American Journal of Engineering Research (AJER)
e-ISSN: 2320-0847 p-ISSN : 2320-0936
Volume-12, Issue-12, pp-57-60
www.ajer.org
Research Paper Open Access

Performance Evaluation of Warm Mix and Cold Mix Asphalt Containing Reclaimed Asphalt Pavement

Anoop Chandran
(*Post Graduate Student, Dept. of Traffic and Transportation, College of Engineering Trivandrum -695016, India)*
R Satheesh Chandran, Dept. of Traffic and Transportation, College of Engineering Trivandrum -695016, India

ABSTRACT : *Sustainability is a cornerstone of today's engineering world. Warm mix asphalt (WMA), Cold Mix and Reclaimed Asphalt Pavement (RAP) are the most prominent sustainable materials in asphalt concrete pavements. To further enhance sustainability benefits, asphalt producers have begun using RAP and WMA in combination and also RAP and cold mix combinations. In the present paper, a WMA mixture containing WMA additive EvothermJ1 along with a RAP content of 30% and Cold mix was prepared with Cationic emulsion along with 30% RAP Content was designed by Marshall Method. The performance of WMA-RAP, Cold Mix - RAP mixtures was evaluated using RUT Test, Sand Patch Test and Skid Resistance Test. The test results was compared with the virgin HMA mix. The test result shows that WMA-RAP & Cold Mix – RAP has similar volumetric properties and increase of rap content increases the rut resistance.*

KEYWORDS HMA, WMA, Cold Mix, RAP

Date of Submission: 06-12-2023 Date of acceptance: 19-12-2023

I. INTRODUCTION

The Sustainability is the cornerstone of today's engineering world and is the most concerned and discussed topic. Environmental experts define sustainability as meeting the needs of the present without depleting the resources required by future generations. Civil engineering materials can significantly contribute to the sustainability movement through the use of recycled materials and by usage of more environmental friendly production processes. In the asphalt paving community, the most commonly employed sustainability practices involve the addition of greater amounts of Reclaimed Asphalt Pavement (RAP), the use of Warm Mix Asphalt (WMA) and Cold Mix Technology. To further enhance sustainability benefits, asphalt producers have begun using RAP and WMA in combination and also RAP and cold mix combinations. Increasing oil prices and scarcity of resources have made asphalt practitioners use more recycled materials with the intent to both lower the cost and save the environment.

II. OBJECTIVES

The main objective of this study includes:

- To study the Volumetric properties of Warm Mix and Cold Mix Asphalt
- To evaluate the performance of warm mix and cold mix asphalt containing RAP
- To study the surface characteristics of the mixes
- To compare the WMA & Cold Mix

III. METHODOLOGY

The Asphalt mix design for Bituminous Concrete mix with RAP and RAP in Warm Mix and Cold Mix was done using Marshall Method. The mix design was done in such a manner that all the volumetric properties were satisfied for the mixes. Bituminous Concrete (BC) mixes were prepared adopting gradation as per MORTH, 2013 specifications. Gradation was fixed using Trial and Error method. In the present study, Texture, Skid resistance and rutting was evaluated for determining the surface characteristics of asphalt mixes.

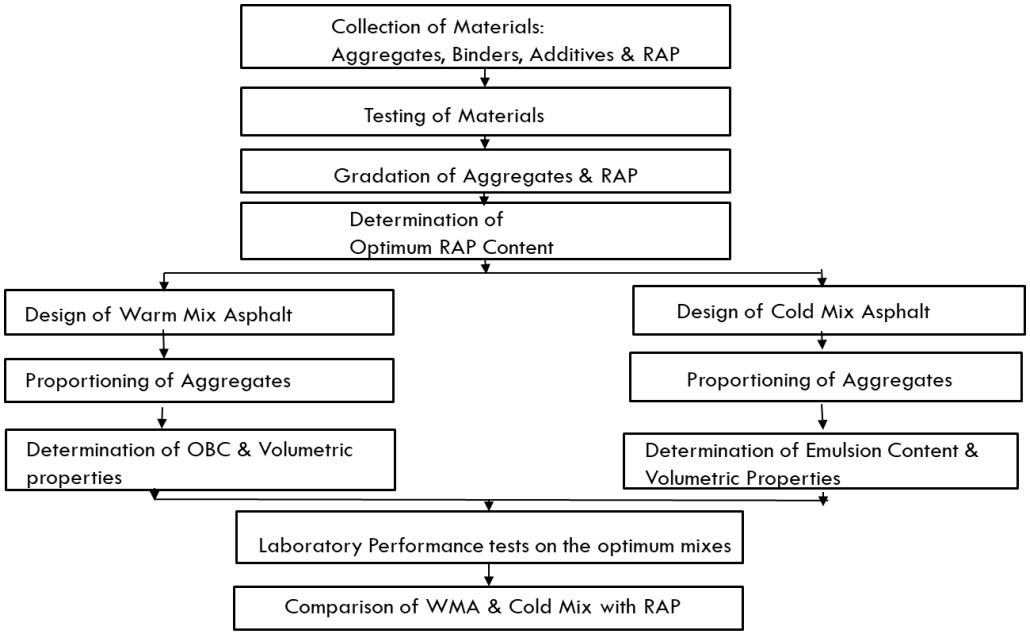

Fig.1. Flow Chart showing methodology

The Optimum Bitumen Content of virgin mix was determined using Marshall Stability Test. For the Optimum Bitumen Content obtained, RAP mixes were prepared by replacing different percentages of Course aggregates with RAP. Optimum RAP Content of the recycled mixes was obtained using Marshall Stability test. Similarly, by keeping the RAP content constant mixes were prepared for Warm Mix Asphalt with Evotherm as an additive to low the temperature. The Evotherm Content was optimised using the Marshall Method of Testing in which the optimum bitumen content obtained before was kept constant. For the design of Cold Mix also Marshall Method was adopted but with lowered temperature and with cationic Emulsion as Binder.

IV. RESULTS AND DISCUSSION

The aggregates were sieve analysed and proportioned using trial and error method to obtain gradation corresponds to that in MoRTH Specifications for Bituminous Concrete Grade II

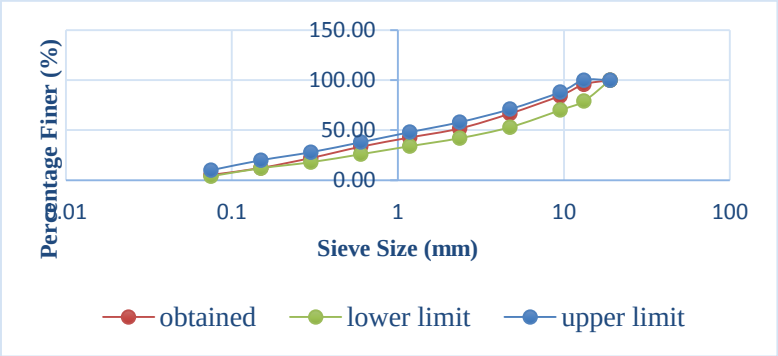

Fig.2: Obtained Gradation of aggregates

The binder content of the collected RAP was found by centrifuge extractor. Benzene liquid was used as the solvent for this. The Test result was confirmed with results obtained from U- Test machine. The average bitumen content present in the RAP was 4%.

The proportion for RAP- WMA mix was taken as 12mm: 6mm: Dust: RAP:: 14:21:35:30. The mixing temperature of 140oc was taken. The 'Evotherm' was used as additive. The optimisation was done with Marshall Method. Thus the optimum Evotherm content was obtained as 3.63% of the binder.

a. INDIRECT TENSILE STRENGTH TEST

Moisture susceptibility of the optimum mixes was measured using Indirect Tensile Strength. The tensile strength ratios of all mixes are shown on Table 1 below. All the values show greater than the lower limit of 0.8, from which it was concluded that the mixes had good resistance to moisture.

Table 1: Results of ITS test

Mix	ITS unconditioned	ITS Conditioned	TSR
Virgin HMA	13.01	11.85	0.91
HMA + RAP	12.28	11.56	0.94
WMA + RAP	10.40	9.97	0.96
Cold Mix + RAP	3.47	2.89	0.83

b. RUTTING TEST

Rutting Test was conducted on the optimised mixes. The rut depth was noted after 60 minutes. The test results are shown below.

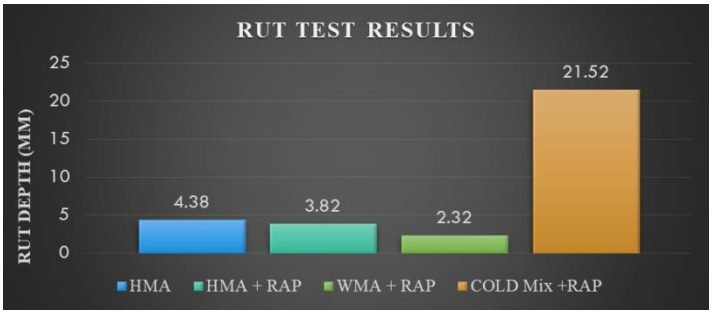

Fig 3: Rut Test Results.

c. SKID RESISTANCE

The Skid Resistance values were measured using British Pendulum Apparatus for all the optimised mixes. Wanbold (1988) recommended an acceptable BPN value of 55 for asphalt pavement.

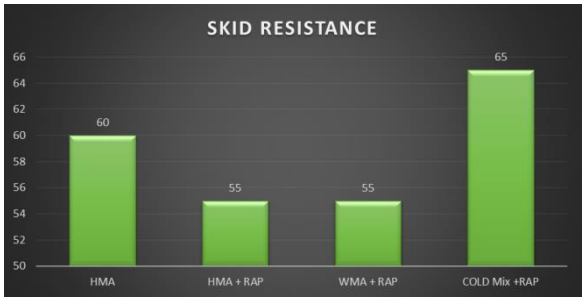

Fig 4: Skid Resistance Test Results.

d. SURFACE TEXTURE

Sand Patch method was used to find out the mean texture depth.

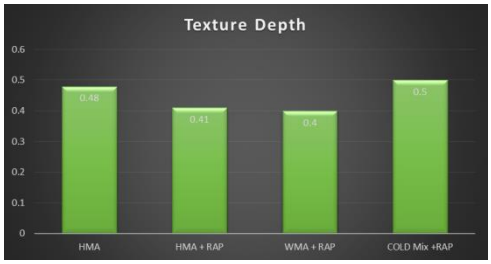

Fig 4: Sand Patch Test results.

The highest Marshall stability was obtained for HMA mixes. For the 30% RAP replaced HMA mixes show similar strength characteristics with the conventional HMA mix. The Warm Mix Asphalt combined with RAP has a stability value of 10.84kN which is less than the HMA –RAP mix but it is greater than the lower limit value of 9kN specified in the MoRTH specifications. Moreover a reduction in temperature of 20oC is also there in the construction of WMA mix. According to Mallick R B et.al (2009) the CO2 emission for HMA at 160oC mixing is 755.23 ppm while for Mixing of WMA at 140oC will emit only 511.3ppm. It shows a reduction of approximately 33% reduction. For the RAP- Cold Mix the stability value is much less, but with 30% RAP replaced Cold Mix have a stability value of 3.18kN which is greater than 2.2 kN the lower limit

specified for the low volume roads. The Flow value for all the RAP added mixes get reduced when compared to the virgin HMA mix. All the optimised mixes show satisfactory volumetric properties.

The results from the Rutting test shows that the highest rut value is for the cold mix- RAP combinations. It has rut depth value of 21.52mm after 60 minutes of rut test which was greater as expected. All the other optimised mixes have lesser rut depth values. The rut depth value for virgin HMA mix was 4.38 but it get reduced to 3.82 when RAP is added and to 2.32 for WMA-RAP combination. The presence of 'Evotherm' additive in the WMA mixes enhances the resistance to Rutting. The reduction in the rut depth value with the addition of the RAP is agreeing with the previous works in the literatures.

From the results of Skid Resistance it is clear that the Cold Mix- Rap combination have the higher resistance value than the Virgin Mix. It has a value of 65 BPN. While for the RAP added other mixes of HMA and WMA have the minimum of 55 which is specified by Wanbold in 1988. The presence of RAP may or may not affect the skid resistance. It can't be say clearly because of the difference in changes.

The Texture depth found using sand patch method shows that higher value for the Cold Mix- Rap combination. All the other RAP combinations also have a value greater than 0.4 which is the minimum value specified for a sealed road by the "Guide to the selection of road surfacings', AP-63/03, Austroads, Sydney.

V. CONCLUSION

The use of Reclaimed Asphalt Pavement gets propelled because of the reduction in the natural resources and also because of growing concern on environment and sustainability. The RAP has both environmental and financial benefits. The Properties of RAP binder will be changed due to the continuous loading and weathering actions but still it has some potential. In this study the RAP percentage was optimised into 30% replacement for the virgin materials. The Optimised RAP mixes were evaluated in three combinations of RAP-HMA, RAP – WMA & RAP –Cold Mix. All the Mixes satisfied the 80% minimum ITS requirement. The volumetric properties were satisfied for all the RAP mixes. The stability of the RAP mixes for HMA and WMA were more than the limit of 9kN and also for Cold Mix combination it is greater than 2.2kN limit for low volume roads. The rap added mix performs better for the Rutting test. WMA-RAP combination mixes have the highest rut resistance. For the Skid Resistance and Texture depth test the Cold Mix- Rap combinations perform better.

REFERENCES

[1]. Ahmad Kamil Arshada, Frag Ahmed Ma Kridanb, Noor Azreena Kamaluddinb, Ekarizan Shafie, "Evaluation of Warm Mix Asphalt Performance with High RAP Content" www.jurnalteknologi.utm.my PP: 51–54

[2]. Brian Hill, Behzad Behnia, William G. Buttlar, and Henrique Reis "Evaluation of Warm Mix Asphalt Mixtures Containing Reclaimed Asphalt Pavement through Mechanical Performance Tests and an Acoustic Emission Approach" *Journal of materials in civil engineering © asce / december 2013 / 1887-97*

[3]. Burak Sengoz, Ali Topal1, Julide Oner, Mehmet Yilmaz, Peyman Aghazadeh Dokandari, Baha Vural Kok, "Performance Evaluation of Warm Mix Asphalt Mixtures with Recycled Asphalt Pavement

[4]. Mohammad Adnan Farooq, Mohammad Shafi Mir, "Use of reclaimed asphalt pavement (RAP) in warm mix asphalt (WMA) pavements: a review" *Springer International Publishing Switzerland 2017*

[5]. Naisheng Guo, Zhanping You, Yiqiu Tan & Yinghua Zhao "Performance evaluation of warm mix asphalt containing reclaimed asphalt mixtures" International Journal of Pavement Engineering, 2016