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Effect Of Fillers On Bituminous Paving Mixes

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Abstract: One of the costliest and highest types of flexible pavement layer used is bituminous concrete or asphalt concrete. Construction of highways involves huge outlay of investment. To satisfy the design requirements of stability and durability the bituminous mixes should be designed effectively. The ingredients of the bituminous 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 behaviour of bituminous mixes. Filler plays an important role in the filling of voids and hence change the physical and chemical properties. An important role is played by the fillers that pass through 0.075mm sieve. Conventionally stone dust is used as filler. An attempt has been made in this investigation to assess the influence of non-conventional and cheap fillers such as brick dust and steel slag in bitumen paving mixes. The properties of bituminous mixes containing these fillers were studied and compared with each other. Various tests were also conducted on aggregates and bitumen and the results were compared with the specifications. Brick dust and Steel slag as fillers with 2%, 3.5%, 5%, and 6.5% was used to improve the physical characteristics of bitumen mixes.

Key words: Steel slag, Brick dust, Marshall Stability test.

INTRODUCTION

Highway construction activities have taken a big leap in the developing countries since last decade. As well 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. 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 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 networks). Conventional flexible pavement are layered systems with high quality expensive materials are placed in the top where stresses are high, and low quality cheap materials are placed in lower layers. Full depth asphalt pavements are constructed by placing bituminous layers directly on the soil sub grade. This is more suitable when there is high traffic and local materials are not available. Contained Rock Asphalt Mat (CRAM) is constructed by placing dense/open graded aggregate layers in between two asphalt layers. Modified dense grade asphalt concrete is placed above the sub grade will significantly reduce the vertical compressive strain on soil sub grade and grade and protect from surface water. **1.**Presented a modified marshal mix design methodology which listed a minimum VMA requirement of 15%. He provided design charts that covered the range of aggregate specific gravity from 2.00 up to 3.00 and asphalt specific gravity from 0.95 to 1.1 **Mc Loed (1956) 2.** Investigated the application of fly ash as an additive in amounts of 5%, 6%,7% and 8% by the total aggregate weight to the asphalt concrete mixture. Marshall Tests were applied and the optimum bitumen content was determined .the highest stability was obtained from 5% fly ash added mix and at 8% of fly ash the stability value decreased. **Henning N.E [4] (1974) 3.** did a comparative study between soma fly ash (F class) and calcareous as fillers in his experiment .he took 60/70 penetration bitumen with 7% of fillers by weight of aggregates. **Tapkin [14] (2007) 4.** investigated the effects of using granular volcanic ash as a partial replacement of conventional aggregate on properties of hot mix asphalt. **Jamil A Nagi, Ibrahim M Asi (2009).**

Pavements can be divided into 3 major types:

- Flexible pavements (surface layer of asphalt).
- Rigid pavements (surface layers of concrete).
- Composite pavements.

The following types of construction have been used in flexible pavement:

- Conventional layered flexible pavement,
- Full depth asphalt pavement, and
- Contained Rock Asphalt Mat (CRAM).

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Objectives:

The objectives of the mix design is to determine an economical blend of stone aggregates, sand and fillers such as brick dust and steel slag proportionate various components so as to have:

1. Sufficient bitumen to ensure a **durable** pavement.
2. Sufficient **strength** to resist shear deformation under traffic at higher temperature.
3. Sufficient **air voids** in the compacted bitumen to allow for additional compaction by traffic.
4. `Sufficient **workability** to permit easy placement without segregation.
5. Sufficient **flexibility** to avoid premature cracking due to repeated bending by traffic.
6. Sufficient flexibility at low temperature to prevent shrinkage cracks.

MATERIALS USED:

- Aggregates
  - Coarse Aggregates
  - Fine Aggregates
- Bitumen
- Fillers
  - Steel Slag
  - D Dust

Coarse aggregate: Aggregates passing through 13mm sieve and retained from 2.36mm sieve is used in this entire project.

Fine aggregate: Aggregates passing through 2.36mm sieve and retained from 0.075 mm sieve is used in this entire project.

Bitumen: Bitumen is hydrocarbon material of either natural or pyrogeneous origin found in gaseous, liquid, semisolid form and is completely soluble in carbon disulphide and in carbon tetra chloride. Bituminous materials are very commonly used in highway construction because of their binding and water proofing properties. The different grades of bitumen used for pavement construction work of roads and airfields are called paving grade bitumen and those used for water proofing of structures and industrial floors etc. are called industrial grade bitumen. For the construction of bituminous pavement, the paving grade bitumen is heated to temperatures in the range 0f 130 to 175c or even higher, depending upon the type and grade of bitumen selected and the type of the construction work. Mixing of the bitumen with the aggregates is done in a hot mix plant to obtain "hot bituminous mix".

Mineral filler: Mineral filler is largely visualized as a void filling agent and is used in the mix for better binding of materials. Crushed aggregates and sharp sands produce higher stability of the mix when compared with gravel and rounded sands. Rock dust, slag dust, hydrated lime, hydraulic cement, fly ash, mineral filler and cement are used as filler in Bituminous mix, also Fraction passing 0.075mm or 75 microns IS sieve was used as a filler. The filler material used in the study is stone dust. In this project, brick dust and steel slag are used as fillers.

Brick Dust: Brick dust is obtained from light red collared bricks consisting alumina, lime, oxide of iron, magnesia. The brick dust is collected from bricks manufacturing plant. The Chemical compositions of Brick Dust are mentioned in Table 1.

Table1: Properties of Brick Dust

Chemical Composition	Percentage
Alumina	20 To 30%
Lime	5%
Oxide Of Iron	5-6%
Silica	50-60%

Steel slag: Steel slag, a by –product steel making, is produced during the separation of the molten steel from impurities in steel making- furnaces. The slag occurs as a molten liquid molten and is a complex solution of silicates and oxides that solidifies upon cooling. The steel slag consisting CaO, SiO_2, MgO, Al_2O_3, and MnO. The steel slag is collected from

. The test flame is applied at intervals depending upon the expected flash and fire points and corresponding temperatures at which the material shows the sign of flash and fire are noted. The results are mentioned in Table 2.

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Table 2: Results of Bitumen

S.No	Description Of Test	Test Result	Specified Limit	Test Method
1	Penetration value	65mm	65-70	IS:1203
2	Ductility	78cm	Not less than 75	IS:1208
3	Specific gravity	1.03	0.99 (Minimum)	IS:1202
4	Flash point	240^0C	220(Minimum)	IS:1209
5	Fire point	255^0C	220(Minimum)	IS:1209
6	Softening point	48.65^0C	40^0C-55^0C	IS:1205

Tests On Fillers

Specific Gravity test and Water Absorption Test are done for the fillers and their results are mentioned in Table 3.

Table 3: Test results of fillers

S.No	Filler	Specific Gravity	Water Absorption (%)
1	Stone dust	2.6	1.43
2	Brick dust	2.15	1.23
3	Steel slag	2.7	1.52

Marshall Mix Design:

- 1200gm aggregate are weighted and heated to a temperature of 160^0C-170^0C. Compaction mould assembly and rammer are cleaned and preheated to a temperature of 100^0C-145^0C.
- Bitumen is heated to a temperature of 160^0C.
- Aggregates & Bitumen are mixed thoroughly until a uniform grey color is obtained.
- The mix is placed in Marshall Mould of diameter 100mm & 64mm height compacted with 75 blows on each face.
- Mould is taken out and kept under normal laboratory temperature for 12 hours.
- It is then immersed in water bath kept at a constant temperature 60^0C for 30 minutes. Load is applied vertically at the rate of 51mm per minute.

The maximum load at sample fails is recorded as the Marshall Stability value. Corresponding vertical strain is termed as the flow value

The above procedure is repeated on specimens prepared with other values of bitumen content; in suitable increments say 0.53.

RESULTS AND DISCUSSIONS

Graphical Representation of Marshall Properties

1.Bitumen Vs Density graph is shown in Fig.1

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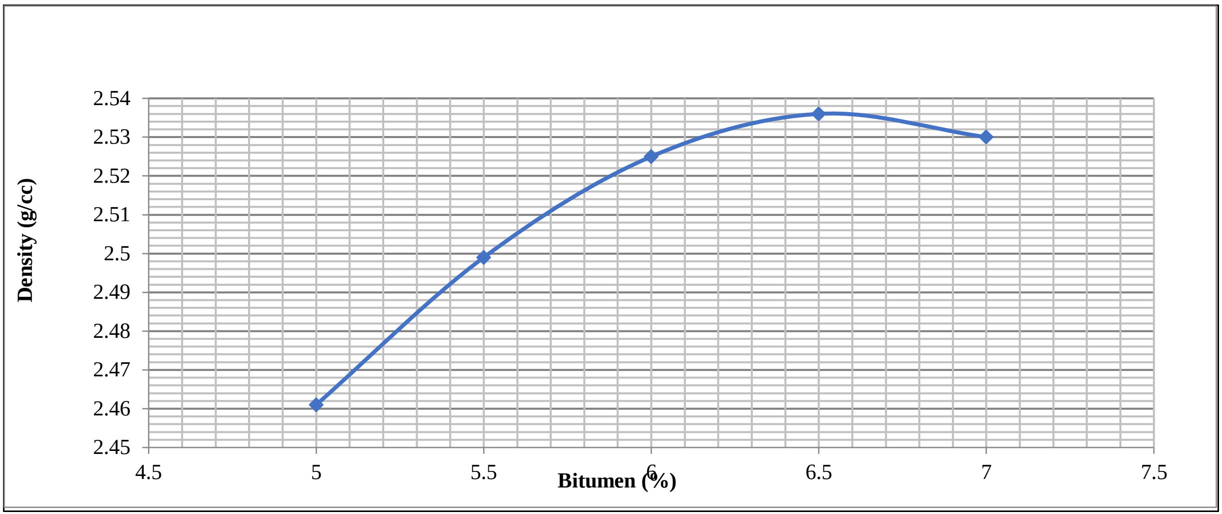

Fig 1: Bitumen vs. Density of Nominal mix

Table 4: Summary of Test Result (Nominal mix)

Summary of Test Result BITUMINOUS CONCRETE					
S.No	**Name of Test**	**Unit**	**Test Result**	**Specified Limit**	
				Min.	**Max.**
1	Stability	KN	13.50	9	-
2	Flow	Mm	3.40	2	4
3	Air Void	%	4.10	3	5
4	G_m	gm/cc	2.635	-	-
5	VMA	%	15.60	12.00	-
6	VFB	%	73.00	65	75
7	Unit Weight	gm/cc	2.525	-	-
8	Optimum Binder	%	6.00	_	-

Table 5: Marshall Properties (Specimen With Steel Slag)

% Bitumen	Density g/cc	Air Voids %	VMA %	VFB %	Stability KN	Flow mm
5	2.47	7.84	16.35	52.04	11.55	2.3
5.5	2.507	5.65	15.54	63.64	13.07	2.9
6	2.524	4.21	14.9	72.69	14.97	3.1
6.5	2.52	3.56	16	77.75	12.65	3.2
7	2.506	3.28	16.91	80.61	11.27	3.3

Table 6: Summary of Test Result (Specimen with Brick dust)

Summary of Test Result BITUMINOUS CONCRETE					
S.No	**Name of Test**	**Unit**	**Test Result**	**Specified Limit**	
				Min.	**Max.**
1	Stability	KN	12.86	9	-
2	Flow	mm	3.40	2	4
3	Air Void	%	4.00	3	5
4	G_m	gm/cc	2.625	-	-

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5	VMA	%	15.00	12.00	-
6	VFB	%	73.00	65	75
7	Unit Weight	gm/cc	2.520	-	-

Table 7: Marshall Properties (Specimen with Brick dust)

% Bitumen	Density g/cc	Air Voids %	VMA %	VFB %	Stability KN	Flow mm
5	2.459	7.9	16.12	50.99	10.54	2.5
5.5	2.491	5.89	15.48	61.94	12.02	3.1
6	2.52	4	14.94	73.24	12.8	3.3
6.5	2.502	3.88	16	75.75	12.1	3.6
7	2.485	3.76	17.02	77.91	11.07	3.8

Table 8: Comparison of Marshall Properties between Steel Slag and Brick Dust

S.NO	PARAMETERS	STEEL SLAG	BRICK DUST
1	Optimum bitumen content (%)	**6**	**6**
2	Optimum filler content (%)	**3.5**	**5**
3	Stability (KN)	**14.95**	**12.86**
4	Flow (mm)	**3.10**	**3.40**
5	% of air voids	**4.20**	**4.00**
6	VMA (%)	**14.90**	**15.00**
7	VFB (%)	**72.50**	**73.00**

CONCLUSIONS

- Bituminous mixes containing stone dust as fillers have found an optimum bitumen content at 6%.
- Bituminous mixes containing steel slag as filler displayed maximum stability at 3.5% of filler content having an increasing trend up to 3.5% and then gradually decreasing, the unit weight/ bulk density also displayed a similar trend with flow value being satisfactory at 3.5% of filler content at Optimum Bitumen Content (6%).
- 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.
- Bituminous mix's containing steel slag as filler showed higher stability values when compared with brick dust and stone dust fillers.
- Though stone dust being conventional filler however steel slag 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.

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