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Experimental Investigation on Effect the Warm Mix Asphalt (WMA) Using Zyco Therm Additive with Partial Replacement of Reclaimed Asphalt Pavement (RAP)

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ABSTRACT

Roads are the backbone of country's development, however the excessive stage of emission generated in paving traditional bituminous pavements is usually a most important concern. For decades, Hot Mix Asphalt (HMA) had a top hand in pavement development all over the world. Use of reclaimed asphalt pavement (RAP) helps keep herbal assets and money. The share of RAP that can be utilized correctly in hot-mix recycling is specifically dictated by means of sensible considerations. To keep away from deterioration of the aged binder, RAP ought to no longer be uncovered to pretty excessive temperatures. This learn about investigated the feasibility of the usage of a warm-mix asphalt (WMA) additive Hot combine asphalt was once convenient to produce, however required excessive temperatures to be maintained at some point of transportation and laying. As HMA manufacturing includes high-energy consumption, manufacturing of bituminous combine with decrease temperatures the usage of specific technique is developed which is labeled as Warm Mix Asphalt Technology. In the existing study, ZycoTherm additive, has been used in one-of-a-kind dosages at exceptional temperatures to put together heat combine asphalt in the laboratory. ZycoTherm additive can be used with an ideal dosage of 0.07% by means of weight of bitumen at 135 ℃, mixing temperature for WMA, and 30% RAP with 70% virgin aggregates containing 0.07% ZT WMA at 135 ℃, offers higher balance and overall performance than different mixes. Hence, 30:70 is the most superior blend.

KEYWORDS: *Bituminous Concrete (BC-II), ZycoTherm, Hot Mix Asphalt (HMA), Reclaimed Asphalt Pavement (RAP), Warm Mix Asphalt (WMA)*

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1. INTRODUCTION

Roads are a necessary factor in state constructing and one of the most tremendous modes to set up socio-economic and political networks and performs a predominant position for a man to step out from region to place. So laying of roads and the strolling of automobiles are growing day-by-day. In India majority of street community is occupied via bituminous pavement solely in which Hot Mix Asphalt (HMA) is used predominantly as a paving combine from many decades. The traditional approach of avenue development entails the burning of bitumen which produces poisonous gases which degrades the environment. Certain barriers related with HMA are, immoderate emission of greenhouse gases (e.g. sulfur dioxide, nitrogen oxides, carbon monoxides and unstable natural compounds) from HMA plant, shut down of warm combine plant all through wet season and the laying of HMA is tough in hilly areas and rural areas having lengthy hauling distances etc. Warm Mix Asphalt (WMA) is one of most up-to-date quick rising applied sciences that enable mixing, production, putting and compaction of asphalt mixes at notably decrease temperatures due to chemical change of the bitumen as in contrast to the

normal Hot Mix Asphalt (HMA) practice. Lower temperatures end result in decreased gasoline usage, fume exhausts, greenhouse gasoline emissions, reduces put on and tear, whilst bettering employee fitness and protection prerequisites at some point of pavement construction. Mixing temperature for WMA is 100°C to 140°C and HMA is commonly 140°C to 160°C relying typically on the kind of binder used. It has been located that common discount of temperature for WMA is 30°C to 40°C when evaluate to HMA. The improvement of WMA used to be initiated in Europe in the late Nineteen Nineties in particular in response to the want for greenhouse fuel discount beneath Kyoto protocol. Warm combine asphalt has been delivered in Europe in 1997 and in the United State 2002 and in India 2009. WMA technological know-how is made feasible by using using an additive that lets in adequate coating of aggregates with asphalt binder whilst preserving workability. The major purpose of WMA is decrease the mixing and compaction temperature with comparable or higher strength, sturdiness and overall performance traits as HMA.

1.1. CHEMICAL ADDITIVE (ZYCOTHERM):

ZycoTherm is a WMA additive developed through Zydex Industries, Gujarat, India. Research groups at Zydex Industries have developed world's first progressive silane nanotechnology for roads. Zydex is on its way to revolutionize the street construction, with a whole suite of nanotechnology primarily based merchandise which holistically grant options to tackle moisture and bonding problems associated to asphalt layer, top coat, tack coat and soil bases. ZycoTherm is a scent free, chemical heat combine additive that has been engineered to grant extensively elevated advantages over contemporary WMA applied sciences via presenting decrease manufacturing and compaction temperatures, whilst concurrently improving the moisture resistance of pavements via serving as an antistrip. It does now not have an effect on binder grading or exchange any different binder properties. It improves energy and compatibility at good value cost. Mixes that have been modified with ZycoTherm can be produced at 120°C - 135°C for and compacted at 90°C - 120°C. Overall, ZycoTherm provides temperature discount rates relying on the houses of the mix. ZycoTherm has constructed in antistrip mechanism that lets in it to dually characteristic as an antistrip as nicely as a heat combine additive universally well suited with all kinds of modified as properly as unmodified binders. Zycotherm is Effective at 0.1% for most of the asphalt binders and at 0.125% for Polymer & CRMB binders. A dosage of 0.1% weight of the additive (Zycotherm) can be introduced in the combine via two ways:

A. Mixing the additive whilst mixing the bitumen with the aggregates.
B. Mixing the additive in the bitumen, whilst heating the bitumen itself.

From the above two processes, 2nd one is viewed as fantastic when in contrast with the first one Because of ideal mixing of additive with the mix. Adoption in India: This science was once used at some point of the development of the Hyderabad-Karimnagar-Ramagundam Four Laning Road (SH-1) in United Andhra Pradesh (June-2014), whereby Zycosoil used to be combined with asphalt. Ladakh in Jammu and Kashmir additionally used this technology. A three and half of kilometer assignment in Gujarat and a forty km challenge in Karnataka have been launched recently

1.2. ADVANTAGES OF ZYCOTHERM:

1. Zycotherm is well suited with all grades of asphalt binder like Polymer Modified Bitumen (PMB) and Crumb Rubber Modified Bitumen (CRMB).
2. It is nonflammable, scent free liquid, which reduces the unsafe gases throughout heating Mixing and setting of pavement mix.
3. It improves the Salt Resistance of pavement in Coastal regions.
4. Acts as a moisture resistant by means of making mixture floor from hydrophobic to hydrophilic surface.
5. Improve the road's durability, lowering its lifecycle value by way of 50 percentage or more
6. Fuel Savings 11-14%. And Energy financial savings 11-40% and additionally minimizes the most reliable bitumen content.
7. Consistent Compaction throughout temperatures.
8. Zydex Nanotechnology permits higher compaction in the avenue construction, which eventually effects in time effectivity in the development process.

2. Literature review

Tiwari, A.V. et al. (2018) were concluded that waste plastic is accumulated everywhere the world causing serious environmental issues. This paper aims to check the plastic waste bituminous concrete using dry method of blending for construction. The study evaluates the addition of sliced waste plastic within the hydrocarbon concrete which ends up in important increase within the stability worth and Marshall Properties of combine. The study reveals that the utilization of waste plastic in hydrocarbon concrete is safe and property for construction.

Singh, P. and Swamy, A.K., (2019) were over that due to inherent benefits, waste polythene (generated from domestic sources) has been used as asphalt modifier. This text discusses elastic properties of the polythene modified asphalt binder. Many asphalt concrete mixtures were designed by varied polythene and asphalt content. Chopped polythene incorporated into asphalt concrete by dry mix process using optimized asphalt content (at many polythene percentages), mixtures were ready and compacted. These compacted specimens were aged for various length in convection kitchen appliance. Asphalt binder (from aged specimens) was extracted and tested for its elastic properties using dynamic shear rheometer. Comparison of master curves indicated increase in complicated modulus and reduce in point values with addition of polythene the least bit reduced frequencies. However, the extent of amendment was extremely passionate about frequency, aging length and polythene content. This indicates that the addition of polythene provides a lot of resilience to asphalt binder particularly with less aging time. Storage modulus master curves (at lower frequencies) and relaxation modulus values (at longer time) indicate polythene provides further stiffening to binder. Further, changes in viscous modulus with addition of polythene were marginal. Overall results indicate that waste polythene improves the properties of asphalt binder over extended loading amount once heated for fewer time throughout intermixture.

Paltasingi Venkata Raju, M Udaya Satish Kumar and Sumathi Misro (2020), Bituminous Mixture and compare the mechanistic properties with conventional Hot Mix Asphalt (HMA) through the laboratory testing programs. Roads are the lifeline for the health & sustained growth of economy. Warm Mix Asphalt (WMA) Technology is considered as good option. In the present study HMA is replaced by WMA for the construction of flexible pavement. Warm Mix Asphalt is one of the newest technologies that allow mixing, production, placing and compaction of asphalt mixes at significantly lower temperatures result in reduced fuel usage while enhancing worker health and safety conditions during pavement construction due to chemical modification of the bitumen as compared to the traditional Hot Mix Asphalt practice. In this study an attempt is made to compare the Marshall properties and environmental benefits of WMA produced with an innovative chemical additive "Zycotherm" and HMA for bituminous Concrete (BC) Grade-2. The adopted mixing temperatures for HMA was 160°C and the mixing temperatures for WMA was 130°C, 125°C and 120°C, with an additive dosage rate of 0.1% by weight of the binder. The optimum binder content was to be found out individually for the mixture for different mixing temperatures. Results of laboratory performance indicated that the WMA at 125°C is better than WMA at 120°C and 130°C and also HMA at 160°C. The outcomes showed that the addition of Zycotherm had slightly improved the Marshall properties of the mixture.

K. Praveen, Dr. M. S. Chauhan. (2021). Arm Mix Asphalt (WMA) is simply seen as one of the predominant pieces of as long as day progressions that grant blending, upgrade, setting and furthermore compaction of dark top mixes at totally decreased temperature level degrees by virtue of man-made trade of the bitumen while stood apart from the standard Warm Mix Asphalt (HMA) procedure. Lower temperature rates achieve decreased gas use, design handicaps, ozone hurting compound deliveries, reduces gas mileage, all the while as invigorating laborer wonderfully being and besides security gives all through of dark top new development. In this paper an endeavor is made to utilize polymer mix dark top (PMB) forty cleansing blend having positive conditions of lessening temperature and cost of help ceaselessly its charming. Polymer changed dark top (PMB) 40 clearing ingest with creative warmth mix secured substance (Zycotherm) in best zones is coordinated close by endeavored to pick fundamental local or present day living courses of action of Marshall Mix technique concerning the plans of codal strategy.

3. EXPERIMENTAL WORK

Study was carried out in two phases. In the first phase, comparison of Marshall Properties of BC-II, HMA and WMA mix at varying dosage of ZycoTherm additive and varying temperature was done. From this, an optimum dosage and temperature was determined. In the second phase, for optimum combination of ZycoTherm dosage and temperature 30% and 40% of RAP material were replaced and Marshal Properties were evaluated

4. Material Selection

A. Aggregates: Aggregates were collected from the crusher site in Gada Betel, M.P and the basic tests on aggregates were conducted in the laboratory as per the specified test methods to determine the physical properties of virgin aggregates.

B. Binder: For the study, Bitumen of VG-30 (50/70) and VG-10 (80/100) were considered for virgin bituminous mixes and RAP mixes respectively. Its basic properties were tested for its requirement in BC grade - II as per IS 73 - 2013 specifications.

C. RAP material: For the studies, the RAP material was collected from the Industrial area J.K Road in

Bhopal. The recovered bitumen content, its properties and RAP gradation were determined in the laboratory.

D. ZycoTherm: ZycoTherm is the new generation additive used for Warm Mix Asphalt introduced by M/s ZYDEX Inustries. It allows WMA mixing and compaction upto 36ºC lower temperatures than traditional Hot Mix Asphalt. According to NCHRP, recommends conditioning for 2 hours at 135ºC will simulate the production temperature of HMA mixing.

5. Marshall Mix Design

The main objective of the mix design is to produce a bituminous mix by proper proportioning of various components so as to have -

A. Sufficient bitumen to ensure a durable pavement.
B. Sufficient strength to resist shear deformation under traffic at higher temperature.
C. Sufficient air voids in the compacted bitumen to allow for additional compaction by traffic.
D. Sufficient workability to permit easy placement without segregation.
E. Sufficient flexibility to avoid premature cracking due to repeated loading by traffic.

The bituminous mix for BC – II was designed by Marshall Method of mix design based on ASTM D 1559-96.

Fig 1.1 Marshall Test being conducted with the Marshall apparatus

6. RESULTS

A. Marshall Properties of following variations in BC-II mix were determined in the laboratoryand the results were analyzed.
B. Conventional HMA mix at 155℃ mixing temperature
C. WMA mix at 135 ℃ mixing temperature with 0.1% ZT
D. WMA mix at 135℃ mixing temperature with 0.07% ZT
E. WMA mix at 125 ℃ mixing temperature with 0.1% ZT
F. WMA mix at 125℃ mixing temperature with 0.07% ZT
G. Conventional HMA mix at 155 ℃ mixing temperature with 30% RAP replacement
H. Conventional HMA mix at 155 ℃ mixing temperature with 40% RAP replacement
I. WMA mix at 135 ℃ mixing temperature with 0.07% ZT and 30% RAP replacement
J. WMA mix at 135 ℃ mixing temperature with 0.07% ZT and 40% RAP replacement
K. The above type of mixes was in agreement as specified by the MoRT&H 5th revision exceptmixes at 125 ℃ .

Table 1 Marshall Results

Marshall properties	VB at 155°C	VB+0.07% ZT at 135°C	VB+0.10% ZT at 135°C	VB+0.07% ZT at 125°C	VB+0.10% ZT at 125°C	RAP 30% at 155°C	RAP 40% at 155°C	30% RAP+0.07% ZT at135°C	40% RAP+0.07% ZT at 135°C
OBC (%)	5.7	5.9	5.9	5.9	6.0	5.5	5.7	5.5	5.6
Gb, g/cc	2.404	2.36	2.337	2.356	2.356	2.401	2.334	2.366	2.396
Vv (%)	5.05	5.96	5.83	5.22	6.37	4.04	5.14	5.78	4.95
VMA (%)	18.05	18.9	19.48	20.97	19.65	16.97	18.4	18.05	17.92
VFB (%)	72.51	72.7	70.02	76.65	70.57	76.65	72.12	68.81	75.1
StSability,kN	17.82	17.78	15.57	15.76	14.38	22.75	20.15	22.21	19.1
Flow, mm	2.2	2.3	2.42	2.62	2.75	2.43	2.33	2.6	2.95

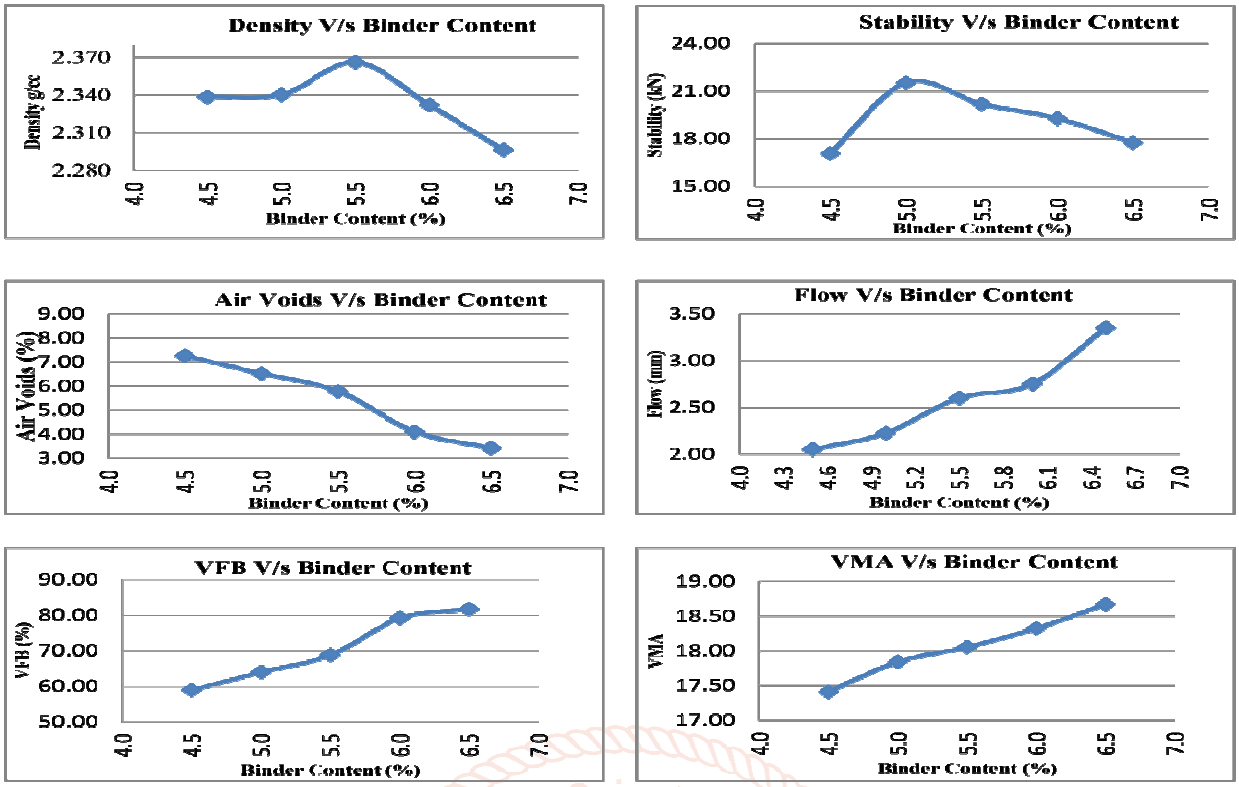

Figure 2 Graphs Showing Relation between Marshal Properties V/S Binder Content of 30% RAP WMA Mix of 0.07% ZT Dosage at 135˚C

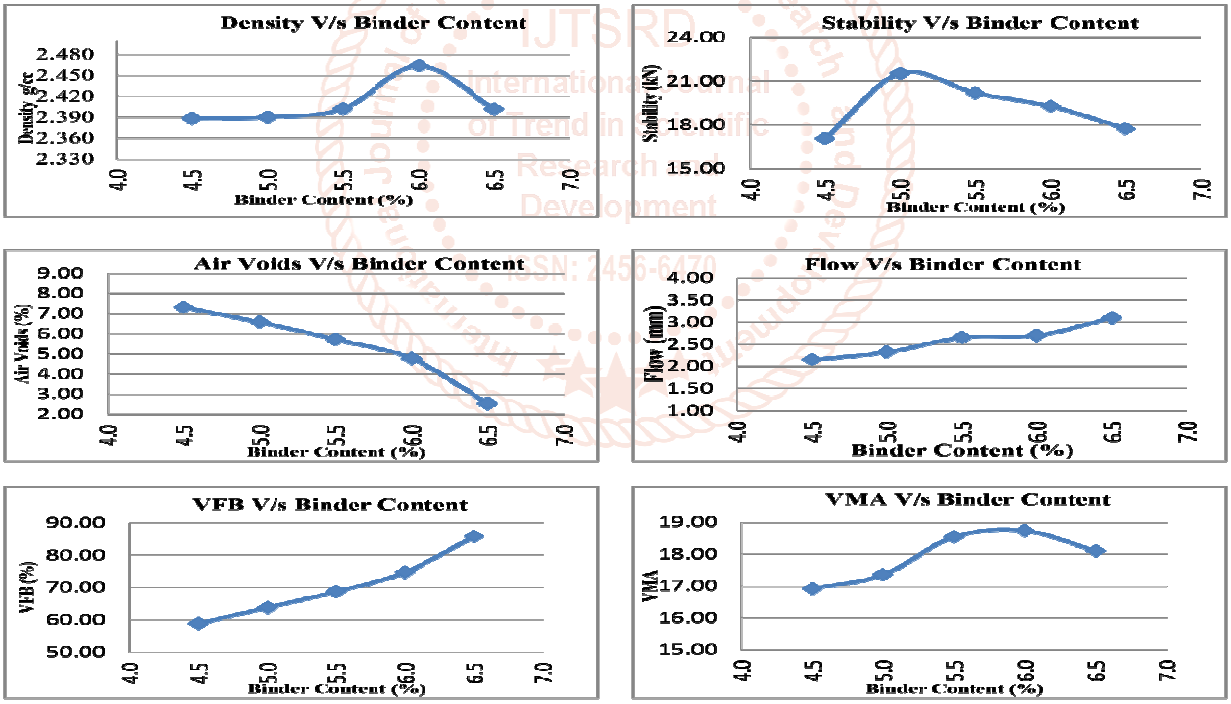

Figure 3 Graphs Showing Relation between Marshall Properties V/S Binder Contentof 40% RAP WMA Mix of 0.07% ZT Dosage at 135˚C

7. CONCLUSIONS

1. Marshall Properties have shown that there is variation in OBC of Warm Mix Asphalt (WMA) sample prepared with natural aggregates at varying temperature.
2. For 30% replacement of RAP, the strength is decreased after addition of ZycoTherm but the OBC of the WMA remains same as the HMA mix. Overall Marshall Criteria are fulfilled as per MoRT&H 5th revision, Table 500-11.
3. The moisture susceptibility of WMA as well as RAP- WMA mixes are less than that of Virgin mix but the load carrying capacity of the reclaimed mix is more than that of virginmix.
4. Based on the above discussions, it can be finally concluded that 30% RAP with 70% virgin aggregates containing 0.07% ZycoTherm WMA at 135°C gives better stability and performance than other mixes. Hence 30:70 is the most optimum blend.

5. Resilient Modulus values have improved in WMA mixes and in WMA with RAP mixes.

8. FUTURE SCOPE

1. Further study can be extended to other bituminous surface courses.
2. In the present study RAP material have been used upto 40% for both HMA and WMA mixes. Studies can be conducted using higher percentage of RAP to understand their effect on the mix properties.
3. In the present study, VG-10 binder is used to enhance the RAP mix properties. Studies can be carried out using rejuvenating agents other than bitumen.
4. Research work can be carried out on the usage of 30% &40% RAP HMA mixes with other types of additives and carrying out a comparative analysis with obtained results of mixes using ZycoTherm.

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