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# BITUMEN EMULSION FOR PLASTIC HIGHWAY CONSTRUCTION

**Madeeha Qazi[1], Er. DeepakKumar[2]**

*[1]Student, Department of Civil Engineering, Desh Bhagat University, Mandi Gobindgrah, Punjab.*
*[2]External Guide, Department of Civil Engineering, Desh Bhagat University, Mandi Gobindgrah, Punjab*

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**Abstract –** Bitumen emulsion is a mixture of fine droplets of bitumen and water has successfully replaced the use of bitumen which was used before for the construction of flexible pavement. Bitumen emulsion helps to maintain the paving temperature of hot mix, so it can be used in colder regions and is also less toxic as compare to bitumen. Experiments performed through Marshal Test shows that bitumen emulsion have high stability value, therefore can be used as binder.

***Key Words***: Marshall Method, Theoretical specific gravity of the mix, Bulk specific gravity of mix

## 1. INTRODUCTION

The modern flexible pavement is generally designed and constructed in several layers for effective stress distribution across pavement layers under the heavy traffic loads. The interlayer bonding of the multi-layered pavement system plays an important role to achieve long term performance of pavement. Adequate bond between the layers must be ensured so that multiple layers perform as a monolithic structure. To achieve good bond strength, a bituminous emulsion is usually sprayed in between the bituminous pavement layers. About 740 people of India live in rural area and nearly 40 percent of village people of the country are not connected by all- weather roads. Either bituminous mix or concrete is required to make these earthen roads into all-weather roads. Concrete is not economical one as a paving mix compared to bituminous mix for rural road construction works. In India majority of road network is occupied by bituminous pavement as a paving mix from many decades. However this bituminous mix is associated with some limitations. These include excessive emission of greenhouse gases (e.g. Sulphur dioxide, nitrogen oxides, carbon monoxides and volatile organic compounds, shut down of hot mix plant during rainy season and the laying of HMA is difficult in hilly areas and rural areas having long hauling distances, cost of putting up HMA plant is high and comparative budgets of small sections of rural road is very less, etc. As, Indian rural road network is developing continuously, paving mix like cold mix emulsions should be tried

## 1.1 MATERIALS AND METHODS

Properties of bitumen emulsions are varied by many parameters like; source of aggregate, curing condition and curing time, etc. Hence there is no universally accepted mix design method for cold mixes. But Marshall Method is popularly used to design emulsified mixes. Marshall Method for emulsified asphalt aggregate design is based on the research conducted at the University of Illinois. This method is applicable to base course mixture for low volume traffic load. Cold mix is used in surface course also for low to medium traffic volume road. The cold mix design is carried out to optimize water and emulsion content for aggregate in the mix. The parameters involved in mix design of cold mix are;

1. Aggregates selection
2. Emulsion selection

### Aggregates Selection

In India aggregates should conform the physical requirement laid by MoRTH specification (2001). Testing of aggregate like sieve analysis, specific gravity, aggregate impact value and soundness is necessary.

### Emulsion Selection

Selection of emulsion depends on aggregate type and aggregate gradation and ability of emulsion to coat the aggregate. According IS 8887:2004 specifications, five grade of emulsion; RS-1, RS-2, MS, SS-1 and SS-2 are used to prepare cold mix. Quality tests should be carried out on the selected emulsion according to IS 8887:2004

## 2. PREPARATION OF MARSHALL SPECIMEN

The coarse aggregate, fine aggregate and filler material are 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:

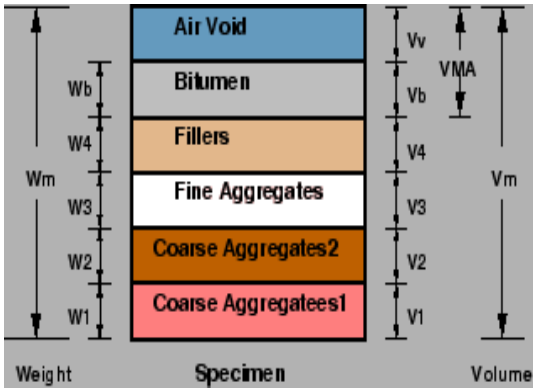
**Table 1.Gradation of aggregate**

| **Sieve size** (mm) | 19 | 12.5 | 9.5 | 4.7 | 2 | 0.42 | 0.17 | 0.07 |
|---|---|---|---|---|---|---|---|---|
| **Passing %** | 100 | 86 | 74 | 56 | 38 | 18 | 9 | 6 |

## 3. Specimen preparation

Approximately 1200 gm of aggregates and filler is heated to a temperature of 175-190 °C. Bitumen is heated to a temperature of 121 to 125 deg.

Bitumen is heated to a temperature of 121 to 125 deg. with the first trial percentage of bitumen (say 3.5 or 4% by weight of the mineral aggregates). The heated aggregates and bitumen are thoroughly mixed at a temperature 154-160 °C. The mix is placed in a preheated mould and compacted by a




rammer with 50 blows on either side at temperature of 138°C to 149°C. The weight of mixed aggregates taken for the preparation of the specimen may be suitably altered to obtain a compacted thickness of 63.5+/-3 mm. Vary the bitumen content in the next trial by +0.5% and repeat the above procedure. Number of trials are predetermined.

## 4. RESULTS AND DISCUSSIONS

Theoretical specific gravity ($G_t$) is the specific gravity without considering air voids, and is given by:

$$G_t = \frac{W_1 + W_2 + W_3 + W_b}{\frac{W_1}{G_1} + \frac{W_2}{G_2} + \frac{W_3}{G_3} + \frac{W_b}{G_b}}$$

where,$W_1$ is the weight of coarse aggregate in the total mix, $W_2$ is the weight of fine aggregate in the total mix, $W_3$ is the weight of filler in the total mix, $W_b$ is the weight of bitumen in the total mix,$G_1$ is the apparent specific gravity of coarse aggregate, $G_2$ is the apparent specific gravity of fine aggregate,$G_3$ is the apparent specific gravity of filler and $G_b$ is the apparent specific gravity of bitumen.

### 4.1 Bulk specific gravity of mix ($G_m$)

The bulk specific gravity or the actual specific gravity of the mix $G_m$ is the specific gravity considering air voids and is found out by:

### 4.2 Air voids percent $V_v$

Air voids $V_v$ is the percent of air voids by volume in the specimen and is given by:

$$V_v = \frac{(G_t - G_m)100}{G_t}$$

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

### 4.3 Percent volume of bitumen $V_b$

The volume of bitumen $V_b$ is the percent of volume of bitumen to the total volume and given by:

$$V_b = \frac{\frac{W_b}{G_b}}{\frac{W_1 + W_2 + W_3 + W_b}{G_m}}$$

where, $W_1$ is the weight of coarse aggregate in the total mix, $W_2$ is the weight of fine aggregate in the total mix, $W_3$ 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 .

### 4.4 Voids in mineral aggregate VMA

Voids in mineral aggregate VMA is the volume of voids in the aggregates, and is the sum of air voids and volume of bitumen, and is calculated from

$$VMA = V_v + V_b$$

Where, $V_v$ is the percent air voids in the mix and $V_b$ is percent bitumen content in the mix.

### 4.5 Voids filled with bitumen *VFB*

$$G_m = \frac{W_m}{W_m - W_w}$$

Voids filled with bitumen VFB is the voids in the mineral aggregate frame work filled with the bitumen, and is calculated as:

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

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

## 5. Determine Marshall Stability and flow

Marshall Stability of a test specimen is the maximum load required to produce failure when the specimen is preheated to a prescribed temperature placed in a special test head and the load is applied at a constant strain (5 cm per minute). While the stability test is in progress dial gauge is used to

measure the vertical deformation of the specimen. The deformation at the failure point expressed in units of 0.25 mm is called the Marshall Flow value of the specimen.

### 5.1 Apply stability correction

It is possible while making the specimen the thickness slightly vary from the standard specification of 63.5 mm. Therefore, measured stability values need to be corrected to those which would have been obtained if the specimens had been exactly 63.5 mm. This is done by multiplying each measured stability value by an appropriated correlation factors as given in Table below.

| Volume of specimen ($cm^3$) | Thickness of specimen (mm) | Correction Factor |
|---|---|---|
| | | |
| 457 -470 | 57.1 | 1.19 |
| 471 -482 | 68.7 | 1.14 |
| 483 -495 | 60.3 | 1.09 |
| 496 -508 | 61.9 | 1.04 |
| 509 -522 | 63.5 | 1.00 |
| 523 -535 | 65.1 | 0.96 |

### 5.2 Prepare graphical plots

The average value of the above properties are determined for each mix with different bitumen content and the following graphical plots are prepared:

1. Binder content versus corrected Marshall Stability.

2. Binder content versus Marshall Flow.

3. Binder content versus percentageof void in the totalmix

### Binder content versus voids filled with bitumen (*VFB*)

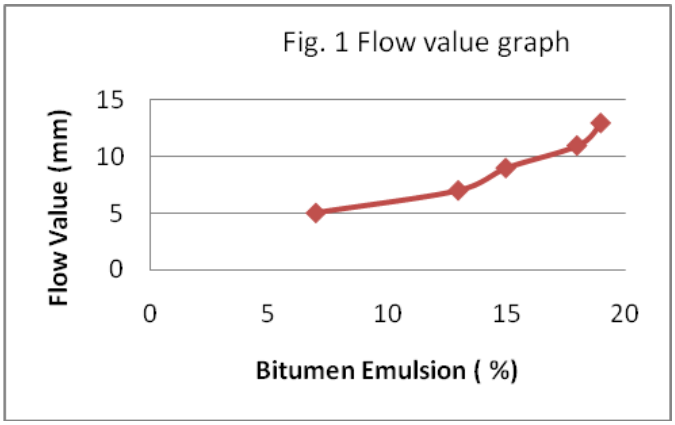
Determine optimum bitumen content

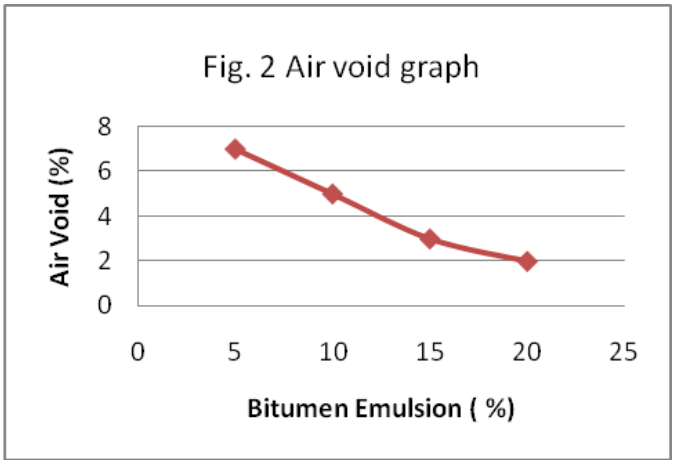
Determine the optimum binder contentfor the mix design by taking average value of the following three bitumen contents found form the graphs obtained in the previous step.

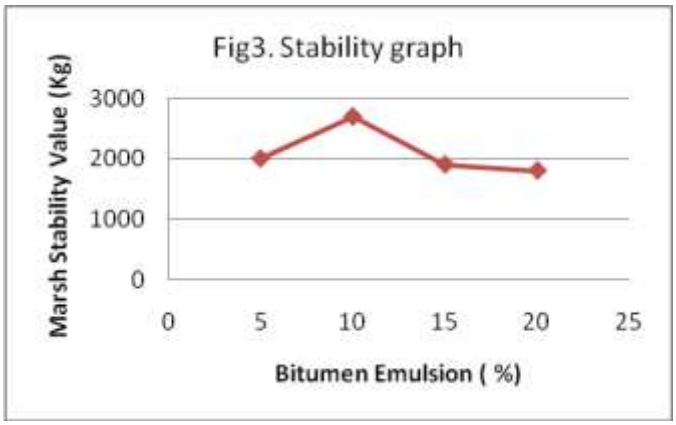
1. Binder content corresponding to maximum stability

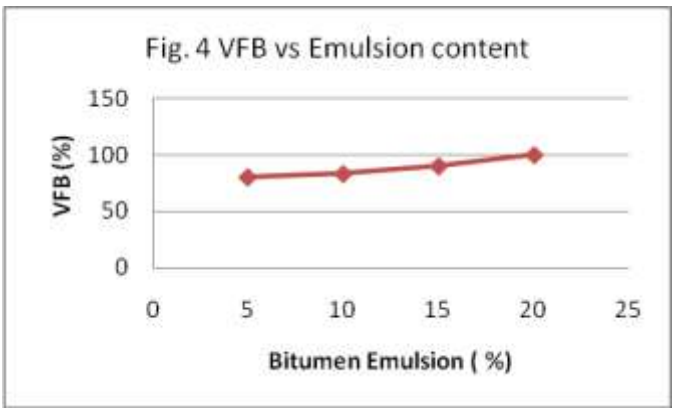
2. Binder content corresponding to maximum bulk specific gravity ($G_m$)

3. Binder content corresponding to the median of designed limits of percent air voids ($V_v$) in the total mix (i.e. 4%)



## CONCLUSION

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. Cold mix can be tried for paving mix in north east region of India. Optimum binder content for mix design is 10%.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. It is economical and high production is possible with low investment.

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