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A REVIEW ON USE OF WAX MATERIAL FOR ENHANCING PROPERTIES OF BITUMEN

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Abstract— Transportation is key to the economic development of every country. There are various modes of transportation are available from which Road transportation is very essential because it provides the feeder service to all other modes. There are mainly two types of pavements are used in road transportation viz. Flexible and Rigid Pavement. Flexible pavement is made up of bitumen, which is by product of distillation of petroleum product. As during the construction of flexible pavement, the mixing temperature for bituminous mix is between 130 to 175 °C as per the grade of bitumen. Now it has been seen that at this temperature, CO2 emission is very high and it is not healthy for the workers. So, bitumen emulsion and cut back are used in the mixed design to decrease the mixing temperature. One more approach i.e. use of wax is emerging for the reduction of mixing temperature. Many countries are using waxes as admixture in bitumen mix. In this research attempt will be made to evaluate the change in physical properties of bitumen and stability of bitumen mix by adding the wax as admixture in VG30 grade of bitumen.

Keywords— Bitumen, Wax, Flexible Pavement, Bitumen Mix, Marshall Test

I. INTRODUCTION

Transportation can simply be define as the movement of people or goods from one place to another. Transportation is playing a vital role for economic improvement of any country. It has a great history as humans are using transportation by the day he learned to walk. In day-to-day life, each person is using transportation for ex. Trip to work, trip to shopping, trip to social activities etc.. Roadway is one of the important mode of transportation as it provides connecting links or feeder service to different modes and provide flexibility to the road users. It is also the chipset and effective mode of the transportation to connect undeveloped area of the country. So, most of the research projects are associated with the investigation of new techniques in road construction and modification of road material.
For the construction of flexible pavement, the bitumen is required to be heated at a temperature of range 130 to 175 °C. Mixing of bitumen is done on the hot mix plant to get hot bitumen mix. Now it is very difficult and dangerous for the workers to work with the environment having that much of temperature. In addition, the emission of CO2 is also very high with respect to rise in temperature. Initial aging of bitumen will be more as temperature of mixing and placing rises according to the grade of bitumen.
In order to reduce the mixing and placing temperature of bituminous mix, bitumen emulsion and cut back bitumen are being used. Again, the properties of bitumen emulsion depends on the type of emulsion selected. To overcome this problem modified bituminous materials are also available in the market. In many countries paraffin wax are being used as modifying agents for bitumen. Therefore, this research is trying to use the natural beeswax, Soy wax and Candle wax in bitumen.

II. LITERATURE REVIEW

S. Rajan, S.N. Bose, T. Jaman, D. Kumar, In this research study, Bitumen grade 80/100 is taken as base bitumen and paraffin wax is taken as admixture. This is study is limited to use of paraffin wax up to 5%. After performing the physical test of bitumen it was concluded that penetration value wad decreased by increasing the paraffin wax percentage. Also by increase of wax % in bitumen shows the increase in Softening point value. By using Dynamic Shear Rheometer, the graphs were plotted for complex modulus and phase angle and it was concluded that with the increase in wax content values of G* and phase angle was also increases. For evaluating rutting resistance characteristics graph between G*/sinδ and wax content was plotted and it has been seen that value of G*/sinδ is increased with increase in wax content but the maximum value is observed at 4%. Therefore, it has been concluded that 4% of wax content is best for the use in bitumen pavement because of the result of all properties and economic point of view.

Flippo Merusi, Sara Felippi, Giovanni Polacco, Authors had selected five different types of waxes for the evaluation of effect of synthetic wax on viscoelastic behavior of 50/70 bitumen. Five types of waxes are P1 (Monton wax), A1 and P2 (mixes of monton wax and high molecular weight hydrocarbon), A2 (Mixes of monton wax and fatty acid derivatives by clariant), P3 (FT wax by Sasol wax). Among the five waxes P1, P2 and P3 are synthetic wax and A1 & A2 are amidic wax. This study is divided into two part: first portion covers the glassy state with intermediate waxy structure on which bitumen mainly determines the mechanical response and in second part, macro region develops along the intermediate viscoelastic domain and propagates towards high temperature, in this domain, complex response is exhibit. At 6% of wax

content basic properties shows that penetration decreases, softening point increases with decrease in viscosity. By performing DSC (Differential Scanning Calorimetry) and POM (Polarized Optical Microscopy) it was concluded that when temperature (T) is less than Glass Transition Temperature (Tg), then the effect of wax is negligible, When T> Tg the wax is start to be effective and when T>>Tg the wax exerts its maximum contribution and it alters mechanical properties deeply with respect to base Asphalt.

Anna Chomicz-Kowalska, Wladyslaw Gardziejczyk, Mateusz Iwanski, In this research study bitumen grade 50/70 is used for the HMA, foamed bitumen mixture is used to prepare HWMA, wax (2.5%) is used before foam preparation for the evaluation of stiffness modulus of foamed bitumen asphalt. The sample of HMA is compacted at 140°C and other two samples are compacted at 95°C. Stiffness modulus is determined by performing test on cylindrical specimen. Based on the laboratory test it was concluded that 2.5% wax is advantageous in physical and mechanical properties than HMA. The synthetic wax improved workability and compatibility. The effectiveness of synthetic wax is confirmed for the analysis of asphalt concrete compatibility and stiffness conducted with the use of static tool viz. Duncan post-hoc test to corroborate the fact of obtaining similar properties of mixture compacted at 95°C relative to conventional HMA.

Mithil Mazumder, Hyunhwan Kim, Soon-jae Lee, In this study Styrene Butadiene Styrene (SBS), Polyethylene Wax (Lead Cap) and FT wax (Sasobit) ware used to evaluate performance on the basis of long term and shirt term aging, fatigue resistance, rutting resistance by performing Rolling Thin Film Oven Test (RTFOT), Pressure Aging Vessel (PAV), Super pave Asphalt Binder Test: Dynamic Shear Rheometer (DSR), Bending Beam Rheometer (BBR), Rotational Viscometer. This study shows that both wax additives decreases the viscosity of bitumen. DSR test indicates that LEADCAP is more resistive to fatigue and temperature cracking than Sasobit as the Sasobit contained bitumen found to be have more G*Sinδ value which decreases the fatigue resistance and higher stiffness value which results in lower resistance to low temperature cracking. Therefore, based on resistance to fatigue and low temperature cracking LEADCAP is significant over Sasobit. However, in terms of rutting resistance the Sasobit is more significant than LEADCAP.

Weislawa Ciesinska, Barbara Liszynska, Janusz Zielinski, Different Polyethelene waxes used are by product formed in ethylene low-pressure polymerization process, physically and chemically modified wax. Differential Calorimetry (DSC) was used to determine temperature of phase transition and thermal effects. After performing various tests it was concluded that waxes formed as by product of high-density polyethylene by suspension method, has highest value of penetration, which means lowest hardness, compared too physically and chemically modified wax. When wax is modified physically by removing fraction of lowest molecular weight crystallization increase and when wax is modified chemically by oxidation, decrease in crystallization is observed. Physical modification increases the thermal resistance. Introduction of hydrophilic functional group to wax (oxidation) unable production of emulsion.

Hasan Fazaeli, Amir A. Amini, Fereidoon Moghadas Nejad, Hamid Behbahani, Bitumen grade 60/70 is used as based bitumen and Sasobit wax with other additives Anti stripping agents, Crumbed rubber, Styrene Butadiene Styrene, polyphospheric acid ware used as other additives in this research work. Evaluation was done based on following tests: Fourier Transform Infrared Spectroscopy (FT-IR), Scanning Electron Microscopy (SEM), Dynamic Mechanical Analysis (DMA), Bending Beam Rheometer (BBM) and other conventional tests. From the results of various tests performed, it has been seen that Sasobit decreases penetration as well as viscosity and it increases softening point value. Sasobit wax also lowers down the mixing and compaction temperature of bitumen mix. Bitumen modified with wax and CR combination has highest viscosity and mixing/compaction temperature. Anti-stripping agents did not show any drastic effect on permanent deformation. BS-C having lowest value of G*Sinδ shows best fatigue resistance among all combination. Anti-stripping agent increases of bitumen, which leads to higher probability of low temperature crack on the other hand CR having lowest stiffness shows grates resistance to thermal cracking. CR has expanded properties of wax-modified bitumen in compares to PPA and SBS. Anti-stripping agent does not have considerable effect on wax-modified bitumen.

S. Minu, R.L. Lija, In this research article, candle wax is used to modify the properties of bitumen. Evaluation is done by the comparison of results of unmodified and modified bitumen. Candle wax are used at different % ware: 5%, 10%, 15%, 20%, 25% by weight of bitumen. Various tests performed ware penetration, viscosity, ductility and softening point. Results of penetration shows the decrease in value by increasing wax content. Similarly, ductility was also decreased by increasing wax content. Viscosity and Softening point values are increases due to increase in wax content. Therefore, from the results it was concluded that by adding wax from 18.85% to 0.54% will produced better bitumen mix than unmodified bitumen in terms of penetration. By adding candle wax up to 4.1% and above will produce ductility that will not flush or bleed due to incremental changes in temperature. By adding candle wax of 5-20% will increases softening point value of bitumen, which is more resistive to boiling temperature.

Julide Oner, Burak Sengroz, Natalia Maidanova, Ali Topal, Gulay Malkoc, Bitumen used in this study were collected form three different places viz. Turkey, Iraq and Russia. From Turkey the sample (Bit-T) has Bitumen grade of 50/70, while other two from Iraq (Bit-I) and Russia (Bit-R) having bitumen grade 70/100. Various conventional tests, dynamic Shear Rheometer (DSR), Differential Scanning Calorimetry (DSC), Bending Beam Rheometer (BBM),

Multiple Stress Creep recovery Test were performed on all three samples. Conventional tests of bitumen indicates bitumen with lower value of wax are less susceptible to temperature. By the result of Brookfield Viscosity test, it was concluded that wax content reduces the viscosity of bitumen.

Yu.A.Urcheva, A.M.Syroezhko, V.M. Strakhov, In this research work Bitumen grade 60/90, activated MP-1 mineral powder, Prophyrite, Granite shifting, mixed dust from granite rubble, Luprene, Saslowax and sasobit were used to evaluate the effect of paraffin wax and polymer in asphalt mix. Various physical tests viz. Penetration, Softening, Ductility and brittleness tests were performed to evaluate the properties of wax and polymer. Test results shows that all modifiers affect the physical properties of bitumen. Bitumen modified with the use of sasobit can be recommended for the industry as it complies all the standard requirements. Mixture with the use of Sasol wax shows the melting at 40°C, which is not recommended for the severe climatic condition. Sample preparation using paraffin wax shows that they were easily handled.

Marek Iwanski, Anna Chomica-Kowalska, The main objective of this research work is to identify optimum content of FT wax and foam water for the improvement of properties of formed bitumen used in road construction. 50/70 bitumen grade and FT paraffin wax were used in this research work. Conventional tests viz. Penetration test, Softening, dynamic viscosity and breaking point tests were performed. Results of various test shows that FT synthetic wax had significant effect on basic physical properties of bitumen concluded from decrease in Penetration and increase in softening point and which shows the resistance to permanent deformation. Increase in FT wax content from 0 to 2.5% also shows the induced improvement in foam ability, at 3% Ft paraffin wax shows reduction in foamablility but result was good as compared to the neat bitumen.

Shivnaath Mehra, Abhishek Mittal, P.N. Sharma, Crumb rubber modified bitumen was evaluated and compare it with and without use of polyethylene wax. Various test, such as penetration test, softening test, viscosity test, elastic recovery test, specific gravity test and DSR were performed to evaluate properties of CRMB with and without TITAN polymer. Tests results shows that addition of PE wax to bitumen significantly affects the binder properties and viscosity profile of base material. Bitumen mixes with PE as additive were able to achieve good properties like stability, durability, resistance to deformation, workability, compaction, but for better elasticity, they may be used with other additives like CRMB, SBR, and SBS etc.

Ambika Behl, Prof. Satish Chandra, Prof. V.K. Aggarwal, In this study Bitumen grade of VG 30 and Sasobit was used for the evaluation of rheological properties of bitumen modified with wax. Sasobit wax was added at 2, 3, and 4% by weight of bitumen and Brookfield viscometer was used for the viscosity test on VG30 bitumen with and without addition of Sasobit wax at 90, 120, 150 and 180°C. Dynamic Shear Rheometer (DSR) was used to study the rheological properties of bitumen. Test results shows that viscosity of bitumen is higher at low temperature and reduces considerably at high temperature by addition of wax due to its melting point (85-115°C). Bitumen modified with sasobit shows the better G and G' values at temperature between 40-80°C that concludes the increase in stiffness of binder material. Phase angle and complex modulus were also increased on addition of Sasobit wax, which shows the better resistance to permanent deformation of mix. After reduction in mixing temperature from 155°C to 120°C it is obvious that overall emission of pollutants were reduces considerably.

Ali Jamshidi, Mwor Othman Hamzah, Zhanping This is study was based on the evaluation of performance of bitumen due to additives such as Sasobit, Crumbed rubber, polymers by performing various tests such as DSR, Super pave asphalt binder test, Homburg asphalt binder test, construction temperature test and other conventional test. After studying several research, it was conclude in this paper that Sasobit has both advantage and disadvantage. As sasobit reduces the viscosity, construction temperature which ultimately reduces pollutant emission during construction of asphalt. It also increase resistance to rutting at intermediate temperature, decreases aging, and reduces viscosity of polymer-modified bitumen and crumb rubber modified bitumen. However, it may increases possibility of fatigue and low temperature cracking. No significant difference was observed between sasobit WMA and HMA in terms of volumetric properties. Rutting resistance is more in sasobit WMA than HMA. Lab study shows that general performance of sasobit WMA was satisfactory but more study is required to analyze long-term performance of sasobit WMA. The main purpose of using Sasobit is to reduce fuel consumption and to reduce the emission of gases during manufacturing of HMA.

Marek Iwanski, Grzegorz Mazurek, In this research article Synthetic wax and bitumen grade 35/50 and 50/70 was used to evaluate optimum wax content for bitumen. Comparative analysis between neat bitumen and modified bitumen with wax was done to evaluate the optimum wax content on the basis of various tests performed viz. Breaking point test, Penetration Test, Softening point test, Dynamic viscosity Test, Low shear viscosity test, Complex modulus test, Multiple stress creep recovery test. On the basis of test results it was concluded that synthetic wax decrease penetration value regardless the grade of bitumen, increases breaking point temperature, presence of synthetic wax directly affects the complex modulus of neat bitumen, viscosity test reveals that the use of wax over 2% reduces plastic deformation of bitumen, MSCR indicates that bitumen containing 2.5% wax can be used for heavy traffic load condition, multi criteria algorithms suggest that best wax content is between 2.5-3%, decreasing trend utility function shows that wax content more than 3% adversely affects properties of neat bitumen.

Hassan Fazaeli, amid Behbahani, Amir Ali Amini, Jafar Rahmani, Golazin Yadollahi, In this study, authors had selected Sasobit wax as admixture for bitumen. Various physical properties were evaluated by adding different % of sasobit wax in Bitumen. After evaluation of the result for physical test it was concluded that at 4% of Sasobit, admixture penetration value was decreased, softening point value was increased, ductility value was decreased and Kinematic viscosity decreases. In this study Rheological properties were also evaluated which is, at 4% of Sasobit value DSR test shows increase in rutting resistance. Also from the graph of viscosity of bitumen at different content of Sasobit shows reduction in compaction and mixing temperature of bitumen mix as compared to base or virgin bitumen.

Yuksel Tasdemir, In this research work two types of waxes viz. paraffin wax and polyethylene wax and two grades of bitumen i.e. Bitumen 50/70 and 160/220 were used for the investigation of performance of wax-modified bitumen. Binder properties were evaluated with the help of conventional tests and dynamic mechanical analysis and bending beam rheometer. The high temperature properties of asphalt mixture was investigated using frejch rutting tester. Based on DMA testing it was concluded that polyethylene wax shows better stiffening than sasobit but conventional tests shows opposite result i.e. sasobit shows greater stiffening than polyethylene wax. Kinematic viscosity at 135°C is decreased in case of sasobit, which reduces mixing temperature and emission during mixing. Low temperature performance of modified bitumen is better than unmodified bitumen. Based on DMA and BBR tests it was concluded that bitumen modified with polyethylene wax shows higher rutting resistance at higher temperature and better low temperature performance than neat bitumen. Asphalt concrete with sasobit shows better resistance to rutting than polyethylene wax modified asphalt concrete.

Ali Azhar Butt, In this research work wax and polymer modified bitumen were used for the investigation of performance of mastic asphalt at lower temperature. Various conventional test viz. penetration, softening, viscosity, elastic recovery rolling thin film oven test, test on rheological properties (DMA, creep test) and tensile stress restrain specimen test were performed to evaluate performance of wax at low temperature in asphalt mix. It was concluded based on test result that at 4% wax content penetration and viscosity values decreases while softening point increases. There was no any negative effect on aging and storage capacity was seen. According to rheological test (DMA), complex modulus was increased and phase angle decreases, which shows the increase in resistance to rutting. According to BBR test, stiffness was also increased and TSRST fracture temperature was 5°C more than neat bitumen. So overall, it can be concluded that wax helped in improvement of performance of modified asphalt at low temperature.

Y. Edwards, Y. Tasdemir, U. Isacsson, This study is based on the investigation done by adding four types of wax viz. FT paraffin wax (Sasobit), Romonta Asphaltan B (Monton wax), Luwax A (polyethylene wax), Sasol wax and polyphospheric acid in binder and asphalt concrete mix. Properties of binder were evaluated using DSR test, Bending Beam Rheometer, Forced Ductilometer, and various conventional tests. Properties of asphalt concrete were evaluated from Tensile Stress Restrain Specimen Test (TSRST), creep test, complex modulus test and dynamic creep test. Test results shows that sasobit wax affects the bitumen in temperature range of 5-90°C. Montan wax shows effect on softening and ductility values. Viscosity is more affected by polyethylene wax than montan wax. Chemical investigation shows that bitumen is less affected for sulphoxide and carbonyl absorbance but increases the area representing straight methylene chains in all cases. Fracture temperature is increased by 2°C of any bitumen at 6% wax content of any commercial wax and BBR stiffness decreased by polyphospheric acid. By the result of dynamic creep test smaller permanent deformation was recorded for asphalt mix containing sasobit wax or montan wax which indicates better resistance to rutting and largest permanent deformation for Sasol wax. In complex modulus, test PPA shows less or minor influence on bitumen while addition of 6% any wax increases the complex modulus and decreases the phase angle.

III. CONCLUSIONS

By studying all the research paper it was very clear that wax helps in improving the properties of bitumen and also lower down the temperature of mixing and placing of bitumen, which helps in reducing the emission of gases in the atmosphere, and also decreases the risk to health of labor working with high temperature. In foreign countries, wax is popular admixture in construction of flexible pavement. In India very, less research has been done on wax. Among all waxes, Sasobit is having strong influencing characteristics. Wax also increase rutting resistance and low temperature crack resistance according to rheological properties of bitumen modified with wax. Therefore, it was clear from the literature review that use of wax enhance the properties of bitumen. So according to the type of bitumen and requirement of improvement in respective properties we can use wax as admixture in bitumen.

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