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Research Paper

EFFECT OF FILLERS ON BITUMINOUS PAVING MIXES

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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 major considerations in this regard pavement design and the mix design. Our project emphasizes on the mix design considerations. A good design of bituminous mix is expected to result in a mix which is adequately strong, durable and resistive to fatigue and permanent deformation and at the same time environment friendly and economical. A mix designer tries to achieve these requirements through a number of tests on the mix with varied proportions of material combinations and finalizes the best one. This often involves a balance between mutually conflicting parameters. Bitumen mix design is a delicate balancing act among the proportions of various aggregate sizes and bitumen content. For a given aggregate gradation, the optimum bitumen content is estimated by satisfying a number of mix design parameters. Fillers play an important role in engineering properties of bituminous paving mixes. Conventionally stone dust, cement and lime are used as fillers. An attempt has been made in this investigation to assess the influence of non-conventional and cheap fillers such as brick dust and silica fume in bitumen paving mixes. It has been observed as a result of this project that bituminous mixes with these non-conventional fillers result in satisfactory Marshall Properties though requiring a bit higher bitumen content, thus substantiating the need for its use. The fillers used in this investigation are likely to partly solve the solid waste disposal of the environment.

Keywords: Filler, Bituminous paving mixes, Optimum binder content, Brick dust, Silica fume

INTRODUCTION

Highway construction activities have taken a big leap in the developing countries since last decade. Construction of highway involves huge outlay of investment. Basically, highway pavements can be categorized into two groups, flexible and rigid. Flexible pavements are those which are surfaced with bituminous (or asphalt) materials. These can be either in the form of pavement surface treatments (such as a Bituminous Surface Treatment (BST) generally found on lower volume roads) or, HMA surface courses (generally used

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on higher volume roads such as the Interstate highway network). These types of pavements are called "flexible" since the total pavement structure "bends" or "deflects" due to traffic loads. A flexible pavement structure is generally composed of several layers of materials which can accommodate this "flexing". On the other hand, rigid pavements are composed of a PCC surface course. Such pavements are substantially "stiffer" than flexible pavements due to the high modulus of elasticity of the PCC material. Flexible pavements being economical are extensively used as far as possible. A precise engineering design of a flexible pavement may save considerable investment; as well as reliable performance of the in-service highway pavement can be achieved.

In recent years, many countries have experienced an increase in truck tire pressures, axle loads, and traffic volumes. Tire pressure and axle load increases mean that the bituminous layer near the pavement surface is exposed to higher stresses. High density of traffic in terms of commercial vehicles, overloading of trucks and significant variations in daily and seasonal temperature of pavements have been responsible for development of distress symptoms like raveling, undulations, rutting, cracking, bleeding, shoving and potholing of bituminous surfaces. Suitable material combinations and modified bituminous binders have been found to result longer life for wearing courses depending upon the percentage of filler and type of fillers used.

BACKGROUND LITERATURE

Ishai *et al*. (1980) investigated six types of fillers possessing a wide range of properties, and two types of mixtures; sand asphalt and bituminous concrete. They performed rheological tests on filler-bitumen mastic samples, and mechanical tests on different sets of bituminous concrete samples. A basic model was adopted in which the bituminous mixture is composed of two components: an aggregate-bitumen system and a filler bitumen system (mastic). The model was analyzed through weight-volume relationship and the optimum mastic needed to obtain the optimal mechanical behavior of the mixture was determined. Craus *et al*. (1981) investigated the role of fillers in long term durability of bituminous concrete mixes. Durability tests were conducted on mixes consisting of one type of aggregate, one gradation and six types of filler. Durability potential was assessed by testing the mixture during and after 14 days of immersion in a 60oC water bath. The results indicated that the properties of filler have a pronounced effect on the durability potential of the mixture. Chari and Jacob (1984) studied the influence of lime and stone dust fillers on fatigue performance of bituminous concrete mixes. Among the two fillers; lime was found to have substantial influence on the fatigue properties, although static strength remained more or less same for both the fillers. Suhaibani *et al*. (1992) investigated the effect of filler type and content on rutting potential of bituminous concrete. Kandhal (1993) discussed laboratory and field evaluation of several waste materials used in bituminous mixes. A general overview of these waste materials including the research work done in the past and their potential for use in bituminous pavements is included in this study. Author suggested that recycling of waste materials in highway construction should be encouraged and demonstration projects should be undertaken to evaluate the performance of bituminous pavements containing waste materials. Fwa and Aziz (1995) performed a series of tests to arrive at an acceptable bituminous mix using incinerator residue as a partial replacement for the aggregate in Singapore. Mix design analysis and stability, durability and resistance to moisture susceptibility tests were performed on mixes. Mixes containing incinerator residue showed higher values of stability and better resistance to moisture susceptibility. Authors recommended of using portion of incinerator residue passing sieve size 0.3 mm to replace the corresponding sizes of granite aggregate in the standard local design mix. Baig and Wahhab (1998) investigated the effectiveness of using hematite (rock wool natural fibres) as filler in improving the performance of asphalt concrete pavements, and to compare hedmanite with lime (as filler) modified mixes and the conventional asphalt mix containing crushed stone filler. Lime modified mixes showed better resistance to fatigue and rutting than other mixes. Katamine (2000) tested three wearing course mixes having three different samples of oil shale fillers, which contained three different oil contents, together with standard mixture containing lime stone filler. The Marshall test results indicated that the incorporation of oil shale fillers instead of limestone filler, does not alter the optimum binder content of the mixes, increases the stability, or increases the Marshall quotients of the mixes. Taha *et al*. (2002) used Cement Bypass Dust (CBPD), a byproduct of Portland cement industry as a filler in their study. Three different asphalt concrete mixtures were prepared using lime (control), and 5 and 13 % CBPD substitution for lime or fine aggregate. They found that the substitution of 5% CBPD for lime will essentially produce the same optimum binder content as the control mixture without any negative effect on asphalt concrete properties. However, the use of 13% CBPD for lime and fine aggregate will require higher optimum asphalt content and will produce an uneconomical mix. Karasahin and Terzi (2007) used marble dust as filler material in asphalt concrete mixes. The Marshall and plastic deformation tests showed that limestone dust and marble dust gave almost the same results. Marble dust had higher values of plastic deformation and hence was suggested for low traffic volume roads. Sharma *et al*. (2010) have shown that presence of high calcium oxide in flyash is an important parameter governing the strength characteristics of bituminous mixes and fly ash up to 7 percent can be used as filler.

EXPERIMENTAL PROGRAM

Tests of Materials Used in Paving Mix (Using Brick Dust and Silica Fume as Filler)

Specific gravity and water absorption of materials used in paving mix are computed as follows:

Size of Material	Specific Gravity	Water Absorption %
13mm	2.73	0.911
10mm	2.71	1.149
Stone Dust	2.69	1.431
Brick Dust	2.15	1.23
Silica Fume	1.78	0.85

Physical Properties of Coarse Aggregate: Table (500-8) As Per Morth

TEST OF BINDER CONTENT

Bitumen Of penetration Grade 60/70 as per IS Code Specification for Paving Bitumen IS :73 (1992) was used .

The Bitumen was tested in our Laboratory and results are As follows:

S. No	Description of Test	Test Method	Test Result Observed	MORT & H Specification Limit (Table No-500-18)
1	Los Angeles Abrasion Test	IS : 2386 Part 4	11.03%	Max 40%
2	Aggregate Impact value	IS : 2386 Part 4	18.81%	Max 24%
3	Water Absorption (Combined)	IS : 2386 Part 3	1.234%	Max 2%
4	Crushing Value Test	IS: 2386 Part 4	18.15%	Max 30%
4	Coating & Stripping Value	IS : 6241	98%	Minimum Retained Coating 95 %

S. No.	Description of test	Test Method	Observed	Specific Llimit
1	Penetration value of bitumen	IS : 1203	65	60 - 70
2	Ductility	IS : 1208	91.3	Not Less than 75 cm
3	Specific Gravity	IS : 1202	1.03	0.99 Min
4	Softening Point	IS : 1205	48.65	$40^{O}C$ -$55^{0}C$
5	Viscosity (Industrial) at 135 0c	IS : 1206	500	Minimum 300 CST

Bitumen Concrete Mix Design

Marshall method of mix design has been adopted in this thesis work .Accordingly aggregates with the grading 2 of IRC and bitumen 60/70 having properties as described in the preceding paragraphs have been used. The objective of bituminous paving mix design is to develop an economical blend of aggregates and bitumen. In the developing of this blend the designer needs to consider both the first cost and the life cycle cost of the project. Considering only the first cost may result in a higher life cycle cost

COMPARISON OF RESULTS

Brick dust and Silica fume specimen Marshall Test Curves

The results of Marshall Tests of specimens conducted with brick dust and silica fume are given in (Tables 1 and 2) respectively and comparison of results are graphically shown in (Figures 1 to 6) .

1. Bituminous mixes containing brick dust and silica fume as fillers are found to have Marshall properties almost nearly same as those of conventional fillers such as cement and lime.

Table 1: Test Properties Curves for Hot Mix Design Data By The Marshall Method
(Having Brick Dust As Filler)

Bitumen Content (%)	Gmb(Gm/Cc)	Va (%)	Vma (%)	Vfb (%)	Stability (kg)	Flow (mm)
5	2.389	4.68	16.27	71.31	945	1.55
5.5	2.393	4.51	16.13	72.04	976	2.08
6	2.397	4.36	15.99	72.76	1007	2.43
6.5	2.401	4.21	15.86	73.49	1123	2.7
7	2.396	4.37	16.00	72.71	1032	3.43

Table 2: Test Properties Curves for Hot Mix Design Data By The Marshall Method
(Having Silica Fume As Filler)

Bitumen Content (%)	Gmb(Gm/Cc)	Va (%)	Vma (%)	Vfb (%)	Stability (kg)	Flow (mm)
5	2.416	3.60	15.33	76.51	992	2.30
5.5	2.425	3.21	14.94	78.62	1083	2.43
6	2.428	3.12	14.91	79.09	1164	2.60
6.5	2.403	4.10	15.76	74.04	1115	2.70
7	2.393	4.55	16.16	71.85	1017	3.0

Figure 1: Stability Vs. Bitumen Content

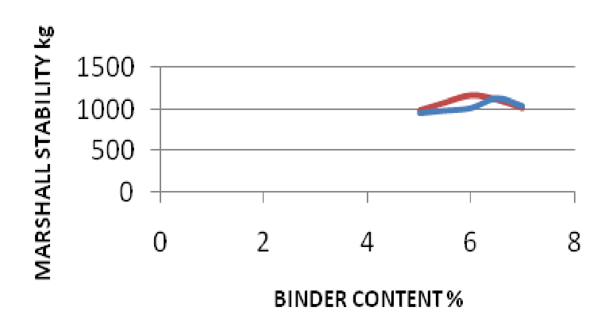


Figure 2: Flow Vs. Bitumen Content

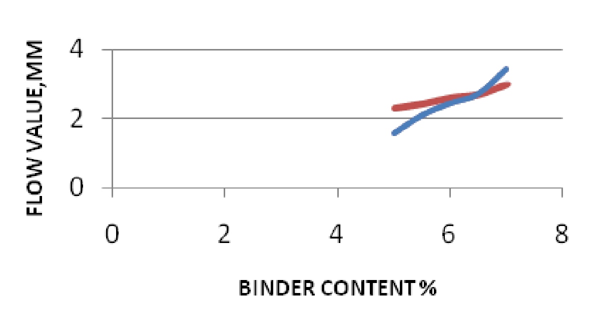


Figure 3: GMB Vs. Bitumen Content

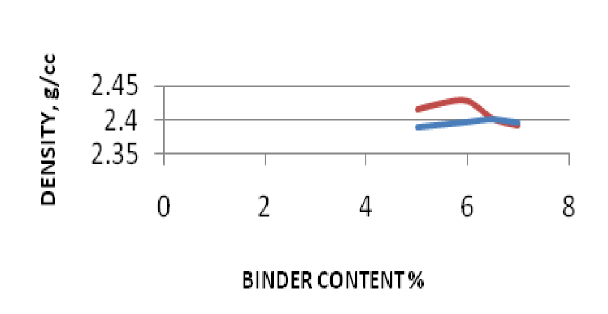


Figure 4: Air Voids Vs. Bitumen Content

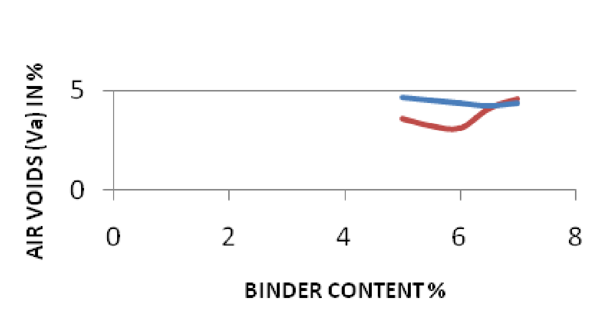


Figure 5: VMA Vs. Bitumen Content

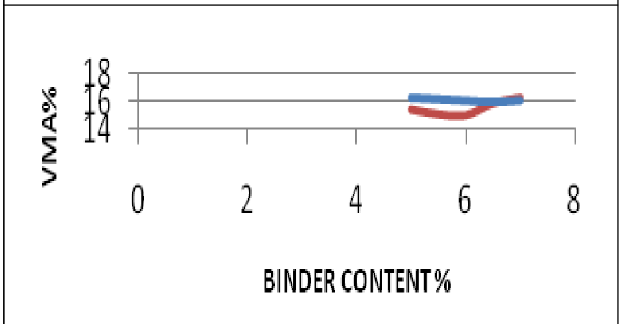
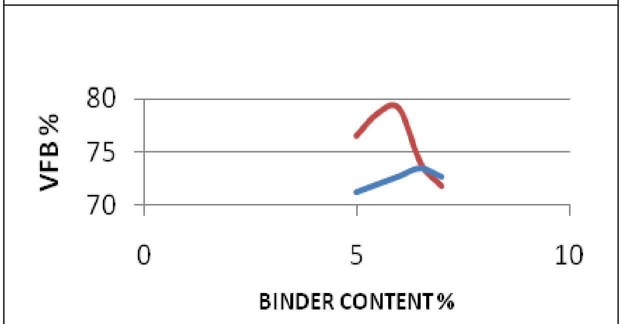


Figure 6: VFB Vs. Bitumen Content



2. Bituminous mixes containing brick dust as filler displayed maximum stability at 6.5% content of bitumen having an increasing trend up to 6.5% and then gradually decreasing, the unit weight/ bulk density also displayed a similar trend with flow value being satisfactory at 6.5% content of bitumen.
3. Bituminous mixes containing silica fume as filler showed maximum stability at 6% content of bitumen displaying an ascending trend up till 6% and then decreasing, the flow value showed an increasing trend and similar was the trend shown by unit weight/bulk density, the percentage of air voids obtained were seen to be decreasing with increase in bitumen content thus from here we can see that at 6% bitumen content we are obtaining satisfactory results.
4. Higher bitumen content is required in order to satisfy the design criteria and to get usual trends.
5. From the above discussion it is evident that with further tests brick dust and silica fume generated as waste materials can be utilized effectively in the making of bitumen concrete mixes for paving purposes.
6. Further modification in design mixes can result in utilization of brick dust and silica fume as fillers in bituminous pavement thus partially solving the disposal of wastes.
7. It is evident that with further tests brick dust and silica fume generated as waste materials can be utilized effectively in the making of bitumen concrete mixes for paving purposes.

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