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# Properties of Warm Mix Asphalt and Synthetic Zeolite

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**Abstract**
A number of processes have been developed to reduce the mixing and compaction temperature of hot mix asphalt (HMA). The mixing and compaction temperature of HMA usually range from 275-325 F. Its use in pavement of roads leads to large consumption of energy and emission of green house gases and other pollutants to atmosphere. Warm mix asphalt is a recent technology used for pavement of roads which utilises relatively low mixing and compaction temperature than HMA. Its use in pavement of roads reduces energy consumption, green house gas emission and asphalt oxidation. It also increases paving season and hauling distance for a better work environment.
**Key Words:** HMX, WMA, IRC, Temperature, Fuel, Consumption, Zeolite.

## 1. Introduction of WMA

Although new to the Pacific Northwest, WMA has been used in Europe successfully for more than 15 years. In 2002, the National Asphalt Paving Association first brought warm mix asphalt technology to the United States and generated significant interest in the U.S. market. Recently the Federal Highway Administration and National Asphalt Paving Association formed the WMA Technical Working Group, whose aim is to check and validate WMA technologies and to implement WMA policies and practices that contribute to a high quality and cost effective transportation infrastructure. As a result of this, various WMA projects have been tested across the United States and recent topics of research includes long term performance, thermal cracking, short and long term aging effects, and additive usage and performance grade binder specifications.

## 2. WMA Technologies

Recently various technologies available to increase the workability at lower temperatures for the production of WMA. Most technologies involve the addition of chemical or plain water additives to emulsify or foam the oil, allowing a reduction in viscosity and an evenly coating of the aggregate mix.

Any of the following WMA technologies can be used:

• Organic additives (including waxes)
• Water-bearing Zeolite
• Water-based foaming processes
• Emulsion-based processes

## 3. Importance Of Using WMA

The importance of using WMA can be categorized into 3 categories: economic, operational and environmental:

**Reduced Fuel Consumption:** The main advantage of WMA is the reduction of mixing and compaction temperatures as compared to HMA, there is significant reduction in the usage of fuels

**Late season paving:** Since WMA is compacted at lower temperatures, the mix can be produced at lower temperatures and can therefore remain compatible for a longer period of time.

**Better Workability and Compaction:** WMA provides better workability at lower temperatures due to the addition of additives. Better workability also results in better compaction.

**Reduced Emissions of Greenhouse Gases:** By using WMA it is possible to reduce the gaseous emissions since the quantity of fuel used in WMA is significantly less.

**Better Working Conditions:** The reduction in the mixing and compaction temperature causes a visible reduction in the smoke and odor and may thus result in improved working conditions.

## 4. Synthetic Zeolites As Additives

Zeolites are crystalline, micro porous and hydrated alumino silicates that are built from an infinitely extending three dimensional network of [SiO4] and [AlO4] tetrahedral linked to each other by the sharing of oxygen atoms. Usually, their structure can be considered as inorganic polymer built from tetrahedral TO4 units, where T is Si4+ or Al3+ ion. Each O atom is shared in between two T atoms.



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Zeolites are silicate frameworks with structures having large empty spaces that can include large cations such as calcium and sodium. These empty spaces may also allow the presence of large cations groups such as water molecules. Zeolites have the property to lose or absorb water without any change in crystal structure. Heat releases the water present in zeolites.When Zeolites is added to the mix as the binder, water gets released. This released water creates an expansion of binder that results in foaming of asphalt and increase in workability. This also helps in coating of aggregates at lower temperature.

Figure 1: Synthetic Zeolites used

## 5. Experimental works

### 5.1Sieve analysis

Sieve analysis was done and aggregates of appropriate sizes were collected and stored in place with sizes as per IRC gradation for SMA and DBM mix. The coarse aggregate, fine aggregate, and the filler should be mixed according to specified proportion so as to fulfill the requirements.

### 5.2 Sample preparation

#### 5.2.1 Weighing of sample

For SMA, 3 samples for each binder content of 5%, 5.5%, 6% were prepared. For DBM mix, 3 samples for each binder content 4%, 5%, 6% were prepared. The sample weight was recorded.

#### 5.2.2 Aggregate heating

For particular binder content, SMA and DBM samples were heated at 110 for 2 hours in oven. An overheating of sample was avoided

Figure 2: Heating of aggregates and filler mixture in oven

#### 5.2.3 Bitumen heating

At a high temperature, 40 grade bitumen was heated to melt down and liquefy which would be used for mixing.

Figure 3: 40 grade bitumen used



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Figure 4: Heating of binder

### 5.2.4 Mixing

All components (aggregate, filler, bitumen and zeolite) are mixed properly to make a homogeneous SMA and DBM mixture.

Figure 5: Mixing of aggregates, bitumen, Zeolite and filler

### 5.2.5 Placing in mould

For preparation of samples, the mixture prepared was put in moulds. The mould is a cylindrical mould made of iron having a diameter of 10 cm.

Figure 6: Marshall Mould

### 5.2.6 Compaction with standard hammer

After putting in mould, hammering was done. A standard hammer was used. Usually hammering was done by giving 75 blows to each side of specimen. In this research each sample was given 75 blows each on both faces. For hammering, mould was attached to a fixed arrangement to make sure that mould is not moved during hammering. A piece of paper was put in the mould over-fitting so that mix is not stuck to arrangement.

Figure 7: Hammer used for compaction



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### 5.2.7. Removing sample from mould

After the sample is cooled down, it is removed from the mould very carefully. Now stickering of each sample is done for distinguishing.

Figure 8: Sample left to cool down

## 6. Measurement of Physical properties

Now dry weights of samples were measured. Weight of sample in water is also required. Because sample has voids so water may enter in voids. To prevent that wax was melted and was coated around the sample by immersing the sample in wax container by holding it through a thread. Once the sample was dipped fully in wax it is allowed to cool so that wax is sticked to sample properly. After wax coating the weight of waxed sample is measured. Now weight of sample in water is also recorded. After all this, the sample is put in water bath before testing up to a maximum of ½ hours. In water bath temperature of 60 C is maintained throughout. If sample is heated more, then the wax may get stripped off. So overheating is avoided.

Figure 9: Samples before and after wax coating

Figure 10: Samples kept in hot water bath

## 7. Marshall Test

This test is performed to measure the resistance to plastic deformation of a compacted cylindrical sample of bituminous mixture when the sample is loaded diametrically at a deformation rate of 50 mm / minute. There are two major features of the Marshall method of mix design, (i) density-voids analysis and (ii) stability-flow tests. The stability of the mix is defined as the maximum load in KN carried by the specimen at a standard test temperature of 60°C and the flow value is the deformation that the sample undergoes during loading up to the maximum load. Flow value is measured in 0.25 mm units.

### 7.1. Procedure

1. The rods and inner surfaces of the test head segments prior to conducting the test are thoroughly cleaned.
2. Guide rods are lubricated so that the upper test head segment slides freely over them and excess water from the inside of the head segments is wiped off.
3. A sample from the water bath is removed and placed in the lower segment of the testing head. The upper segment of the testing head is placed on the sample and the complete assembly is paced in position in the loading machine.



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4. Then the dial gauge is placed in position over one of the guide rods. The time elapsed from removal of the test specimens from the water bath to the final load determination should not exceed 30 .The readings of dial gauge and proving ring are recorded. In this case 36 divisions of proving ring were equal to 100 kg.


Figure 11: Marshall Test apparatus

Figure 12: Marshall Test being conducted with the Marshall apparatus

| Bitumen | Coarse Aggregate | Fine Aggregate | Cement | Stone dust | Synthetic Zeolite |
|---|---|---|---|---|---|
| 1.08 | 2.75 | 2.75 | 3.15 | 2.63 | 2.3 |

Table 1: Specific gravities of material components

| BITUMEN CONTENT (%) | STABILITY (KN) |
|---|---|
| 5 | 10.86 |
| 5.5 | 13.17 |
| 6 | 11.47 |

Table 2: Average stability and Bitumen content for SMA samples



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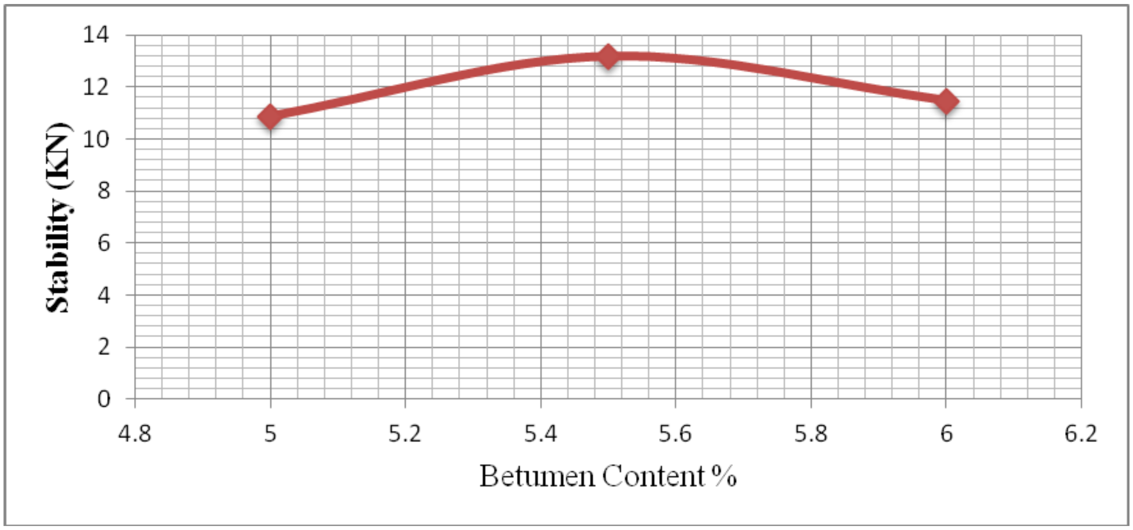


Figure 13: Average stability vs. Bitumen content for SMA samples

| BITUMEN (%) | stability(KN) |
|---|---|
| 4 | 11.08 |
| 5 | 12.48 |
| 6 | 10.27 |

Table 3: Average stability and Bitumen content for DBM samples

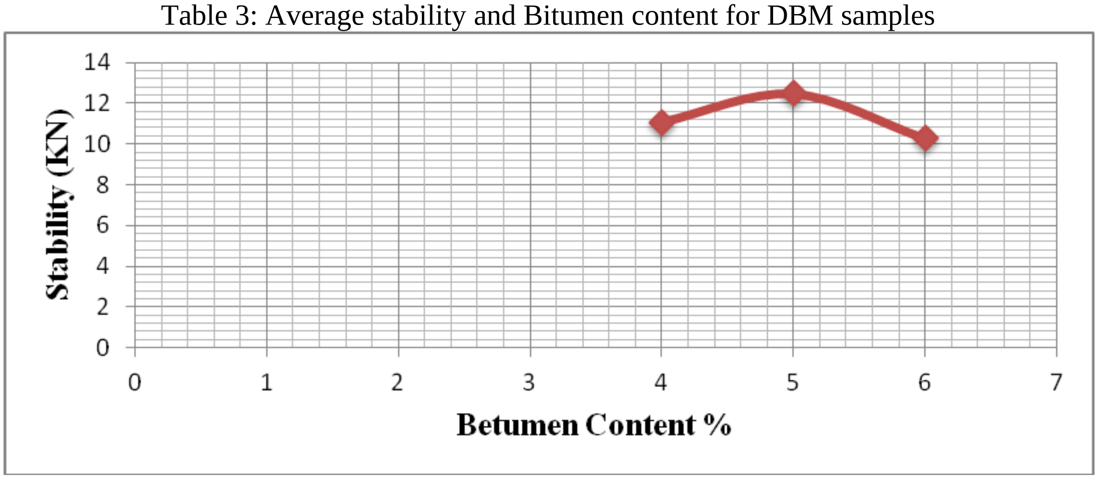


Figure 14: Average stability vs. Bitumen content for DBM samples

| BITUMEN CONTENT (%) | flow value(mm) |
|---|---|
| 5 | 2.46 |
| 5.5 | 2.53 |
| 6 | 2.83 |

Table 4: Average flow value and Bitumen content for SMA samples



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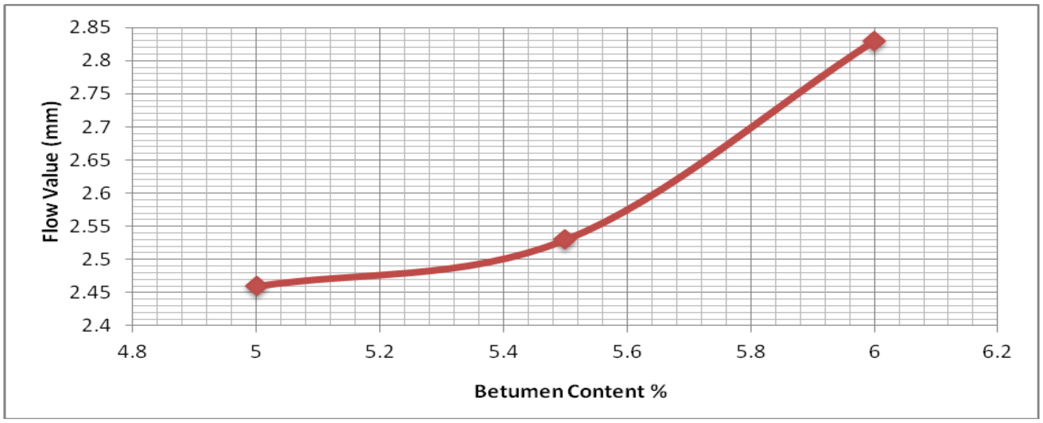


Figure 15: Average flow value and Bitumen content for SMA samples

| BITUMEN (%) | flow value(mm) |
|---|---|
| 4 | 2.1 |
| 5 | 2.3 |
| 6 | 2.86 |

Table 5: Average flow value and Bitumen content for DBM samples

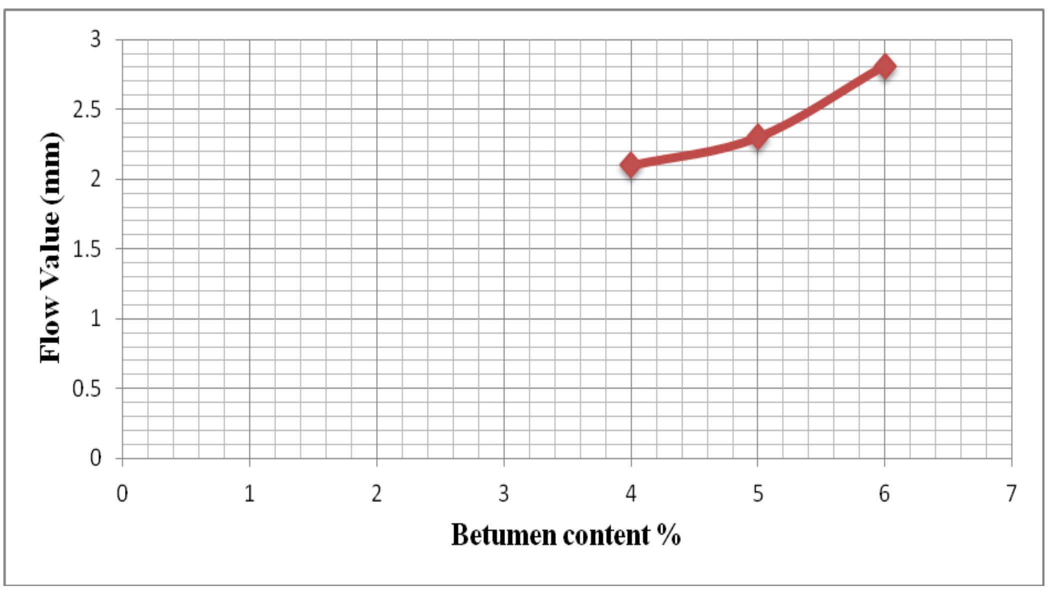


Figure 16: Average flow value vs. Bitumen content for DBM samples

## 8. Conclusion

The WMA samples were prepared using varying bitumen content of 5%,, 5.5%, and 6% and SMA samples were prepared using bitumen content of 4%,5%,6% at a temperature of $110^0$C . This was done to find out the effect of increasing bitumen content on the stability value. The plot obtained also helps us to find the Optimum binder content for this mix. The plot indicates that the stability value increases initially with increase in bitumen content but then decreases gradually.

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