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Effect of Fillers on Bituminous Mixes

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Abstract
One of the costliest and highest types of flexible pavement layer used is bituminous concrete or asphalt concrete. To satisfy the design requirements of stability and durability the bituminous mixes should be designed effectively. The ingredients of the mixture include dense grading of coarse aggregates, fine aggregates, fillers and bitumen binder. In this Study an attempt was made to find the effect of filler on the behavior of bituminous mixes. Fillers play an important role in the filling of voids and hence change the physical and chemical properties. Thus their effect is of utter importance. Bitumen in combination with filler forms mastic. This mastic can be seen as a constituent of mixture of asphalt that holds the aggregates together. An important role is played by the fillers that pass through 0.075mm sieve. With the increase in the amount of filler, Marshall Stability of the bitumen mix increases directly. Use of 4-8% filler in asphalt concrete is recommended by the Asphalt Institute. In India, waste concrete dust and brick dust are considered to be cheaper and are available in plenty. In this study an attempt was made to find the effect of fillers on the bitumen mixes. In this study, concrete dust and brick dust was used as filler. The properties of bituminous mixes containing these fillers were studied and compared with each other. For the purpose of comparison Marshall Method of mix design was used. In this study various tests were also conducted on aggregates and bitumen and the results were compared with the specifications. The study revealed that use of concrete dust and brick dust as filler improves the physical characteristics of bitumen. Marshall Stability and flow value of bitumen mix also improved.

Keywords
Brick dust, concrete dust, Marshall Test, Stability, Air voids, Voids in mineral aggregates, unit weight.

I. Introduction
As the traffic demand is growing at a rapid rate along with the increase in the axle loads, it is necessary to improve the highway paving materials. The main objective of highway authorities is to provide safe, smooth, imperishable, and economical pavements that are capable of carrying the anticipated loads. To achieve this objective, many specialists, engineers and researchers are anxious and dedicated to select the paving material that can curtail pavement distress and upgrade the performance of asphalt pavements. Filler, as one of the constituent in an asphalt mixture, plays a major part in determining the properties and performance of the mixture, especially its binding and interlocking effects. Mineral fillers on adding to asphalt mixtures serve dual purpose. Asphalt cement binder mixes with mineral filler (finer than thickness of asphalt film) forms mortar that leads to improved stiffening of the mix. Particles larger than the thickness of the asphalt film act as mineral aggregate and hence contribute to the contact points between distinctive aggregate particles (Puzinauskas 1969). Also, they affect the moisture sensitivity, workability stiffness and ageing features of hot mix asphalt (HMA) (Mogawer 1996). Due to variation in gradation, particle shape, surface area, voids content, physico-chemical properties and mineral composition of fillers their influence on the properties of HMA mixtures varies. For various types of fillers, the maximum allowable amount should be different. By increasing the surface area of mineral particles the filler also influences the optimum asphalt content (OAC) in bituminous mixtures and, simultaneously, the surface properties of the filler particles modify significantly the properties of asphalt such as penetration, ductility, and also of the mixture, such as resistance to rutting. The pavement performance is improved by ensuring that sufficient behavior of the bituminous mixtures is achieved, which essentially depends on their composition. Therefore, selecting the proper type of filler in asphalt mixtures would upgrade the filler's properties and, thus, enhance the mixture's performance (Kandhal 1981). Bituminous mix of good design is expected to result in a mix which is sufficiently (i) durable (ii) strong (iii) resistive to fatigue and permanent deformation (iv) economical (v) environment friendly and so on. A number of tests on the mix are conducted by a mix designer to achieve these requirements. Numbers of tests are conducted on the mix with varied proportions and then finally the best one is selected. A balance between mutually conflicting parameters is often involved in achieving this.

II. Materials
A bituminous mixture is generally composed of aggregate and bitumen. According to the size of the particles, the aggregates are generally divided into coarse aggregates, fine aggregates and filler fractions. The following sections covers the description of the coarse aggregate, fine aggregate, bitumen and mineral fillers used in the study.

A. Coarse Aggregate
The coarse aggregates should have good abrasion value, impact value and also crushing strength. The function of coarse aggregates is to bear the stresses due to wheels. Function of Coarse aggregates is also resisting wear due to abrasion. That portion of the mixture which is retained on 2.36 mm (No. 08) sieve according to the Asphalt Institute is termed as Coarse aggregates. Coarse aggregate used was Basalt rock.

B. Fine Aggregate
Voids which remain in the coarse aggregates are filled by the fine aggregates. So the function of fine aggregates in to fill the voids of coarse aggregates. Fine aggregates consist of crushed stone or natural sand. Aggregates that passed through 2.36 mm sieve and retained on 0.075 mm sieve were selected as fine aggregate. The source of fine aggregates used was River sand.

C. Filler
As the name indicates function of fillers is to fill up the voids. Fillers used may be brick dust, stone dust, concrete dust, limestone

dust, fly ash or pond ash. Waste concrete dust and brick dust finer than 0.075 mm size sieve were used in the bituminous mixes for comparison and also for economy point of view.

D. Bitumen

Bitumen is used as a water repellant material. 80/100 grade of bitumen was used in this study. Same bitumen was used for all the mixes so the type and grade of binder was kept constant.

III. Methodology

This study consists of three stages: - characterization of materials, mixing of brick dust and concrete dust as filler, suitability of filler in the bituminous mixes. In the first stage, properties of aggregates, fillers and bitumen were established while in second stage brick dust and concrete dust were used as filler unanimously and in the third stage Marshall Mix design method was used to find stability, flow, air voids, VMA.

A. Laboratory Tests for the Properties of Materials

1. Properties of Aggregates

Tests were performed to determine the Crushing Value, Aggregate Impact Value, Los Angles Abrasion value, Specific gravity, Elongation index, Flakiness index, and Water absorption of aggregates according to the procedures specified by BIS and IRC standards and results are summarized in Table 1.

Table 1 Different Test Results of Aggregates

Properties Tested	Test Result	Specification
Crushing test	18.40%	Max 30% (IRC and BIS)
Los Angles Abrasion Value	19.45%	Max 30% (MORTH)
Specific Gravity Fine aggregates Coarse aggregates	 2.6 2.75	 2.5-3.0(MORTH) 2.5-3.0(MORTH)
Elongation test	32.50%	No recognition
Flakiness test	22.52%	Max 25% (IRC and BIS)
Impact Value	14.50%	Max 24% (MORTH)
Water Absorption	1.05%	Max 2%(MORTH)

2. Properties of Bitumen

Softening point, penetration value, specific gravity, ductility value and viscosity were determined according to the procedure specified by AASHTO and the results are summarized in table 2.

Table No. 2 Different Test Results of Bitumen

Properties Tested	Test Result	Specification IS: 73-2013	BIS code for Testing
Softening Point Test temp. 0C	43	40 min.	IS:1205
Penetration Test (mm)	87	80min	IS:1203
Specific Gravity Test	1.03	1.01min	IS:1202
Ductility Test (mm)	81	75min	IS:1208
Viscosity Test at 1350C (Cst)	261	250min	IS:1206 (part-2)

B. Mixing of Materials

About 1200 gm of sample aggregates were taken and kept in oven until it dried. Heating of aggregates was done up to 135^{o}C before the addition of bitumen. Bitumen mix was added varying from 4.5 to 6% at an increment of 0.5%. Also the fillers, concrete dust and brick dust were mixed as per design. For each binder content 3 samples were prepared by compacting to 75 blows on both sides of sample in Marshall Compactor. Then the sample was de-moulded and the weight of sample in air and in water was noted down to determine the bulk density of mix. For the determination of stability and flow value on Marshall Apparatus, sample was immersed in water bath at 60^{o}C for 40 minutes before testing.

IV. Results and Discussions

The results of the Marshall test of specimens prepared with concrete dust and brick dust as filler for varying bitumen contents have been presented in tables 3 and 4 respectively.

Table 3 Marshall Properties of Specimens with Filler Concrete Dust.

Bitumen Content (%)	Unit weight (kg/m_3)	Stability (KN)	Flow Value (mm)	Air Void VA (%)	VMA (%)
4.5	2360	11.5	2.50	6.7	18.50
5.0	2370	12.1	2.65	5.4	17.6
5.5	2385	12.8	2.82	4.8	16.8
6.0	2395	13.2	3.15	4.3	16.1

Table 4 Marshall Properties of Specimens with Filler Brick Dust.

Bitumen Content (%)	**Unit weight (kg/m^3)**	**Stability (KN)**	**Flow Value (mm)**	**Air Void VA (%)**	**VMA (%)**
4.5	2315	14.63	1.9	8.16	18.20
5.0	2330	15.75	2.5	7.40	17.83
5.5	2343	16.85	3.3	6.23	17.26
6.0	2356	18.12	3.8	5.42	16.52

A. Comparison of Concrete Dust and Brick Dust Specimens Results

1. Marshall Unit Weigh Curves (kg/m^3)

Fig 4.1 shows the graphical representation of unit weights for variation in % of bitumen content for Marshall Specimens having concrete dust and brick dust as fillers. It can be seen that with increases in percentage of bitumen, unit weight increases. In this figure concrete dust specimens are found to display almost equal unit weight in comparison with brick dust as filler.

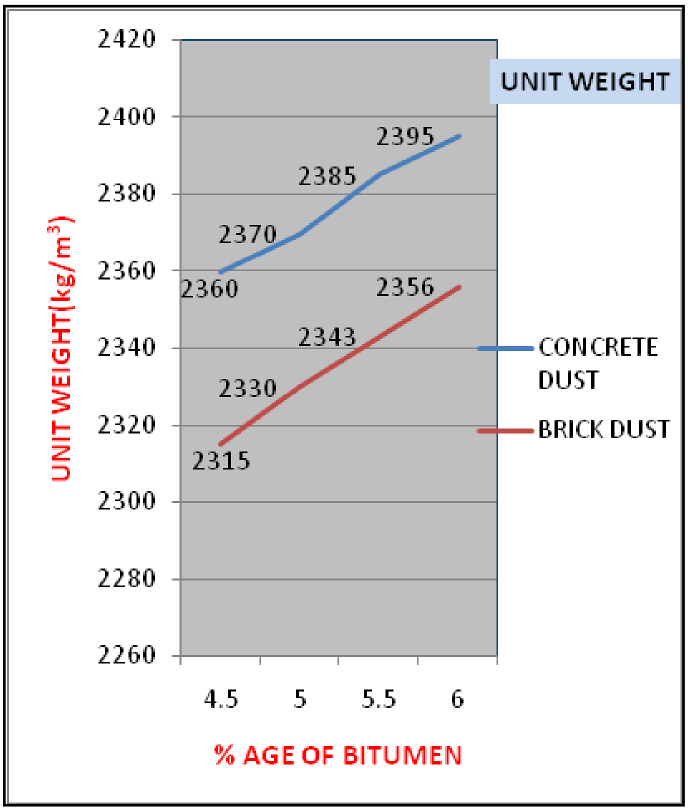

Fig. 4.1 Variation of Unit Weight With %age of Bitumen.

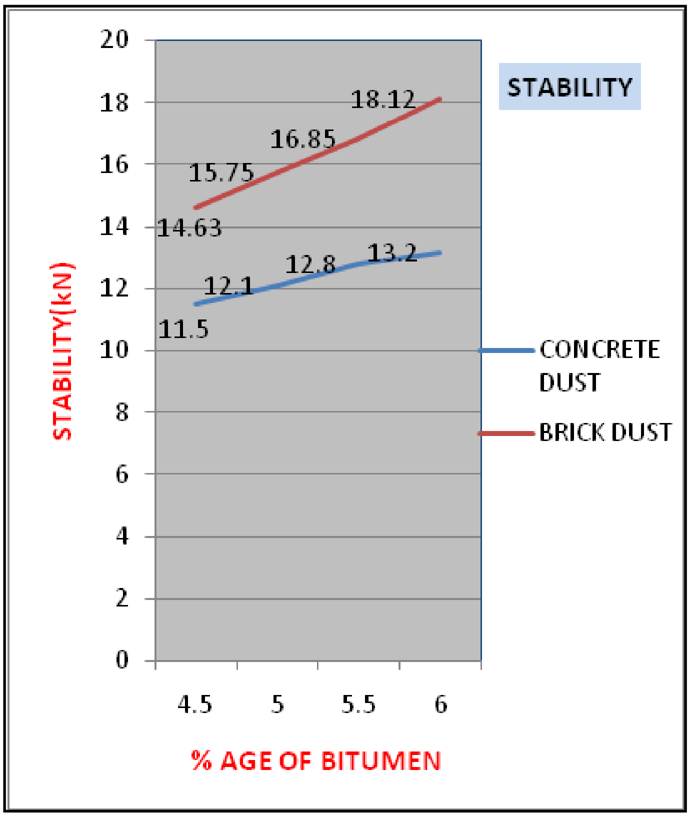

Fig. 4.2 Variation of Stability With %age of Bitumen.

2. Marshall Stability Curves

Fig.4.2 shows the variation of Marshall Stability with bitumen content where it is seen that as usual the stability value increases with bitumen content increases. Maximum stability value of 13.2 KN is observed at 6% bitumen content in case of concrete dust as a filler and in case of brick dust a maximum stability value of 18.12 KN is obtained at 6% bitumen content in case of brick dust as a filler. Brick dust has a higher value of stability comparative to the concrete dust.

3. Marshall Flow Value Curves

Fig.4.3 shows the variation of Marshall Flow value with bitumen content where it is seen that as usual the flow value increases with bitumen content increases. Maximum flow value of 3.15mm is observed at 6% bitumen content in case of concrete dust as filler and in case of brick dust a maximum flow value of 3.8mm is obtained at 6% bitumen content. Brick dust has a higher value of flow value comparative to the concrete dust.

4. Marshall Air Void Curves

Fig.4.4 shows the variation of Marshall Air void with bitumen content where it is seen that as usual the Air void decreases with increase in bitumen content. Minimum air void of 4.3% is observed at 6% bitumen content in case of concrete dust as filler and in case of brick dust a minimum air void of 5.42 is obtained at 6% bitumen content.

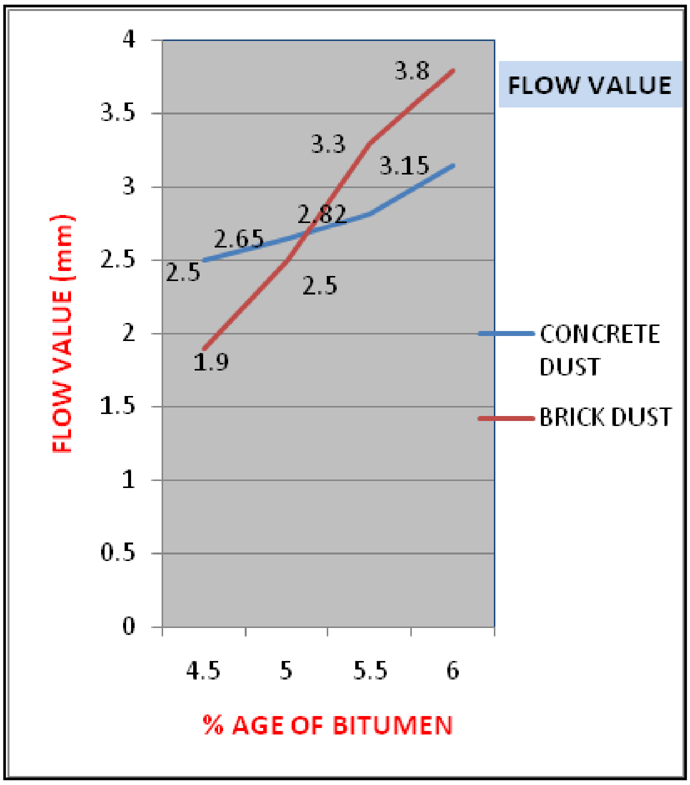

Fig. 4.3 : Variation of Flow Value With %age of Bitumen.

Concrete dust has a lesser air void comparative to the brick dust.

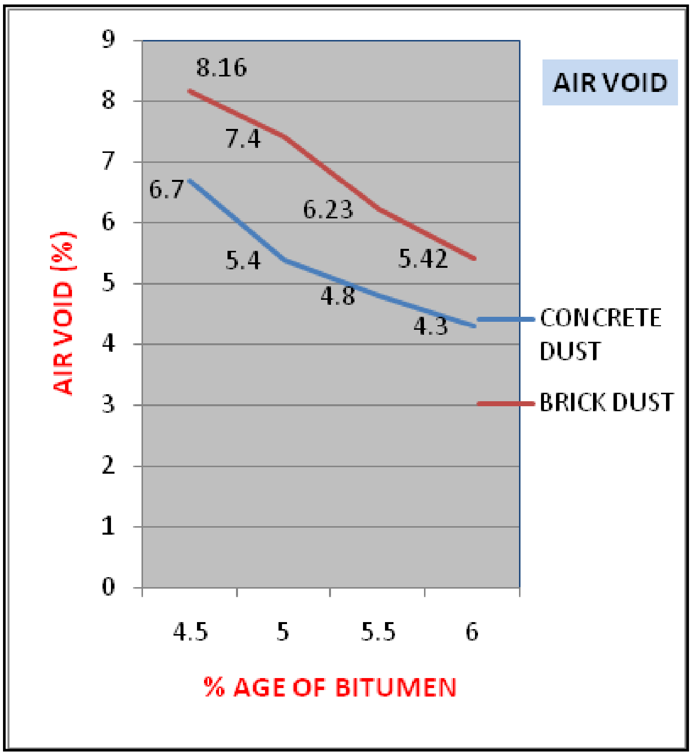

Fig. 4.4 : Variation of Air Void With %age of Bitumen.

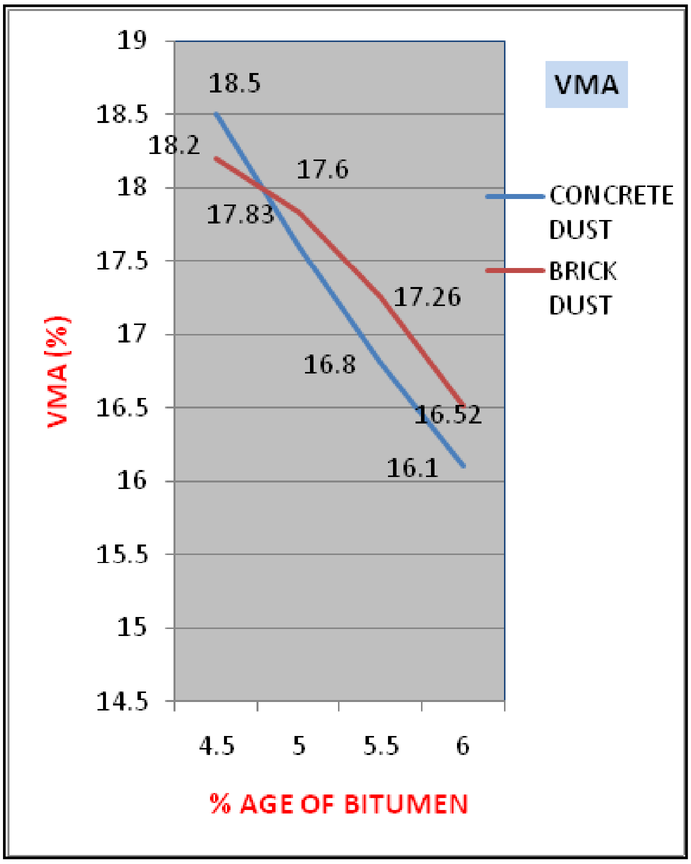

Fig. 4.5 Variation of VMA With %age of Bitumen.

5. Marshall VMA

Fig.4.5 shows the variation of Marshall VMA with bitumen content where it is seen that as usual the VMA decreases with bitumen content increases. Minimum VMA of 16.1% is observed at 6% bitumen content in case of concrete dust as filler and in case of brick dust a minimum air void of 16.52 is obtained at 6% bitumen content. Concrete dust has a lesser VMA comparative to the brick dust.

6. Comparison for optimum binder content

A Comparison of Results against Various Parameters for Optimum Bitumen Content is tabulated in Table no 5.

Table No. 5 Comparison of Results against Various Parameters for Optimum Bitumen Content

Filler Type	Maximum Unit Weight	Maximum Stability Value	Maximum Flow Value	Minimum Air Void	Minimum VMA
Concrete Dust	6%	6%	6%	6%	6%
Brick Dust	6%	6%	6%	6%	6%

V. Conclusions and Future Scope

A. Conclusions

- Bituminous mixes containing concrete dust as fillers are found to have Marshall Properties almost same as of brick dust fillers.
- Bituminous mixes containing concrete dust as filler displayed maximum unit weight at 6% content of bitumen having an increasing trend up to 6%. In case of brick dust, also maximum unit weight at 6% content of bitumen was achieved.
- Bituminous mixes containing concrete dust as filler showed maximum stability at 6% content of bitumen. Also in case of brick dust as filler maximum stability is attained at 6% content of bitumen.
- It is found that bituminous mixes containing 6% of bitumen content gives the satisfactory results in both concrete and brick dust as fillers.
- 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.
- Problem of disposal of industrials waste can be reduced by using these waste materials.
- It is found that with further tests on concrete dust and brick dust generated as waste materials can be used effectively in the making of bitumen concrete blend for paving purposes.
- 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.

B. Future Scope

- Pavement mixes with stone dust, cement, fly ash, can also be used as fillers to improve the quality of pavement mixes.
- Creep test, Indirect tensile test of bituminous mixes can give us an idea about the tensile strength of the bituminous mixes.
- We can also use the different types of binders and additives like rubber, plastic waste, polymers etc.

- We can also use the different types of fibers like synthetic fiber and natural fiber to improve the quality of pavement mixes.

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