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REVIEW OF STRENGTH CHARACTERISTICS OF WARM MIX BC MODIFIED USING NATURAL ZEOLITE

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Abstract

Bituminous concrete is composite material made by mixing aggregates and bitumen in fixed proportions used for construction of bituminous pavement. Bituminous pavement transfer wheel load to sub grade by grain to grain transfer mechanism and to transfer loads by this mechanism, the bituminous concrete should have high stability value. Conventional bituminous concrete works efficiently under normal loading and environmental conditions butnowadays vehicular traffic is increasing exponentially and environmental conditions are deteriorating fast. Humongous increase in traffic load cause many types of problems to bituminous concrete pavements, some of them are shear failure of pavements, rutting, alligatorcracking etc. To overcome the problems imposed by increased traffic load and deteriorated environmental conditions different type of modifiers are being used in bituminous concrete. The failures of the bituminous pavements are not only due to increase in traffic but also due toextreme climatic conditions prevailing in our country The Warm Mix Asphalt (WMA) technologies are very popular in recent years because of its property to the reduction in compaction and mixing temperature of Hot Mix Asphalt (HMA) mixtures without compromising the quality. On the other hand, the utilization of Natural Zeolite in modified bituminous mixtures are that these increase the durability the pavement. Also use of Polymer Modified Bitumen can enhance fatigue life of bituminous mixes. These also help in reducing the cracking and rutting potential of the pavement. However bituminous concrete modified using Natural Zeolite requires a low mixing and compaction temperature ascompared to conventional Hot Mix Asphalt because of lower melting point of Natural Zeolite (110^{o}C). Therefore, in this study an investigation of the strength characteristics of bituminous concrete (using VG 30 and PMB 40 bitumen) modified with Natural Zeolite using Sasobit as an additive was initiated.

Keywords: Hot Mix Asphalt (HMA); Warm Mix Asphalt (WMA).

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1. Introduction

Bituminous mix are wide use every flexible pavement constructions. It consist of hydrocarban and minerals aggregates which is mixe with it, and lay downs in layer and after that compressed. in normals situation, conservative bitumins pavement but design and execute correctly execute quites sufficiently except presentation on bitumins mix are extremely poors below a variety of situation. Today asphaltics concretes pavement are likely to performs best as they is expectant improved load of traffics, improved traffics and increase variation in daily or serial heat over what has been skilled in the pasts (Murphy et al., 2001). This starting concept of WMA technology were impliment in Europeans to decrees green house gases release due to pollutions. Every country in Europeian Unions were facing withs green houses gases reductions target to the 1998 Kyoto agreement on climate changes. the majority WMA technology dones by lower the viscosity to the asphalts which allows to better coats aggregates surfaces and reduces the targetes temperature to reaches enough workability of the mixtures. This way it could be use in colder climate or for highway and throughway invention For the same cause, it can be ship long distance also. The WMA is produced by the addition of certain chemicals in the asphalt mixes. These substances help in the reduction in the viscosity of the mix. Reduced viscosity results in significantly lower mixing temperature than the hot mixes. Warm mix asphalt (WMA) technology enables an engineer to reduce energy consumptions and emissions in asphalt paving industry. Compare to hot mix asphalt (HMA) in which compacting and rolling is do neat higher temperatures here in WMA mixing, compacting and rolling is done at lower temperatures. The main ingredients of the warm asphalt mixes are the modifiers which are added in order to reduce the mix production and compaction temperatures. Apart from reducing temperatures, modifiers have been found to be immensely efficient owing to its economical and environment friendly attributes. Hence it is suggested that in arrange to progress the quality of bitumen certain admixtures should be added. Natural Zeolite has proven to be a promising modifier when it comes to incorporating pavement sustainability principles. Numerous studies have been done to determine the usage of warm-mix asphalt (WMA) technology in order to lower the mixing and compacting temperatures. WMA technology works on two principles, either it reduces the asphalt & aggregate interface friction or it lowers the viscosity of the bituminous mix. Various environmental benefits such as lower emissions of hazardous gases, decreased consumption of energy and better surrounding conditions for workers at the construction site can be achieved by incorporating WMA technology.

2. REVIEW OF PREVIOUS RESEARCH ON MAKING WARM MIX BC MODIFIED USING NATURAL ZEOLITE

2.1 Stimilli et al. (2017) studied about the environmental effect of Warm Mix Asphalts (WMA). Warms Mixes Asphalts (WMA) is bitumins mix formed at reduce temperatures through specifics additive base on differents mechanism. Mix was ready counting Styrene-Butadiene-Styrene polymer customized bitumens and 25% of RAP to assess potentials profit deriving froms the mixture of warms and recycle techniques, mechanicals tests (i.e. compactability, stiffness, fatigue) carry outs on mixes in a broad ranges of load configurations was included by rheological analysis on bitumen.WMA considerably reduces mix and compact temperatures compared to traditional Hot Mix Asphalts (HMA) with remarkable advantages in term of situation and cost aggregats heat at reducedes temperatures risks to retain humidity compromise the adhesion among bitumens and aggre-gate. . All mixes had 25% by aggregate weights of unfractioned RAP (0/16 mm) combined withs a variety of virgins lime stone aggregates fractions (0/4, 8/16, 14/25 and filler) and the Nominals utmost Aggregates Size was 20 mm. A PMB contain-ing 3.8% of Styrene – Butadiene-Styrene is use as virgin. Compaction Energy Index (CEI) and the air void content were adopted as main parameters to compare ma-terials. Results showed that the higher the CEI, the lower the compatibility.

2.2 Costa et al. (2016) studied the environment impact and economic study between warm mix asphalt and hot mix asphalt. The warm mix asphalt was produced by a chemicals additive into bituminous mix and the max-imum cost of the warm mix addi-tive was determined. The optimum content of bitumen was taken as 5.2% of the total weight of the aggregate and the mixing temperature was taken between 1140C to 1240C. The composition of aggregates mixture is of 23% of limestone aggregate of 10/20 mm size, 19% of limestone aggregate of 4/10 mm size, 56% of limestone aggregate 0/6 mm size and 2% of lime-stone filler. The result showed the reduction in 18.4% energy of warm mix asphalt as compared to the hot mix asphalt. Very high reduction in temperature is recorded as the total emissions during warm mix asphalt are only 36% of con-ventional one. The introduction of the warm mix asphalt technology has also decreased 8.6% of energy of rough asphalt concrete.

2.3 Zamanillo et al. (2014) conducted various laboratory tests to determine adhesion or sensitivity to water test, rigidity or resili-ent module and density of bituminous mixtures. Three different temperature ranges were selected viz. 120 °C, 140 °C and 160 °C with three different warm mix additives viz. a surfactant which is made of amino substances, a paraffin produced by the synthesis process called Fisher-Tropsch and synthetic zeolite in the form of powder at a content of 0.4%, 3% and 0.3% re-spectively. The Marshall’s stability tests were performed with B- 50/70 grade bitumen and 16mm aggregate size. Gyratory machine was used to com-pact all the samples. The stiffness test and water sensitivity test were conducted on total of 192 specimens of different production temperature and warm mix additive.

2.4 Khan et al. (2012) have conducted study to determine the variation of viscosity of the mixes. In their study, they used two binders CRMB 55 & VG 30 with two additive Evotherm & Sasobit of different combination at temperature ranging from 90 °C to 160 °C at a regular interval of 10 °C. They determined the various physical properties of two binders by varying the proportions of warm mix additives. All tests were carried out in the laboratory. Viscosity of the mixes was determined by Brookfield Viscometer. Sasobit used in this study was at a percentage of 0.5%, 1%, 1.5%, 2% of the weight of bitumen. Bitumen was first heated to fluid condition and then mixed with different type of additive in the lab with a stirrer at 1550 rpm. The test results expressed that the viscosity varied exponentially with temperature and linearly with WMA contents. They also explained that these additives have a potential to reduce the viscosity even when the temperature is constant. Mixing temperature was reduced by 200 °C to 250 °C while compaction and laying temperature was reduced by 101 °C to 151.

3. PREVIOUS STUDIES IN THE AREA OF POLYMER MODIFIED BITUMEN (PMB)

3.1 Iwański et al. (2017) investigates the visco elastics property of polymers customized bitumens (PMB) in Warm Mix Asphalt technology in terms of aged. The base bitumens use was PMB 45/80-65. For bitumens viscosity-reducing modifi-ers, Fischer-Tropsch synthetic wax (SW) and the liquids surfaces active agents (FA) were considered. Whole property of binders has been in use into accounts before ageing (NEAT) and after long-term ageing (RTFOT+PAV). Studies of basic property (softening point and the breaking point) and rheologicals characteristics (zero shear viscosity, complex viscosity and rutting factor) is done. Fatty amine additive works as an ageing inhibitor. The ageing process showed degradation process in polymer. WMAs can be made and kept at approximately 20 °C –40°C temperature lower than those of regular hot mix asphalt but higher than the boiling water temperature. Organic additives such as synthetic waxes or chemical compounds (surfactants) have to be used at temperature range 85 °C to 140°C. The results showed that after the RTFOT+PAV ageing procedure, the PMB 45/80-65 had the breaking point about 1o C higher than the reference bitumen. The breaking point of the bitumen with the addition of synthetic wax of 3.5% was 2 °C higher. The increase in modifier content decreases the ZSV, in case of the bitumen modified with surface active agents (FA). It was noted that all variants of bitumen modification satisfied the requirements as dic-tated by the rutting factor G*/sinδ with respect to the criteria. The increase in the number of synthetic wax crystals and asphaltenes could lead to instability of the polymer modified bitu-men mixture. It was concluded that the bitumen viscosity and stiffness increased with synthetic wax SW in each dosage variant. Surface active agents added to the bitumen.

3.2 Awanti et al. (2016) studied the characterization of SBS polymer modified and neat bituminous mixes using Warm mix asphalt for paving application. Warm mix asphalt (WMA) was developed in Europe that permits HMA to be made at lower temperature. WMA is produced at temperatures 20ºC to 40 ºC lower than that of Hot Mix Asphalt (HMA).The cre-ating and placing asphalt mixes at lower temperatures has an advantage of reduction in energy consumption, greenhouse gas emissions, flumes and odors generated. Also they are more sustainable including reduction of short term binder hard-ening reduction of mixtures tenderness, possible extension of construction season. For characterization, modified bitu-men (PMB) of grade (SBS-PMB 40) and neat bitumen of VG 30 grade with and without WMA chemicals is used. Two specimens each are pre-pared for soaked and for un-soaked for both the grade bitumenVG30 and PMB40 without warm mix asphalt.

The soaked specimen are kept in a thermostatic container at 60˚c for 24hours then are kept at room temperature for 30 minutes after which checked for Marshall Stability value. Marshall mix design is carried out on bituminous concrete specifications prepared usingSBS-PMB70 and VG30 Grade far virgin as well as aged bitumen are to be deter-mined with and without WMA chemicals. The aggregates of 20mm down, 12.5mm down, 6.0mm down and 75micron down passing dust are used along with SBS-PMB-40 zycotherm chemical used in Warm Mix Asphalt. It is concluded that Fuel consumption for heating the bitumen with WMA is reduced as compared to without WMA chemical. Also, Stability of bitumen with WMA is same as compared to bitumen without WMA at higher temperature. The temperature required for mixing and compaction of bitumen with WMA (warm mix asphalt) chemicals is reduced as compared to the bitumen without WMA about 40˚C.

3.3 Fakhri et al. (2013) investigates the effect of warm mix asphalt (WMA) additives on fatigue life of unmodified and SBS modified asphalt mixes. To achieve this, two Warm mix additives (Sasobit and Aspha-min) are used with SBS modi-fied bitumen .Constant stress indirect tensile fatigue tests were performed using the Universal Testing Machine (UTM) at 20ºC Fatigue test was performed on warm polymer modified asphalt (PMA) by indirect tensile test on two stress level (300,450 kPa) on 21 °C and exhaustion life were compare with PMA mixture. Also, indirect tensiles strengths (ITS) test were perform to determines the humidity vulnerability of warm PMA. In orders to evaluate the fatigue performance of warm mix asphalt (WMA) mixtures in comparison with hot mixture asphalt (HMA), four-point flexural beam test was employe. Fours points flexurals beam test were conducte at four strain levels (650, 800, 1000 and 1200) and frequencs of 7.5 Hz at 20°C .According to the test result, it werw show this warm PMA mixtures prepare by Aspha-min and Sasobit, has less fatigue resistance on comparison with PMA mixture. Also the fatigue resistance of warm PMA mixture made by Sasobit is greater than fatigue resistance of warm PMA mixture made by Aspha-min. Based on the ITS test results, SBS-modified mixture has the highest value of ITS. Warm PMA with Sasobit additive and PMA achieved the desirable tensile strength ratio (TSR) criterion (80%) but warm PMA Aspha-min had TSR lower than 80%. Also fatigue life determination based on 51% reduction in initials stiffness showed that the fatigue life of HMA mixture is less than WMA mixtures at lowers strain levels whereas it was comparable with warm mix asphalt at higher strain levels. Economic benefits such as reduced energy consumption, less wear on asphalt plant due to reduced temperature.

Natural Zeolite

The word “zeolites” comes from Greek words means “boiling stones”, because when they release water vapour at elevated tempera-ture it seems to boil. The structures of the zeolites has large air voids where cations and even molecules or cation groups (such as wa-ter) can be hosted. Their ability to lose and absorb water without damaging the crystalline structure is the main characteristic of this silicate framework (Chowdhury and Button, 2008). The utilization of zeolites decreases the optimum bitumen content. Zeolites im-prove the repetitive loading strength of bituminous mixtures, improve permanent deformation ability and increases rigidity. Natural zeolite is an ac-ceptable alternative to commercial synthetic zeolite.

Warm Mix Modified Using Natural Zeolite

Modification of bitumen is being practiced for long time now and there have been so many modifiers used in this sec-tion. About 99 persant of the all road networks make up the flexible road, somewhere in bitumens use as a binders. con-servative bitumin material has normally perform suitably in nearly all highways pavements appli-cations. Though in the modern year, harsh climate, improved traffics level, bigger truck by new axles design and highly tyres pressure, has seem to include to harsh demand of loads and environments on highways systems. This have result in needed to im-prove the propertie of exist asphalts materials. Some of the studies done in this field using Natural Zeolite are being pre-sented below:

3.4 Burak Sengoz et al. (2013) aim of the studied was to become familiar with WMA technology for the bitumen manu-facturers by the help of limited investigated studies. Requirements of manufacturers, the researchers have begun detailed investigations which involve the addition of organic additives, synthetic and natural zeolite, chemical additives and foam-ing with water in mineral.WMA technology can be classified based on the utilization of organic and chemical additives as well as on the utilization of water. Organic additives are used to achieve temperature reduction by reducing the viscosity of bitumen. A decrease of viscosity produces asphalts at small temperature. s. After crystallizations, the rigidity om bitumens increase creation and as-phalt's resistances improved againsts buckle. use of water for WMA can be seprate into two main groups; mostly the directs inoculation of water to the bitumen and the utilizations of hydro-thermally crystallized minerals such of zeolite. Synthetic Zeolite are a finely powdereds hydrated sodium aluminum silicate is hydro-thermally crystallized and it holds 18–23% (by mass) of water. in theory, the zeolite releaseses water which create foam that reduce the viscosity and increase the workability. It provide best coatings of the bitumen on aggregate. Natural zeolites is micro porous, hydrated alumino silicate minerals commonly useed such as commercial adsorbents. Clinoptilolite is one of the most common natural zeolite comprising a micro porous agreement of silica and alumina tetrahedra. It is used in many application as a chemicals sieve, gas ab-sorber, feeds, food and fertilizers additive, a soil amendments as well as use in the production of pozzolan cements and concrete in buildings. Clinoptilolite is well conformed to these applications owing to its large amounts of pore space, high resistance to great temperature and chemically neutral basic structures. Most of the clinoptilolite ore beds are located around the Aegean Sea Region. In addition, Turkey has the necessary environmentals geological activity for the for-mation of natural zeolites and it is estimated that there are nearly 50 billion tons of natural zeolite ore. This study aims to characterize the properties of bitumen samples involving clinoptilolite type of natural zeolite and other types of warm mix additives (synthetic zeolite, organic and chemical) with their different contents. For this purpose conventional test methods as well as dynamic shear rheometer (DSR) at different temperatures and low and high frequency level have been performed. Natural Zeolite varies from 4 to 8% by the weight of binder. Ductility charge of bitumens (VG 30) mod-ifiy use Natural Zeolite decreases with increases in Natural Zeolite contents. Softening point, Flash point and Fire point of Bitumen (VG 30) modified using Natural Zeolite increased with increment in Natural Zeolite content.

4. CONCLUSIONS

In this chapter a critical literature review of the work was carried out. Modified warm mix bituminous concrete is obtained by mixing modifiers with bitumen and then constructing bituminous concrete (wet process) or by mixing aggregates with modifiers and then constructing bituminous concrete (dry process). Previous works shows that Marshall's stability values increases with increase in content of modifiers up to a certain value than it starts decreasing this value up to which Marshall's stability values increases is called optimum content of modifier.

As there are so many modifiers which are being used in bituminous constructions it is very important to grade them as per their performance for this we have to conduct a detailed investigation of warm mix bituminous concrete modified with different modifiers but until today we don't have any such studies which have graded modifiers. Literatures which were reviewed in this chapter describe history of modification of bitumen, how and why modification started what was the need to go for modification is covered in few literatures. Next few literatures are based on the general modification and types of modifiers used for modification of bituminous constructions, there are too many modifiers which have been used for modification but only few of them are found to be performing satisfactorily. Some of these modifiers are Natural Zeolite, glass, natural rubber, HDPE, PET etc. it was found that modifiers can increase the stability value of bituminous concrete and also enhance the water resistance:

Further following conclusions are drawn from the present study:

1. Ductility value of bitumens (VG 30) customized use Natural Zeolite decrease with increases in Natural Zeolite contents. That ductilitys value of bitumens depend upon the compositions of the bitumens and but some new materials mixes with bitumens form uniform mix it will affect ductility but not as much as when a modifier mixed forms heterogeneous mixes, but anything kind of modifier are mix it will certainly decreases the ductility as the particles of modifiers will break the continuity of the bitumen film which in turn will break on elongation and hence ductility value decreases with increase in Natural Zeolite. Viscosity of bitumen (VG 30 and PMB 40) modified using Natural Zeolite is more at 5% of Natural Zeolite in both the grade of bitumen. Viscosity of bi-tumen (VG 30 & PMB 40) increased to 5% from previously found out 4%, with further decrease of 6%. Vis-cosity of the modified bitumen was

found be maximum at 5% composition, thus, indicating better performance compared to conventional bitumen.

2. 2. The Marshall stability of warm mix bitumin concretes customized use Natural Zeolite of VG 30 and PMB 40 grade bitumen both decreased at 4% & 6% but at 5% increased compare to conventional warm mix BC. This give the best dose of Natural Zeolite at 5% by the weights of the bitumens. Marshall Stability values of warm mix BC using Natural Zeolite in VG 30 grade of bitumen increased by 34.82% and in case of PMB 40 grade in-creased by 45% when compared with conventional warm mix BC. Percentag of air void (VV) decrease with addition of Natural Zeolite. This tendency is mostly since of the fact that at first when Natural Zeolite are mixed with bitumen and bitumin concretes is ready by use this customized bitumens the voids are filled by these mod-ifiers also which reduces the void content of mix while in conventional bituminous concrete (for VG 30 and PMB 40) only bitumen fills the voids, this may be a reason to the observed trend. Marshalls Quotient (MQ) val-ues are not direct measure of toughness of bitumin concrete. MQ initially increase then started decreasing with increment in Natural Zeolite content for both Natural Zeolite. Maximum Marshall Quotient (MQ) value was ob-served at 10% of Natural Zeolite for VG 30 and at 9% of Natural Zeolite by weight of bitumen for PMB 40.(Sengoz, Topal and Gorkem,2017)
3. Flows values improved with increments of Natural Zeolite content for VG 30 grade of bitumen. This trends can be explained by the fact that addition of Natural Zeolite decreaseses the inter-particles fric-tions in the mix, when loads is applied on specimen since the resistance has been compact the particle movement in the direc-tions of applied force and the magnitude of movement are more when compared with flow of conventionals warm mix BC. (Sengoz, Topal and Gorkem,2017)
4. Warm mix is successfully mixed at lower temperature (130 °C) as compared to conventional hot mix (160°C); hence the mixing temperature can be reduced up to 300C.

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