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Experimental use of kenaf fibre in hot mixed pavement

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Abstract - *This project studies the suitability of kenaf fibre as a material in bituminous mixes for preparation of the mixes aggregate gradation has been taken as per Ministry of Road Transport and Highways India (MoRTH) specification binder Content has been varied regularly from 4% to 7% and fibre content varied from 0% to 0.5% of total mix. The fibre at different content of 0.3%, 0.4%, 0.5% (By weight of total mixture), each at two different lengths of 10mm, 15mm, 20mm have been used and found the properties mixes prepared at OBC and OFC. The Stone matrix asphalt (SMA) mixes prepared at OBC and OFC are subject to different performance test like, Static Indirect Tensile Strength test, Marshall Stability etc. to evaluate the effects of fibre addition on mix performance.*

***Key Words*: Natural fibre, kenaf fibre, Marshall Stability, Ageing test.**

1. INTRODUCTION

Kenaf Fibre

Fig 1:- Kenaf Fibre (Source: - Green Flower.com)

General Properties of kenaf fibre:

- Kenaf Fibre is exceptionally durable with a low maintence with minimal wear and tear. Kenaf Fibre have Good sound and impact absorbing properties.
- It is recyclable
- Kenaf fibre are obtain from outer leaf skin, removing the inner pulp
- Kenaf fibre are anti-static, does not attract or trap dust particle and does not absorb moisture or water easily
- The fine texture takes dyes easily and offer largest range of dye colours
- Good sound and impact absorbing properties.

General using Kenaf fibre:

- Roping: it is use in making ropes.
- Paper: it is use in paper production.
- Use in coarse cloths,
- It is used in automotive product.
- Engineered wood, Insulation, Clothing-grade cloth
- Soil-less potting mixes
- Animal bedding, Packing material

Kenaf fibre specific properties:-

Table 1 Specific Properties of Kenaf fibre

Plant fibre	Kenaf fibre
Tensile Strength (MPa)	295-1191
Young's modulus (GPa)	22-60
Length of ultimate L (mm)	2-61
Diameter of ultimate (μm)	17.7-21.9
Aspect ratio L/D	119
Density (kg m-3)	1220-1400
Moisture Content (%)	17

(Source: - Analysis and Performance of Fibre Composites Book)

3. Scope of the Study-

This necessitates the need for thorough experimental and field investigations in various aspects of Kenaf fibre mixed pavement. Presently, Kenaf fibres are used as stabilizing additives in pavement. Here, a study on the impact of natural fibre as additives in bituminous pavement and their role in the mechanical property of the mixture is proposed. Emphasis is also given to assess the effect of water immersion on the performance of Kenaf fibre mixtures. The rutting characteristics of the mix are intended to study indirectly by analysing the stability and strength characteristics of the mixtures.

4. Aim of the Study

The aim of the study is to experiment the use of Kenaf fibre in hot mixed pavement.

5. Research Objectives

Considering the importance of the problem discussed, this research mainly focuses on the following objectives.

1) To propose a durable surface course with Kenaf fibre with Hot mix Pavement.
2) To study the best natural fibre additive from the fibre stabilized bituminous mixtures.
3) To determine the optimum mix design conditions such as optimum fibre content and optimum bitumen content.

5. Problem definition

- One of the main problem which is faced by government is maintenance problem.
- While India being the second largest in terms of the length of the road network.

a. India has a road network of over 4,689,842 kilometres (2,914,133 mi) in 2013, the second largest road network in the world after USA.
b. India has less than 3.8 kilometres of roads per 1000 people, United States has 21 kilometres of roads per 1000 people, while France about 15 kilometres per 1000 people. However, the usage of the roads are more on every 1000 peoples in compare to other countries.
c. According to a survey every year about 25% of the roads needs maintenance which costs a lot to government.

6. MATERIAL PROPERTIES

The tests were conducted properties of selected aggregates and VG-30 bitumen. The results are shown in Tables 2 and 3:

Table 2. Properties of Aggregates

Sl No.	Property	Test Results	Remark
1	Impact value	12%	Satisfactory
2	Los Angeles Abrasion Value	14.18%	Satisfactory
3	Flakiness index	21.89%	Satisfactory
4	Elongation index	24%	Satisfactory
5	Gradation of aggregate	--	Satisfactory

Table 3. Properties of Vg-30 Bitumen

Sl No.	Property	Test Results	Remark
1	Penetration value of bitumen	64.25	Satisfactory
2	Ductility of bitumen	80	Satisfactory
3	Softening Point of bitumen	46 °C	Satisfactory
4	Flash Point test for Bitumen	230 °C	Satisfactory
5	Viscosity Test for Bitumen	38 sec	Satisfactory

7. Bitumen test for adding Optimum Fibre Content:

Table 4 Test is conducted after adding optimum fibre content (0.4%)

Test for the Bitumen	Test result
• Penetration test for adding 0.4% kenaf fibre in Bitumen	45
• Ductility test for adding 0.4% kenaf fibre in Bitumen	65 cm
• Viscosity test for adding 0.4% kenaf fibre in Bitumen	50 sec
• Softening Point test for adding 0.4% kenaf fibre in Bitumen.	*65 °C*
• Flash Point test for adding 0.4% kenaf fibre in bitumen	250

8. Aging Effect in Bitumen:

8.1 General:-

Aging: - Is the accumulation of changes in an organism or object over time. Asphalt/Bitumen properties changes over time on exposure to high temperature

and the atmosphere. This Process is referred to as aging.

- Aging in Bitumen normally resulted from the weathering of the binder due to oxidation.
- The aging of bitumen is one of the principal factors causing the deterioration of asphalt concrete pavement.
- The aging modes of failures includes fatigue, thermal induce cracks.

8.2 Factors affecting the ageing of Bitumen binder

- Binder characteristics
- Bitumen content in the mix
- Nature of aggregate and particle size distribution
- Air voids content in the mix
- Temperature

8.3 Aging Concepts: - The amphoteric are the most reactive in terms of reactivity are capable of forming interlinked structures because they have more than one reactive site. Mono functional materials with one oxidizable site, can act as chain terminators, limiting the degree of associations. The amphoteric have a large effect on the viscosity of the bitumen; the mono functional polar molecules do not.

8.4 Thin – film oven test (Reference: AASHTO T 240 and ASTM D 2872)

- Short term binder ageing is a well-accepted concept that represents ageing of binders during plan mixing, production, transportation and construction
- This test method also can be used to determine mass change, which is a measure of asphalt volatility
- The test is conducted by using the Thin Film oven test (TFOT) in accordance with ASTM D1754

8.5 Result and Analysis

8.6 General: - Aging effect of Bitumen was worked out after binder content of kenaf fibre. Initially bitumen sample was mixed with kenaf fibre optimum mix (0.4%) and tested for its all properties. Then it is put in thin film oven test for shears at 163°C to general aging effect. The all test of bitumen was again performed on treated sample in thin film oven test. The Comparison of both the result are listed below table.

Table 5 Comparison of both the results

Description	Result without addition of fibre after treating with thin film oven	Result with addition of fibre after treating with thin film oven
Penetration	65	45
Softening Point	46	65
Ductility	80 cm	65 cm
Viscosity	38 sec	50 sec
Flash point	230	250

8.7 Comparative Performance of Kenaf Fibre in Bituminous Mix

On observing the values presented in table 5, a comparison can be drawn between conventional Reference bituminous mix and kenaf fibre added bituminous mix. There is a significant decreasing in the penetration value on addition of optimum kenaf fibre content 0.4%. The Softening point 65 observed in kenaf fibre bituminous mix lies within the specified limits of prescribed for MoRTH. This increasing in the Softening point in the reference mix. The ductility value is decrease in magnitude on addition of optimum kenaf fibre (0.4%) to the bituminous mix. Also the viscosity and Flash point value increase significant with addition of the optimum fibre added in the reference mix.

Over all concluding after the thin film oven test is that the addition of optimum percentage of kenaf fibre (0.4%) in the reference mix there are decreasing in elasticity and decrease in ductility significantly.

9 Economic Analysis for the 1 km Stretch of Pavement.

- For the calculating 1 km stretch of Bitumen Concrete the following calculation should be done.
- The following value is converted in meter

Length	1 km	=	1000 m
Width	3.6 m	=	3.6 m
Thickness	40 mm	=	0.04m

- Calculation For: - Total quantity of Bitumen mix required

Density of Bituminous mix (BC) = 2380 kg/m^3

Volume of BC layer for 1 km stretch = 1000 X 3.6 X 0.04 = 144

Weight required = 2380 X 144

= 342720 kg

= 342.720 Tone

- Percentage of Aggregate as Per the Design

10 mm = 30%

6 mm = 35%

Dust = 35%

- Percentage of Optimum Binder Content as per the Design.

Optimum Bitumen Content = 5.5%

Optimum fibre content = 0.4%

Following table shows calculation of different material weight with or without adding of kenaf fibre

Table 6 Material Weight with or without adding Kenaf fibre

Sr. No.	Material Description	Without Fibre weight in tone	With Fibre in tone
1	Bitumen	18.85	18.85
2	Kenaf Fibre	----	1.37
3	10 mm	97.16	97.16
4	6 mm	113.37	113.37
5	Dust	113.37	113.37

- Cost Analysis

- Price for MT of the below material is as following

Bitumen per MT price = 36000

10 mm aggregate per MT price = 290

5 mm aggregate per MT price = 220

Dust per MT price = 150

The Following table calculation of different material weight with or without adding of kenaf fibre

Table 7 Material cost with or without adding Kenaf fibre

Sr.No.	Material Description	Without Fibre cost per tone	With fibre cost per tone
1	Bitumen	18.85 X 36000 = 678600	18.85 X 36000 = 678600
2	Kenaf Fibre	----	1.37 X 45000 = 61650
3	10 mm	97.16 X 290 = 28176.4	97.16 X 220 = 28176.4
4	6 mm	113.37 X 220 = 24941.4	113.37 X 220 = 24941.4
5	Dust	113.37 X 150 = 17005.5	113.37 X 150 = 17005.5
Total Cost		748723.3	810373.3

10.1 Comparative Cost of with and without add kenaf fibre in Bituminous concrete pavement.

On observing the values presented in table 7, a comparison can be drawn between Comparative Cost of with and without add kenaf fibre in bituminous pavement. There is an increase of cost with the 0.4% addition of kenaf fibre in bituminous concrete pavement.

11. SUMMARY AND CONCLUSION

11.1 SUMMARY

A total number samples of bituminous concrete including the reference mix were tested. The mix variables were as follows.

Fibre type- Kenaf fibre

Fibre content (By weight of the mix) - 0.3%; 0.4%; 0.5%

Bitumen content - 4%; 5%; 6%; 7%

Adopting the Marshall method of mix design the mix volumetric were computed along with tests for

Marshall Stability and flow. The optimum bitumen content and its corresponding parameters were determined for the reference mix. The optimum bitumen content, optimum fibre content were computed for the kenaf fibre reinforced bituminous mix and the following result was obtained.

Optimum Bitumen Content**:** 5.5%

Optimum Fibre Content: 0.4%

Aging effect of Bitumen was worked out after binder content of kenaf fibre. Initially bitumen sample was mixed with kenaf fibre optimum mix (0.4%) and tested for its all properties. Then it is put in thin film oven test conducted at 163°C to general aging effect. The all test of bitumen was again performed on treated sample in thin film oven test. The Comparison of both the result are also done. The Economic analysis also calculated for the 1 km Stretch of Pavement with and without addition of optimum fibre content.

11.2 CONCLUSION

For using thin film oven test concluded that addition of kenaf fibre to bitumen concrete mix contributed significantly in improving the performance of mix. Penetration and Ductility value decrease. And Viscosity, flash point and softening point is increase. There for decreasing in elasticity and decrease in ductility significantly.

The cost of total material with fibre is increase in but at the same serviceability criteria may be increase.

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