OPTIMUM BITUMEN CONTENT (OBC).

The OBC for a mix having a particular fibre content and fibre length is determined by taking the average of the bitumen contents corresponding to the maximum Marshall stability, minimum flow, mean Vv and mean VFB.

% Coir Fibre	Bit Vs % Voids (OBC) (%)	Bit Vs Density (OBC) (%)	Bit Vs Stability (OBC) (%)	Avg. OBC (%)
0%	5.46	5.52	5.57	5.516
0.2%	5.52	5.54	5.61	5.556
0.4%	5.55	5.58	5.54	5.556
0.6%	5.54	5.56	5.58	5.56
0.8%	5.61	5.60	5.56	5.590

VII. DETERMINATION OF OPTIMUM FIBRE CONTENT (OFC)

The optimum fibre content for a mix having a particular fibre length is determined following the same procedure used for obtaining the optimum binder content. The OFC for 15 mm fibre length is then computed.

VIII. CONCLUSIONS

Addition of coir fibre to Semi Dense Bituminous Concrete mix significantly improving the performance of the mix. Stability value increases by 1.3 times when compared to the reference mix making the mix more stable to the traffic operation load. The flow value showed a negligible increment on comparison with the reference mix.

The strength and void parameters of the coir fibre reinforced bituminous mix also satisfy the requirements of Specifications for Road and Bridge Works (up-gradation of third revision), MoRTH.

No significant variation in the optimum bitumen content was observed even with addition of coir fibre. The OBC for coir fibre reinforced SDBC mix does not vary when compared to the reference mix. With this, it can be concluded that additional bitumen is not required to prepare fibre reinforced SDBC mix.

From the test results obtained, the optimum fibre content computed was 0.4% by weight of the total mix. The Marshall parameters corresponding to this fibre content satisfies the requirements of MoRTH. The optimum fibre length determined from the results was 15 mm whose results also satisfy MoRTH specifications for SDBC. The values of OFC obtained are in agreement with already published literature on coir fibre (OFC – 0.3-0.6%) reinforced SDBC mixes.

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