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Use of Bitumen Emulsion for Flexible Road Construction

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ABSTRACT
In the present study bitumen is replaced by bitumen emulsion for the construction of flexible pavement. The conventional method of road construction involves the burning of bitumen which produces toxic gases which degrades the environment. In colder region it is difficult to maintain the paving temperature of hot mix. To overcome these problems and conserve the energy bitumen emulsion is considered as good option. Likewise emulsion can be used in the areas having higher rate of rainfall where the hot mix plant is closed most of the time because of rain. Emulsified bitumen can be used during rainy season and colder regions. To study the suitability of emulsion Marshal Test is carried out to find the stability value, flow value and optimum binder content. Experiments performed shows that bitumen emulsion (Cold Mix) have high stability value therefore it can be used as binder.

***Keywords*:** Bitumen emulsion, Cold Mix, Flow Value, Marshall Test, Stability value

I. INTRODUCTION

Road network play a very significant role in the development of any nation. But the development at cost of environment is also dangerous. Therefore there is great need of sustainable development for conservation of nature. In India bitumen is used as main binder constituent in construction of flexible pavement. The bitumen is first of all heated to melt and then mixed with aggregates to prepare road. This produces the huge amount of harmful gases which creates pollution. The other limitations of hot mix (bitumen) are that it is not possible to heat the bitumen during rainy season. Therefore areas having high rainfall the hot mix plants are mostly shut down. In colder region it is difficult to maintain the paving temperature thus large amount of fuel is required to heat the mix again and again as the hot mix solidify early. The use of cold mix technology can be used to reduce the problem of heating and pollution. In India use of cold mix is very limited though it has great advantages**.**

II. MATERIALS AND METHODS

Cold mix consists of aggregates and bitumen emulsion. Emulsion consists of bitumen in dispersed state in water in continuous phase. The bitumen globules are positively charged due to the NH3 + group cover which is formed around bitumen droplets and provide stability for emulsion by electrostatic repulsion. These bitumen droplets have an affinity with the negatively charged aggregate. Various emulsifiers are used to kept bitumen globules in dispersed state. The Cationic Bitumen Emulsion is chocolate brown and free flowing at normal temperature. Once it breaks, the bitumen breaks out and color changes to black. An Emulsion is said to break when the organic and the aqueous phase separate into two distinct layers i.e. the dispersion ceases to exist. Emulsions are classified as Rapid Setting-1(RS-1), Rapid Setting-2(RS-2), Medium Setting (MS), Slow Setting-1 (SS-1), and Slow Setting-2 (SS-2).

In present study following tests are performed to obtain the various properties of aggregates:

(i) Impact test for toughness
(ii) Los Angeles Test for hardness
(iii) Compression test for strength
(iv) Specific gravity
(v) Sieve analysis for coarse and fine aggregates

Since there is no universally accepted method for the design of cold mix therefore in present study Marshal Method has been adopted. This test is carried out to find out the stability and optimum binder content of the mix design. There are two major features of the Marshall method of designing mixes.

1) Stability – flow test
2) Density – void analysis

Marshal Stability value is the maximum load bear by specimen without failing. The vertical deformation of test specimen corresponding to maximum load, expressed in mm units is known as flow value.

Preparation of Marshall Specimen

The coarse aggregate, fine aggregate and filler material should be proportioned and mixed in such a way that the final mix after blending has the gradation within the specified range. Grade A aggregate are used here. The gradations of aggregates for bituminous concrete surface course are given below:

Table 1: Gradation of Aggregate

Sieve Size (mm)	**Weight Retained (gram)**
12.5mm -10.0mm	120
10.0 mm -4.75 mm	300
4.75 mm -2.36 mm	270
2.36 mm -600 micron	228
600 micron -300 micron	66
300 micron -150 micron	72
150 micron - 75 micron	60
75 micron - PAN	84
Binder content, % by wt of mix	6 - 14 %

Following steps are involved in preparing a Marshall Specimen (Yadav Om prakash and Manjunath K.R, 2012):

1) Approximately 1200 gram of the mixed aggregates and filler are taken and heated to a temperature of upto 60 degree centigrade for 10-15 minutes.
2) Now bitumen emulsion is mixed with aggregate and filler and mixing is done thoroughly for 3-4 minutes as required.
3) Now this mixture is poured into pre oiled Marshall Mould.
4) Compaction of this mixture is done by Marshall
5) Compaction hammers by giving 50 blows.
6) After compaction, sample is extruded and kept it for 24 hours at room temperature.
7) After 24 hours, measure the dimensions of sample (height) and weight of sample. Now sample is immersed in water bath at 35-40 degree centigrade for 40-60 minutes.
8) After completion of time sample is taken out and weight of the sample is noted. After taking weight, keep the sample for 24 hours at room temperature.
9) After completing 24 hours, curing is done for 48 hours and after the curing period, test the sample in Marshall Apparatus and determine stability value and flow value.

III. RESULTS AND DISCUSSION

Following values are obtained from the testing of aggregates.
Aggregate impact value = 17.86%
Abrasion value = 20.38 %
Crushing value = 17.88 %,
Aggregate specific gravity = 2.72

Numbers of specimens are prepared having different bitumen emulsion content for Following graphs are plotted to show the variation in different properties of cold mix design due to change in bitumen emulsion content.

Marshall Test. The Marshall Stability value and flow value are obtained from the dial gauge. The other parameters such as air voids, bulk density, voids filled with bitumen are calculated using relations as given below.

a) Theoretical Specific Gravity **(G_t)**

$$G_t = \frac{Wca + Wca + Wca}{\frac{Wca}{Gca} +}$$

Where,
Wca= weight of coarse aggregate,
Wfa= weight of fine aggregates
Wf = weight of filler material,
Wb= weight of bitumen emulsion.

b) Bulk Specific Gravity (G_m)

$$G_m = \frac{Wm}{Wm - Ww}$$

Where,
W_m is the weight of mix in air and W_w is the weight of mix in water

c) Air Voids (V_v)

$$V_v = \frac{Gt - Gm}{Gm} \times 100$$

Where G_t is the theoretical specific gravity of the mix and G_m is the bulk or actual specific gravity of the mix.

d) Percent Volume Of Bitumen (V_b)

$$V_b = \frac{\frac{Wb}{Gb}}{\frac{Wca + Wfa + Wf}{Gm}} \times 100$$

Where, W_{ca} is the weight of coarse aggregate in the total mix, W_{fa} the weight of fine aggregate in the total mix, W_f is the weight of filler in the total mix,
W_b is the weight of bitumen in the total mix,
G_b is the apparent specific gravity of bitumen, and
G_m is the bulk specific gravity of mix.

e) Voids Filled With Bitumen (VFB)

$$VFB = \frac{Vb}{VMA} \times 100$$

Where V_b is percent bitumen content in the mix and VMA is the percent voids in the mineral aggregate.

Table 2. Various properties of Bituminous mix

Bitumen Emulsion (%)	Unit Weight (g/cc)	Flow value (mm)	Stability Value (kg)	VFB (%)	VMA (%)	V_b (%)	V_v (%)	G_t Value (g/cc)	G_m Value (g/cc)
7	2.376	8.50	2104	77.704	29.153	20.322	8.831	2.140	1.951
9	2.408	14.20	2600	79.832	30.656	24.475	6.181	2.087	1.958
11	2.425	17.35	1952	89.172	32.168	28.685	3.483	2.038	1.967
13	2.408	21.85	1880	96.942	33.817	32.783	1.034	1.993	1.967

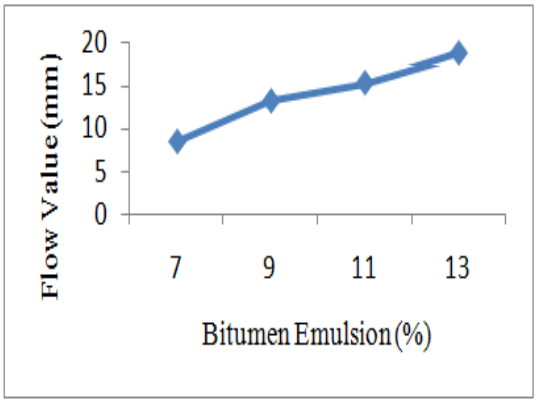

Fig1. Flow value graph

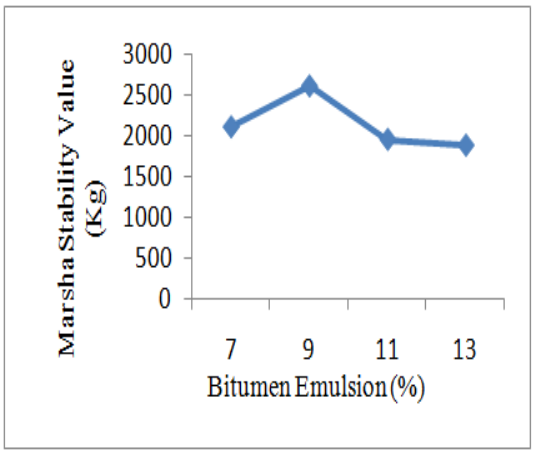

Fig2. Stability graph

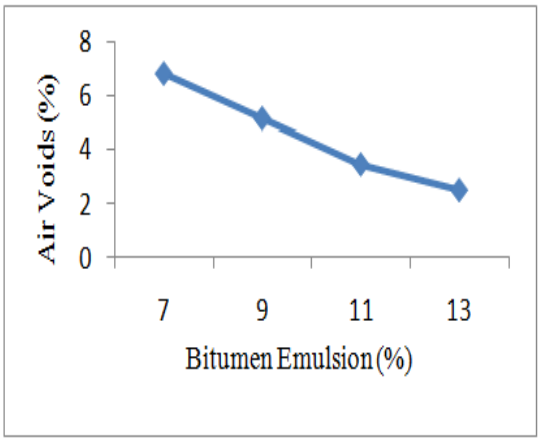

Fig3. Air voids graph

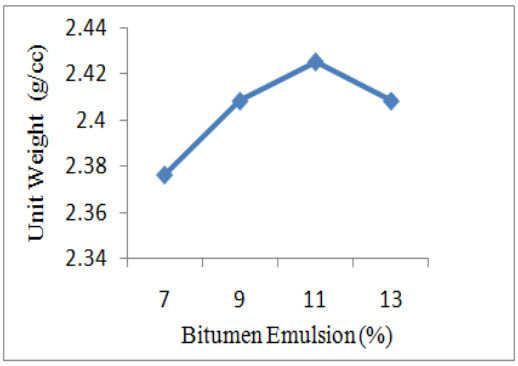

Fig4. Unit weight vs emulsion content

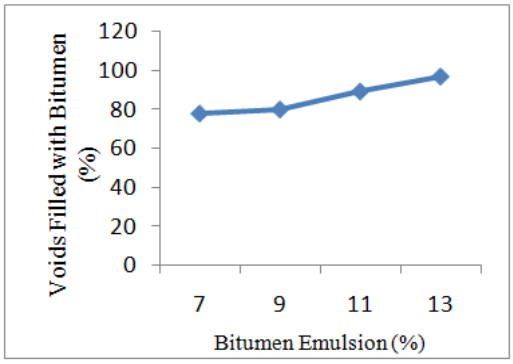

Fig5. VFB vs Emulsion content

From the obtained graph the optimum bitumen emulsion required for mix design is calculated by taking average value of three bitumen content corresponding to maximum Marshall stabilty value , maximum unit weight and air voids at 4 % . The calculated value for optimum binder content is 10 %.

IV. CONCLUSIONS

1) Heating is not required when bitumen emulsion is used as binder for the construction of the road. Therefore the construction is possible during rainy season and colder regions.
2) Optimum binder content for mix design is 10%.
3) Hot mix design have minimum stability value of 300 kg and here in cold mix design, stability value of samples is greater than 300 kg so it can be used in road construction.
4) It is economical and high production is possible with low investment.

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