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A ZYCOTHERM-BASED EXPERIMENTAL STUDY TO CONTROL MOISTURE DAMAGE TO PAVEMENT

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ABSTRACT
Warm temperatures are ideally suited for producing asphalt mixture, which has been shown to increase energy savings and reduce CO2 emissions. The warm mix method has been extensively employed for road construction and restoration due to its performance being equivalent to that of hot mix asphalt (HMA). When compared to other innovations in the history of the asphalt business, the technique is widely acknowledged as the most successful invention, claim Crew et al. From a few thousand in 2005 to an estimated 46 million metric tonnes in 2010 and 55 million metric tons in 2011, the United States alone produced a lot more of it. According to global field observations, the majority of the warm mix trial portions exhibit satisfactory performance or performance as good as HMA control sections Seepage through soil sub bases in most commonly facing problem in sub base of pavements. in order to avoid this problem researchers found a revolutionary technologies in the form of waterproofing chemicals for soil. Due to reduction in the water seepage, the soil bases can be compacted better and they act as structural layers to offer better strength and durability for the pavements.
Zycotherms are the nano materials when sprayed, it offers waterproofing basement for different soils. Zycotherms changes the surface of an aggregate from hydrophilic (water- loving) to hydrophobic (oil-loving).its particles capture and isolate the asphalts in bitumen and drag them to the surface of the aggregate.

INTRODUCTION

The following advantages of nanotechnology with regard to the characteristics of asphalt and asphalt mixtures are used mostly in the developing countries. The longevity of these bituminous surfaces is often not very long, necessitating maintenance over time. Heavy vehicle damage and seasonal temperature variations in the pavement can contribute to pavement distress [1]. Water also has a number of negative effects on how well a pavement performs and causes the bituminous mix to lose strength and durability [2]. As a result, the cost of maintenance is increased by this parameter. Nevertheless, further studies have demonstrated that adding some chemicals to these bituminous mixes might enhance the characteristics of the pavement and aid to avoid discomfort symptoms. Adding these admixtures also helps in providing increased durability and cost effectiveness to the entire bituminous mix.
The additive used in the current study is Zycotherm an organosilane additive. Zycotherm comes in form of pale yellow liquid which is miscible with water. The chemical is stable under normal temperature and pressure conditions. It works as a bitumen binder and is added to bitumen before it is mixed with aggregates. It helps in resisting moisture by promoting chemical bonding at aggregate interface. The Nano clay exists as minute particles of layered mineral silicates. Clays occur in different forms such as bentonite, kaolinite, montmorillonite etc. However not all clays are Nano-sized and not every clay finds its application as a modifier in asphalt mixtures. Some may have only one dimension that is Nano- sized such as the thickness of bentonite and montmorillonite platelets. The Nano clay utilized in this study is Montmorillonite Bentonite Clay of 99.9 % purity. Montmorillonite is the most common type of Nano clay used as a modifier because of its easy modification through use of nanotechnology. Previously done researches are evident that the additions of Nanomaterials to bituminous mixes considerably enhance the properties of the mixes.
Zychotherm as Antistripping Agents The chemical affinity between bitumen and aggregate can be improved by the addition of very small quantities of chemicals which change the nature of the bitumen or the aggregate to have more affinity for the other. These chemicals are known as "Anti- stripping Agents" or "adhesion

promoters". I since the stability of bituminous pavement largely depend on adhesion between bitumen and aggregates, the ionic nature of aggregate is an important factor explaining the problem of stripping that varies for different type of aggregates. This also explains non- formation of stable bond in bituminous pavement construction. The widely used class of Anti-stripping agents belong to Fatty Polyamine group of chemicals where even in a very small dose they serve to provide Active and passive adhesion between Bitumen and the aggregates. A new class of Nano technology- Organo-silicon based anti-stripping additives is now popular which utilizes the chemistry of Silicon-Silicon bonding [which is nature's strongest chemical bond. Being surface active agents Antistripping Agents improve bituminous wetting of aggregates, thereby reducing the requirement of Bitumen. They also prolong the pavement life by slowing the ageing process. The main goal of anti- stripping additives, is to increase the strength and durability of the adhesion between aggregate and bituminous binders. Here we use Zychotherm as antistripping agent which is help the Bituminous Concrete from water damage.

Moghadas et al. performed a test to investigate the performance characteristic of asphalt mixture by using zycosoil as an anti-strip agent with limestone and granite aggregate. It was seen that the fatigue life increased because of formation of a hydrophobic nanolayer on aggregate, and aggregate coverage with zycosoil increased the amount of filler and decreased the void content in asphalt mixture. It is also observed that the zycosoil modified aggregate surface caused a better compaction of asphalt mixture.

Rohith investigated the stability and Marshall Property of hot mix asphalt specimens produced at 155˚C, 130˚C and 115˚C and compared with warm mix asphalt specimens containing zycotherm nanomaterial produced at 130˚C and 115˚C. It was concluded that the stability and Marshall Property were improved with the addition of 0.1% of zycotherm nanomaterial. Another study conducted by Yao et al. on asphalt and asphalt mixtures by using nanosilica at 4% and 6% by weight of bitumen estimated the characteristics of nanomodified asphalt binder and mixture. Different tests (such as Rotational Viscosity RV, Dynamic Shear Rheometer DSR, Bending Beam Rheometer BBR, Fourier Transform Infrared Spectroscopy FTIR, Scanning Electron Microscopy SEM, Asphalt Pavement Analyzer APA, Dynamic Modulus DM and flow number FN) were performed to analyze the change in chemical bonding and rheological properties of modified asphalt binder and also the performance characteristic of asphalt mixture after modification. It was shown that the anti- aging property, rutting and fatigue cracking performance of nanosilica modified asphalt binders are enhanced and the addition of nanosilica in the control asphalt mixture significantly improves the dynamic modulus, flow number and rutting resistance of asphalt mixtures. The nanotechnology, with the usage of asphalt and asphalt mixture properties, has the following benefits.

d their use mostly in the developing parts of the world. These bituminous surfaces do not generally have great lifespan and maintenance is needed after duration of time. Distress in the pavement is caused due to damage by heavy vehicles and seasonal temperature changes in the pavement

OBJECTIVES

The main objective of this study is

- To evaluate the mix design properties as per the MORTH specification.
- To Compare between WMA properties to that of HMA for the bituminous concrete mix as per the MORTH specification.
- To evaluate the properties of the bituminous concrete (BC) mix using Zycotherm additive of varying percentage of 0.05%to 0.1% by weight of binder

LITERATURE WORKS

Warm mix asphalt (WMA) technology is introduction to the transportation industry to overcome unsatisfactory performance of traditional road materials exposed to mixed traffic patterns. Various types of modifiers for bituminous mixtures like fibres and polymers are used to improve the performance of bituminous mixes used in the surfacing course of road pavements, The additives such as fibres, rubbers, polymers, carbon black, artificial silica, or a combination of these materials are used. The various researchers

have carried out research on warm mix asphalt using additives with Warm mix asphalt.(Metta Pavanchandra et.al (2017), Harpreet Singhet.al (2017), Manjunath S Sharanappanavar (2015) , Vatsal v. Raja, et.al (2015), Bheemashankar, Amarnath.M.S, Elsa Sanchez-Alonso et al.,Mogawer et al. , Mallick et al.,Hurley and Powell ,.)

The additive used was supplied and produced by Zydex Industries, based in Gujarat, India. This additive is soluble in water and generates polymeric material and alcohol when exposed to moisture. ZycoTherm is characterized as stable under normal temperatures and pressures. It consists of 65% to 75% hydroxyalkyl-alkoxyalkylsilyl compounds, 25% to 27 %

benzyl-alcohol (CAS #100-51-6), and 3% to 5% ethylene glycol .

In Malaysia, most if not all asphalt mixtures, especially for wearing courses, are produced using granite aggregates. Granites are known to be water loving in nature (hydrophilic), while bitumen is predominantly hydrophobic. Hence, coating granite with conventional bitumen will result in weak physicalbonding between aggregate and binder, leading to de-bonding and premature moisture damage especially in wet weather. The unique, organo-silane chemistry of ZycoTherm, gives, a strong and permanent chemical bonding (Si-O-Si– mother nature bond available in sand/quartz) between the bitumen andthe aggregate surface. The permanent chemical bonding enables excellent moisture resistance, complete coating of bitumen on aggregates and allows wider temperature zone for mixing and compaction resulting in a pavement with extended life cycle. Faster wetting and complete coating with Zycotherm enables easy mixing, adhesion and improved stability of pavements. This silane additive also enables asphalt mixtures to be compacted at roughly 35oC to 40oC lower than HMA.

Behavioral Characteristics of bitumen. Bitumen can be defined as a civil engineering construction material manufactured by extracting the lighter fractions such as liquid petroleum gas, petrol and diesel from heavy crude oil during refining process and is commonly referred to as refined bitumen (Bejjenki, 2015).

MATERIALS AND METHODOLOGY

Material properties

Materials needed for this study are the constituents of hot mixasphalt and molasses, present sources of these materials.

Table: Material Details

Materials	Material Source
Aggregates	Crushed Stone
Bitumen	Bitumen
Zycotherm	Nano material additive

Materials Used

a. Coarse Aggregates (stone)
b. Fine Aggregates (Natural Sand, stone chippings)
c. Filler Material (Crushed Stone Dust)
d. Binder (Bitumen)
e. Replacement Material (Zycotherm)

Zycotherm

ZycoTherm is an organo silane odour free, chemical warm- mix additive(WMA) .Additives are added to materials to enhance their properties. They are mostly added to improve either workability or durability. However, there are also certain targeted additives that work on improving a particular aspect of a material, like lowering softening point of bitumen. In this study the Nanomaterial used is Zycotherm. Zycotherm is an organo silane odour free, chemical warm-mix additive (WMA). In India Zydex Industries is a chemical company thatproduces Zycotherm and for the current study, it was procuredby directly contacting their sales headquarters in Vadodara (Gujrat). Material required for casting each specimen

EXPERIMENTAL RESULTS

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Test Results

Trail	Zycotherm Content in %	Air voids	VMA	VFB	Flow	stability
1	2	4.94	14.0	64.71	2.50	13.92
2	4	4.22	13.90	69.61	2.97	13.04
3	6	3.73	14.00	73.36	3.23	14.36
4	8	3.70	14.52	74.53	3.67	11.86
5	10	3.62	14.99	75.83	4.27	11.73

Indirect tensile strength results

Zycotherm %	ITS		TSR(%)
	Unconditioned	conditioned	
0	1126	891	79
2	1066	820	78
4	957	623	65
6	845	393	46
8	722	290	36
10	640	168	24

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Material	Proportion	Weight of material in grams
Bitumen	**5.5**	**66**
19 to 14 mm aggregates	**14.175**	**170.10**
14 -7 mm aggregates	**15.120**	**181.44**
7 -3mm aggregates	**17.955**	**215.46**
3 mm down	**45.36**	**544.32**

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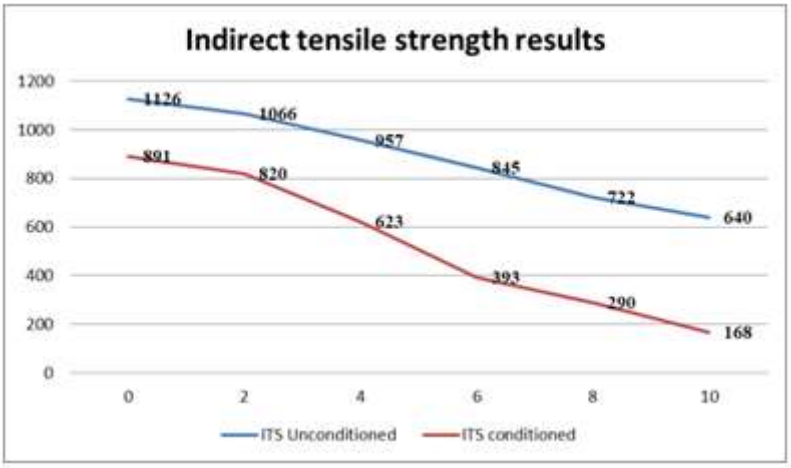
Mix Proportions



The research clearly shows the scope of using Nano Chemicals in the field of pavement construction.

Addition of Zycotherm has the following advantages:

It is also important to see how aggregate type and gradation can affect the fundamental properties of bituminous mixtures in terms of moisture susceptibility because bituminous mixtures are composed of nearly 80% by volume or 95% by weight, coarse and fine aggregates. Adherence and cohesion between asphalt mixture particles must be strong enough to resist stripping in the presence of water. Chemical features of coarse and fine aggregates related to their nature, significantly contributes in this adhesion. Furthermore, compatibility with ASA that is probably incorporated in the binder is another main parameter which, unquestionably, has a significant influence on performance of asphalt mixtures against moisture damage. Therefore, the surface chemistry of the aggregate particles plays an important role in performance of both HMA and WMA. It was also firmly established in SHRP studies that mineralogy and chemical composition of aggregate are of primary importance in stripping.

DiVito and Morris evaluated the performance of aggregates treated with silane to aggregates treated with commercial aminebased ASAs against moisture damage and their investigations revealed that silane treated materials have better resistance than the other one does. In recent years, some researches have been carried out focusing on the use of nano- organosilane as ASA in HMA mixtures; however, the effects of these additives on moisture susceptibility of WMA are still contemplative.

The main work of this research is to investigate the role of a warm-mix and anti-striping additive named zycotherm on moisture susceptibility of asphalt mixtures prepared with different aggregate types and gradations in terms of laboratory tests. Test methods related with the evaluation of water damage. To better investigate and analyze the parameters which affects the stripping of the mixtures, FTIR was performed on binders and XRF was applied on aggregates in Further Work

· Improved Marshall Stability Value The Marshall Stability Value % bitumen content whereas when Zycotherm at 2% (by weight of bitumen) was used which was calculated as the optimum dosage for the Nano chemical the Marshall Stability Value was considerably higher.

· Improved Workability at optimum dosage 4% (by weight of bitumen) the workability of the mix was greatly improved. The mixing force required for the manual mixing of the bituminous concrete was enough to support the claim. Improved Compaction The heights of the two Marshall Stability samples in the two cases with and without Zycotherm were different. The sample with Zycotherm showed improved compaction

and therefore was lesser in height when comparedto sample without Zycotherm.

· Reduced Stripping Value Though Zycotherm is not advertised as an anti-strip its use still improved the stripping resistance of the bituminous concrete mix. Stripping Value without Zycotherm= 20%. Stripping Value with Zycotherm= 5%. DiVito and Morris evaluated the performance of aggregates treated with silane to aggregates treated with commercial aminebased ASAs against moisture damage and their investigations revealed that silane treated materials have better resistance than the other one does. In recent years, some researches have been carried out focusing on the use of nano- organosilane as ASA in HMA mixtures; however, the effects of these additives on moisture susceptibility of WMA are still contemplative.

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The rapid growth of cities in recent years resulted in a lot of transportation. Road surface have experienced a significant increase in traffic volume and higher magnitudes of load. In tropical countries, the normal temperature in summer time will make the bitumen material become softer. This will also reduce the service life of the road. The two main damages in flexible pavements are permanent deformation and fatigue cracking. Therefore, the issue of improving qualities and properties of bituminous material is made by using Nanotechnology additive and Polymer Modified Bitumen (PMB40). The bituminous mix design aims to determine the proportion of coarse aggregates, fine aggregates, filler, additive and bitumen to produce a mix which is workable, strong, durable and economical. The materials like Polymer Modified Bitumen (PMB40), hydrated lime as filler may improve the properties of mix. By using additives in mix can reduce the Optimum Bitumen Content (OBC) and increses in the strength properties like ITS and TSR of the Polymer Modified Bituminous Concrete (PMBC) mix compared to conventional BC mix, because of their excellent binding characteristics and water proofing properties at low cost. Now a days due to drastic increase in traffic, Use of modified bitumen and Nanotech additives are dominating and taking main role in the improvement of Marshall and strength properties of PMBC mix. Also which may reduces the OBC compared to with that of PMBC mix without zycotherm additive.

CONCLUSION

a. The physical properties of the aggregates and bitumen of 60/70 (VG – 30) grade and warm mix binder used for the present studies satisfies the requirements as per MORT&H specifications.
b. The Optimum Bitumen Content was found mix at 160oC mixing temperature.
c. The maximum stability for 60/70 grade bitumen is achieved at 135º C temperature with the additive dosage of Zycotherm by the weight of binder.
d. This study tries to study the conventional and rheological properties of binder mixes, HMA made from this binder mixes and their sensitivity to moisture. In doing so, testparameters were evaluated. Based on the results obtained fromthis study, the following conclusions can be made:
e. Neat asphalt binder was more affected by aging compared to asphalt binder containing Molasses. Meaning addition of Zycotherm to asphalt binderdecreases the aging effect of HMA mixtures.
f. Addition of Zycotherm has affected rheological behavior of asphalt binder thereby making the asphalt binder stiffer at high temperatures which results in a durable binder.
g. The replacement of asphalt binder with Zycotherm at optimum binder content of 6%, decreased the stability, flow, unit weight and the Va% of the HMA,while the VMA and VFA percentages increased as the percentage of Zycotherm increased. The increment and reduction value of these properties of HMA up to 10% Zycotherm is within the Marshall criteria for heavy traffic.
h. The Warm Mix Asphalt with Zycotherm of 4% hasthe Optimum Binder Content value.

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