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Research Article

An Experimental Study on Behaviour of Steel Fibre on Bituminous Mixes (Dense Bitumen Macadam)

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Abstract

One of the innovative technique of improvement in dense bitumen macadam surface practiced all over the world is addition of steel fibres in it.The performance of dense bituminous macadamMixes with steel fibre in varied proportions (2%,2.5%,3%,3.5%,4%,4.5%,5%,5.5% & 6% with 18 mm and 11 mm length was studied by conducting Marshall Stability Test for Stability of Bituminous Mixes .The results have been noticed that the considerable improvement in stability of dense bitumen macadam was at an optimum percentage of added steel fibre for bitumen concrete at 3 % of 18 mm long steel fibre.Therefore these fibres content has been recommended for making improvements in parameter of Bituminous Mixes.

Keywords: *Steel Fibre, Dense Bitumen Macadam etc.*

Introduction

The Indian Roadways play an important role in connecting the different paths of India. Over the years after independence, there has been an extensive development of the network of roads across the length and breadth of India. India has the largest road network (about 3.315 million kilometer) in the world. India's road network consist of national highways, state highways, district roads and village roads. National Highways are found all over the country. They are indispensable as far as communication by road is concerned. National highways connect States, states' capitals, big cities and ports .National highways carry approximately 40% of the total traffic but they are only 2% of to entire road network. Whereas state Highways are considered as the main roads of the states. Major cities of the States and capital of the state are connected by state highways. While District roads are connecting with major roads and village roads. Village roads provide linkage to other roads in order to meet their daily needs and access to nearby markets.

The road transport sector in India has expanded manifold in 50 years after independence both in terms of spread and capacity. The growth in the importance of road transport within the transport sector is born-out by its growing share in GDP. The share of road transport in GDP is presently 3.69% which accounts for a major share of all transport modes which contributes 5.5% to GDP and Handles more than 60% of the freight and more than 80 % of the passenger traffic in India

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Requirements of Bituminous mixes

Stability

Stability is defined as the resistance of the paving mix to deformation under traffic load. Two example of failure are (i) Shoving- a transverse rigid deformation which occurs at areas subject to severe acceleration. (ii) grooving-longitudinal ridging due to channelization of traffic. Stability depends on the inter-particle friction, primarily of the aggregates and the cohesion offered by the bitumen. Sufficient binder must be available to coat all the particles at the same time should offer enough liquid friction. However, the stability decreases when the binder content is high and when the particles are kept apart.

Durability

Durability is defined the resistance of the mix against weathering and abrasive actions Weathering causes hardening due to loss of volatiles in the bitumen. Abrasion is due to wheel loads which cause tensile strains. Typical examples of failure are (i) pot holes, deterioration of pavements locally and (ii) stripping loss of binder from the aggregates and aggregates are exposed. Disintegration is minimized by high binder content since they cause the mix to be air and waterproof and the bitumen film is more resistant to hardening.

Flexibility

Flexibility is a measure of the level of bending strength needed to counteract traffic load and prevent cracking

of surface. Fracture is the cracks formed on the surface(hairline-cracks alligator cracks),main reasons are shrinkage and brittleness of the binder. Shrinkage cracks are due to volume change in the binder due to aging. Brittleness is due to repeated bending of the surface due to traffic loads. Higher bitumen content will give better flexibility and less fracture.

Skid resistance

It is resistance of the finished pavement against skidding which depends on the surface texture and bitumen content.It is an important factor in a high speed traffic. An open graded coarse surface texture offers good skid resistance but it is equally important to contain the void which may result into higher friction. Therefore surface texture should be such as it provides a good riding quality and also sufficient roughness.

Workability

Workability is the ease which is the mix can be laid and compacted and formed to the required condition and shape. This depends on the gradation of aggregates ,their shape and texture ,bitumen content and its type. Angular, Flaky and elongated aggregates have adverse effect on workability. On the other hand,rounded aggregates improve workability.

Constituents of a mix

1.Coarse aggregates: offer compressive and shear strength and shows good interlocking properties e.g. Granite Coarse aggregate is usually crushed or broken stone aggregate with angular face.

2. Fine aggregates: Fills the voids in the coarse aggregate and stiffens the binder e.g Rock dust or stone dust.

3. Filler: Fills the finer voids, stiffens the binder and improves resistance to stripping e.g. Cement, lime, flyash

4. Binder: The binder is responsible to keep aggregate mixture firmly bound. In addition,its function is to fill the voids that cause particle adhesion and gluing and offers impermeability e.g Bitumen-(VG-10,VG-30) and Modified Bitumen-(CRMB,PMB etc.)

DenseBitumen Macadam

Dense Bituminous Macadam is commonly used as a bituminous base course for heavy traffic loads. It consists of Bitumen as binder and well graded aggregate premixed and laid down in alayer of 50 to 100 mm thickness. It is also known as dense bituminous Macadam. The combined grading of aggregate mix should confirm to the following:

Table 1 Combined grading of aggregates for Dense Bituminous Macadam

	% age Finer	
Sieve Size	**Grading-1**	**Grading -2**
	(80-100mm)	**(50-75mm)**
37.5 mm	95-100	100
26.5mm	63-93	90-100
19.0mm	---	71-95
13.2mm	55-75	56-80
4.75mm	38-54	38-54
2.36 mm	28-42	28-42
300 µ	Jul-21	Jul-21
75 µ	02-Aug	02-Aug
Bitumen* Content%	Min 4%	Min 4.5 %

Steel Fibre

Steel fibres are filaments of wire,deformed and cut to lengths for reinforcement of concrete mortar ,cement slurry and other composite materials. They have anti-crack anti bend, anti-wear anti shear anti fatigue stretching resistance, abrasion resistance character Widely be used in industry,military, construction machinery, metallurgy petrifaction pottery areas.

Usage

The project blending the concrete steel fibre with concrete in certain ratio will evidently strengthen bending resistance stretching resistance abrasion resistance and pressure resistance. it is widely used in highway bridge tunnel airport runway basic structure construction of tall building as well as shock resistance structure and high temperature kiln stove construction

Feature

Bow shape in cross section ,it looks like ripple outside.

Material

Low Carbon Steel

Specification

Length of fibre used were 18mm,11mm (manually cut).Originally of 387 mm Width is 2.0-2.6 mm, thickness is 0.4-0.6mm ,wave length is 6-7 mm wave height is 2mm + 0.2.

Chemical detail property (%)

C	Mn	Si	S	P
0.07-0.12	0.8-1.25	0.07	0.03 MAX	0.03 MAX

Marshall Mix Design

The Marshall Mix Design method wa originally developed by Bruce Marshall of the Mississipi Highway Department in 1939.The main idea of the Marshall mix design method involves the selection of the asphalt binder content with a suitable density which satisfied the satability

Marshall Method

Marshall stability test is used in designing and evaluating bituminous paving mixes and is widely applied in routine test program for the paving jobs. The major feature of the Marshall method of designing mixes are to be determined the two important properties of strength and flexibility. Strength is measured in term of the Marshall 's Stability of the mix which is defined as the maximum load carried out by a compacted specimen at a standard test temperature of 60°C.This temperature represent the weakest condition for a bituminous in use. The flexibility is measured in term of the flow value which is measured by the change in diameter of the sample in the direction of load application between.

Apparatus

Specimen mould assembly-Mould cylinder of 10 CM diameter and 7.5 CM Height, Base plate and extension, specimen extractor,compaction Hammer having flat circular temping face 4.5KG having a free fall of 45 CM, loading machine, flow meter oven to heat aggregates and mould,hotplate to heat bitumen and compaction hammer water bath air bath dial type thermometer, mixing apparatus, Weighing balance.

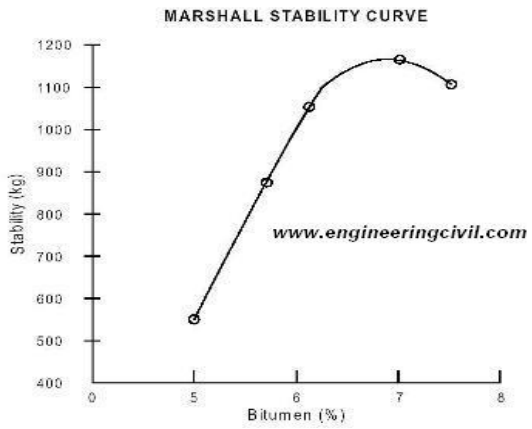

Fig.1 Marshall Stability Curve

Experimental Procedure

Dry the aggregates at 105-110 Degree Centigrade measure a total quantity of aggregates according to the mix, heat the tray aggregates and binder to specified temperature than dry mix the aggregate blend thoroughly add required amount of bitumen, mix rapidly in the heated pan until aggregate is thoroughly quoted under specific temperature .Return the mixture to the oven and reheat to the compacting temperature., clean the mould assembly and heat it to a temperature between 94 degree centigrade to 149 degree centigrade. compact by applying 75 blows with heated face of compacting hammer. Remove the collar and invert the mould, replace collar and compact the reverse sample remove the base plate and collar and extract the specimen carefully.Allow the sample to stand overnight Prepare at least 2 or 3 samples each. Determine the marks of the sample in air and water.

Result

Table 2 Marshall Stability corresponding to the fibre content use (18mm) of DBM

Fibre content in %	Stability in Kg
0%	1152
2%	1350
2.50%	1548
3%	1872
3.50%	1656
4%	1540
4.50%	1404
5%	1350
5.50%	1404
6%	1170

Marshall stability curve for 18 mm steel fibre

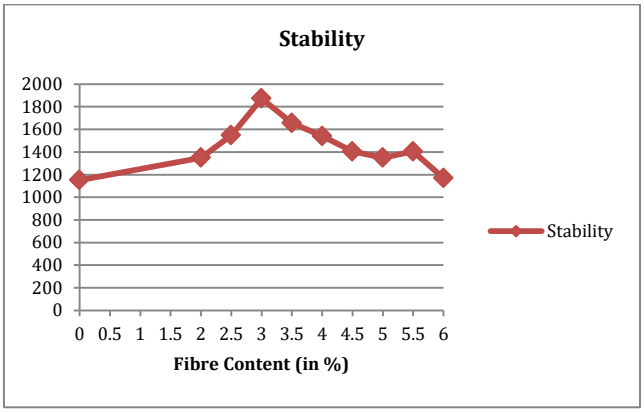

Fig.2 Marshall Stability vs. Fibre content (18mm) for DBM

In the above figure 2 graph had been plotted between Marshall Stability and fibre content of Steel Fibre (18 mm cut in length) where fibre content is on X-Axis varying from 0% to 6% with an interval of 0.5% and Marshall Stability on Y axis from 0Kg to 200Kg with and interval of 2000Kg.The preferable range of Marshall Stability is minimum 820KG according to BIS norms and specification. The graph had been plotted with values of Marshall Stability for each corresponding value of fibre content. For each Fibre content Three (3) sample specimens of DBM with steel fibre (18mm cut in length were prepared and the averaged value of which is used here for analysis.

Marshall Stability curve for 11 mm steel fibre

Table 3 Marshall Stability corresponding to the fibre content used (11mm) of DBM

Fibre content in %	Stability in Kg
0%	1166
2%	1296
2.50%	1346
3%	1461
3.50%	1373
4%	1230
4.50%	1232
5%	1190
5.50%	1210
6%	1155

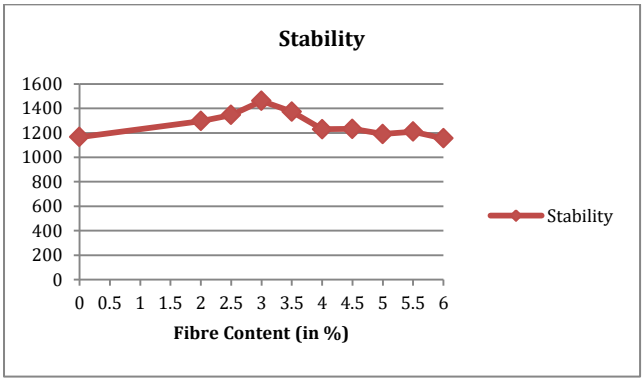

Fig.3 Marshall Stability vs. Fibre content (11mm) for DBM

In the above figure 3 graph had been plotted between Marshall stability and fibre content of steel fibre (11 mm cut in length) where fibre content is on x axis varying from 0% to 6% with an interval of 0.5% and Marshall stability on y axis from 0kg to 1600 kg with an interval of 200kg.The preferable range of Marshall stability is minimum 820KG according to BIS norms and specification. The graph had been plotted with values of Three (3) sample specimens of DBM with steel fibre (11mm cut in length) were prepared and the averaged value of which is used here for analysis.

Table 3 Marshall Stability v/s Fibre Content (11 mm) for dense bitumen macadam

Fibre content in %	Stability in Kg
0%	1166
2%	1296
2.50%	1346
3%	1461
3.50%	1373
4%	1230
4.50%	1232
5%	1190
5.50%	1210
6%	1155

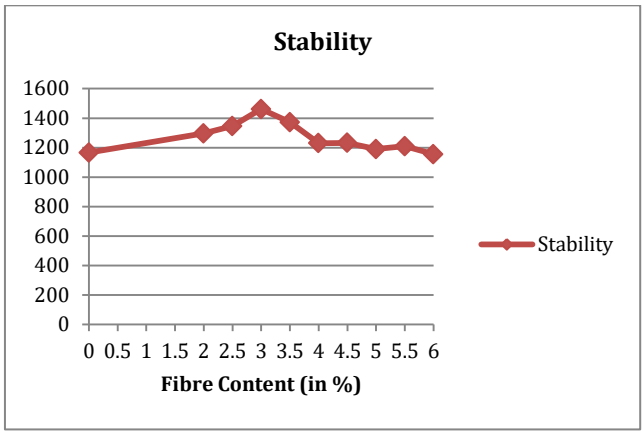

Figure Marshall Stability vs. Fibre content (11mm) for DBM

In the above figure a graph had been plotted between Marshall stability and fibre content of steel fibre (11 mm cut in length) where fibre content is on x axis varying from 0% to 6% with an interval of 0.5% and Marshall stability on y axis from 0kg to 1600 kg with an interval of 200kg.The preferable range of Marshall stability is minimum 820KG according to BIS norms and specification. The graph had been plotted with values of Three (3) sample specimens of DBM with steel fibre (11mm cut in length) were prepared and the averaged value of which is used here for analysis.

Conclusions

For 11 mm steel fibre

The stability increased up to addition of 3 % of the steel fibre and then decreased with the further increment of the steel fibre content .The percentage increment in stability is 62.5%.

For 18 mm steel fibre

The stability up to addition 3% of the steel fibre and then slightly decreased with the further increment of the steel fibre content. All the specimen result of flow values were in the prescribed preferable limit.

With the above result and discussion it was concluded that all the properties of the Dense Bituminous Macadam has been improved with the addition of the steel fibre but with the limiting value of 4.52 % and less. Here it is also important to state that the results of the specimens with 18mm long steel fibres also enhance the stability of the dense bituminous Macadam much more than its requirement. The best value of Stability and flow value are with 3% and 3.5 % of steel fibre content. Therefore in this current study it was found that the 18mm long corrugated steel fibre better result in the chosen parameter and an addition of 3% of fibre content will improve the performance of dense Bituminous Macadam.

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