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BITUMEN CONCRETE MIX DESIGN USING WASTE MATERIALS AS FILLER MATERIALS

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ABSTRACT

Construction and development of highways involve much huge outlay of investments. A précised engineering design saves considerable investment and reliable performances of the highways can be achieved. Following things are of major importance in the context – pavement design & the mix design. Our project emphasizes on the mix design considerations. A desired design of a bituminous mix is expected to result in that mix which is perfectly strong, durable and resistive to permanent deformation and fatigue also environment friendly economical as well. 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 marble dust 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 solve the problem of solid waste disposal of the environment to a considerable extent.

Key Words: *Mix Design, Marshall Stability Test etc.*

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. 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 tyre 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.

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

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durable pavement, sufficient void in total compaction mix to allow for a slight amount of additional compaction and traffic loading without flushing bleeding and lots of stability yet low enough to keep out harmful air and moisture, sufficient workability to permit sufficient placement of the mix without segregation.

II. METHOD AND MATERIALS

The materials used in this study work along with their desired characteristics are stated under.

Table 1: Materials and their properties

Material	Desired Properties
Coarse Aggregate	The coarse aggregate should have good crashing strength, abrasion value, impact value. Its function is to bear stresses coming from wheels. It has a resist wear due to abrasive action of traffic.
Fine aggregate	It shall be fraction passing 600 microns and retained on 75 microns sieve consisting of crushed stone or natural sand. Its function is to fill up the voids of the coarse aggregate
Fillers (Brick dust and Marble dust are use in this study).	It shall be fraction passing 600 microns and retained on 75 microns sieve consisting of crushed stone or natural sand. Its function is to fill up the voids of the coarse aggregate.
Aggregate Characteristic	The mineral aggregates most widely used in bitumen mixes or crushed stone, slag, crushed or uncrushed gravel, sands and mineral fillers. Since mineral aggregates constitutes of approximately 88% to 96% by weight and approximately 80% by volume of the total mix. Their influence upon the final characteristics of bituminous mixes is very great. Desirable aggregate characteristic gradation and size appropriate to type of constructions, strength and toughness, cubical shape, low porosity, Proper surface texture, Hydrophobic characteristics.

The gradation aggregates used in this project are as per IRC grading 2 as given in the following:
Table (MORTH: Specifications for Road and Bridge works 2003):

Table 2: IRC Grading 2 for bituminous concrete mixes

Grading	2
Nominal Aggregate size	
Layer thickness	30-45mm.
I.S. sieve	Cumulative Percentage by weight of total aggregate passing
19	100
13.2	79-100
9.5	70-88
4.75	53-71
2.36	42-58
1.18	34-48
0.6	26-38
0.3	18-28
0.15	12-20
0.075	4-10
Bitumen content by mass of total mix Bitumen Grade (penetration)	5.0-7.0 VG 30
Bitumen	60/70 grade of bitumen has been used

III. EXPERIMENTAL INVESTIGATIONS

1. Penetration Test:

The consistency of bitumen cement is measured by the penetration test. A weighted needle (100 g) is allowed to bear on the surface of a dish of bitumen of standard test temperature (770 F) for a given length of time (5 sec). The depth of penetration of needle into the bitumen is termed as the penetration of the bitumen and is measured in units of 0.1mm.The needle penetrates farther into soft bitumen than into the harder grades, and thus the lower the penetration, the harder the bitumen.

Mean Penetration value = 6.1
Grade of Bitumen =60/70.

2. Specific Gravity:

Specific gravity is used to calculate voids in the compacted bituminous mix and to adjust quantities in mixture. Specific gravity of bitumen is found to be 1.05 by balance method. The specific gravity of aggregates was found to be 2.67

The results of various tests performed on the materials are tabulated as under:

Table 3: Tests performed on materials

Parameter	Observed Value
Mean Penetration value of bitumen	6.1
Grade of bitumen	60/70
Specific gravity of bitumen	1.05
Ductility Test (mm)	48.33
Specific gravity of Filler (Brick dust)	2.15
Specific gravity of Filler (Marble dust)	2.69
The specific gravity of aggregates	2.67
Crushing Value of aggregate (%)	13
Los Angeles abrasion test (%)	22.08
Water absorption of aggregates (%)	3.15

3. Marshall Stability Test:

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. Marshall Method of mix design has been adopted in this study. Accordingly aggregates with the grading 2 of IRC and bitumen 80/100 having properties as described in the preceding paragraphs have been used.

In this method, the resistance to plastic deformation of a compacted cylindrical specimen of a bituminous mixture is measured when the specimen is loaded diametrically at a deformation rate of 50mm/minute. The two major features of Marshall Method are Density Void Analysis and Stability Flow Test. The marshall stability of mix is defined as the maximum load carried by the specimen at a standard test temperature of 60ºC. The flow value is the deformation that the test specimen undergoes during loading upto maximum load. Flow is measured in 0.25 mm units. In this test, an attempt is made to obtain optimum binder content for the type of aggregate mix used.

Marshall Test Data Compilation:

Marshall Stability Test
Type of Grading aggregate = B
Mixing Temperature =60ºC
Number of blows = 75

Grade of Bitumen VG 30
Compaction temperature 27ºC

Table 4:Marshall Test Data Sheet

FILLER	BRICK DUST			MARBLE DUST			NORMAL AGGREGATE		
BITUMEN STABILITY PROPORTION	5%	6%	7%	5%	6%	7%	5%	6%	7%
Stability (kg.)	810	1076	964	1806	2286	2139	2035	2590	2277
FlowValue (mm)	1.6	2.3	3.1	1.8	2.21	2.53	2.2	3.45	4.02
Unit Wt. (g/cc)	2.18	2.24	2.22	2.41	2.4	2.36	2.33	2.38	2.35
% air void	8.01	4.68	4.31	2.03	0.83	1.26	2.89	1.65	1.26

IV. RESULTS AND DISCUSSIONS

Bituminous mixes containing marble dust as filler displayed maximum stability at 6% content of bitumen, having an increasing trend upto 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.

Table 5: Results of marshall stability test

Parameters	Brick Dust	Marble Dust	Aggregate Dust
Optimum bitumen content (%)	6	6	6
Stability (kg.)	1076	2286	2595
Flow Value (mm)	2.3	2.21	3.45
Unit Weight (g/cc)	2.24	2.4	2.38
% Air Voids	4.68	0.83	1.65
VMA	17.48	14.54	15.25

Various parameters are plotted in order to show the relationship between various constraints of Marshall Stability Tests

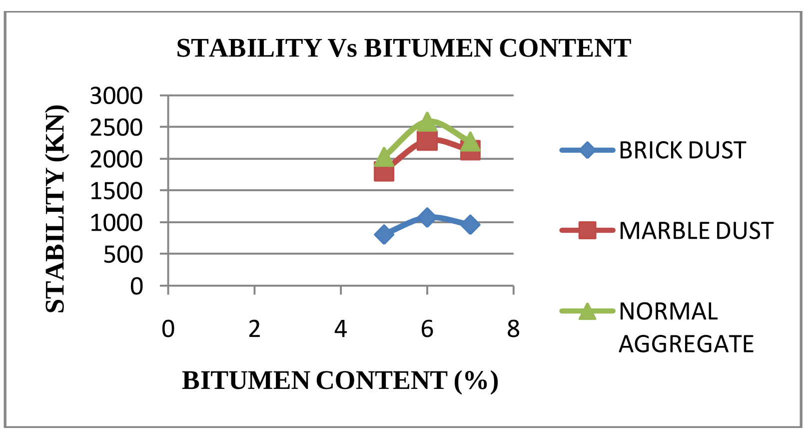

Fig 1: Graph between Bitumen content and Stability

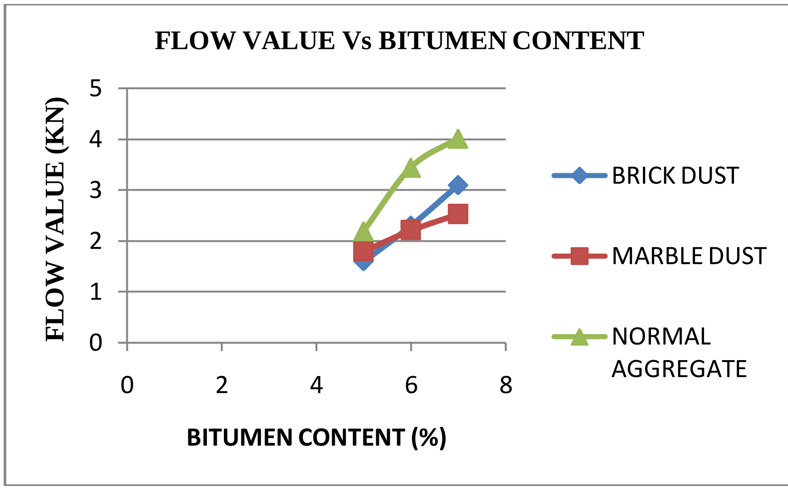

Fig 2: Graph between Bitumen content and Flow Value

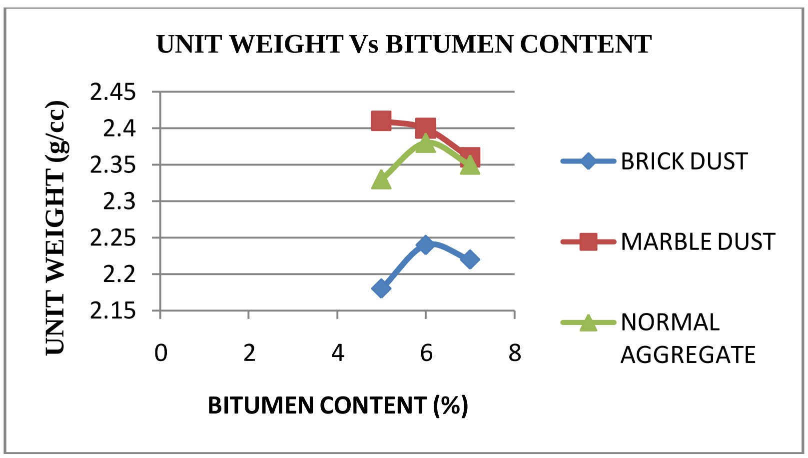

Figure 3: Graph between Bitumen content and Unit Weight

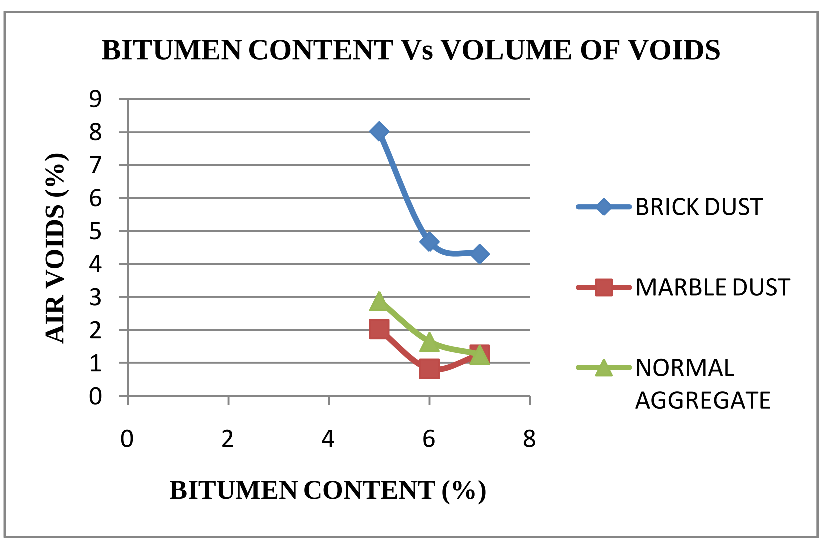

Figure 4: Graph between Bitumen content and Volume of Voids

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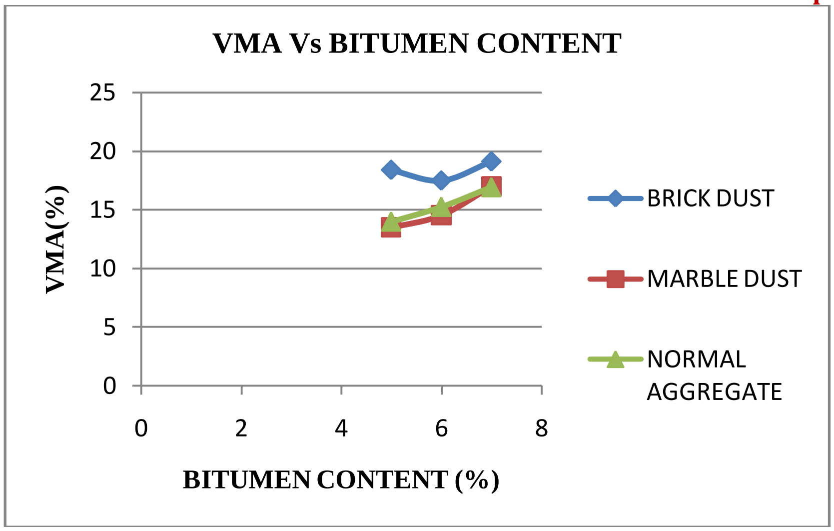

Fig 5: Graph between Bitumen content and VMA

V. CONCLUSIONS

1. Bituminous mixes containing marble dust as filler is found to have Marshall properties almost nearly same as those of conventional fillers.
2. Bituminous mixes containing marble dust as filler displayed maximum stability at 6% content of bitumen having an increasing trend upto 6% and then gradually decreasing, the unit weight or bulk density also displayed a similar trend with flow value being satisfactory at 6% content of bitumen.
3. Bituminous mixes containing brick dust as filler showed maximum stability at 7% bitumen content 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 or bulk density, the percentage of air voids obtained were seen to be decreasing with increase in bitumen content thus from here we can seat 7% bitumen content, satisfactory results are obtained.
4. These mixes are seen to display higher air voids then required for normal mixes.
5. Higher bituminous content is required in order to satisfy the design criteria and to get usual trends.
6. From the above discussion it is evident that with further tests marble dust generated as waste material can be utilized effectively in making of bitumen concrete mixes for paving purposes.
7. Further modification in design mixes can result in utilization of marble dust as filler in bituminous pavement thus partially solving the waste material disposal substantially resulting in utilization of industrial space being consumed in disposal of industrial wastes.
8. Though stone dust being conventional filler however marble dust can be utilized in its place effectively thus solving the waste material disposal substantially resulting in utilizing of industrial space being consumed in disposal of industrial wastes.
9. 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 cost considerably.
10. It is evident that with further tests marble dust generated as waste material can be utilized effectively in making of bitumen concrete mixes for paving purpose.

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