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Emulsified Cold Mix Design for Bituminous Macadam (BM)

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Abstract:-**This report presents the strengths and stability characteristic of bituminous concrete by using cold mix design. The report will be helpful for the engineers in public and private sector with responsibility for the design, construction and maintenance of bituminous macadam (BM) particularly to the cold region of India such as Northeast. In the present study Ground-Granulated Blast-Furnace Slag (GGBS or GGBFS) and cement is used as filler material in bituminous macadam (BM) and comparing their Marshall properties.**

Keywords- Marshall Stability Test, Cement, Ground Granulated Blast Furnace Slag (GGBS)

I. INTRODUCTION

Cold mix is bituminous mixture containing mineral aggregate, water and binder (bitumen emulsion) prepared by a suitable device like concrete mixer or cold mix plant or a modified hot mix plant. A cold mix is defined as a mixture of bitumen emulsion and aggregate that is mixed together at ambient temperature. Bitumen emulsion being liquid at room temperature, there is no need to heat or dry the mineral aggregate. Cold mix is useful in the areas, where there is long distance between the job site and plant and temperature of climate is low and moderate (<40°C). Further, the versatility of cold mix allows it to be mixed in-place at the job site as well as at a plant site and then subsequently transported to the job site. Cold mix may be used in bituminous base (BM), binder course (BM/SDBC) as well as wearing course (SDBC) offlexible pavement. These mixes may be designed for a broad range of bitumen emulsions, aggregates, field conditions and tailored to specific performance requirement. The cold mix should be designed to meet the performance requirements which include workability, coating, strength development, and other applicable targets. The quality of residual bitumen, aggregate, and climatic conditions should be taken into account.

II. PRESENT INVESTIGATION AND SCOPE

The present experimental work is focused on the characteristics of bituminous macadam (BM) using bituminous emulsions SS-2 (Slow Setting) emulsion with additive Cement and Ground-Granulated Blast-Furnace Slag (GGBS or GGBFS) for achieving better Marshall Satiability. The Marshall properties like Marshall Load, flow value, air voids and density of the Bituminous Macadam are determine in this research paper according to the MORTH specification.

III. METHODOLOGY

Different materials are such as aggregates, Cement, Ground-Granulated Blast-Furnace Slag (GGBS or GGBFS) and bituminous emulsions are collected from their quarry and different tests on aggregates are being conducted such as Impact Test, Crushing Test, Los Angeles Abrasion Test and Specific Gravity and Water Absorption Test. Further with trial and error method gradation is obtained and Marshall Specimen is prepared and Marshall Stability Test is conducted and graphical and theoretical analysis is done.

IV. MATERIALS USED IN THE STUDY

The different materials used in the study are aggregates, Cement, Ground-Granulated Blast-furnace Slag (GGBS or GGBFS) and bituminous emulsions. The Proportion of aggregates used is 19 mm, 6 mm and Stone dust which is brought from a quarry near Jabalpur city. The type of binders used in the present study is the SS-2 (Slow Setting) Emulsion which has Specific Gravity of 1.10. After procuring of aggregate different tests were conducted on aggregate and the results are as shown below in Table 1

S No.	Tests	Value
1	Water Absorption	**.449**
2	Impact Test	**14.20%**
3	Los Angeles Abrasion	**23.20%**
4	Specific Gravity Of Aggregate	**2.89**
5	Crushing	**18.83%**

Table 1: Aggregate Test

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V. OBTAIN GRADATION

The different sizes of aggregates i.e., 19 mm, 6mm, and dust were selected from the heap and the sieve analysis was done to obtain the individual gradation of these aggregates. By trial and error method, using Microsoft excel, the desired gradation for BM mix is obtained as shown in the Table 2 and Figure1.The gradation adopted 33% of 19 mm, 35% of 6 mm, 30% of stone dust for BM.

BM JOB MIX FORMULA						
Sieve Size	% Passing by Weight				Combined Grading	MORTH Specification
	19mm	6mm	DUST	FILLER		
	A	B	C	D	(0.33A+.35B+ .30C+.02D)	TABLE NO 500-18
26.5	100	100	100	100	**100**	**100**
19	93	100	100	100	**97.69**	**90-100**
9.5	35	100	100	100	**78.55**	**60-80**
4.75	0	56.5	100	100	**51.775**	**35-65**
2.36	0	16.5	80	100	**31.775**	**20-50**
0.3	0	3.5	21	100	**9.525**	**3-20**
0.075	0	0	4	95	**3.1**	**2-8**

Table 2: Individual Gradations by Trial and Error Method for Cold Mix BM

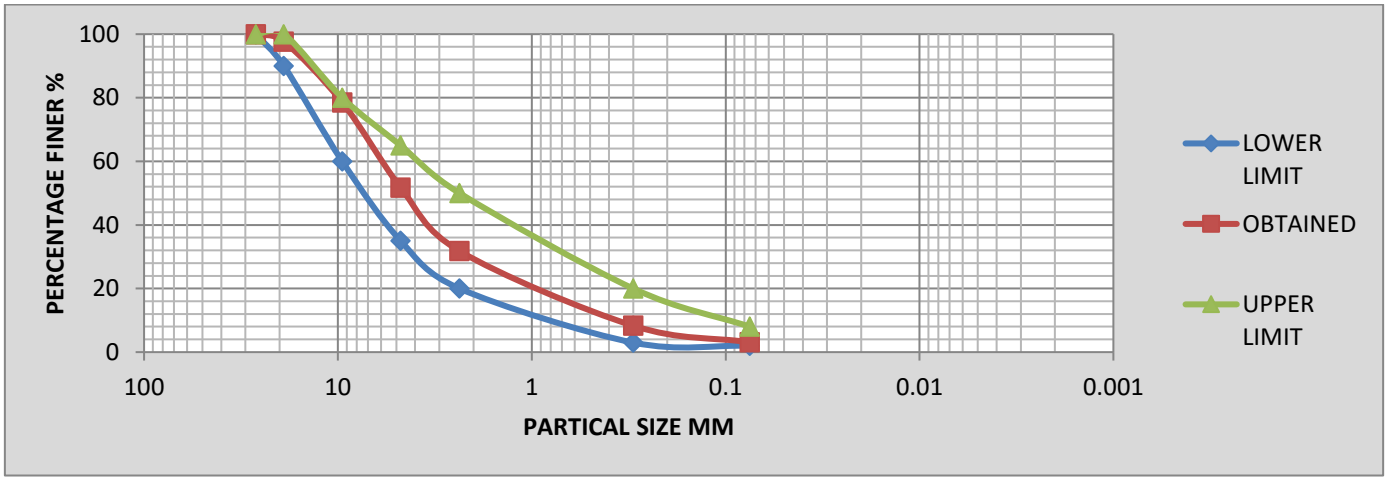

Figure 1: Graph of Gradation Obtained for Bituminous Macadam Mix

VI. PREPARATION OF MARSHALL SPECIMEN FOR BM MIX

- The dry aggregate was blended into 1200g batches by combining the different aggregate sizes to the desired gradation.
- The aggregate was used cold (at room temperature)
- The moisture content was added 3% to the aggregate and mixed thoroughly. The mix was left for 10-15 minutes at room temperature before adding bitumen emulsion.
- The emulsion was added cold to the wet aggregate and mixed thoroughly for about 2 minutes. The suitability of the mix and degree of coating was then evaluated.
- After mixing the mixture was kept in oven at 40 degree c for 72 hours. At the end of 72 hours the specimen were taken out from the oven and poured into the cold pre oiled Marshall Mould.
- In my study done the compaction of the mixture by the Marshall Compaction hammer on each side of specimen 50 blows.
- The prepared samples were extruded after 24 hours.

In my study took 7 to 10 percent of bitumen emulsion and add 2% additive i.e. cement and granulated grinded blast furnace slag (GGBS) to all percentage of bitumen emulsion.

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VII. ANALYSIS OF TEST RESULTS

A. Result Data

BM (CEMENT FILLER)							
COLD MIX CONTENT	**HEIGHT OF SAMPLE**	**WEIGHT, gm**		**BULK DENSITY**	**Vv %**	**STABILITY VALUE,**	**FLOW VALUE**
,%	**MM**	**in air**	**in water**			**KG**	**mm**
7	75.66	1247.66	730	2.41	5.34	370.42	3.3
8	78	1255.33	731.33	2.4	4.78	428.17	4.4
9	77.66	1270	736.33	2.37	3.58	473.98	4.96
10	78.33	1273.66	738.33	2.36	3.22	444.1	5.53

Table 3-Percentage Variation of Cement (Additive) With Different Bituminous Emulsion Content in Cold BM mix

BM (GGBS FILLER)							
COLD MIX CONTENT	HEIGHT OF SAMPLE	WEIGHT, gm		BULK DENSITY	Vv %	STABILITY VALUE,	FLOW VALUE
%	MM	in air	in water			KG	mm
7	73.66	1253.33	719.66	2.34	7.5	467.89	2.62
8	75.66	1260.33	726.33	2.36	6.03	518.58	3.1
9	74	1270	730.66	2.35	5.04	479.59	3.7
10	76	1275	732	2.34	3.37	432.8	4.3

Table 4- Percentage Variation of GGBS (additive) with Different Bituminous Emulsion Content in cold BM mix

OPTIMUM BINDER CONTENT FOR BM (CEMENT FILLER)					
OBC	FLOW MM	MARSHALL VALUE KG	BULK DENSITY	AIR VOIDS %	VFB %
8.46%	4.65	449.24	2.38 gm/cc	4.22%	80.47%

OPTIMUM BINDER CONTENT FOR BM (GGBS FILLER)					
OBC	FLOW MM	MARSHALL VALUE KG	BULK DENSITY	AIR VOIDS %	VFB %
8.54%	3.42	497.498	2.354 gm/cc	5.50%	76.02%

Table 5 Optimum Binder Content

B. Optimum Binder Content

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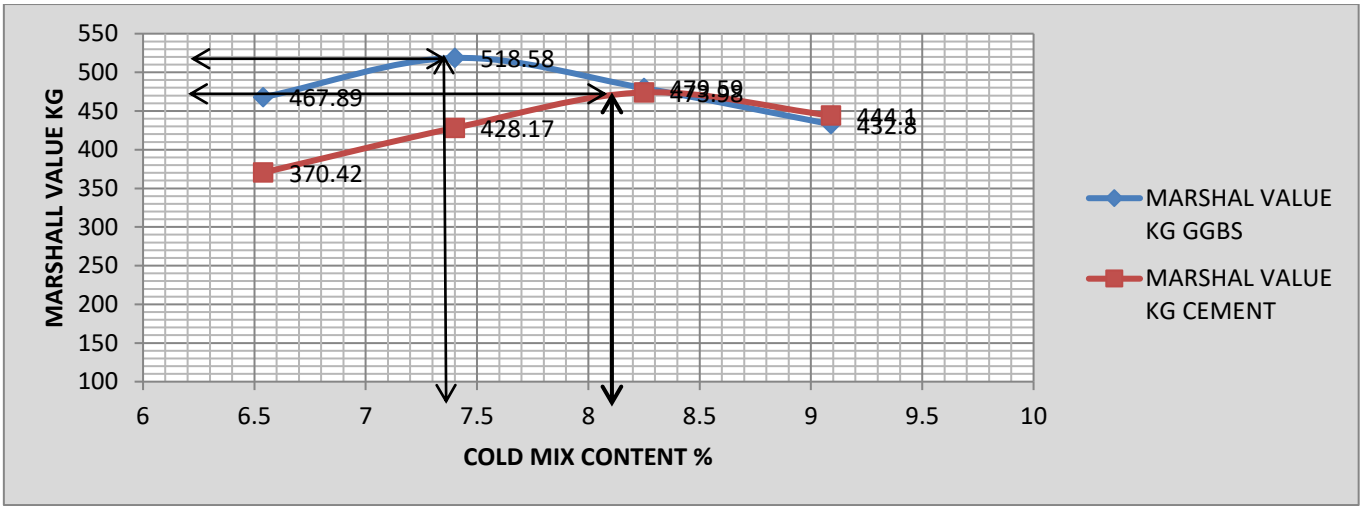

Figure 2: Variation of Marshall Value with Cold Mix Content

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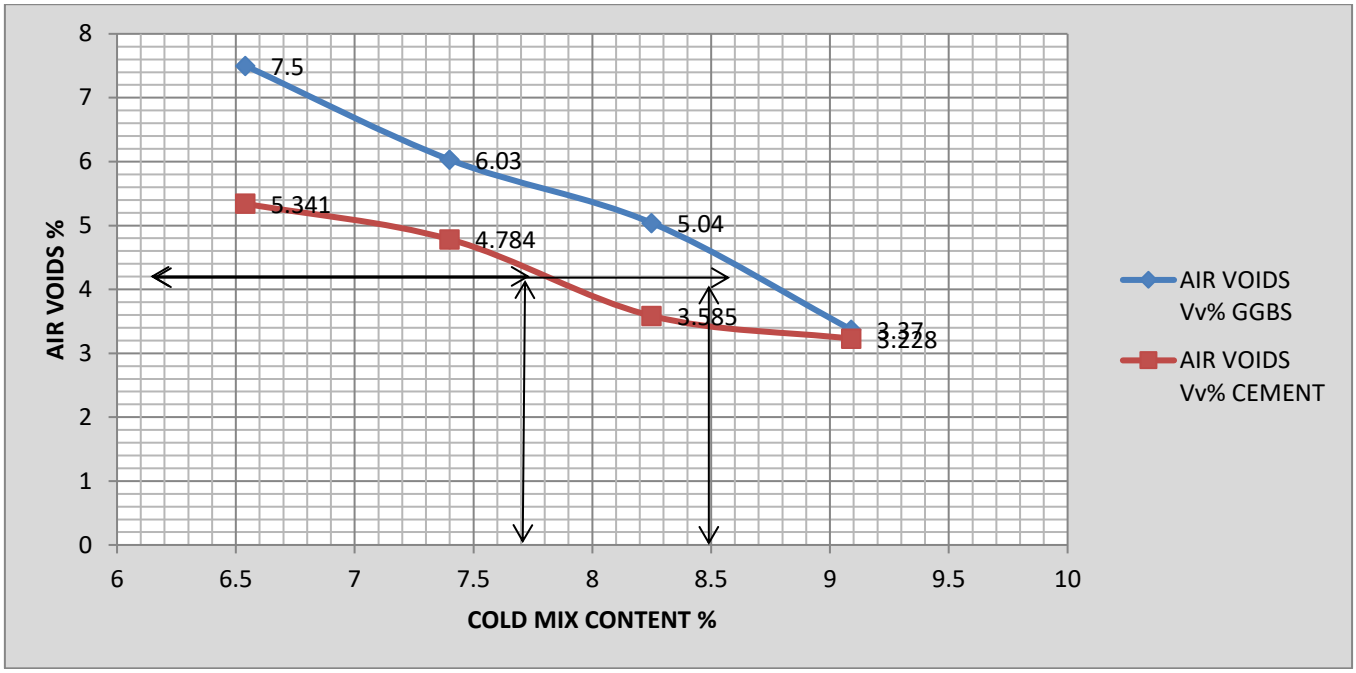

Figure 3: Variation of Air Voids with Cold Mix Content

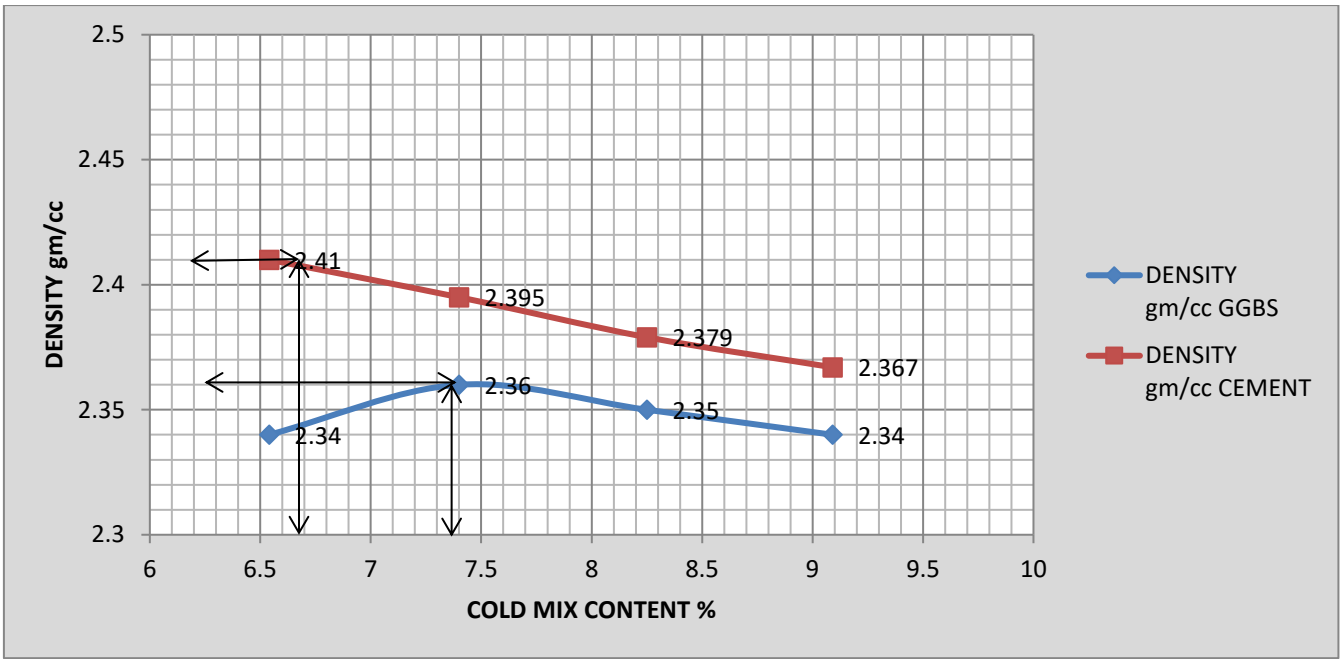

Figure 4: Variation of Density with Cold Mix Content

VIII. DISCUSSION

A. *BM Cold Mix*

- Effect on Marshall Value: Maximum Marshall Satiability Load of 473.98 kg has been obtained from the Marshall test done for the BM with a cold mix content of 9% (With Cement Filler) and with 8% cold mix (with GGBS Filler) Maximum Marshall Stability Load of 518.58 Kg is obtained.
- *Effect on Density:* The value of Maximum Density Obtained with 7% cold mix content (with cement filler) is 2.41 gm/cc and with 8% cold mix content (with GGBS filler) is 2.36 gm/cc.
- *Effect on Air Voids:* At cod mix content of 9.39 % (with cement filler) the value of minimum air void content is

obtained is 4% and at 9.62% (with GGBS filler) the value of minimum air voids obtained is 4%.

- *Optimum binder content*: The optimum binder content is the average of Maximum Marshall Stability load, maximum density and minimum air voids at 4% in the respective cold mix content.

IX. CONCLUSION

From above experimental work on following conclusions are drawn based on Marshall Properties of the BM mix using cold emulsion with Cement and GGBS filler.

- From the Marshall stability test perform on BM mix using cold emulsion as binder and Cement as filler material the optimum binder content is found to be 8.64 %with Marshall stability value as 449.24 kg the corresponding flow value, density of mix, air voids, and VFB are found as 4.65 mm, 2.38 gm/cc, 4.22% and 80.47 % respectively. These values are well within the ranges specified in MORTH specification.
- From the Marshall stability test perform on BM mix using cold emulsion as binder and GGBS as filler material the optimum binder content is found to be 8.54%with Marshall stability value as 497.49 kg the corresponding flow value, density of mix, air voids, and VFB are found as 3.42 mm, 2.354 gm/cc, 5.50% and 76.02 % respectively. These values are well within the ranges specified in MORTH specification
- If we compare the Marshall Stability values using GGBS and Cement as filler it can be concluded that the Marshall satiability obtained using GGBS filler comparatively higher than those obtained Cement as filler at all binder contents. The flow values using GGBS filler slightly lower than the value using Cement as filler.

Cold mix can be laid on low to medium volume road as a green paving mix. Mixture can be produced by using conventional plant or by hand. So it can be laid as surface course or bituminous base course for rural road construction. When incorporating cement, the cold mix should be compacted soon after mixing to maximize the results and to avoid workability problems.

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