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Laboratory Study on Use of RAP Material in WMA Pavement Using

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ABSTRACT- With the advent of new technologies, the use of Recycled Asphalt Pavement material (RAP) has gained increasing importance. Using RAP not only economises Asphalt production, but also decreases the demand for virgin material. The limit in the use of RAP proportion is restricted due to stiffness and workability issues related to RAP. This problem is addressed with the help of Warm Mix Asphalt (WMA) which increases the proportion of RAP used by producing mixes having same/better properties viz., better workability, reduced viscosity than Hot Mix Asphalt (HMA) at lower temperatures. The use of Rejuvenator has also improved workability of RAP- HMA mixes by rejuvenating the stiff binder of RAP. This study deals with the effect of Rejuvenator on WMA mixes produced with different proportions of RAP. In this study effect of varying proportions (Viz. 10%,15% & 20%) of Used-Mobile Engine Oil (Rejuvenator), used in conjunction with 0.5% Evotherm (WMA additive) was studied with different proportions of RAP. The Evotherm additive dosage of 0.5% by weight of bitumen and Rejuvenator dosage of 10%, 15% and 20% by weight of bitumen was taken on the basis of research by Hurley & Prowell 2006, and Zaumanis et al 2014 respectively. Laboratory study was conducted involving material characterization of Virgin and RAP material, followed by Mix design of Dense Bituminous Macadam (DBM) using Virgin and RAP Material. Various tests viz., Marshal Stability, Retained Stability, Indirect Tensile Strength, Unconfined Compressive Strength, Compactibility and Aggregate Coating were conducted on HMA and WMA Mixes prepared from virgin materials, and WMA mixes prepared with 20%, 40% and 60% RAP material. These tests helped in analysis and determination of Density, Voids, Flow value, Strength, Moisture Susceptibility, Aggregate Coating, etc. Based on the above analysis it was found that the optimum dosage of Rejuvenator for Warm Mixes prepared with 20%, 40% and 60% RAP material is 10%, 15% and 20% respectively. All the three RAP proportions with these Optimum dosages of Rejuvenator satisfied all the requirement of DBM mix (MORTH specification) prepared using Warm Mix technology. It was also found that upto 20% RAP material can be used to prepare WMA mixes even without addition of Rejuvenator and that the optimum bitumen content is reduced as RAP proportion is increased. This results in saving in the overall cost by lesser use of Virgin materials**.**

KEYWORDS- Hot mix Asphalt(HMA), Warm Mix Asphalt(WMA), Aggregate, Unconfined Compressive Strength Dense Bitumen Macadam(DBM)

I. INTRODUCTION

Recycling asphalt pavement initiates a reusing-materials cycle, which maximises the use of natural resources. Because it eliminates the requirement for raw aggregate, reclaimed asphalt pavement (RAP) is a beneficial alternative to virgin materials. It also cuts down on the amount of expensive new asphalt binder needed to make asphalt paving mixtures[1]. The recycling of bituminous materials has sparked a lot of debate and development during the last decade. While it is not a new concept, recent research appears to be in reaction to several countries' desire to reduce their reliance on imported crude oil and derivative products such as bitumen. In terms of global environment production, the current recycling development is environmentally safe and energy-saving. The exorbitant cost of extracting petroleum and raw materials has prompted scientists to look for novel materials capable of combining durability and performance at a low cost[2].

Environmental protection has become a key issue in transportation, especially asphalt manufacture, in recent years. Although hot mix asphalt (HMA) is commonly utilised around the world, some new research advise utilising a different procedure that lowers the temperature of asphalt mixtures during production and placement[3]. Warm mix asphalt (WMA) is a new technique that is largely employed in European countries [Wasiuddin et al 2007]. The goal of a blend like this is to provide strength and durability comparable to or better than HMA [Newcomb 2007]. Organic and chemical additions, as well as the use of water, are used to classify WMA technology. RAP is being used to prepare WMA mixes, and there is a lot of progress being made. However, more research into the various features of these combinations is required in order to assess their long-term performance[4].

The effect of varying the doses of RAP and Rejuvenator while keeping the dose of WMA additive constant on Marshal stability number, Flow value, Air voids, Indirect tensile strength, Aggregate Coating, Compactibility, Moisture Susceptibility, Bulk specific gravity, and Unconfined Compressive Strength must be investigated.
The study's goals are as follows:
1) Determine the best rejuvenator dose for different RAP ratios.
2) Determine the maximum RAP proportion with and without the Rejuvenator that meets the Marshal Quotient, Air voids, Flow value, Aggregate Coating, and Compactibility requirements.
3) Determine the RAP fraction that demonstrates the best mechanical qualities as Marshal Stability, Indirect Tensile Strength, and Unconfined Compressive Strength.

II. METHODOLOGY

The methodology has been divided into two parts:

A. Tests on Materials and Design for Warm Mix Asphalt

Aggregates, Sand, Stone Dust, and Bitumen (VG-10) were among the materials gathered. Following the acquisition of materials, they were characterised by a series of tests. On various sizes of aggregates, tests such as grading, impact, crushing value, abrasion, shape, soundness, specific gravity, and water absorption were performed (40 mm, 20 mm & 10 mm). Gradation, water absorption, and specific gravity were also studied on sand and stone dust. Penetration Value, Softening Point, Ductility, Specific Gravity, Flash and Fire Point, Absolute and Kinematic Viscosity were all tested on bitumen. Material characterisation aided in the creation of a WMA mix design**.**

B. Tests on RAP and Incorporation of RAP for Production of WMA Using Rejuvenator

The bitumen content of RAP was discovered after it was obtained. The number of virgin aggregates to be added to satisfy the graduation requirement of DBM with varying RAP material proportions was established after the RAP aggregates were graded according to DBM criteria. Chemical additive Evotherm (0.5 percent by weight of bitumen) was employed. Used-Mobile Engine Oil (UMEO) was applied as a Rejuvenator in three quantities, namely 10%, 15%, and 20% by weight of bitumen. For the above-mentioned doses of Evotherm and UMEO, mixes were produced with 20%, 40%, and 60% RAP, respectively. Specimens for Marshal Stability Test, Indirect Tensile Test, Unconfined Compressive Test, Compactibility, and other tests were made from the mixes.

III. CONCLUSIONS

The following conclusions are drawn from the study's findings and discussion:

- As the RAP proportion increases, the optimum bitumen content (OBC) for virgin materials decreases. With 20%, 40%, and 60% RAP material proportions, the OBC reduced from 4.66 percent to 3.73 percent, 2.80 percent, and 1.86 percent, respectively. However, for 20%, 40%, and 60% RAP material proportions, the overall bitumen content (RAP bitumen + Bitumen to be added) increased from 4.66 percent to 4.75 percent, 4.84 percent, and 4.92 percent, respectively.
- All RAP proportions, i.e. 20%, 40%, and 60%, meet the minimum Stability requirement of 9KN for DBM mix without Rejuvenatok, and with all Rejuvenator dosages, i.e. 10%, 15%, and 20%.
- The Marshal Stability of HMA and WMA mixes made with virgin materials was 1645.3 Kg and 1545.23 Kg, respectively. As the proportion of RAP increases, the stability declines. This could be caused to RAP material fatigue as it ages. When the proportion of RAP material (without Rejuvenator) was increased from 0% to 20%, 40%, and 60%, the stability dropped by 2.8 percent, 12.9 percent, and 21.4 percent, respectively.
- For the same RAP fraction, the Stability reduced as the Rejuvenator dosage was increased. The percentage drop in Stability for 20 percent, 40 percent, and 60 percent RAP material was 24.3 percent, 28.2 percent, and 24.6 percent, respectively, when the Rejuvenator dosage was increased from 0 to 20%.
- For a WMA mix without Rejuvenator, only 20% of the RAP fraction meets the Marshal Quotient criterion of 2–5 KN/mm. However, all RAP proportions (20%, 40%, and 60%) meet the Marshal Quotient requirement of 2 - 5 KN/mm for WMA mix with Rejuvenator (10%, 15%, and 20%).
- unconfined Compressive Strength (UCS) reduced as the fraction of RAP material increased, as did the dosage of Rejuvenator. For all three RAP material proportions, the percentage decrease in UCS with an increase in Rejuvenator dosage from 0% to 20% was greater than 50%.

IV. FUTURE SCOPE

However, more research is needed to determine the workability, fatigue, and rusting potential of warm mixtures made with various amounts of RAP material and Rejuvenator. Different WMA Additives, such as Sasobit, Zycotherm, Zeolite, and others, can be used in further research. Using a variety of rejuvenators such as used vegetable oil, used vegetable grease, organic oil, distilled tall oil, aromatic extract, and so on. By raising the RAP material proportion above 60%. By looking into the performance of RAP Incorporated's WMA mixes in cold climates.

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