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Research Article

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

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Abstract

One of the innovative technique of improvement in bitumen concrete surface practiced all over the world is addition of steel fibres in it. The performance of Bituminous concrete Mixes 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 bitumen concrete was at an optimum percentage of added steel fibre for bitumen concrete at 3.5 % of 11 mm long steel fibre . Therefore these fibre content has been recommended for making improvements in parameter of Bituminous Mixes.

Keywords: *Steel Fibre, Bituminous Mixes etc.*

Introduction

Roads- The Lifeline

An efficient transport system is a pre-requisite for sustained economic development. It is not only the key infrastructural input for the growth process but also plays a significant role in promoting national integration ,which is very important for all the countries. The transport system also plays an important role of promoting the development of the backward regions and integrating them with the mainstream economy by opening them to trade and investment. In a liberalized set-up, an efficient transport network becomes all the more important in order to increase productivity and enhancing the competitive efficiency of the economy in the world market.

Of the various modes of transport that connect the cities and villages of the country, road transport constitutes the crucial link. Road infrastructural facilitates movement of men and material, helps trade and commerce, links industry and agriculture to markets and opens up backward region worldwide. In addition, the road system also provide last mile connection for other modes of transport such as railways ,airports, ports and inland waterway transport and complements the efforts of these modes in meeting the needs of transportation. Good roads are essential for the development of a country. The Romans realized this centuries ago. Wherever they establishment themselves, they tried to improve the roads there. Today, the governments of all countries in the world are building more and more roads to gain access to the remotest regions of their countries.

Roads link towns and villages and enable the people of one place to communicate with the people of another place. When food is scarce in one place, it can be brought from another place without much difficulty. Even things which cannot be produced in one region can be brought from another region where they are produced in abundance. The invention of motor-vehicle has made it easy to transport goods from place to place. These vehicles, however, require good roads to travel faster. The better the roads, the more goods can be transported from place to place Thus trade is improved. Further, good roads help people to travel easily to places where they can work and to develop their lands and industries. In Malaysia, for example, the improvement of roads has made it easy for skilled workers from the towns to work in remote villages. The people of the villages, on the other hand, have been able to learn much from the towns. As a result, there has been a lot of improvement in this country in all spheres of activity.

General

The Construction of highway involves huge outlay of investment. A precise engineering design may save considerable investment as well as reliable performance of the in service highway can be achieved. Two things are of main considerations in flexible pavement engineering, pavement design and the mix

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design. The present study is related to the mix design consideration. A good design of bituminous mix should be adequately

- Strong
- Durable
- Resistive to fatigue and permanent deformation
- Environment friendly
- Economical

Evolution of mix design

As per Das et al (2004); During 1900's, the bituminous paving technique was first used on rural roads -so as to handle rapid removal of fine particles in the form of dust from Water Bound Macadam which was caused due to rapid growth of automobiles. At initial stage, heavy oils were used as dust palliative. An eye estimation process, called pat test was used to estimate the requisite quantity of the heavy oil in the mix. By this process the mixture was patted like a pancake shape, and pressed against a brown paper. Depending on the extent of stain made on the paper, the appropriateness of the quantity was adjudged. The first formal mix design method was Hubbard field method, which was originally developed on sand asphalt mixture. Mixes with large aggregates could not be handled in Hubbard field method. This was one of the limitation of this procedure. Francis Hveem, a project engineer of California Department of Highways, developed the Hveem stabilometer. Hveem did not have any prior experience on judging the just right mix from its color and therefore decide to measure various mix parameter to find out the optimum quantity of bitumen. Hveem used the surface area calculation concept (which already existed at that time for cement concrete mix design) to estimate the quantity of bitumen required.

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.)

Pavement of different courses

Pavement consists of more than one layer of different material supported by a layer called sub grade. Generally pavement is two type flexible pavement and Rigid pavement. Flexible pavements are so named because the total pavement structure deflects or flexes under loading .A flexible pavement structure is typically composed of several layers of material. Each layer receives the loads from the above layer, spread them out then passes on these loads to the next layer below.

Typical flexible pavement structure consisting of:

- Surface Course: This is the top and the layer that comes in contact with traffic. It may be composed of one several different HMA sub layesr.HMA is a mixture of coarse fine aggregates and asphalt binder.
- Binder Course: This is base course directly below the surface course for higher category roads; this is made from aggregates of suitable grading mixed with stone dust and binder.
- Base course: This is the layer directly below the HMA layer and generally consist of aggregates (either stabilized or un-stabilized). It is granular material.
- Sub-base course: This is the layer (or layers) under the base layer. A sub-base is not always needed, in case of low volume roads where only one layer of sub as base layer may be provided.

Bitumen Concrete

Bituminous concrete is commonly used as surface course for high volume roads and airports. It consists of Bitumen (used as a binder) and well graded mineral aggregate mixed together, then are laid down in a layer of 25 to 100 mm thickness and compacted.

Table 1 Grading for bitumen concrete

	% age Finer	
Sieve Size	Grading-1	Grading -2
	(50mm)	(30-40mm)
18mm	90-100	100
13.2mm	59-79	91-100
9.5mm	52-72	70-88
4.75mm	35-55	53-71
2.36mm	28-44	42-58
1.18mm	20-34	34-48
600 µ	15-27	26-38
300 µ	10-20	18-28
150 µ	5-13	12-20
75 µ	2-8	4-10
Bitumen* Content%	Min 5.2%	Min 5.4%

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.

Marshall Mix Design

The Marshall Mix Design method was 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 stability

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 determine 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.

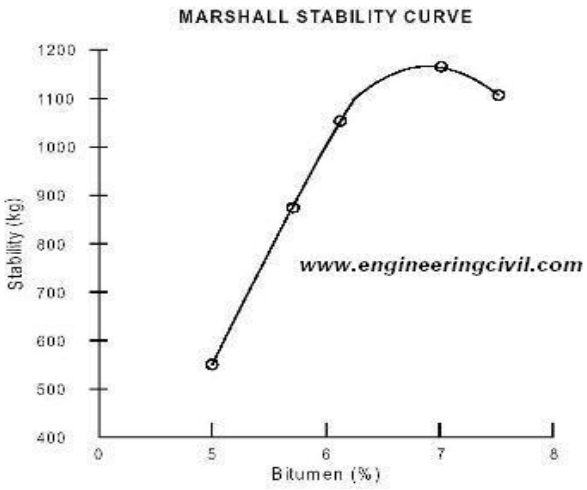

Fig.1 Marshall Stability Curve

2. Experimental Procedure

1) Heat the weighed aggregates and to bitumen separately up to 170 °C and 163°C respectively.
2) Mix them thoroughly with varied proportion (2%,2.5%,3%,3.5%,4%,4.5%,5%,5.5% & 6%) steel fibre of 11mm and 18mm transfer the mixed material to the compaction mould arrange on the compaction pedestal.
3) Give 75 blows on the top side of the specimen mix with a standard hammer (45cm,4.86 Kg).Reverse the specimen and give 75 blows again. Take the mould with the specimen and cool it for a few minute
4) Remove the specimen from the mould by gentle pushing, Mark the specimen and cure it at room temperature overnight.
5) A series of specimen are prepared by a similar method varying quantities of bitumen content, with an increment of 0.5% (3 specimen) of 1 bitumen content.
6) Before testing of the specimen, keep the specimen in the water bath having a temperature of 60 °C for around 40 minute.
7) Check the stability of the specimen on the Marshall Stability apparatus

2. Result

Table 2 Marshall Stabilty vs Fibre Content (11mm) for Bitumen Concrete

Fibre content in %	Stability in Kg
0%	1228
2%	1276
2.50%	1340
3%	1472
3.50%	1497
4%	1346
4.50%	1293
5%	1266
5.50%	1204
6%	1184

Marshall Stability curve for 11mm steel fibre

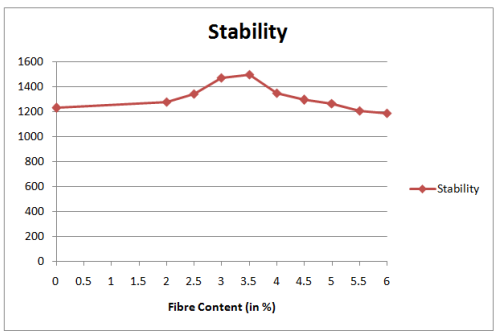

Fig. 2 Marshall Stabilty vs Fibre Content (11mm) For Bitumen Concrete

In the above 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 marshal Stability on Y axis from 0 to 1600 with an interval of 200.The preferable range of Marshall Stability is minimum 820KG according to BIS norms and specialization. The graph had been plotted with values of Marshall Stability for each corresponding value of Fibre Content. For every fibre content three (3) sample specimens of BC with Steel Fibre (11mm cut in length) were prepared and the averaged value of which is used here for analysis.

Marshall stability curve for 18mm steel fibre

Table 3 Marshal Stabilty vs Fibre Content (18mm) For Bitumen Concrete

Fibre content in %	Stability in Kg
0%	1132
2%	1170
2.50%	1267
3%	1297
3.50%	1366
4%	1330
4.50%	1294
5%	1253
5.50%	1224
6%	1176

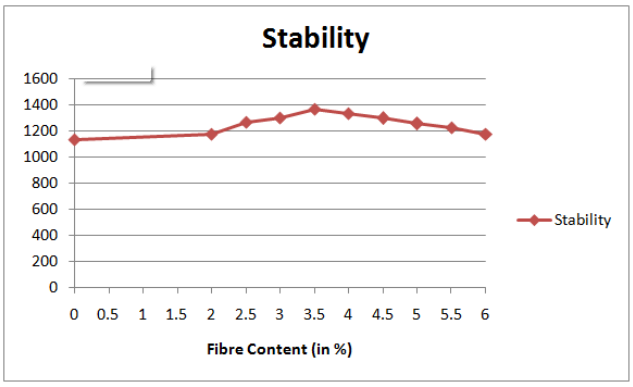

Fig.3 Marshall Stabilty vs Fibre Content (18mm) for Bitumen Concrete

In the above graph had been plotted between Marshall Stability and fibre content of steel Fibre (18mm cut in length) where fibre content is on X-axis from 0Kg to 1600 Kg with an interval of 200KG.The preferable range of Marshall Stability is minimum 820KG according Stability for each corresponding value of Fibre Content. For each Fibre Content three (3) sample specimens of BC with Steel Fibre (18mm 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 3.5 % of the steel fibre and then decreased with the further increment of the steel fibre content. The percentage increment in stability is 21.9%

For 18 mm steel fibre

The stability increased up to addition of 3.5 % of the steel fibre and then decreased with the further increment of the steel fibre content. The percentage increment in stability is 20.67%. Tt was concluded that all the properties of the bituminous Concrete has been improved with the addition of the steel fibres but with the limiting value of 4.5% and less Here it is also important to state that the results of the specimens with 11mm long steel fibres are much better than the 18mm long steel fibres.The 11mm long steel fibres also enhance the stability of the bituminous concrete more than its requirement .The best values of stability and flow value are with 3% and 3.5 % of steel fibre content. So in this current study it was found that the 11mm long corrugated steel fibre gives better result in the chosen parameter and an addition of 3.5% of fibre content will improve the performance of bituminous concrete.

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