iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 9 **Issue:** VI **Month of publication:** June 2021

DOI: https://doi.org/10.22214/ijraset.2021.36046

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue VI June 2021- Available at www.ijraset.com

A Laboratory Study of Warm Mix Asphalt with Synthetic Zeolite

Roshani Patidar[1], Prof. Shashikant B. Dhobale[2]
[1]M.E. Student, [2]Assistant Professor, Civil Engineering Department, JIT Borawan, Khargone (M.P.), India

Abstract:** Warm mix asphalt (WMA) is a recent technology used to reduce working temperatures without affecting the property of pavement. warm mix asphalt technology is a find out the optimum temperature of asphalt mixture. A number of WMA processes have been developed in recent days. One of the processes is the use of synthetic zeolite as an additive. A number or try in the laboratory to develop warm mix asphalt and using synthetic zeolite as an additive at a specified mixing and optimum temperature which were obtained after a number of trials. Warm mixing with additive is becoming popular because of mixing at a lower temperature which reduces the fuel usage and emission of hazardous gases consequently decreases the mixing as well as compaction temperature of the mix. Reduction of 20º C to 40º C has documented, such reduction has the obvious benefits of cutting fuel consumption and decreasing the production of greenhouse gases. Also, there will improvement in the performance of the pavement. In the present study, The mix asphalt with aggregate gradation as per MORTH specifications was made with varying binder contents (5%,6% and7%). The zeolite content was 0.3% by weight of aggregate. Stone dust and VG 30-grade Asphalt were used as a binder for the mixes. and the help of laboratory tests to find the physical properties of WMA with synthetic zeolite at optimum temperature. These additives are zeolites, that is, minerals of the aluminosilicate group, the crystalline structure of which contains water bound in a specific way. Its release, at mixed asphalt production temperatures, causes asphalt foaming. It is currently known that zeolites can be used in WMA, including natural and synthetic zeolites obtained using chemical reagents and waste. This review presents the results of studies of WMA technology, including the effects of zeolite addition on asphalt properties and mixes asphalt, as well as related environmental, economic, and technological benefits.
Keyword: warm mix asphalt, Additive, marshall properties, optimum temperature

I. INTRODUCTION

The area of work of this study covers laboratory study on Asphalt, asphalt mixes, and asphalt mixes with additive. The purpose of this study is mainly concentrated to find out the optimum temperature by which the synthetic zeolite additive asphalt optimum temperature is reduced through the warm mix asphalt technology. The asphalt industry is a great concern existing in the world related to the atmosphere emissions for the greenhouse effect and the energy consumption. The current industrial tendency is trying to improve the working systems to reduce the emissions of harmful components to the atmosphere and the consumption of energy as well. Until recent years the two fundamental criteria use in deciding the best pavement to be used are economic and technical considerations whereas today the environmental impact must also be taken into consideration. In the road sector, the main research goal is the development of new systems which allow reducing the manufacturing and the application temperatures of the asphalt mixes. Asphalt mixes are most commonly use all over the world in pavement construction. Most of the highway in India is flexible pavements, within which are included surfacing of various types and thickness. Various studies are undertaken to improve the strength characteristics of asphalt surfaces by modifying Asphalt grades, aggregate gradation mix proportion, and by adding different additives to the Asphalt. It is seen from various literature reviews that the strength of paving mixes can be enhanced by using modified binders. Such binders also improve temperature susceptibility and help to eliminate some common Problems like bleeding in peak summer temperature. Keeping these facts in mind it was felt that efforts can be made to use some modifier material or Asphalt additive. As per MORTH - Section 509, asphalt concrete for wearing course should be made with Asphalt of viscosity grade-30 (VG-30) for nominal aggregate size 19mm with Asphalt content 5-6% having layer thickness 50-65mm and for the nominal aggregate size of 19mm with Asphalt content 5-7% having layer thickness 30-45mm. Asphalt VG-30 improves the performance of the binder to minimize the stress cracking that occurs at low temperatures. The warm mix asphalt (WMA) is an asphalt mixture that is mixed at a temperature lower than conventional hot mix asphalt (HMA).

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue VI June 2021- Available at www.ijraset.com

A. Materials

1) *Synthetic Zeolites as Additives:* Zeolites are crystalline, microporous, and hydrated aluminosilicates that are built from an infinitely extending three-dimensional network of [SiO4] and [AlO4] tetrahedra 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. (5) 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 cation groups such as water molecules. Zeolites have the property to lose or absorb water without any change in the crystal structure. The heat releases the water present in zeolites. When zeolite 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 an increase in workability. This also helps in the coating of aggregates at a lower temperature.

Fig 1: Synthetic zeolite

2) *Aggregates:* The aggregates used in this design of BC are 6mm and 20mm nominal size aggregates. They are graded as per MORTH section 500 clause 509 which satisfies the requirement for the design of BC. The aggregates are clean, cubic in shape and rough texture to resist the fracture of pavement under heavy traffic loads. The aggregates taken should pass a 20mm sieve and retain on a 75 micron IS sieve should be taken into consideration while designing the BC.
3) *Asphalt:* The ASPHALT used for the mix is of the viscosity grade-30 (VG-30). This VG-30 grade binder is used for the construction of heavy-duty flexible pavement. These heavy-duty flexible pavements are constructed for the tolerance of extensive traffic loads. The VG-30 can also be used in substitution for 60-70 penetration grades.

B. WMA Technologies Available

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:

1) Organic additives (including waxes)
2) Water-bearing zeolites
3) Water-based foaming processes
4) Emulsion-based processes

C. History 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 include long-term performance, thermal cracking, short and long-term aging effects, and additive usage and performance grade binder specifications.

II. OBJECTIVE

1) To prepare warm mix Asphalt (WMA) samples of stone matrix Asphalt (SMA) and Dense Asphalt Macadam (DBM) mix with Syntheticzeolite as an additive at different binder contents at 110°C.
2) To Evaluate the engineering properties and performance of WMA samples through Marshall Test.

III. SCOPE OF STUDY

The main aim of this thesis studyto find out the optimum temperatures in Warm mix asphalt use of synthetic zeolite as an additive.

IV. LITERATURE REVIEW

A. Previous Studies On Warm Mix Asphalt Technology

In 1997, at the Asphalt Forum of Germany warm mix asphalt (WMA) technology (3) was identified as one of the means to lower emissions. In 2002, the WMA technology was introduced in the United States. It was this time when the NAPA sponsored an industry scanning tour to Europe for asphalt paving contractors.

The World of Asphalt convention in 2004 featured a WMA demonstration project, after which the manufacturers of WMA additives have successfully demonstrated many projects throughout the United States.

1) Hurley and Prowell,2005 (a,b,c) (8, 9, 10) evaluated three different WMA additives: Aspha- Min®(synthetic zeolite), Sasobit®(wax) and Evotherm™(emulsion) and concluded that all three technologies improved the asphalt mixture compatibility and resulted in the reduction of air voids as compared to HMA. They stated that the addition of Aspha-min lowered the air voids in WMA measured in the gyratory compactor. This can also improve the compatibility of both the gyratory compactor and a vibratory compactor. Statistical analyses of test results indicated an average reduction in air voids of 0.65% using the vibratory compactor. Aspha-min did not have any significant effect on the resilient modulus of asphalt mixtures.WMA with the addition of Aspha-min successfully incorporated a higher percentage of RAP materials thanHMA. Aspha-min was added to a Superpave mixture containing 20% RAP during a demonstration project in Orlando, Florida. The addition was able to reduce the production and compaction temperatures by 20 °C while yielding the same in-place density.
2) Hurley and Prowell, 2006(11) reported that the rutting potential was not increased based on the wheel-tracking test with these three WMA additives Aspha-Min® (synthetic zeolite), Sasobit®(wax), and Evotherm™(emulsion). The low compaction temperature used while producing warm asphalt with the addition of Aspha-min may increase the potential for moisture damage. Low mixing and compaction temperatures can result in incomplete drying of the aggregate and the water trapped in the coated aggregate may cause moisture damage. . The addition of 1.5% hydrated lime has resulted in acceptable performance, in case of both cohesion and moisture resistance, that was better than the performance of warm mixtures without hydrated lime.
3) Powell et al., 2007 reported that the WMA test sections which were accelerated exhibited excellent field performance in terms of rutting.
4) Goh et al., 2007 evaluated the properties of WMA with the addition of Aspha-min (synthetic zeolite) based on the Mechanistic-Empirical Pavement Design Guide (MEPDG). They found that the addition of Aspha-min did not have any effect on the dynamic modulus values for any of the asphalt mixtures examined. The rut depths predicted from the MEPDG simulations showed that WMA could decrease rutting and the greatest difference of rutting between WMA and its control could be up to 44%.
5) Lee et al.,(2008),(18) prepared three types of CIR-foam specimens: (a) CIR-foam with 1.5% of Sasobit® (wax), (b) CIR-foam with 0.3% Aspha-min® (synthetic zeolite),and (c) CIR-foam without any additive. They reported that WMA additives have improved the CIR-foam mixtures compactibility resulting in the reduction of air void. The indirect tensile strength of CIR-foam mixtures with Sasobit®(wax) was the highest. The flow number of CIR-foam mixtures with Sasobit® was the highest followed by ones with Aspha-min®(synthetic zeolite), and the specimens without any additive.
6) Wielinski et al.,2009 (22) conducted a study based on laboratory tests and field evaluations of foamed WMA. They found that the Hveem and Marshall properties of HMA and WMA were almost similar, and all met the Hveemdesign requirements and the mixture property requirements. The in-situ densities were also almost similar.
7) Hodo et al.,2009 (7) stated that the foamed asphalt mixture presented better workability at lower temperatures which showed greater ease in placing and compacting it and the moisture susceptibility tests showed marginal results and they suggested that if anti-stripping agents were added to the WMA mixture, the moisture damage resistance would be improved.

V. METHODOLOGY

In this study Asphalt concrete for pavement is designed for the 20mm nominal size aggregate. The Asphalt of VG- 30 grade used as binder and aggregates are crushed aggregate from quarry. At the first the laboratory testing is carried out to find the physical properties of aggregate by conducting tests like Aggregate Impact Value, Abrasion Test, Crushing value test, Flakiness and elongation Index (combined), Water absorption, Specific Gravity, Grain size analysis, etc.

As per the MORTH section, 500 clauses 509 the gradation of 20mm size aggregate is decided. Same for the tests of Asphalt of VG-30 grade with and without Synthetic zeolite including penetration test, specific gravity, softening test, elastic Recovery Test, Viscosity, etc. which satisfy the requirement of IS:73-2013 " SPECIFICATION OF ASPHALT ".In the second part of the study samples for Marshall Mix design are prepared and the optimum binder content for BC using Asphalt of VG-30 can be determined. After this the sample at temperatures 110°C, 120°C, and 130°C with different doses of Synthetic zeolite. Based on these samples the optimum temperature and optimum doses of Synthetic zeolite can be determined for the binder.

The methodology chart
1) Problem identification
2) Objective
3) Literature review
4) Design experiments
5) Laboratory tests
6) Analysis of laboratory tests
7) Conclusion

VI. LABORATORY TESTS

The warm mix design of the Asphalt concrete starts with the laboratory tests originated by finding the physical properties of aggregate and Asphalt which must satisfied the requirement of MORTH specification and relevant IS codes. Subsequently this determination of physical properties the Marshall Stability test for the determination of OBC as well as optimum temperature and optimum doses of the Synthetic zeolite for making the BC is carried out. At last the testing for certain engineering properties of controlled along with warm mix using binder of VG-30 can be carried out for checking the specification.

A. Aggregate Testing

Aggregates used in this study of designing the BC is crushed aggregate collected from the quarry. Before using the aggregate in design of Asphalt mix it has been tested for their physical properties consist of Hardness, Toughness, Cleanliness, Particle shape, Water absorption, Stripping etc. These test should be performed as per procedure revealed in the applicable IS codes. The tests performed on the aggregate in the laboratory are as follows:
1) Grain size analysis, IS: 2386 (Part 1)-1963
2) Impact value test, IS: 2386 (Part 4)-1963
3) Shape test, IS: 2386 (Part 1)-1963
4) Abrasion test IS: 2386 (Part 4)-1963
5) Water absorption and Specific Gravity test, IS: 2386 (Part 3)-1963

B. Asphalt Tests

Asphalt used in the warm as well as control design of BC is VG-30. Asphalt is used to bind the material together. Before use of Asphalt in design mix it has been tested for their physical properties. All these test should be performed as per procedure in relevant IS codes. The tests to be performed are enlisted as follows:
1) Penetration test, IS: 1203-1978
2) Softening Point test, IS: 1205-1978
3) Ductility test, IS: 1208-1978
4) Viscosity test, IS: 1206-1978
5) Specific Gravity test, IS: 1202-1978

C. Marshall stability test

The Marshall Stability Test gives the following:
1) Optimum Binder Content
2) Optimum Dose of Synthetic zeolite
3) Optimum Temperature

VII. CONCLUSIONS AND RESULT

After all calculations and tests on the material the final result comes out and we give the final conclusion

REFERENCES

[1] ASTM D 1559 (1989), "Test Method for Resistance of Plastic Flow of Asphalt MixturesUsing Marshall Apparatus".
[2] Chakraborty, Partha, Das Animesh, Principles of transportation engineering, PHI 2003, page no 294-299.
[3] D'Angelo, J., Harm, E., Barloszek, J., Baumgardner, G., Carrigan, M., Cowsert, J. Warm-Mix Asphalt: European Practice. Alexandria, VA: Federal Highway Administration, 2008. FHWA- PL-08-007.
[4] Gandhi, T.S. and Amirkhanian, S.N., (2007), "Laboratory Evaluation of Warm Asphalt Binder Properties – A Preliminary Analysis", 5th International Conference of Maintenance and Rehabilitation of Pavements and Technological Control, Park City, Utah, pp 475-480.
[5] Georgiev D., Bogdanov B., Angelova K., Markovska I., Hristov Y.,2009, " Synthetic zeolites - structure, classification, current trends in zeolite synthesis", Review report, International Science Conference, Stara Zagora, Bulgaria.
[6] Goh, S.W., Zhanping, Y., Van Dam, T.J., 2007, "Laboratory Evaluation and Pavement Design for Warm Mix Asphalt", 2007 Mid-Continent Transportation Research Symposium, Ames, Iowa,pp-17-35.
[7] Hodo, W. D., Kvasnak, E., and Brown, E. R. (2009). ―Investigation of Foamed Asphalt (Warm Mix Asphalt) with High Reclaimed Asphalt Pavement (RAP) Content for Sustainment and Rehabilitation of Asphalt.‖ Transportation Research Board 2009 Annual Meeting, Washington, D.C.
[8] Hurley, G.C. and Prowell, B.D. Evaluation of Asphamin for Use in Warm Mix Asphalt. Auburn, Alabama: National Center for Asphalt Technology, 2005. NCATReport 05-04.
[9] Hurley, G.C. and Prowell, B.D. Evaluation of Sasobit for Use in Warm Mix Asphalt. Auburn, Alabama: National Center for Asphalt Technology, 2005. NCAT Report 05-06. 44
[10] Hurley, G.C. and Prowell, B.D. Evaluation of Evotherm for Use in Warm Mix Asphalt. Auburn, Alabama: National Center for Asphalt Technology, 2005. NCAT Report 06-02.
[11] Hurley, G., and Prowell, B., (2006), "Evaluation of Potential Process for Use in Warm Mix Asphalt", Journal of the Association of Asphalt Paving Technologist, Volume 75, pp 41 – 90.
[12] BIS: 2386 (1963), "Methods of Test for Aggregates for Concrete (P - I): Particle Size and Shape", Bureau of Indian Standards, New Delhi
[13] BIS: 2386 (1963), "Methods of Test for Aggregates for Concrete (P-III): Specific Gravity, Density, Voids, Absorption, Bulking", Bureau of Indian Standards, New Delhi
[14] BIS: 2386 (1963), "Methods of Test for Aggregates for Concrete (P-IV): Mechanical Properties", Bureau of Indian Standards, New Delhi
[15] Khanna S.K. and Justo C.E.G. (2001), "Highway Engineering", Nem Chand and Bros, Roorkee, pp315-321.
[16] Kunnawee, K., Samak, S., Kitae, K., Wilfong, M., &Hussain, B., "LaboratoryStudy on Warm Asphalt Additives. Washington D.C.: Transportation Research Board,2007.
[17] Lee, S.J.; Amirkharian, S.N.; Park, N. –W.; Kim, K.W, 2009. Characterization of warm mix asphalt binders containing artificially long–term aged binders, Construction and Building Materials, pp. 30-43.
[18] Lee, H., Kim, K., Hwang, S., &Jeong, K. Use of Warm Mix Asphalt Additives for Cold In-place recycling using Foamed Asphalt. Park City, Utah: InternationalConference on Maintenance and Rehabilitation of Pavements and TechnologicalControl, 2007
[19] PandaN, "Laboratory investigations of stone matrix asphalt using sisal fiber for Indian roads "Btech project report Nit Rourkela, 2010.pp23 - 36.
[20] Prowell, B.D., Hurley, G.C. and Crews, E. Field Performance of Warm Mix Asphalt at the NCAT Test Track. Washington D.C.: Transportation Research Board, 2007. 45
[21] Sampath Anand, "Compressive evaluation of four warm mix asphalt mixtures regarding viscosity, tensile strength, moisture sensitivity, dynamic modulus and flow number" University of Iowa, May 2010, pp.8-11.
[22] Wielinski, J., Hand, A., and Rausch, D. M. (2009). ―Laboratory and Field Evaluations of Foamed Warm Mix Asphalt Projects.‖ Transportation Research Board 2009 Annual Meeting, Washington, D.C.