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EVALUATION OF ORGANOSILANE BASED ASPHALT ADDITIVE FOR FLEXIBLE PAVEMENT

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Abstract - *Stripping is one of the most commonly occurring distresses in bituminous pavements. This occurs as a result of destruction of the bond between aggregate particles and bitumen. Impacts of traffic loading, aggregate type, bitumen characteristics and properties of the additives in mixes can modify resistance of mixes against moisture damage. Microscopic strength covers the total strength of the contact surface, adhesion strength between the aggregate and bitumen, and the cohesive strength of the bitumen binder. This study investigates the effects of anti-stripping agent on the microscopic strength of the mineral aggregate contact surface of mixture.*

Organosilane based technologies are very helpful to solve these problems. Organosilane based technologies are very well known for decades for their applications in the composite material and surface modification. Recent development of water based Organosilane coupling agents are made possible for new applications and working at nano level. This research work includes in detailed about effect of antistripping agent on asphalt surfaced pavement.

Key words: stripping, adhesion strength, anti stripping agent, organosilane.

1. INTRODUCTION

India has a road network of over 5,472,144 kilometres as on 31 March 2015, the second largest road network in the world. Approximately 42.65% of the Indian roads are unsurfaced and are not suitable for use of vehicular traffic. The poor maintenance of the roads aggravates the problem especially in the rainy season. According to one estimate there is about per year loss of Rs. 200 crores on the wear and tear of the vehicles due to poor quality of roads.

Many roads are paved applying hot mix asphalt (HMA) that imparts flexibility, comfort and ease of application. Environmental factors such as temperature, air, and water can have a profound effect on the durability of asphalt concrete mixtures. In mild climatic conditions where good-quality aggregates and asphalt cement are available, the major contribution to the deterioration may be traffic loading, and the resultant distress manifests as fatigue cracking, rutting (permanent deformation), and ravelling. However, when a severe climate is in question, these stresses increase with poor materials, under inadequate control, with traffic as well as with water which are key elements in the degradation of asphalt concrete pavements. Water causes loss of adhesion at the bitumen–aggregate interface. This premature failure of adhesion is commonly referred to as stripping in asphalt concrete pavements. The strength is impaired since the mixture ceases to act as a coherent structural unit. Loss of adhesion renders cohesive resistance of the interstitial bitumen body useless. Water may enter the interface through diffusion across bitumen films and access directly in partially coated aggregate. Water can cause stripping in five different mechanisms such as detachment, displacement, spontaneous emulsification, pore pressure, and hydraulic scour.

2. Brief of Organosilane Based Technologies:

Organosilane based technologies are very well known for decades for their applications in the composite material and surface modification. Silanes are versatile products that react with a wide variety of organic and inorganic materials. Recent development of water based Organosilane coupling agents made possible for new applications. This technology offers unique applications in construction, environmental and other industries.
Silane coupling agents are silicon-based chemicals that contain two types of reactivity – inorganic and organic in the same molecule. They are known as Organofunctional silanes. Most of the widely used organosilanes have one organic substituent and three hydrolyzable substituents. A typical general structure is shown,

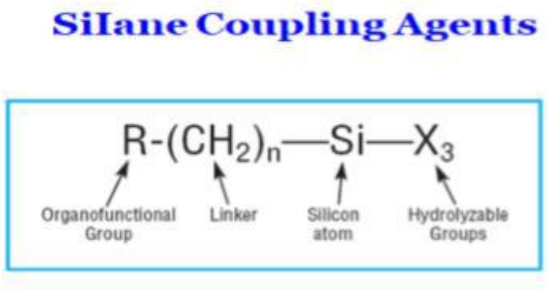

Figure 1: General Structure of Silane Coupling Agents

where X is a hydrolyzable group, such as methoxy, ethoxy, or acetoxy, and R is an organofunctional group, such as amino, methacryloxy, epoxy, alkyl, etc **.**

Mineral fillers, such as silica, talc, mica, wollastonite, clay and others, are either pretreated with silane or treated in situ during the compounding process. By applying an organofunctional silane to the hydrophilic, nonorganoreactive filler, the surfaces are converted to reactive and organophilic. Fiberglass applications include auto bodies, boats, shower stalls, printed circuit boards, satellite dishes, plastic pipes and vessels, and many others. Mineral filled systems include reinforced polypropylene, silica-filled molding compounds, silicon-carbide grinding wheels, aggregate-filled polymer concrete, sand-filled foundry resins and clayfilled EPDM wire and cable. Cost of nano size organosilane chemical is only 600 Rs. Per Kg. and it will be use only 0.1% weight of mix. Bitumen content (one gram per one Kg of bitumen) So it is very economical to use in repair of road distress or road construction.

Nano size organosilane additives are is important recent development for asphalt pavement. Organosilane compounds are known for their reactivity with inorganic substrates. The reaction of organosilane compound with inorganic substrates, such as clay, sand, aggregate, modifies the surfaces. The surface of these substrates can be altered to make for better interaction and bonding with asphalt. Use of these compounds as antistripping additive in HMA and as a bonding agent in asphalt emulsion gave significant improvement, in moisture sensitivity and bonding in tack coat. Applications clearly indicated that organosilane as antistripping additives gave superior performance irrespective of the climate. The results conclusively also suggest that organosilane additive improves significantly moisture sensitivity of HMA and hence extend the pavement life.

3. CRITICAL LITERATURE REVIEW

The following are the previous research review based on application of engineering project.

Cesare Oliviero Rossia et.al. (2017) The performances of a modified bitumen as a function of the concentration of an added Organosilane modifier was examined in terms of its consistency, adhesion and rheological properties. In particular, the modifier guarantees excellent performance at 0.01 wt% loading, and almost complete resistance to water at 0.03 wt% loading. A quantitative evaluation of the modified bitumen's performance was carried out by a contact angle test. Moreover, SEM/EDS analysis showed that the Organosilane modifier was able to penetrate the surface of the stone, thus aiding anchoring of the binder to the surface.

Mineral aggregates and bitumen binder are the principal constituents of road surfaces which are subjected to wear. Bitumen from an asphalt pavement typically comprises about 5 to 7 percent of the total asphalt mixture. The bitumen is required to coat and bind the aggregate particles together, whereby its adhesion properties will be of great importance in all asphalt pavement applications. In order to improve adhesion, bitumen may be modified with antistripping additives.

Bagdat Teltayev et.al. (2017) This review focuses on certain classes of organic compounds known variously in the specific literature of asphalt as adhesion promoters, antistripping agents, wetting agents, antistrips, or adhesion agents. These kinds of organic additives are currently formulated to enhance the bitumen coating of mineral aggregates and improve the workability of asphalt mixtures. In this review, the term "adhesion promoters" includes both synthetic organic compounds as well as those extracted from natural resources, mixed in trace amounts to bitumen. Their main role is to alter the interfacial energy, so that the presence of water, even in trace, does not weaken the bitumen-aggregate bond and tends to favour adhesion.

Mahmoud Nazirizad et.al. (2015) This study is aimed at determining the effects of two different anti-stripping additives, namely hydrated lime and a liquid anti-stripping agent (Iterlene In/400-S) on hot mix asphalt (HMA). Moisture susceptibilities of samples were determined by analyzing digital images taken from coated aggregate particles after performing boiling water test (ASTMD 3625). In addition, Modified Lottman test (AASHTO T283) was performed on mixes containing 0.2%, 0.3% and 0.4% of liquid anti-stripping agent and mixes containing 1%, 1.5% and 2% of hydrated lime. The results indicated that the addition of hydrated lime and liquid anti-stripping agent increased moisture resistance of asphalt mixes to some extent (i.e. 13% and 16% of TSR ratio, respectively). Moreover, it was concluded that mix samples prepared using the liquid anti-stripping additive imparted more correlation and greater resistance to water damage, compared with control mixes and those containing hydrated lime.

Haider Habeeb et.al. (2014) The present study explains the effect of aggregate gradation on moisture damage in bituminous mixes. Three types of aggregate gradation, two types of binder; VG-30 and Polymer modified bitumen (PMB-40) and two types of mixes Bituminous Concrete (BC) and Dense Bituminous Macadam (DBM) are used. Moisture susceptibility tests like retained stability and tensile strength ratio are conducted on Marshall specimens. The static creep test was also conducted for conditioned and unconditioned specimens to observe the effect of moisture on creep behaviour. The results indicate that Marshall stability and flow values are higher in PMB-40 mixes than in VG-30 mixes. Moisture susceptibility of PMB-40 mixes is low when compared with mix using VG-30. The reduction in retained stability, and Indirect Tensile Strength (ITS) and increase in creep are evaluated for finer, coarser and normal gradation of aggregates to observe the effect of gradation on moisture susceptibility of mixes. The retained stability is least affected when

compared with other moisture susceptibility parameters. Also, gradation parameters σ1 and Gradation Ratio (GR) are introduced in this paper to establish relation between aggregate gradation and moisture susceptibility and permanent deformation. Models are suggested to estimate rut depth from ITS and stability values.

Ilham Ibrahim1 et.al. (2015) This study is conducted to determine the optimum amount and potential applicability of zycotherm nanomaterial in asphalt and asphalt concrete mixtures with two different systems: directly applying to bitumen and diluting and applying to aggregate in order to address the solution of potential failure problems in flexible pavements. The study is carried out experimentally by conducting tests on bitumen and bituminous mixtures. Tensile strength test and retained stability tests were performed on bituminous mixture in order to measure the tensile strength ratio (TSR) and the retained stability index (RSI), which are both the indexed parameters to determine the mixture resistance to de-bonding and disintegration in the presence of water. Penetration, softening point, RTFOT, PAV, BBR and DSR tests were also performed on bitumen to determine the effect of zycotherm on bitumen's contribution on rutting, fatigue and low temperature cracking of the mixture. It is found that using zycotherm material greatly increases the resistance of asphalt mixture to moisture induced damages and also increases its resistance to rutting, fatigue and low temperature cracking.

Jizhe Zhang et.al. (2015) The effects of aggregate mineralogical composition on moisture sensitivity of aggregate–bitumen bonds were investigated using four aggregate types (two limestone and two granite) and two bitumen grades (40/60 pen and 70/100 pen).Moisture sensitivity (or water resistance) of the aggregate–bitumen bonds were characterized using retained strength obtained from three different tensile tests (peel, PATTI and pull-off). The results showed significant differences in the amount of moisture absorbed by a given aggregate which suggested strong correlations between aggregate mineral composition and moisture absorption.

The effects of aggregate mineralogical composition on moisture sensitivity of aggregate – bitumen bonds were investigated using four aggregate types (two lime stone and two granite), two types of bitumen (40/60 pen and 70/100 pen) and three mechanical tests: peel test, PATTI test and pull-off test, as a function of moisture immersion time. Retained strength was used as measure of moisture sensitivity of aggregate–bitumen bonds. The results were analysed by relating aggregate moisture absorption and mineral composition to retained bond strength.

Jiusu Li et.al. (2014) Stripping of asphalt-binder (bitumen) from the aggregate surface can undesirably contribute to various distresses in hot-mix asphalt (HMA) pavements such as ravelling (aggregate loss), cracking, pot-holing, etc. As a means to minimize this phenomenon, a quantitative adhesion test and evaluation method (QATE) was proposed and investigated in this study to characterize the bitumen-aggregate bond strength and adhesion properties. Concurrently, an innovative anti-stripping additive was developed in the laboratory through appropriate combination of the following chemical agents: Polyamide (PA), anti-moisture polymer (AMP), epoxy resin (EP), and dioctyl phthalate (DOP). The optimum anti-stripping mix proportions were determined and proved effective with an adherence percentage of 97.3% after 10 minutes boiling in water.

Ahmed Ebrahim et.al. (2013) Moisture damage in asphalt mixtures refers to loss in strength and durability due to the presence of water. Egypt road network is showing severe deterioration such as raveling and stripping because the bond between aggregates and asphalt film is broken due to water intrusion. To minimize moisture damage, asphalt mixes are investigated to evaluate the effect of air voids, degree of saturation, media of attack and the conditioning period. Two medias of attack are considered and two anti-stripping additives are used (hydrated lime and Portland cement). The retained Marshall stability and tensile strength ratio are calculated to determine the resistance to moisture damage. The results showed that both lime and cement could increase Marshall stability, resilient modulus, tensile strength and resistance to moisture damage of mixtures especially at higher condition periods. Use of hydrated lime had better results than Portland cement.

Ayman M. Othman et.al. (2006) Major pavement deterioration can be attributed to the presence of water on the pavement surface. Within this framework, this research is focused on studying the impact of accelerated moisture conditioning on pavement deterioration. This study is based on laboratory evaluation of creep characteristics and mechanical properties of asphalt concrete mixtures. This evaluation can aid in assessing the long-term stripping susceptibility and permanent deformation potential of asphalt concrete mixtures. Cement dust was incorporated in the mixture as mineral filler and compared with traditional lime stone filler. Accelerated moisture damage program was established to evaluate the mixture resistance to moisture damage. Marshall specimens were immersed in a water bath under vacuum of 510 mm of mercury (Hg) for different moisture conditioning periods of 0, 1, 2 and 7 days. A power law model was used to characterize the creep compliance behavior of the studied mixtures. Creep testing results have revealed that the creep compliance power law parameters have a strong relationship with mixture type and moisture conditioning period. The creep resistance of the studied mixtures, as indicated by the creep compliance parameters, decreases as the moisture conditioning period increases. Results also revealed an enhancement in the creep resistance, Marshall stability, indirect tensile

strength and compressive strength for mixtures containing cement dust as compared to mixtures with traditional lime stone filler.

SUMMARY

Stripping is one of the most commonly occurring distresses in bituminous pavements. This occurs as a result of destruction of the bond between aggregate particles and bitumen. Due to this road distresses are occurring. Different types of aaditives are been used for improving strength of road and bond between aggregate and bitumen. Organosilane is the additive is used in hot mix asphalt(HMA) to improve bond between aggregate and bitumen and also improves strength of road.

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