© INTERNATIONAL JOURNAL FOR RESEARCH PUBLICATION & SEMINAR
ISSN: 2278-6848 | Volume: 13 Issue: 02 | April - June 2022
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Refereed & Peer Reviewed

A REVIEW PAPER ON PERFORMANCE OF WARM MIX ASPHALT COUPLED WITH RECLAIMED ASPHALT PAVEMENT

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ABSTRACT
Transportation is one of the most crucial measures of a country's progress. India, being a developing country, requires a well-developed road network to support its rapid socio-economic development. With improved exchange of goods, better road connection promotes faster growth. About 95% of roads in India are flexible roads. This paper aims at giving the brief review on performance of the flexible pavement when Warm Mix Asphalt technology is used in conjunction with the usage of Reclaimed Asphalt Pavement Material.
Keyword: Warm mix Asphalt, Reclaimed Asphalt Pavement, Flexible Road, Road Network

I. INTRODUCTION

Pavement can be divided into two types based on design considerations: rigid pavement and flexible pavement. Rigid pavement is designed to provide a slab of sufficient strength to resist traffic load, whereas flexible pavement is designed so that the load intensity reduces as the load is transferred to downward layers and spread over a larger area. A flexible pavement is made up of layers of compacted granular material of appropriate quality laid over a subgrade of bituminous or asphaltic material with aggregate. Upper layers are typically bituminous and account for roughly 70% of the total pavement construction cost. Bituminous pavement accounts for more than 95 percent of all road surfaces due to its low cost and ease of installation.

A. ABOUT WARM MIX ASPHALT

Warm Mix Asphalt (WMA) is a type of asphalt that is made and applied at a lower temperature than Hot Mix Asphalt. The following temperature-based classification of asphalt mixes has resulted from at least 30-degree temperature reduction. The reduction in temperature is achieved by the addition of some additives known as Warm Mix Asphalt additives.

B. ABOUT WARM MIX ASPHALT ADDITIVES

Warm Mix Asphalt additives can generally be broken down into three types figure 1 shows flow chart of types of Warm Mix Additives.

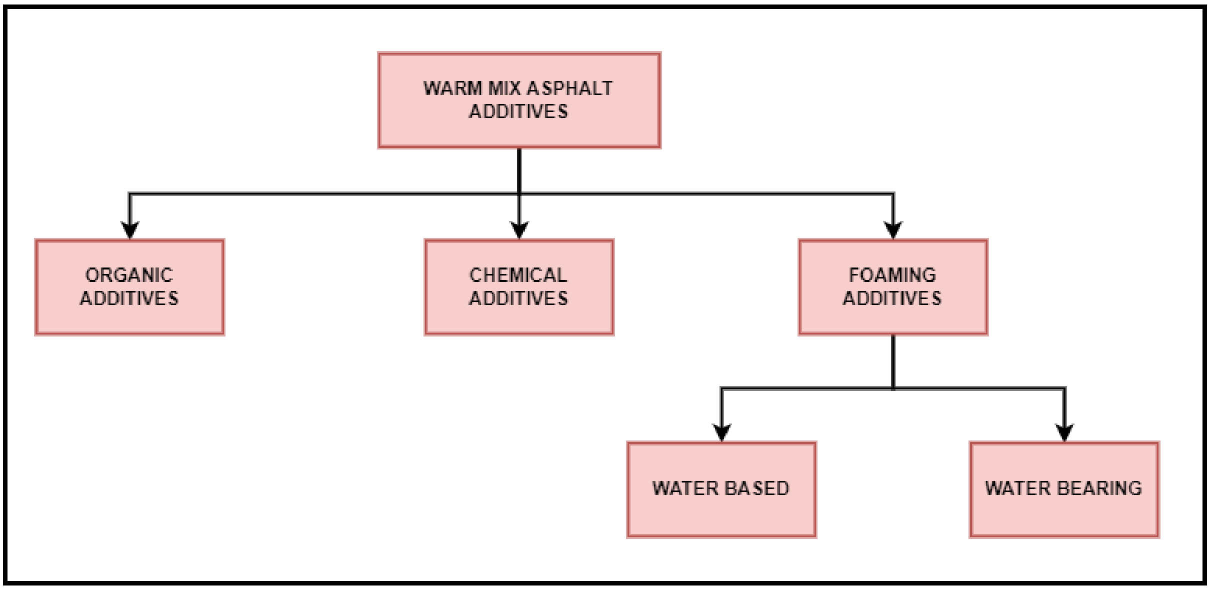

Figure 1 Types of warm mix additives

- **ORGANIC:** At temperatures above 90°C, various organic additives can be employed to reduce the viscosity of the binder (bitumen). A frequent ingredient is a particular paraffin wax made from natural gas conversion. Organic additions often reduce temperature by 20–30°C while also improving the deformation resistance of asphalt that has been changed.
- **CHEMICAL:** Chemical additions have no effect on the viscosity of bitumen. They function as surfactants at the tiny interface between the aggregates and the bitumen. At a range of temperatures, typically between 140 and 85°C, they regulate and reduce frictional forces at that interface. As a result, mixing the bitumen and aggregates and compacting the mixture at a lower temperature is conceivable. Chemical additions can lower the temperature of the mix and compaction by 20–40°C.
- **FOAMING:** Bitumen viscosity is reduced using a variety of foaming processes. Small amounts of water are introduced into the heated bitumen by a variety of methods. For a brief time, the water converts to steam, increasing the volume of the bitumen and lowering its viscosity. The bitumen's expansion helps it to cover the aggregates at lower temperatures, and the leftover moisture aids in the compaction of the asphalt on the job site. Temperatures in both production and paving can be decreased at the same time.

C. ABOUT RECLAIMED ASPHALT PAVEMENT

Every year, a huge amount of material is scraped from old, damaged pavements; this material is referred to as reclaimed asphalt pavement when it is reprocessed and utilized in new pavement (RAP). National roads and expressways make for 2% of the Indian roadways, or 31078 kilometres. If only BC is counted, the total amount of RAP material produced during the next five years will be roughly 1.52107 m3. This has a high material and economic value if reused after proper recycling, and it can be a viable solution to a range of challenges such as

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rising road levels due to periodic overlaying, material disposal, and depletion of high-quality natural resources.

II. LITERATURE REVIEWS

(Wasiuddin et al., 2007) in his study observed Reduced binder viscosity and improved binder grading without increasing viscosity suggest that the Sasobit additive reduces manufacturing temperatures in two ways (direct and indirect). It was also shown that as mixing and compaction temperatures decrease, rutting potential decreases. Adding the Aspha-Min additive, on the other hand, resulted in a lower reduction in rut depths.

(Taylor et al., 2010) proved that WMA could take longer to compact than HMA due to a larger compaction temperature range and the ability to compact more quickly at low air temperatures. After the laboratory performance of the mixture was examined, the AC-13 warm asphalt concrete test road was paved at low air temperature. The test road performed well in the field, demonstrating that Evotherm warm mix asphalt technology proved successful in China when used at low air temperatures.

(Calabi-Floody et al., 2020) presented a laboratory-scale analysis of gas emissions, as well as energy usage and production costs, of five varieties of WMA with natural zeolite added. The investigation revealed that all of the asphalt mixtures assessed reduced gas emissions and energy/fuel usage while maintaining a cost comparable to the control HMA. Furthermore, the benefits will be greater if the mixtures are made with RAP because of the energy and cost reductions; mixtures with RAP also have environmental benefits, such as lower emissions and the use of reclaimed asphalt pavement materials.

(Sun et al., 2019) centered on a laboratory investigation that used multiple stress creep and recovery (MSCR) and linear amplitude sweep (LAS) tests to assess the effects of two common WMA additives, wax-based and surfactant-based, as well as various high percentages (from 30% to 70%) of artificial RAP binder on the rutting and fatigue performance of asphalt binders. As a result, the inclusion of the RAP binder significantly improved the binders' rutting and fatigue resistance. However, when the RAP binder percentage was increased to 70%, the fatigue performance started to decrease.

(Lu et al., 2019) This investigation aimed to see if a rejuvenator designed for HMA could be utilized to make WMA using RAP. The rejuvenator's WMA with RAP combinations were compared to a control HMA and other WMA-RAP mixtures created using the Evotherm WMA additive. The results demonstrated that combining RAP with rejuvenators makes it feasible to create WMA. When RAP concentration is less than 50%, the mechanical behaviour of mixes does not alter much, regardless of the mixing method utilised, according to the study. However, when the RAP composition is 50% or more, a rejuvenator can be added straight to the RAP.

(Faheem Ahmed, Abboud Bechara, Coe Joseph, 2018) This study looks at the impact of six variables on mixture compaction and cracking resistance, including mixing/compaction temperatures, RAP content and source, WMA type, binder grade, and conditioning period. The results show that at 15% RAP WMA mixes meet volumetric limits at the warm production temperature level. However, at 30% RAP, a hot production temperature is required to achieve the same level of compaction.

(Valdes-Vidal et al., 2018) characterized the mechanical behavior of WMA mixture made with natural zeolite and various proportions of RAP for durable pavement construction. WMA combinations with natural zeolite can be manufactured at a temperature 20 degrees Celsius lower than standard HMA while still meeting design parameters, according to the findings. Similarly, recycled asphalt mixtures made with natural zeolite may be made at a lower temperature, displaying strong performance characteristics for application in sustainable pavement development.

(Kusam et al., 2017) used two different WMA technologies—Evotherm additive and foamed asphalt—to examine the workability and moisture reactivity of WMA-RAP asphalt mixtures. The researchers determined that a softer binder is necessary to develop high RAP-HMA combinations. The same binder can be used for high RAP-WMA combinations. For WMA combinations with the high RAP concentrations, additional anti-strip additive doses may be necessary to pass the moisture sensitivity criteria.

(Behbahani et al., 2017) In his paper, attempted to find the effect of warm mix asphalt additives on the qualities of WMA incorporating RAP was investigated, and the results were compared to the same graded HMA. Sasobit and Zycotherm were used to make WMA mixes. Mix with RAP in different proportions were prepared. Increased RAP content in the mixtures enhances resilient modulus and the rutting resistance of all mixtures, according to the findings.

(Wang et al., 2017) The laboratory performance of recycled binders containing large proportions of artificial RAP binders (up to 70%) and 2 kinds of WMA additive, namely polyethylene wax (R) and surfactant, is investigated in this study (M). In addition, the bulk of test results demonstrated a strong linear or exponential relationship between RAP binder concentration and performance test outcomes. The percentage of RAP binder could rise as a result of WMA technology.

(Haghshenas & Kim, 2016) evaluated the mechanical of the asphalt concrete mixture and binder modified by three different rejuvenators and a WMA additive. The test like dynamic modulus, dynamic creep, and semi-circular bending (SCB) fracture were used to examine AC mixes in this regard. According to test and analytical results, the rejuvenators can soften the materials, improve rutting potential, and reduce moisture damage resistance, while also enhancing the cracking and fatigue resistances of the asphalt mix.

(Giani et al., 2015) analysed the life cycle of a 1-kilometer road pavement, all stages of life cycle were included, from the extraction of virgin material to the end of the life cycle. Three kinds of materials are tried to compare: one built with virgin materials and traditional plant methods as a control, and two made with a combination of RAP and WMA technologies as a comparison. When RAP and WMA are coupled, environmental impacts are decreased by up to 12% for CO2eq, 15% for energy usage, 15% for water used during the lifespan, and 10–15% for the three macro-categories of impact evaluated in the Design endpoint method.

(Xiao et al., 2015) studied rheological properties of a high percentage RAP binder (up to 50%) were investigated using three base binders and five RAP binder content. Various asphalt binders were tested for high failure temperature, rutting resistance, and fatigue resistance. The results showed that the binders met the Superpave binder standards during short-term ageing (for rutting) and long-term ageing (for fatigue). Furthermore, raising the RAP concentration can improve the asphalt binder's rutting resistance while lowering fatigue resistance.

(Moghadas Nejad et al., 2014) The purpose of this paper is to describe the persistent deformation of a WMA mix with RAP. The results showed that substituting RAP for up to 50% of the virgin aggregate met the minimum permissible tensile strength ratio (TSR) of 70%;

however, combinations containing 60% RAP had a TSR of less than 70%. As a consequence, RAP was optimally replaced at 50% of its original value.

(Zhao et al., 2013) did Several laboratory performances experiments to compare rutting, fatigue, and water susceptibility of asphalt mix laid in different thicknesses, which contrasted the combined effects of WMA methods and large percentages of RAP. WMA-high RAP mixtures exhibited less rutting and water resistance than HMA-high RAP mixtures, but done much better than WMA-low RAP mixtures, according to the findings. WMA-high RAP mixtures, on the other hand, surpassed HMA-high RAP or HMA-low RAP mixtures in terms of fatigue resistance, regardless of WMA technique or asphalt layer.

(Shu et al., 2012) Evaluated moisture susceptibility of plant-produced foamed warm mix asphalt (WMA) containing large percentages of recycled asphalt pavement (RAP) in a laboratory investigation. WMA loose mixtures were gathered and compacted at an asphalt plant, and laboratory performance tests were used to compare them to hot-mix asphalt (HMA) samples. The results showed that the Superpave IDT and dynamic modulus tests could effectively evaluate moisture susceptibility. Foamed WMA is projected to function as well as HMA in terms of moisture susceptibility with the addition of RAP.

(Cookson & Stirk, 2019) studied WMA with 50%RAP and HMA with RAP and compared both for fatigue performance through the damage accumulation method and reported that WMA with 50% RAP content performed better than the HMA with 50% RAP content in terms of Fatigue performance.

III. CONCLUSION

1. Warm mix asphalt when used in combination with low to medium RAP% (generally up to 50%) yields good moisture resistivity.
2. Increasing RAP percentage in the mix increases the rutting resistance but lowers fatigue performance of the pavement.
3. The fatigue performance of RAP-WMA mix is increased due to less aging of the mixture.
4. Besides increasing the field performance of the mix WMA-RAP technology has proved to be environment friendly as well as cost effective.

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