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COMPARATIVE STUDY OF SBS AND EVA POLYMER MODIFIED BITUMEN- A REVIEW

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Abstract: The deterioration of the bituminous pavements is because of various conditions prevailing in the country like in addition to the heavy climate and also due to extreme climatic condition. The quality of bitumen could be improved by the addition of polymer as well as improving the quality of binder and also enhancing the property of binder used for the construction of pavements. Due to the prolonged exposure to air and environmental conditions of the bitumen, the major or principle factors take place which causes the deterioration of the asphalt pavements that is Bitumen ageing. There are two types of binder ageing long term ageing and short term ageing. Long-term ageing takes place after pavement construction and is generally due to loading and environmental exposure and Short-term ageing takes place when binder is mixed with aggregates in a mixing plant.

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1. Introduction

Increase in the traffic factors like heavier loads, higher traffic volume, and tire pressure increased the demand of high performance pavements. A high performance pavement requires asphalt cement that is less prone to low temperature cracking or high temperature rutting. Asphalt exposed to a wide range of load and weather conditions, however, does not have good engineering properties, because it is brittle in cold weather and soft in a hot environment. Hence to improve the mechanical property asphalt is generally strengthened by polymers A limited number of polymers have been employed to mix with asphalt, including thermoplastics—ethylene-vinyl acetate (EVA), high density polyethylene (HDPE), low density polyethylene (LDPE), ethylene-propylene-diene (EPDM), and elastomers—styrene-butadiene-styrene (SBS), styrene-butadiene random copolymers (SBR), and styrene-isoprene-styrene (SIS).

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1.1 The History of Modified Bitumen Development

Bitumen is been used as a protective and binding material for the last 5000 years. The first records were found in Entre Rios, northwestern India and Iran. Bitumen was used by Egyptians in construction and for protection from moisture. It is still not exactly clear why it took so long to go from extensive usage of bitumen in the Ancient times to worldwide use. Romans were also unable in using it properly for road construction hence the decision to improve binder quality by introduction of special additives. At that time bitumen was already used in application with plastic materials as roof coat. Research focused into improving road bitumen started in the beginning of the last century. Scientists started to observe different types of polymers like: PE, EMA, SBS and EVA. Testing of bitumen's modified with these polymers took several years.

1.2 Production of Bitumen

Bitumen or Asphalt is a derivative resulted by refining of crude oil and usually used as binder during road construction due to its high viscous property. It is generally bright dark black or dark brown. . The crude oil heated at 300° C and slightly vaporized in an Atmospheric Distillation Column and the various components are divided substantially, during the separation the lighter components rise to the top and the heaviest components (the atmospheric residue) fall to the column's bottom and treated in a vacuum distillation column after passing through a second heat exchanger. At last Bitumen is attained by vacuum distillation (flashing) of atmospheric residue. This is "straight run bitumen". This process is called bitumen production by straight run vacuum distillation

1.3 Materials Used For Bitumen Modification

1.3.1 Ethyl-Vinyl-Acetate (EVA)

Ethylene-vinyl acetate (EVA) is the copolymer of ethylene and vinyl acetate. The weight percent vinyl acetate usually varies from 10-40%, ethylene composes the remainder. Broadly speaking, EVA copolymer can be classified into three types, varying in the vinyl acetate (VA) content and the way the materials are used. EVA (Ethyl-Vinyl-Acetate) is type of an elastomeric polymer material which creates soft and flexible materials having similar qualities like rubber. The material has low-temperature toughness, good clarity and gloss, hot-melt adhesive waterproof properties, stress-crack resistance, and resistance to UV radiation.

1.3.2 Low Density Polyethylene (LDPE)

Low-density polyethylene (LDPE) is a thermoplastic manufactured from the monomer ethylene. The first grade of polyethylene is produced by Imperial Chemical Industries (ICI) in 1933 by with applying a process of high pressure with unrestricted radical polymerization.

1.3.3 High Density Polyethylene (HDPE)

High-density polyethylene (HDPE) is a polyethylene thermoplastic manufactured from petroleum. It is also known as "alkathene" or "polythene" when used for pipes. HDPE has higher ratio of strength-to-density and normally used for the construction of corrosion-resistant pipes, plastic bottles, plastic boards and geo-membranes. Number 2 is the resin identification number for HDPE (a recyclable material). HDPE has higher ratio of strength-to-density. The density of HDPE varies from 0.93 to 0.97 g/cm3 or 970 kg/m3For identifying the variations in physical properties a definite and deterministic factor is employed by the international standardized testing methods in precise method such as for Rotational Molding, identification of the environmental stress crack resistance of a sample is done by Notched Constant Tensile Load Test (NCTL).

1.3.4 Ethylene-Propylene-Diene (EPDM)

EPDM rubber (ethylene propylene diene monomer (M-class) rubber), a type of synthetic rubber, is an elastomer having many applications. The M refers to its ASTM standard D-1418 classification; the M class includes rubbers having a saturated chain of the polymethylene type. EPDM rubber is thoroughly associated to ethylene propylene rubber which is a copolymer of ethylene and propylene, while EPDM rubber is a terpolymer of ethylene, propylene, and a diene-component.

1.3.5 Styrene-Butadiene-Styrene (SBS)

Styrene-butadiene Styrene is a synthetic rubber generally known as SBS. These are classified as a block co-polymer. The structure of SBS allows for a blend of hard plastic and elastic properties. Compatibility of SBS with bitumen is very high, thus it is perfect bitumen modifier to achieve cold weather flexibility and elastic properties. The synthetic rubber is widely used in modified bitumen roofing, mastics, sealants, coatings, and paving.

1.4 Application of Bitumen

Bitumen is often popular for its properties of adhesive and cohesive possessions. It is widely used for construction field. It is employed on road pavement due to its viscous nature when heated but solid once it cools down. Therefore Bitumen is used as the binder/glue for aggregate pieces.

Bitumen is used in construction and maintenance of:

- Highways
- Airport runways
- Footways / Pedestrian Ways
- Car parks
- Reservoir and pool linings
- Building Water Proofing
- Tile underlying waterproofing
- Newspaper Ink Production

2. Literature Review

Previous works:

Avido Yuliestyan, Antonio Abad Cuadri and Pedro Partal (2016)[1] investigated the modification of bitumen with low melting point EVA copolymers. Firstly they investigated, different modified binders containing EVA with varying VA contents (and so different crystalline fractions and melting temperatures) and Melt Flow Index (MFI) values. In the second stage, emulsification was implemented, in which the above EVA modified bitumen was suspended in the form of micro-size droplets in aqueous phase, in the presence of a surfactant. The results suggest that an optimum balance between VA content and MFI value will improve the binder rheological performance at medium-high in-service temperatures as well as its workability, and will facilitate its emulsification. Additionally, the binder viscosity is tremendously reduced after its emulsification, which allows mixing to be performed at much lower temperature, so reducing both energy consumption and environmental risks

Xing Liu, Shaopeng Wu, Gang Liu and Liping Li (2015) [2] applied two types of LDHs (Mg-Al-LDHs and Zn-Al-LDHs) to modify bitumen by melt-blending. The effect of ultraviolet aging on the rheology and chemistry of LDH-modified bitumen was studied by means of dynamic shear rheometer (DSR), thin-layer chromatography with flame ionization detection (TLC-FID), Fourier transform infrared spectroscopy (FTIR), and Ultraviolet-Visible (UV-Vis) spectrophotometry to reveal the mechanisms of action for LDHs and bitumen. The results showed that within the UV spectra (220–400 nm), the reflectance of Zn-Al-LDHs was larger than that of Mg-Al-LDHs. These two LDHs have different influences on the performance of bitumen. Mg-Al-LDHs had a more obvious influence on the physical and dynamic rheological properties of bitumen than Zn-Al-LDHs. Zn-Al-LDHs improved the UV-aging resistance of bitumen more. The reason can be that the reflectance of the Zn-Al-LDHs to the UV light is larger than that of the Mg-Al-LDHs. The Zn-Al-LDH-modified bitumen had more potential to improve the UV-aging resistance during the service life of asphalt pavement.

Zhu, J., Birgisson, B., Kringos, N. (2014) [3] reviewed the achieved advances and encountered challenges in the field of bitumen polymer modification during the last 40 years. The largely discussed technical developments include the application of some popular plastomers (PE, PP, EVA and EBA) and thermoplastic elastomers (SBS, SIS and SEBS), saturation, sulfur vulcanization, adding antioxidants, using hydrophobic clay minerals and functionalization (including application of reactive polymers). In their study they found that Polymer modification was an effective way to improve bitumen properties to some extent by many researchers and has been used widely in practice. However, the currently popular polymer modifiers have various disadvantages limiting their application. Some important problems with bitumen polymer modification are still not well understood. More efforts are supposed to be made to promote a further development

Suleiman Arafat Yero, and Mohd. Rosli Hainin (2012) [4] reviewed the bitumen modification process in relation to warm mix asphalt (WMA) technology, using S as a modifier. They also investigated the viscosity measurements of modified bitumen, using the Brookfield viscometer. The binders mixed with various percentage of the wax S 1%, 2%, 3%, 4%and 5% were investigated. The results from their study showed the viscosity of the binder decreasing at higher temperatures while at midrange temperatures the viscosity increases with an increase in the additive. Their study provided a valuable data on the effect of the additive S on increasing the dynamic viscosity of the binder at low temperature and decreasing the kinematic viscosity at high temperature, been attributed to the presence of the S wax with high hydrocarbons molecular content in the binder, which is expected to improve the viscosity properties of the modified binder and enhance its resistance to deformation when used in warm asphalt concrete mixtures.

Jian-Shiuh Chen, Min-Chih Liao, and Ming-Shen Shiah (2002) [5] investigated the morphology and engineering properties of the binders using transmission electron microscopy ~TEM!, rotational viscometer, and dynamic shear rheometer. The morphology of polymer-modified asphalt was described by the SBS concentration and the presence of microstructure of the copolymer. When the SBS concentration increased, the copolymer gradually became the dominant phase, and the transition was followed by a change in engineering properties of SBS-modified asphalt. Results from TEM showed that depending on the asphalt and copolymer source, a variety of morphology can be found. The SBS-modified binders might show a continuous asphalt phase with dispersed SBS particles, a continuous polymer phase with

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dispersed asphalt globules, or two interlocked continuous phases. The optimum SBS content was determined based on the formation of the critical network between asphalt and polymer. Because of this network formation, the binders showed a large increase in the complex modulus that indicates resistance to rutting. At low SBS concentrations, the Kerner model was found to be appropriate to estimate the rheological properties of SBS-modified asphalt.

M. Garcı´a-Morales (2004) [6] dealt with the viscous properties of recycled-polymer modified bitumens (PMBs) in a wide range of temperatures. With this aim, two different penetration grade bitumens (60/70 and 150/200) and recycled EVA copolymer (EVAR) from agriculture films were processed in an open reactor using a four blade propeller. Polymer concentration ranged from 0 to 9 wt%. Viscous flow and DSC measurements, from 5 to 165 8C, and optical microscopy, at room temperature, were performed on the samples. From the experimental results obtained, we may conclude that the viscous properties of bitumen, at high temperature, are improved by adding recycled EVA copolymer in amounts that depend on bitumen penetration grade. Moreover, significant microstructural changes, related to the development of a polymer-rich phase, tend to occur in the bitumen as polymer concentration increased. These changes in microstructure have a significant influence on the flow behaviour of the binder and on its in-service performance. They concluded that the use of recycled EVA in PMBs can be considered a suitable alternative from both environmental and economical points of view.

Sinan Hınıslıog˘lu and Emine Ag˘ar (2004) [7] investigated the possibility of using various plastic wastes containing High Density Polyethylene as polymer additives to asphalt concrete. It was investigated that the influence of HDPE-modified binder obtained by various mixing time, mixing temperature and HDPE content on the Marshall Stability, flow and Marshall Quotient (Stability to flow ratio). The binders used in Hot Mix Asphalt (HMA) were prepared by mixing the HDPE in 4–6% and 8% (by the weight of optimum bitumen content) and AC-20 at temperatures of 145–155 and 165 0C and 5–15 and 30 min of mixing time. HDPE-modified asphalt concrete results in a considerable increase in the Marshall Stability (strength) value and a Marshall Quotient value (resistance to deformation). Four percent HDPE, 165 0C of mixing temperature and 30 min of mixing time were determined as optimum conditions for Marshall Stability, flow and Marshall Quotient (MQ). MQ increased 50% compared to control mix. They

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concluded that waste HDPE-modified bituminous binders provide better resistance against permanent deformations due to their high stability and high Marshall Quotient and it contributes to recirculation of plastic wastes as well as to protection of the environment.

Mahabir Panda and Mayajit Mazumdar (2002) [8] in their investigation, used reclaimed polyethylene obtained from LDPE carry bags to modify asphalt cement. The basic properties of modified binder and mixes containing such binders were studied and compared with those of asphalt cement. It was observed that the optimum requirement of PE is 2.5%. Marshall stability, resilient modulus, fatigue life, and moisture susceptibility of mixes were improved as a result of modification of asphalt cement by reclaimed polyethylene.

A. Pe´rez-Lepe, F. J. Martı´nez-Boza, P. Attane´ and C. Gallegos (2006) [9] argued that although suitable bitumen mechanical properties have been obtained by HDPE modification, such binders may not be relevant for the pavement application, since phase separation may occur during the application of the binder on the road. An effective way of stabilizing HDPE within the bitumen is still to be developed. However, functionalized reactive polymers are envisaged to make up the separation problems in bituminous binders

3. Conclusion

By studying Previous Research paper it is observed that there are various areas where study can be performed. Here study is done on comparing the two material Ethylene-vinyl acetate (EVA) and Styrene-butadiene Styrene (SBS) for Bitumen Modification. They are easily available in the market. There physical properties were better than other materials. Ethylene-vinyl acetate shows similar properties that of a low density polyethylene but increased gloss (useful for film), softness and flexibility and considered as a non-toxic material. Similarly SBS with bitumen is very high, thus it can achieve cold weather flexibility and elastic properties. So the study has been performed.

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