

## **Effect of Grades of Binder on Properties of WMA Mixes**

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**Abstract—** WMA(Warm Mix Asphalt) technology is an emerging technology in today modern world which gives us better results as compared to traditional hot mix. In this an additive/chemical is added(Bitubuild WM) to the mix which gives us higher density and high strength. A total of 56 samples were made and various properties were studied such as Voids Filled With Bitumen(VFB),VMA(Voids in Mineral Aggregate), Marshall Stability Value, Flow value etc. As it requires less production temperature and lesser mixing time as compared to conventional hot mix consumption of fuel is reduced Also it produces less carbon emissions thereby making it eco friendly.

**Keywords—** Warm Mix Asphalt, Hot Mix, VFB, VMA, Flow Value.

### **I. INTRODUCTION**

As many cities in the world have come under the clouds of poor air quality produced due to carbon emissions, there is a need to protect the earth by developing some suitable technology which should be eco friendly. And the emerging technology comes into existence namely Warm Mix Asphalt which is a substitute to Hot Mix Asphalt (HMA)

Warm Mix Asphalt means an additive is added to the bitumen through which the necessity of higher production temperature and mixing time is lowered thereby requirement of fuel consumption is reduced and hence it is energy saving technology too. There are some additional benefits such as reduced green house gas emissions, fumes and odors generated at the plant and site.

### **II. BENEFITS OF WMA**

To make WMA a better substitute in place of Hot Mix, we need to know its advantages :

- Environment Friendly:- As it is having very less amount of carbon content, hence in this emission of volatile as well as non volatile organic compounds gets reduced.
- Economy:- This technology involves less temperature than the traditional hot mix asphalt. So less temperature is required, less energy is required to heat the mix, less fuel(reduction is almost 20%) is needed to produce WMA. So In this way cost is reduced.
- Better Performance:- WMA helps to achieve proper density and pavement performance gets improved.
- Durability:-As we know that less temperature is required for WMA production, so premature ageing of binder does not take place. In this way life of the pavement gets increased and requirement of maintenance gets reduced.
- Haul Distances:- Viscosity of the binder gets reduced in this technology, so it can be applied at longer distances with improved workability and reducing risk of compaction troubles.
- Longer Paving Season:- As we know that difference between ambient temperature and production temperature is small, hence it can also be used in cold climate regions.
- Compaction:- Compaction becomes easier in warm mixes as compared to control mixes.

### **III. WMA TECHNOLOGY**

Warm Mix Asphalt is different from Hot Mix Asphalt. Its production temperature generally varies from (100 to 140) degree Celsius temperature whereas for HMA it lies b/w (150 to 170) degree Celsius. The Warm Mix Asphalt has distinct advantages over Hot Mix Asphalt and they are:-

- As we know the temperature required is low as compared to HMA, chances of air pollution due to fumes and emission is relatively low.
- It requires less compactive effort so as to achieve specific compaction level.
- The manufacture of WMA is simple and does not require any major modification to the hot mix plant system. Major ingredients are patented products but the manufacturing processes are somehow different. Given below are the processes that are involved in manufacturing of WMA.

- One suggested way of manufacturing WMA is that, fine powder is added which get released upon heating and makes the binder workable at a temperature range of (130-140) degree Celsius by generating foam effect to binder.
- Another way is that in which WMA production involves a two stage process. In the first stage, aggregate surface gets covered by a specially manufactured soft asphalt binder @ (100-120) degree Celsius. In the second stage, harder grade of asphalt binder is added in powder, in foam, in emulsion form to the precoated aggregates.
- In another processes, organic additives are mixed along with asphalt binder which then gets melted about 100 degree Celsius and hence viscosity-temperature behavior of the binder gets changed, hence making the binder to be workable at lower temperature of 90 degree Celsius.

Hence at lower temperature range i.e. @ (80-90) degree Celsius, the final mixture can be compacted.

Warm Mix Asphalt seems to be quite promising. It consumes 30% less energy, making carbon dioxide emission less than 30%, reduces dust emission by 50-60% as compared to Hot Mix Asphalt. This technology does not involve any major modification to the mixing plant as well as the construction procedure. Further research is needed so as to calculate the expected field performance of mix and its parameters such as rate of gain of structural strength after construction, resistance against rutting.

- **Organic Additives:** These are the compounds of hydrocarbons of high molecular weight. When such compounds get added to binder, viscosity of the mix gets decreased beyond melting point and when it cools down, it solidifies increasing the stiffness of binder.
- **Chemical Additives:-** These are emulsifying agents, surfactants and polymers which helps the binder by improving their coating, workability and ease of compaction by reducing frictional forces at the interface between aggregates and the bitumen. Eg. Evotherm, Rediset.
- **Hybrid Technology:-** It consists of two or more WMA technologies using a chemical admixture along with water injecting system and hence improving the coating of aggregates at relatively lower temperature. Eg. Low energy asphalt.

#### **IV. WARM MIX CHEMICALS**

- **Evotherm:-**It is a warm mix asphalt technology which is water free that is designed to allow the production and compaction of high quality asphalt pavements at lower temperatures when compared to HMA. It increases the adhesion between asphalt and aggregate
- **Zeolites:-** Zeolites are silicates which is mainly used to soften the water . It is a large vacant structure and is described by its ability to loose or absorb water and care is being taken so that crystal structure is not disturbed.
- **Sasobit:-** It is a result of Sasol wax produced through the natural gas by polymerization. It is a long chain available in form of crystals and fibres whose melting point is 99°C generally which gets dissolved fully in asphalt binder at a temperature greater than 115°C, as a result of which viscosity is reduced and its behavior becomes like flow modifier. The recommended dosage is 1.5% by weight of bitumen content.
- **Advera:-**It is in powder form and a compound of aluminosilicate and does not affect the performance of binder. It reduces both temperature and emission by (10-20%) and emission by 60% respectively at the site.
- **Cecabase RT:-** It is an organic additive which is used as an additive in the production of WMA. Adding a liquid surfactant into the bitumen, the temperature of WMA gets lowered and paving process up to 40°C.
- **Rediset:-** It not only allows the processing of asphalt mixes at lower temperatures but also allows the compaction of asphalt mixes. It provides to resistance to ageing and water.
- **Warm-Foam:-** WAM foam is a product which is formed by using two separate binder components in the mixing stage.
- **Revix:-** It is a chemical additive that allows reduction of temperature of about (15-30) degree Celsius as compared to that of traditional HMA mixture.

#### **V. CONCLUSIONS**

From the above study it have been made clear that WMA technology requires less production temperature(120°C-130°C) and also requirement of mixing time is also less as compared to conventional HMA technology. The traditional method i.e .HMA (Hot Mix Asphalt) requires the temperature in the range of 150°C -180°C. Also the other aim was to achieve desired binder viscosity so that coating of aggregates at lesser production temperature can be done without making any compromise on its quality.

With lowering the production temperature, some benefits can also be achieved. As HMA technology requires higher production temperature and longer mixing time, it make an impact on environment by emitting harmful carbon emissions, odors and other particulate matter thereby impacting both environment and public health. With lowering the mixing time and production temperature the above mentioned harmful impacts can be minimized.

## **VI. GAPS**

- The technology is new. Thus need to be practiced more in India as most of the investigation has been carried out outside India.
- No particular specifications are studied for different grades of binder.
- No specific study is carried out at secondary level for determining the retained stability of mixes.
- Chemicals used in warm mixes production are not locally available, making it inefficient.
- Rutting potential can be improved with a help of considerable decrease in temperature.
- Very less study for variation in aggregates, its shape and size, moisture content for suitability for WMA has been done.

## **VII. REFERENCES**

- [1]S.D. Capitaov et al. ; gave a brief overview about the uses of warm mix technology. The author discussed the benefits of WMA w.r.t aspects of environment as it aims at saving energy, reducing emissions and construction process is generally easy without reducing the service performance.
- [2]M. Carmen Rubio et al ; gave an overview of the different technologies used in production of WMA and the author also discussed WMA advantages that are not related to reduction of gas emissions. It can be manufactured or produced by three processes ; organic additives, chemical additives and water containing foaming processes. Their general aim is to reduce the bitumen viscosity, hence improving the workability, produces fewer emissions and thereby creating better working conditions.
- [3]Zhanping You, P.E. et al ; In this author has discussed about the evaluation of low bituminous binder , properties of Warm Mix Asphalt, Extracted and recovered RAP(recycled asphalt shingle (RAS)) and RAS (reclaimed asphalt pavement (RAP) and Bioasphalt. Also, the author has also presented the low temperature performance of energy efficient as well as environmentally friendly WMA paving materials. Bioasphalt was produced from swine waste and used to modify PG 64-22(it is a performance grade where 64 is the average seven day maximum pavement design temperature whereas 22 is the minimum pavement design temperature ) asphalt binder. Advantage of using Bioasphalt is that it can enhance low temperature asphalt binder performance.
- [4]Gui-juanZhao et al; In this the author has discussed about the Workability of Warm Mix Asphalt after addition of Sasobit Warm Mixture asphalt. He computed the workability of Sasobit Warm Mixture Asphalt in different temperature and frequency and compared with Hot Mixture Asphalt. He concluded with the statement that when the mixing temperature of Sasobit Warm Mixture Asphalt was reduced 30°C then we attain the workability of Sasobit Warm Mixture matched the workability result of Hot Mixture Asphalt.
- [5]Yuan Deming et al; the author has discussed the various benefits such as it is temperature susceptible and strong stability. It was also concluded that while using crumb rubber in asphalt not only the bitumen properties got improved but also we could reuse the rubber as well as reduce the chances of environment pollution.
- [6]Mejias-Santiago et al ; the authors evaluated the Warm Mix Asphalt for the use on Airfield Pavements. Researchers of the US Army Engineer Research and Development Center and Mississippi State University compared the results of WMA mix with that of HMA using the same technologies(Evotherm 3G, Sasobit , and foamed asphalt) and the binder was PG 67-22. Authors stated that while performing tests three reclaimed-asphalt pavement (RAP) contents were used to study the incorporation of higher percentages of RAP in WMA than allowed in HMA., The WMA is a viable product for airfield pavement. However it becomes susceptible to moisture damage and rutting from traffic. So adding RAP(Reclaimed Asphalt Pavement) to WMA could be a better option. He gave a final conclusion that WMA with RAP is less susceptible to low-temperature performance problems as compared to HMA with RAP.
- [7]Ali Jamshidi et al ; The authors have highlighted the benefits of WMA while incorporating Sasobit in WMA . The WMA after adding Sasobit would be having energy saving potential, reduction in Green house gas emissions. They gave the conclusion that while adding Sasobit to WMA , temperature required for the mix is lowered as compared to the traditional Hot Mix Asphalt.
- [8]Shu Wei Goh et al ; the authors have discussed the advantages of WMA using Sasobit in Cold Regions. The main advantage of using sasobit in WMA in cold weather regions is that it has slower cooling rate due to very small temperature difference between ambient and production temperature. The authors collected the samples of HMA and WMA containing 1.5% sasobit from site and tested from Dynamic Modulus and Tensile Strength Ratios to evaluate WMA's Moisture susceptibility, fatigue and rutting potential. The results indicated that the moisture susceptibility was almost equal to HMA. However WMA was susceptible to fatigue failure but showed the high resistance against rutting failure than HMA.
- [9]H. S Jagadeesh et al , The authors have evaluated the various performance parameters of Bituminous concrete mix and Dense Bituminous Macadam with respect to stability, tensile strength and rutting characteristics after adding additives in Bituminous grade such as VG10,VG30. They also gave us the conclusion about the various benefits of WMA over HMA such as decreased emissions and fumes, decreased binder aging and extended paving season and it can be used at high

altitudes. They also performed the lab tests such as Marshall Method, Indirect Tensile test and rutting tests. Marshall stability test is used to determine the stability and flow properties of BC and DBM mixes. They also studied the uses of chemical additives Sasobit and Zycotherm which improved the stability, tensile strength and reduces rutting. The rutting characteristics were studied through immersion wheel trafficking test which have been prepared by varying the mixing temperatures and by adding additives. WMA was prepared both for BM and DBM.

[10]Duggal A.K. et al.; In this the authors aim was to find out the various advantages of WMA over HMA. They concluded that WMA is a better alternative to HMA due to its various benefits such as lower emission of carbon dioxide , energy saving and decreased binder ageing, paving in colder regions etc. The authors further gave the conclusion that with certain modifiers the properties of the bitumen could be increased such as the desired viscosity of bitumen could be achieved with (20-30)<sup>o</sup>C less temperature as compared to HMA.