Use Non-Conventional Materials on Bituminous Paving as a Fillers

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Abstract— 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 fly ash 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.

Key words: Highway, Bituminous Mix, Fillers, Stone Dust, Brick Dust & Fly Ash

I. 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 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.

A. Objective

The overall objective of the design of bitumen pavement mixtures is to determine an economical blend of stone aggregate, sand and fillers such as fly ash and brick dust that yields a mix having

- Sufficient bitumen to ensure a durable pavement.
- Sufficient mix stability to satisfy the demands of traffic without distortion or displacement.
- Sufficient void in total compaction mix to allow for a slight amount of additional compaction and traffic loading without flushing bleeding and lost of stability yet low enough to keep out harmful air and moisture.
- Sufficient workability to permit sufficient placement of the mix without segregation

II. REVIEW OF LITERATURE

Merrin Baby et al (2017) was examine the use of waste materials in road construction can reduce the difficulties in disposal of wastes. In the current study, the feasibility of improving the properties of Bituminous Concrete (BC) mix with waste glass as filler in place of conventional costly fillers like lime and cement was studied. BC mixes were prepared at OBC with three different fillers namely cement, lime and glass powder at three different dosages (4%, 6% and 8%). The Marshall and volumetric properties of these samples were investigated and compared. BC mixes with glass powder displayed nearly same properties as those of BC mixes with conventional fillers. Also at the optimum dosage of 6.2% glass modified BC mixes displayed higher stability, density and lower flow values as compared to normal BC mixes with quarry dust alone as filler

Cesare Sangiorgi et al (2017) had been a significant increase in the demand for using recycled materials in construction because of the lack and limitation of available natural resources. A number of industrial and domestic waste products are being used in the replacement of traditional materials for road construction, and many studies have been carried out in recent years on the use of different recycled materials in substitution of conventional fillers in Asphalt Concretes (AC).

III. RESULTS & DISCUSSION

A. Marshall Test Results

The results of the Marshall test of individual specimens and average Marshall Properties of specimens prepared with fly ash as filler for varying bitumen contents have been presented in tables 4.1 and 4.2 respectively.

Bitumen %	5	5.5	6	6.5
Stability (kN)	18.64	22.05	24.13	21.43
Flow value (mm)	1.93	2.4	2.8	3.50

Unit wt (g/cc)	2.08	2.09	2.10	2.07
% air void	8.17	6.69	4.18	4.5
VMA (%)	18.40	17.85	16.40	17.6

Table 1: Average Marshall Properties of samples with fly ash

Bitumen %	5	5.5	6	6.5	7	7.5
Stability (KN)	16.56	16.68	18.28	19.27	20.88	18.52
Flow value (mm)	1.85	2.4	3.2	3.73	4.57	5.3
Unit wt (g/cc)	2.245	2.27	2.27	2.29	2.3	2.33
% air voids	9.13	7.6	6.2	5	3.9	2.4
VMA (%)	18.91	18.55	19.3	19.37	19.5	20.36

Table 2: Average Marshall Properties of samples with Brick dust as filler

B. Marshall Stability

Fig.4.1 shows the variation of Marshall Stability with bitumen content where it is seen that as usual the stability value increases with bitumen content initially and then decreases. Maximum stability value of 24.23 kN is observed at 6% bitumen content in case of fly ash as a filler but in case of brick dust a maximum stability value of 20.88 kN is obtained at 7% bitumen content in case of brick dust as a filler. A lower value of stability in case of brick dust specimen in comparison with fly ash may be attributed due to higher bitumen content.

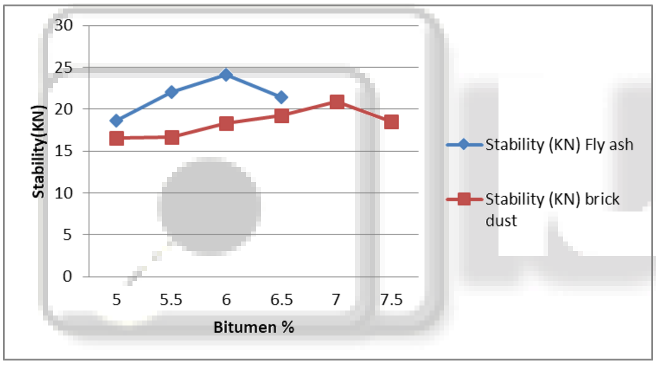

Fig: 4.1: Marshall Test Curves for Stability (fly ash & brick dust)

C. Marshall Flow Value (mm)

Fig 4.2 shows the variation of Marshall flow value with % of bitumen content where it is seen that usually an increasing trend is followed with increase in bitumen content and on comparing fly as and brick dust results graphically it can be seen that brick dust specimens are found to display a higher flow value in comparison with fly ash specimen , from here we can speculate that this might be due to a higher bonding in specimens with fly ash as filler in comparison with specimens having brick dust as filler material.

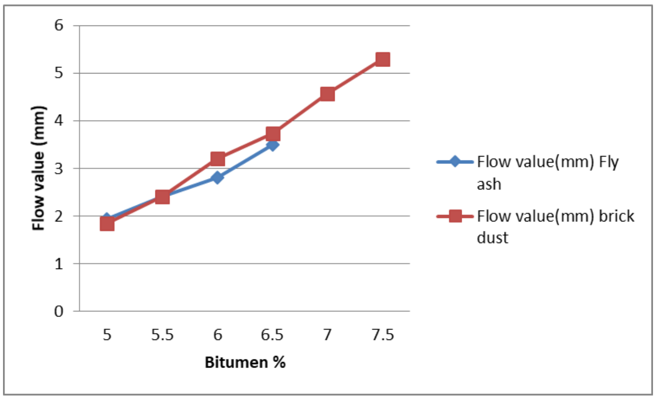

Fig. 4.2: Marshall Test curves for Flow value (fly ash and brick dust)

D. Marshall Unit Weight Curves (g/cc)

Fig 4.3 displays the graphical representation of unit weights for variation in % of bitumen content for Marshall Specimens having fly ash and brick dust as fillers. In this figure brick dust specimens are found to display a higher unit weight in comparison with fly ash as filler due to lesser no of air voids in case of specimens having brick dust as filler, this may be due to brick dust acting as a filler material having better ability to fill up air voids than fly ash. In fly ash specimens maximum unit weight obtained is 2.10 g/cc at 6% bitumen content whereas in case of brick dust specimens it is 2.33 g/cc at 7.5% bitumen content showing an increasing trend in brick dust specimens which might tend to reduce at higher percentage of bitumen content.

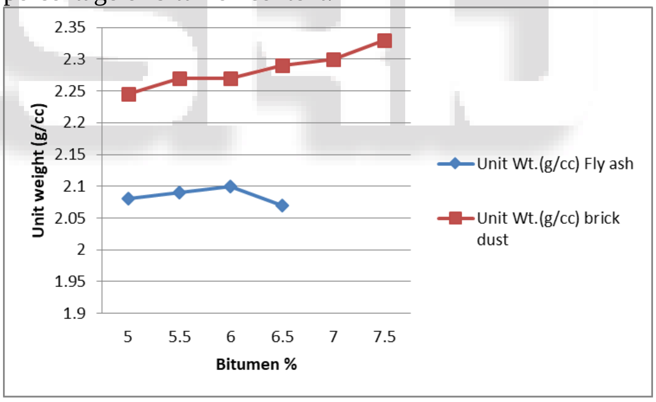

Fig. 4.3: Marshall Test Curves for Unit Weight (G/Cc) (Fly Ash and Brick Dust

E. Marshall air voids (%) curve (fly ash and brick dust)

Fig 4.4 shows the variation of air voids with variation in percentage of bitumen content with the minimum percentage of 4.18 % air voids being obtained at 6% bitumen content, however the curve obtained in brick dust specimen is found to have a decreasing trend displaying a greater bonding between brick dust and bitumen thus showing a decreasing trend in case of air voids with increase in bitumen content.

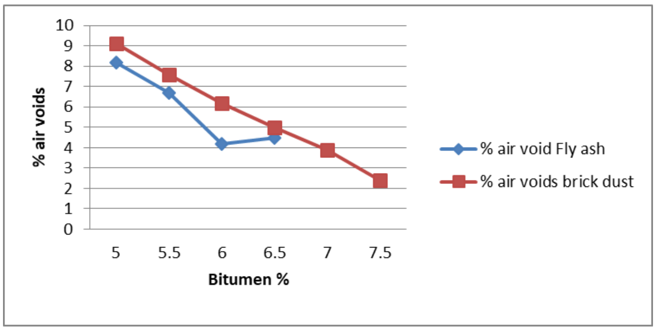

Fig. 4.4: Marshall Test Curves for Air Void (%) (Fly Ash & Brick Dust)

F. Marshall's VMA (%) Curve (Fly Ash and Brick Dust)

In fig 4.5 Brick dust specimens are found to be displaying higher values of VMA than fly ash specimens but in fig 4.4 they are found to display lesser amount of air voids thus leading to the conclusion that brick dust absorbs higher amount of bitumen in comparison with fly ash specimens.

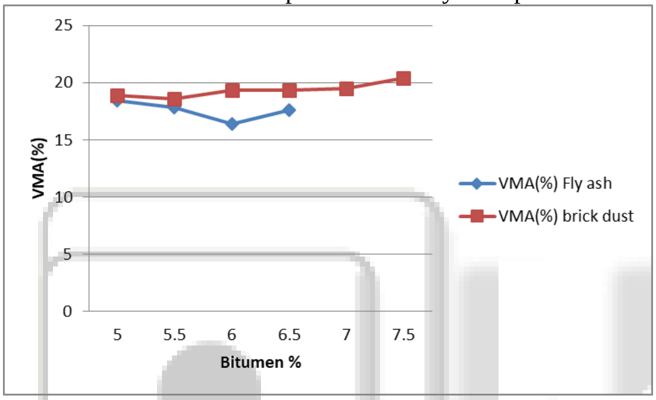

Fig. 4.5: Marshall Test Curves For VMA (%) (Fly Ash & Brick Dust)

IV. CONCLUSIONS

- Bituminous mixes containing fly ash and brick dust as fillers are found to have Marshall Properties almost nearly same as those of conventional fillers such as cement and lime.
- Bituminous mixes containing fly ash as filler displayed maximum stability at 6% content of bitumen having an increasing trend up to 6% and then gradually decreasing, the unit weight/ bulk density also displayed a similar trend with flow value being satisfactory at 6% content of bitumen.
- Bituminous mixes containing brick dust as filler showed maximum stability at 7% content of bitumen displaying an ascending trend up till 7% 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 7% bitumen content we are obtaining satisfactory results.
- These mixes were seen to display higher air voids than required for normal mixes.
- Higher bitumen content is required in order to satisfy the design criteria and to get usual trends.
- From the above discussion it is evident that with further tests fly ash and brick dust generated as waste materials can be utilized effectively in the making of bitumen concrete mixes for paving purposes.
- Further modification in design mixes can result in utilization of fly ash and brick dust as fillers in bituminous pavement thus partially solving the disposal of industrial and construction wastes respectively.
- Though cement and stone dust being conventional fillers however fly ash and brick dust can be utilized in their place effectively thus solving the waste material disposal substantially resulting in utilization of industrial space being consumed in disposal of industrial wastes.
- The cost effectiveness of these non-conventional filler specimens can be realized after performing a cost analysis of these non-conventional materials against the conventional specimens resulting in reduction of the construction costs considerably.
- It is evident that with further tests fly ash and brick dust generated as waste materials can be utilized effectively in the making of bitumen concrete mixes for paving purposes.

V. FUTURE SCOPE

- Pavement mixes with brick dust and fly ash as fillers using modified binders such as CRMB (60).
- Indirect tensile test of bituminous mixes can give us an idea about the tensile strength of the bituminous mixes.
- Repeated load testing can give us an overview about the fatigue failure resistance of the specimen.

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