Study on Retardation of Reflection Cracks using Glass Fibres in Composite Pavement

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Abstract: As the population in India is increasing day by day the growth rate of vehicles became the backbone of economic development. In India infrastructure has not yet developed to serve the whole population in a most efficient way it can and already design pavements like rigid pavements and flexible pavement are not enough to provide adequate performance to withstand present situation of excessive traffic on road. So to overcome these problems there is a need that we have to focus to shift from traditional flexible and rigid to composite pavements. The composite pavements are far better than concrete road and bituminous concrete in many ways. Composite pavements has more design life and be easily maintained and repaired. Despite this, reflective cracking which reflects on the bituminous surface from underlying cracked surface is now become a big matter of concern, it not only affect the riding surface but also leads to potholes formation on the surface. For this, utilisation of different fibres like carbon fibres, glass fibres, polypropylene fibres, cellulose fibres etc to enhance the property of pavements and to reduce the propagation of reflective cracks is must.

1. Introduction

1.1 GENERAL

Infrastructure plays an important role in growth of any country. The massive development of highway is increasing everywhere throughout world. The main aim of the project is to increase the life span and stability of pavement. The design of composite pavement are more than rigid and flexible pavements. In this study we will carry out our work with composite pavement using glass fibres as a modifier so as to retard the propagation of reflective cracks in bituminous concrete surface. Glass fibres has many advantages such as it has strong mechanical strength, it can be moulded to any shape and it has long life. It provide inherent compatibility and excellent mechanical properties. Glass fibres that are used in study was the recycled waste glass that is generated from glass industry as we know all over India millions of glass waste are disposed outside in form of jar and bottles. The review includes physical tests which are to used to determine the various physical properties of plain bituminous mix and modified bitumen mix and make the comparative study. The optimum dosage of glass fibre was found to be 0.3% considering economy and performance as the most crucial factor for designing with an optimum binder content of 5.5% in bituminous concrete layer. Our expectation from the study to minimize the cost of bitumen by replacing it with glass fibres as an additive for the retardation of propagation of reflective cracks.

2. OBJECTIVES

The objectives related to the research work are as follows

(i)To develop a composite section with bituminous overlay over cracked concrete surface
(ii)Compare the result of plain bituminous concrete mix with Glass Fibre modified bituminous concrete mix.
(iii)To prepare job mix formula for determination of optimum binder content, optimum dosage of glass fibre and volumetric properties of bituminous mix.

3. MATERIAL USED

3.1 AGGREGATES

According to MORTH specifications, Tests were performed like crushing test, abrasion test, impact test, soundness test, shape test, specific gravity and water absorption etc . The properties of aggregates shown in table.1.

Table 1. Properties of Aggregate

Property	Test Performed	Method of Test	Specification as per MoRTH 2013	Test Result
Cleanliness (dust)	Grain Size Analysis	IS:2386 Part I	Max. 5% passing 0.075mm sieve	2%
Particle Shape	Combined Flakiness and Elongation Test	IS:2386 Part I	Max 35%	18.94%
Strength	Aggregate Impact Test	IS:2386 Part IV	Max 24%	16.66%
Soundness	Soundness in Sodium Sulphate	IS:2386 Part V	Max 12%	9%
Water Absorption	Water Absorption test	IS:2386 Part III	Max 2%	0.55%
Specific Gravity	Specific Gravity Test	IS:2386 Part III	-	2.725 (20 mm) 2.723(10mm) 2.26(dust)

3.2. Test on bitumen

The bitumen of Grade VG 40 has been procured from IOCL Vadodra and was tested for all basic properties as per IRC codes and MoRT&H whose results are shown below in *Table 2*

Table 2 Properties of VG 40 Bitumen

S. No.	Description	Method of Test	As per Test results	Specifications as per IS Code(min)
1	Penetration Test (1/10 mm)	IS 1203	43	35
2	Kinematic Viscosity at 135°C, cSt	IS 1206, Part 3	552	400
3	Softening Point, °C	IS 1205	55.15	50
4	Solubility Test, %	IS 1216	99.36	99
5	Ductility Test, cm	IS 1208	56	25

From the above table, it is concluded that the bitumen used in research work renders all the basic requirement and hence, the surety of sample for further work is assured.

4. Glass fibres

Glass fibres should have high melting point which was selected for the study and it should have high tensile strength so that adequate strength was provided to make bituminous mix in tension. The test results of glass fibre properties are given below in TABLE3

Table 3 Optimum Binder Content from Marshall Method

S. No.	%Bitumen by weight of mix	Average Gmb (gm./cc)	Gmm (gm./cc)	%VA	%Vb	%VMA	%VFB	Marshall Stability (kg)	Marshall Flow (mm)
1	5.2	2.39	2.538	5.8	12.18	17.98	67.72	864	3.8
2	5.5	2.42	2.532	4.4	13.01	17.45	74.34	1016	4.0
3	5.8	2.412	2.517	3.2	13.85	17.05	81.22	976	4.4

Table 4. Optimum Glass Fiber Dosage

S. No.	Binder Content	Glass Fiber Dosage (by weight of mix)	Marshall Stability (kg)	Marshall Flow (mm)	%VA	%VMA	%VFB
1	5.5%	0.2 %	1032	2.35	4.4	17.4	76.28
2		0.3 %	1190	2.85	4.32	17.28	74.1
3		0.4 %	1248	3.15	4.15	17.24	73.9

From the above results, conclusion drawn was that 0.3% and 0.4% glass fiber can be used for our research work but considering economy as one of the major factor, 0.35 glass fibre was selected as Optimum Dosage .

5. PAVEMENT EVALUATION TESTS:

From pavement evaluation test we should compare the engineering and mechanical properties of bituminous concrete mix with or without the addition of glass fibres , bituminous mix is used as an overlay over concrete slab and the major aim is to achieve the retardation of reflection of cracks using glass fibres. Various samples are prepared for evaluation performance test and these are conducted to compare the properties and behaviour change of bituminous mix with addition of glass fibres.

5.1 INDIRECT TENSILE STRENGTH

The Indirect Tensile strength (ITS) test is done to determine the splitting tensile strength of bituminous mix and this is related to the cracking potential of pavement. Higher the tensile strength of bituminous mix, stronger will be the cracking resistance. The test was conducted as per ASTM D 6931 . For Dry ITS, Samples casted were kept for conditioning for about 3-4 hours at 25°C and whereas For Wet ITS few samples casted were first kept in water (for 24 hours at 60°C)and then tested after 2 hours conditioning at 25°C. The test result of various samples with and without Glass Fiber are shown in *Table 5* and their Tensile Strength Ratio is determined.

Table 5 Mechanical Properties of Marshall Sample

Property	Sample No.	Dry ITS (kN)	Wet ITS (kN)	Tensile strength Ratio Min. 80
Without Glass Fiber	1	10.966	8.844	80.83
	2	10.845	8.786	
	Average	10.905	8.815	
With Glass Fiber	1	12.335	11.01	89.78
	2	11.834	10.69	
	Average	12.084	10.85	

5.2MARSHAL STABILITY TEST

Marshall Test is conducted in order to determine the resistance to plastic deformation of cylindrical specimen when loaded at its periphery at a rate of 50.8 mm/minute.

Samples were casted as per ASTM D 6927 and were cured in water bath for 30-40 minutes at a temperature of 60°C to determine Marshall Stability and for 24 hours. Once the optimum binder content and optimum dosage of glass fiber to be used were determined, Marshall Samples were made and tested for Marshall Stability and Retained Stability and then the stability ratio was determined (which should be more than 80% as specified in code).

Table 6. Marshall and Retained Stability Results

Property	Sample No.	Marshall Stability (kN)	Marshall Flow (mm)	Retained Stability (kN)	Retained Flow (mm)	Stability Ratio = (Av Retained stability/Av Marshall Stability) Min. 80
Without Glass Fiber	1	10.38	3.04	8.51	4.53	82.98
	2	9.88	2.88	8.32	4.25	
	Average	10.09	3.01	8.35	4.395	
With Glass Fiber	1	12.56	2.84	11.38	3.66	90.52
	2	11.80	2.79	10.67	3.46	
	Average	12.235	2.84	11.076	3.55	

It can be concluded from the above table with that glass fiber increases the Marshall and Retained Stability of samples and thus increases the strength of mix.

6. DISCUSSION AND CONCLUSIONS

Based on the study conclusions are drawn:

Use of Glass Fibre in the bituminous mix improves its property in many ways.

- Glass Fibre not only increases the stability but also improves the tensile strength of bituminous mix.
- Use of Glass Fibre in the bituminous mix increased the stability ratio by 7.54% whereas the tensile strength ratio improved up to 8.98 % and is an indication that cracks will be delayed in the mix casted with Glass Fibre.
- From the Marshall Stability test and volumetric analysis, optimum binder content was determined to be 5.5% and the optimum dosage of Glass Fibre was selected to be 0.3%.
- The Marshall Stability Value and Indirect Tensile Strength Value of sample increased with the usage of Glass Fibre as compared to the sample prepared with plain bituminous mix.
- The retained stability ratio was found to be 82.98 % for sample without Glass Fibre whereas the stability ratio of sample with Glass Fibre increased and was found to be 90.52%.

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