# STUDIES ON LAB PERFORMANCE EVALUATION AND CRITICAL RE-EXAMINATION ON BITUMINOUS CONCRETE MIXES

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## ABSTRACT

Road network in India aggregates to about 4.2 million kilometers. This extensive road network, the second largest in the world only after US, caters to about 65 per cent of the freight traffic and 87 per cent of the passenger traffic. National Highways (NH) constitute about 70,934 kilometers which is only 2 percent of the total network. However, it caters to nearly40% of the total road traffic. The important highways in India are built by Dense Bituminous Macadam (DBM) or Bituminous Concrete (BC). In India Marshall Method is adopted for designing bituminous mixes where specimens are prepared using Marshall Hammer. Another major concern for distress of road surface is overloading of commercial vehicles and increased traffic density. Compaction plays a vital role in performance of a bituminous mixes. In the present study, Polymer modified bitumen is used as a binder in Bituminous Concrete Grading I mix, also the engineering properties of the bitumen and physical properties of aggregates have been determined. The Hugo Hammer was used to simulate the field condition in the laboratory because the compaction achieved by it is alike kneading action. The optimum bitumen content for Polymer Modified Bituminous Concrete mix has been determined by Marshall Method of mix design by casting the specimens using Hugo hammer. Marshall Properties have been obtained at optimum bitumen content. Indirect tensile strength test has been conducted on Polymer Modified Bituminous Concrete mix by varying number of blows for compaction.

*Keywords: Bituminous Concrete, Hugo Hammer, Marshall, Polymer Modified Bitumen*

## 1. INTRODUCTION

Flexible pavements are the most common pavement structure. The surface course of the structure is bituminous mixture. In India, approximately 98% roads are flexible types, probably because of economy. There are two million miles of paved road-ways in India. The performance of a bituminous mixture depends on external and internal conditions; the external conditions being traffic load and environmental and the internal conditions being properties of the materials, structure of the mixture, design of the mixture, and process of the construction. Bituminous mixture consists of bitumen binder, aggregates and air voids. The properties of a bituminous mixture depend on the mix design proportions. In India Marshall Method is adopted for designing bituminous mixes where specimens are prepared using Marshall Hammer. Compaction effort generated by Marshall Hammer does not simulate the field compaction effect which leads to aggregate degradation. Compaction plays a vital role in performance of bituminous mixes. The drawback of Marshall Procedure is the number of blows given to compact the specimen is fixed. The conventional compaction effort by Marshall Method which is75 blows is not adequate to examine the field condition in laboratory. To achieve the field densities and compaction efforts an improvised Marshall rammer called as Hugo hammer, having indentations on the surface can be made use of or a much more appropriate method is to use the Super gyratory compaction.

### 1.1 OBJECTIVES

1. To determine the optimum bitumen content of Bituminous Concrete (BC) Mix prepared using Polymer Modified Bitumen and compaction procedures by Hugo hammer.

2. To assess the Marshall Properties of Bituminous Concrete Mix prepared using Polymer Modified Bitumen at optimum bitumen content by varying number of compaction blows using Hugo hammer.
3. To compare the Marshall properties of the specimen cast using Hugo hammer and the standard Marshall rammer at 75 Blows compaction effort.

## 1.2. NEED FOR STUDY

1. The compaction foot used in the Marshall method is not very appropriate to the field condition whereas Hugo foot stimulates the field condition.
2. The normal assumption done in the Marshall method is that density achieved during the test represents the actual density on the field after the pavement is allowed to the traffic movement. The severity of the movement of the traffic will be underestimated in this case.
3. Polymer modified bitumen can increase the various performance parameters of the bituminous mixes where as bitumen exposed to a wide range of load and weather conditions, however, does not have good engineering properties.

## 2. LITERATURE REVIEW

A good road network is a critical infrastructure requirement for rapid economic growth. It provides connectivity to remote areas; provides accessibility to markets, schools, and hospitals; and opens up backward regions to trade and investment. Roads play an important role in inter-modal transport development, through links with airports, railway stations, and ports. An axle load survey indicated that about 73 percent of the commercial vehicles moving on the national highways in the eastern sector of India have axle loads in excess of the standard axle load of 8.2 tonnes and about 65 percent exceed the legal limit of axle load of 10.2 tonnes. Also, large variations in seasonal and daily temperatures are responsible for the early deterioration of flexible pavements Shivangigupta et.al [1]. Although the Marshall compactor is still the most frequently used compaction method, it produces samples that differ considerably from in situ material. But this method lacks the mechanical properties of mixes manufactured using different compaction devices have been widely studied. Methods of laboratory compaction include static, impact (Marshall), vibratory, kneading, gyratory and roller (rolling wheel). Performance properties influenced by compaction methods are fatigue, stiffness, and permanent deformation. A. M. Hartman et.al [2].

## 2.1 COMPACTION

Kiran Kumar et.al [3] suggests that the quality of bituminous pavement to greater extent depends upon the degree of compaction. Depending upon the degree of compaction, the strength, durability and stability of the bituminous pavement vary with variation in compaction. The objective and sufficiently accurate control on the degree of compaction appears to be the most important factors. R.Sridhar et.al [4] Hugo hammer has a rotation base of 100 mm diameter with indents on the face of hammer. Indents that are 3.2 mm in depth with an angle measuring 30° each provide shearing action to the mix, thereby providing enough room for re-orientation of aggregates and simulating the field condition. Marshall Samples prepared using Hugo hammer has shown higher densities that are closer to the field compaction. The compaction for 75 blows is done by rotating the base for the first 60 blows and the remaining blows by the conventional rammer.

## 3. EXPERIMENTAL INVESTIGATIONS

The mix design selected for the present study is bituminous concrete - grading I (BCI).the aggregate gradation is selected as per MoRTH (Ministry of Road Transport and Highways) Specifications (2004)Marshall methods of mix design was followed.

## 4. LABORATORY INVESTIGATIONS

### 4.1 Aggregate

The aggregates used in the present study were tested and found to meet MoRTH (Ministry of Road Transport and Highways) Specifications (2004). Coarse aggregate, fine aggregate and hydrated lime was used in the BC I mix. The properties of aggregates are given in Table 1

**Table 1. Physical Properties of Aggregates**

| Properties | Values obtained | Specifications |
|---|---|---|
| Impact value(AIV) in % | 26.2 | 24% (Max) |
| Crushing value in % | 27.12 | <30% |
| Flakiness & Elongation index % | 30.3 | 30 % (Max) |
| Water absorption,% | 0.43 | 2 (Max) |
| Abrasion value (los Angeles),% | 30.04 | 30 (Max) |

### 4.2 Specific Gravity of the Materials used in the Present Study

**Table 2. Specific Gravity of Materials**

| Description of materials | Specific gravity. |
|---|---|
| Coarse aggregate | 2.67 |
| Fine aggregate | 2.75 |
| Dust | 2.82 |
| Filler (Hydrated Lime) | 2.35 |
| Polymer Modified Bitumen (PMB – 70) | 1.03 |

### 4.3 Binder

For the laboratory study binder modified with SBS (PMB 70) were considered in the present investigation. The physical properties of binders are given in Table 3.

**Table 3. Binder properties**

| Designations | Values obtained (PMB 70) | Requirements (PMB 70) | Method of Test. |
|---|---|---|---|
| Penetration at 25º , 5 sec | 62.17 | 50-70 | IS : 1203-1978 |
| Softening Point, (R&B) ºC, | 72.5 | 55 (Minimum) | IS : 1205-1978 |
| Ductility at 27ºC,cm | 87 | +60 (Minimum) | IS : 1208-1978 |
| Flash point , ºC, | 285 | 220 (Minimum) | IS : 1209-1978 |
| Elastic recovery at 15ºC | 80 | 75 (Minimum) | SP-53-2002 |
| Viscosity at 150º C, Brook Field viscometer | 5 | 2-6 | ASTM - D- 4402 |
| Separation, difference in softening point, ºC. | 1.5 | 3 (Maximum) | SP-53-2002 |

## 5 STUDIES ON MARSHALL PROPERTIES OFBITUMINOUS MIXES

The purpose of the Marshall test is to determine the optimum binder content for a particular blend of aggregates and bitumen.. The stability, flow, bulk densities, air voids and VFB are plotted versus bitumen content. The specimens used for the determination of Marshall Properties were casted using Hugo hammer. Hugo hammer shall have the diameter of 100mm, 3.2mm Indents at every 30°. After every 10 blows the mould or the hammer face is rotated by an angle by 30°. Table4 gives the Marshall properties of the PMB mix at OBC. Figure 1 to Figure 6 shows the Marshall properties of the materials for various compaction efforts in combined form.

**Table 4. Marshall properties at OBC**

| Properties<br>Number of blows | Marshal stability (kgs) | Bulk density (g/cc), Gb | Flow(mm) | Total air Voids (%) Vv | Voids Filled with bitumen (%)VFB | Voids in Mineral Aggregates, (%)VMA |
|---|---|---|---|---|---|---|
| 50 | 1358.172 | 2.390 | 4.10 | 4.061 | 75.664 | 16.688 |
| 75 | 1669.547 | 2.3941 | 3.87 | 4.20 | 74.250 | 16.31 |
| 100 | 1705.104 | 2.402 | 3.73 | 3.90 | 75.62 | 16.01 |
| 150 | 1965.112 | 2.405 | 3.53 | 3.80 | 76.072 | 15.89 |
| 200 | 2093.04 | 2.408 | 3.46 | 3.84 | 75.431 | 15.63 |
| 600 | 2307.604 | 2.423 | 3.10 | 3.61 | 75.68 | 14.85 |
| 75 Normal | 1608.128 | 2.392 | 3.60 | 4.09 | 75.219 | 16.50 |

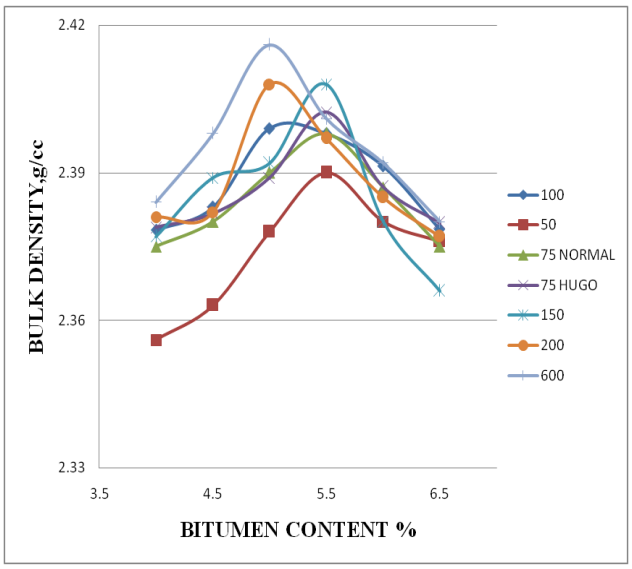


**Fig1** Bulk Density Vs Binder content

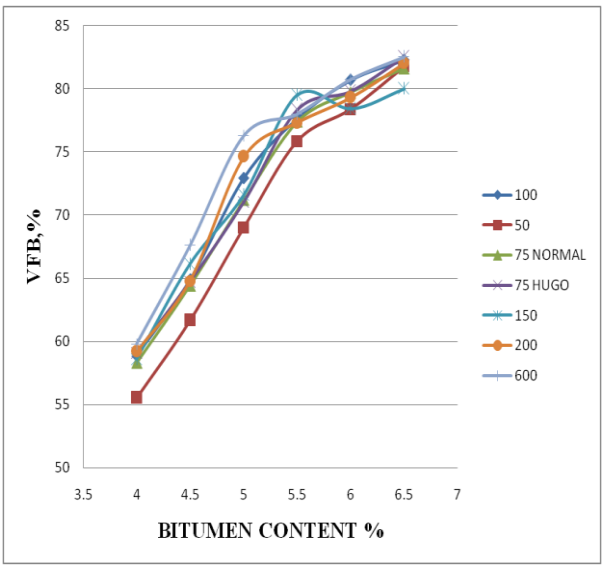


**Fig2** VFB Vs Binder content

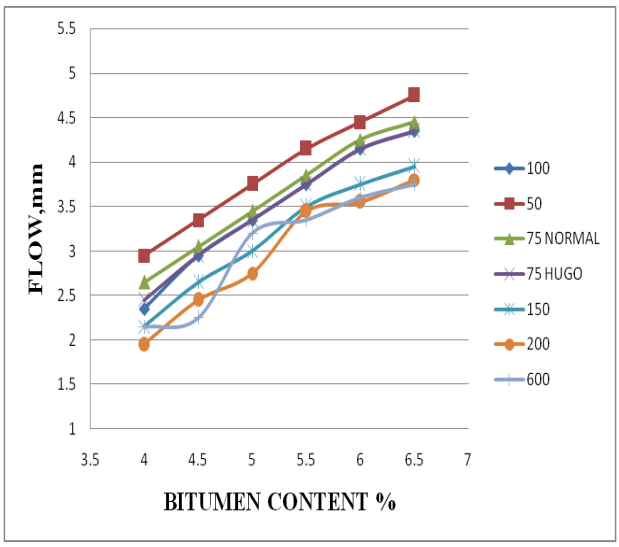


**Fig3** Flow Vs Binder content

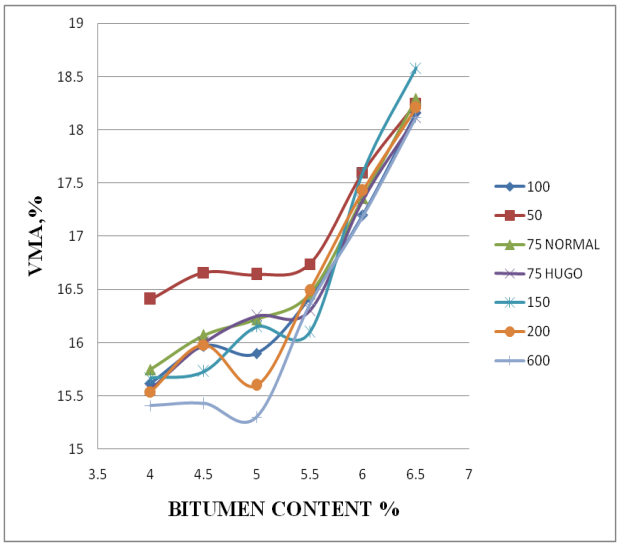


**Fig4** VMA Vs Binder content

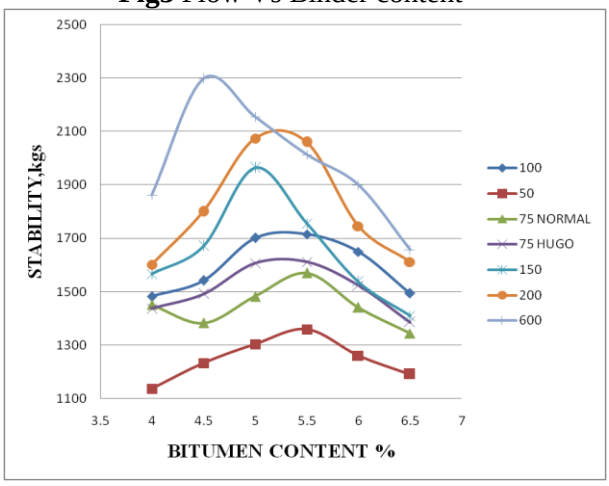


**Fig5** Stability Vs Binder content

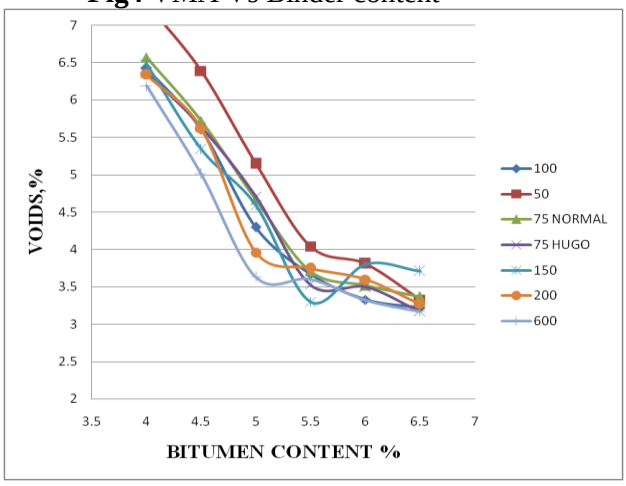


**Fig6** Voids Vs Binder content

**Studies on Indirect Tensile Strength**

The indirect tensile strength of different compaction energy is tested for bituminous concrete mix with different binder is shown in Figure 7

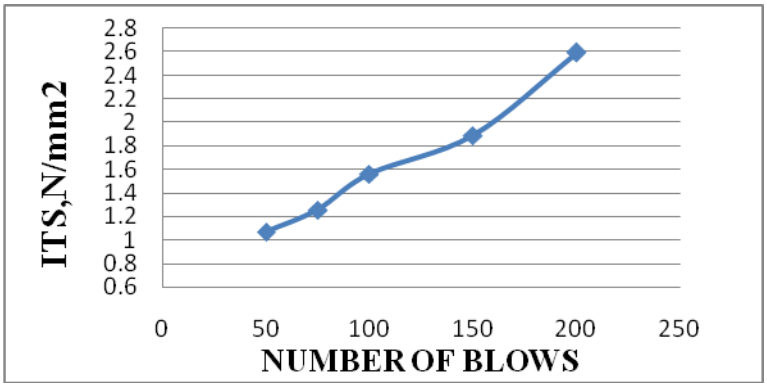


**Figure 7 The variation of ITS with Number of Blows**

The Indirect tensile strength test from the Table 4.17 shows that as the compaction energy increases from 50 to 200 blows the ITS value in $N/mm^2$ has increased.

## RESULTS AND CONCLUSIONS

The experimental investigation has proved that the increase in the compaction energy shows a increase in the bulk density and decrease in the air voids level. The density has increased by 0.57% from 75 blows to 200 blows. The Va has decreased by 0.36% from 75 blows to 200 blows. The stability has increased by 20% from 75 blows to 200 blows. The flow has decreased by 0.41mm from 75 blows to 200 blows. From analyzing the results, the following can be concluded:

1. The variation in the Marshall properties plotted with binder content shows a different trend line for Hugo hammer compaction as compared to the normal Marshall Rammer compaction
2. The bitumen content at the maximum bulk density is lesser than that for specimen compacted using Marshall Rammer
3. The stability of the mix prepared with Hugo hammer has increased when compared to that of the Conventional Marshall Rammer.
4. The binder content of the specimen casted by Hugo hammer has decreased when compared to that of the Conventional Marshall rammer.

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