.COIR FIBER REINFORCED BITUMINOUS MIXES CHARACTERIZATION

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ABSTRACT

The advancement of transportation is critical to the nation's progress. With the widespread use of flexible pavements in India, actions must be taken to extend the life of bituminous pavements. Because of the repetitive traffic pressures, flexible pavements are prone to cracking and rutting. As a result, in order to increase the performance of flexible pavements, these issues must be addressed. The study investigates the suitability of coir as a bituminous mix reinforcing material.

KEYWORDS- Bitumen, coir fibre, stability, Marshall mix design.

INTRODUCTION

Based on its structural behaviour, a pavement structure can be constructed as a flexible or rigid pavement, with flexible pavements being frequently favoured in India due to their advantages over rigid pavements and cost savings. Flexible pavements have low or no flexural strength and are structurally flexible under load. The following layers make up these pavements:

1. Subgrade or Road bed
2. Sub base course
3. Base Course
4. Surface Course

Vertical or compressive stresses are transmitted to the lower layers via grain-to-grain transfer through the sites of contact in the granular structure with strong graded aggregates, and the compressive stresses should be transferred across a larger area. Based on the foregoing, bituminous mix is one of the best flexible pavement layer materials.

Bituminous mix is commonly utilised as a surface course and wearing course in flexible pavements because the wearing course must provide a smooth, dense riding surface while also taking up traffic wear and tear.

DISADVANTAGES OF BITUMINOUS MIXES

The following are the common issues that arise when bitumen is used in paving mixes.

1. Mixing difficulty
2.Assuring mix stability

3.Bitumen surface cracking

4.Maintaining adequate aggregate adhesionCombined

Cracks in the bituminous surface are caused by changes in temperature and fatigue. Due to repeated loads, pavement deformations (plastic and elastic deformations) may result in permanent deformations and even failure.Excessive strain in the pavement layers causes cracking and plastic failure (rutting) in bituminous surface courses. Vertical oscillations are caused by undulations and unevenness of the surface caused by plastic deformations of the pavement, which consumes more gasoline, wears down vehicle components, and raises vehicle operation costs. As a result, passengers experience discomfort and tiredness.To overcome the difficulties in using and maintaining flexible pavements, it is vital to address the problems of rutting and cracking. Since the stresses under the wheel loads generate deformations owing to repetitive load applications, it is also vital to take the necessary actions to keep elastic deformations within the allowable limits.

OBJECTIVE

The goal of this research is to look at the qualities of coir fibre reinforced bituminous mixes and compare them to traditional bituminous mixes.

EXPERIMENTAL WORK

The work technique used, material characterization, mix proportioning, and experimental studies on coir fibre reinforced bituminous mix are all covered in this chapter.

MATERIAL CHARACTERIZATION

Tests on Aggregates

A standard weight aggregate with a maximum size of 13 mm was employed as the coarse aggregate. The fine aggregate was made of stone dust. The listsof the aggregates' key features are determined by standard tests.

1. Specific gravity
2. Apparent Specific gravity
3. Water absorption test

The aggregates were sieved using IS sieves of sizes 0.075,0.3,1.18,2.36,4.75,9.5,13.2

TESTS ON BITUMEN

The binder is 60/70 grade bitumen, and its parameters as determined by normal test procedures are listed below

Penetration(mm)-71.4

Specific gravity -1.02

Softening Point(ºC)- 50.5

Ductility(mm)->100

Static Immersion Test-no visible stripping

TESTS ON COIR FIBRE

We utilised unrutted brown coir for the experiments on coir reinforced bituminous mixes since it is readily accessible and has similar qualities to retted coir. The coir was cut to the requisite lengths of 10 mm, 15 mm, and 20 mm from bundles as illustrated in the diagram below.

The qualities of coir fibre as determined from various sources.

- Diameter(mm):0.1-0.4
- Density(g/cm^3):0.67-10.0
- Natural moisture content (%):11.44-15.85
- Water absorption (%):85-135
- Tensile strength (MPa): 108.26-251.90
- Modulus of elasticity (GPa):2.5-4.5
- Strain at failure (%):13.7-41.0

The below are some of the properties of coir fibre that were determined in the lab using standard test protocols.

- Specific gravity:0.98
- Water absorption:73.47
- Bitumen adsorption:107.14

AGGREGATE PROPOTIONING

Semi-dense bituminous concrete

The semi dense bituminous concrete mix grade 1 as stipulated by the Ministry of Road Transport and Highways (MoRTH) in Specifications for Road and Bridge Works (up-gradation of third revision) was chosen as the bituminous mix to explore the properties of coir fibre reinforced concrete. Wearing/binder and profile correcting courses are made of semi dense bituminous concrete (SDBC).

On a previously prepared bituminous bound surface, this usually consists of a single or many layers of semi dense bituminous concrete. A single layer might be anything from 25mm to 100mm thick.

The physical parameters of the aggregates used in SDBC grade 1 are listed in the table below shows the required aggregate gradation for semi-dense bituminous concrete grade 1 as specified in the MoRTH requirements.

PROPERTY	TEST	VALUE(%)
Cleanliness	Grain size analysis	5max passing 0.075mm sieve
Sieve	Aggregate Impact value	27max
Water Absorption	Water Absorption	2max
Stripping	Static Immersion Test	95Min retained coating

SDBC Grade 1 Proportioning

The following mix proportion was obtained after proportioning the aggregates for semi dense bituminous concrete mix according to MoRTH requirements.40 percent of 13.2 mm aggregate ,35 percent of 4.75 mm aggregate,25 percent stone dust.

MIX DESIGN FOR MARSHALL METHOD

According to Indian (MoRTH) recommendations, the Marshall Test is used for bituminous mix design.

MARSHALL METHOD PRINCIPLE

The Marshall Test is an unconfined compression test in which a load is applied to a cylindrical bituminous mix specimen and the sample is monitored until failure. When a cylindrical bituminous mixture specimen is loaded at 5 cm per minute at the periphery, its resistance to plastic deformation is measured. At various binder contents, stability and flow, as well as density, voids, and the percentage of voids filled with binder, are determined to obtain a 'optimal' bitumen content for stability, durability, flexibility, fatigue resistance, and other properties.

The three stages of the Marshall mix design approach are as follows:

1. Determination of bulk density
2. Flow test and stability
3. Void analysis and density

MARSHALL APPARATUS

According to ASTM D 1559, the Marshall test apparatus consists of the following components.

(a)Mould Assembly

(b)Compaction Pedestal and Hammer

(c)Breaking Head

(d)Loading Machine

(e)Flow Meter

MARSHALL COMPACTION SPECIMENPREPARATION

This section describes and illustrates the technique for preparing specimens for the Marshall test. In addition to the reference

- Materials were weighed according to proportionate values for the various mixes, which included aggregates of three distinct sizes, 13.2 mm, 4.75 mm, and stone dust, 60/70 grade bitumen, and coir fibre of appropriate length. For the cylindrical samples, 1350 grammes of materials per mix were used to achieve a theoretical density of 2.4-2.5 g/cc.
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- Aggregates were heated in a pan with aggregates of the necessary grade. The coir fibre was also added to the aggregates and well stirred to ensure consistent fibre distribution. A temperature of 150-160°C was reached throughout the combination.
- Bitumen addition: A sample of weighed bitumen was added to the heated aggregate mix. At 160-170°C, the bitumen was heated to a liquid condition and thoroughly mixed with the aggregates to produce a homogeneous slurry.
- Pouring into the mould: The homogeneous bituminous mixture was poured into the mould for compaction at 160-170°C to assure compaction at 150°C. The cylindrical moulds, base plates, and extension collars, with an internal diameter of 101.7 mm and a height of 76.2 mm, must meet ASTM D1559 -Standard Test Method for Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus.
- To obtain the Marshall Compaction Specimen, a conventional Marshall hammer with a circular tamping face and a sliding weight of 4.536 kg with a free fall of 45.7 cm was used to compact the specimen. Allowing the crushed specimen to cool to room temperature was necessary before the sample was extracted.
- Extraction of the compacted specimen from the mould: A steel disc with a diameter of not less than 100 mm and a minimum thickness of 13 mm was used to withdraw the compacted specimen from the mould by applying a slow incremental force to the face of the specimen using a hydraulic jack.


FLOW VALUE TEST AND STABILITY TEST

The bituminous mix specimens must be evaluated at 601°C, according to ASTM D 1559 standards. After bulk density assessment, the wax coated samples were held in a water bath at 60°C for 30-40 minutes to aid this. The guide rods were cleaned and lubricated, as well as the entire breaking head configuration. The specimen was taken out of the water bath and placed horizontally between the test heads. The entire system was swiftly mounted on the Marshall compression machine's base plate.

The flow dial gauge was positioned above the guide rod, and the proving ring and flow metre dial gauges were set to zero. The machine was programmed to apply load until it reached its full capacity. The maximum load and flow dial gauge values were recorded, after which the machine was reversed and the failed specimen was removed from the test head.

RESULT AND DISCUSSION

The Marshall test findings on samples of coir fibre reinforced bituminous mixes are analysed, and the Optimum Bitumen Content (OBC) for the various mixes is calculated. The Marshall procedure is used to find the Optimum Fibre Content (OFC) and Optimum Fibre Length (OFL) in the same way. The results of the coir reinforced mixes are compared to the results of the conventional reference mix, and the performance of coir fibre reinforced bituminous mixes is addressed.

The salient elements of this project work on coir reinforced bituminous mixtures are reviewed in this chapter, and conclusions are formed after a thorough study of the findings. The potential for future research in the same field is also explored.

EXPERIMENTAL RESULTS

The following were the mix variables:
Coir is a type of fibre.
0.3 percent, 0.5 percent, and 0.7 percent fibre content (By weight of the mix)
10mm, 15mm, and 20mm fibre lengths
Bituminous blend Grade 1 Semi-Dense Bituminous Concrete
4 percent, 5 percent, and 6 percent bitumen content
Mix volumetrics were calculated using the Marshall technique of mix design, as well as tests for Marshall stability and flow. For the reference mix, the optimum bitumen content and its accompanying characteristics were calculated. The optimum bitumen content, optimum fibre content, and optimum fibre length for the coir fibre reinforced bituminous mix were calculated, yielding the following result.

Optimum Bitumen Content: 5.00%
Optimum Fibre Content: 0.46%
Optimum Fibre Length: 17.25 mm

CONCLUSION

- The addition of coir fibre to a semi-dense bituminous concrete mix improves the mix's performance dramatically. When compared to the reference mix, the stability value increases by 1.3 times, making the mix more stable for the traffic load. However, as compared to the reference mix, the flow value increased by nearly 1.8 times.
- The coir fibre reinforced bituminous mix's strength and void parameters also meet the standards of MoRTH's Specifications for Road and Bridge Works (up-gradation of third revision).
- Even with the addition of coir fibre, there was no substantial change in the optimum bitumen content. When compared to the reference mix, the OBC for coir fibre reinforced bituminous mix decreased by 8.9%. As a result, it can be inferred that additional bitumen is not necessary for the preparation of fibre reinforced SDBC mix.
- Based on the test results, the optimal fibre content was calculated to be 0.46 percent by weight of the overall mix. The Marshall specifications for this fibre content meet MoRTH's criteria. The optimum fibre length determined by the results was 17.25 mm, which meets MoRTH SDBC requirements. The reported values of OFC and OFL are consistent with previous research on coir fibre (OFC 0.5-0.7 percent; OFL 10-20 mm) reinforced bituminous mixes.

SCOPE FOR THE FUTURE WORK

Because the coir is anticipated to give additional expandability to the bituminous mix, a systematic study is required to understand the elastic behaviour of coir fibre reinforced semi dense bituminous concrete. Experiments on the rutting behaviour of coir fibre reinforced bituminous mixes will aid in the understanding of the mix's performance under load. A case study on the abrasion resistance of coir fibre reinforced semi dense bituminous concrete might be conducted as well.

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