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"A REVIEW ON STUDY ON STONE MATRIX ASPHALT USING NATURAL FIBRE"

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ABSTRACT:
Stone matrix asphalt, was as a matter of first importance created in 1960 in Germany which now to a great extent helps in giving a more noteworthy changeless twisting protection, strength to surfacing materials, longer administration life, enhanced maturing, high protection in splitting, exhaustion, wear, better slide protection and like in diminishing commotion. A fiber that is promptly accessible in nature. Less savvy contrasting with other non-traditional filaments has been utilized as stabilizer. It is Sisal fiber, which is fiber. It has high quality in fiber course, more noteworthy malleable, flexural and affect quality. Slenderness level of fiber can undoubtedly be acquired from it. It is solid in nature, has steadiness and great security esteem. An endeavor has been made to discover its appropriateness in expanding the dependability and stream an incentive in the blend of Stone Framework Black-top Blends. For this task, we have arranged SMA blends utilizing stone as coarse aggregate, slag in fractional substitution of coarse aggregate and utilized distinctive stabilizers and have endeavored to think about the outcomes at a fluctuating bitumen substance of 4%, 4.5%, 5%,5.5% and 6 % bitumen with stabilizers
0.4%.

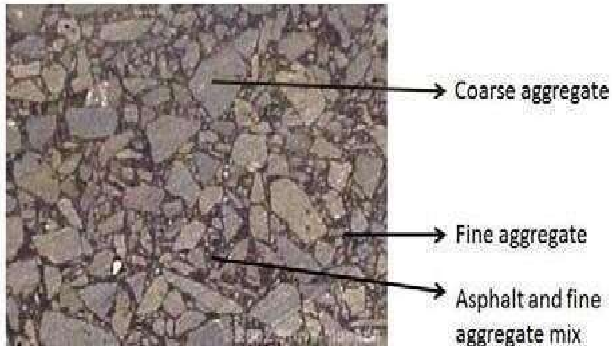
KEY WORDS: Sisal Fiber, Natural Aggregate, Binder content, SMA, HMA, Marshall Test.

INTRODUCTION

In the outlining of Street Asphalt, Adaptable Asphalt Planning is favored constantly finished all other in flexible asphalts. It is basically because of the better load conveying limit, sturdiness, protection from tear and wear, more noteworthy quality to perform well amid substantial burdens. This Properties of the street is primarily accomplished because of its surface bituminous asphalt. It is the surface covering over the Stone Grid Black-top which is the hole evaluated blend gives quality by stone-to-stone contact. What's more, this properties of the SMA are resolved at first in the research center testing in order to give greatest dependability, better stream esteem utilizing Ideal cover Content.

Stone Framework Black-top essentially comprises of coarse total of around 70-80% of aggregate total, cover is taken 4-7%, filler 8-12% and fiber as stabilizer between
0.3 to 0.5%. Coarse total in the blend gives stone-stone contact to oppose rutting, filler helps in filling the voids between total to avert tearing and wearing, fastener helps in restricting every one of the materials together. Fiber gave go about as stabilizer to build the security restricting the blend amid high temperature and forestalls seepage amid generation, laying and transportation.

Fig 1.1 Gap graded mix structure



Stone matrix asphalt has been proved, most expensive when compare to the dense graded mixes for high volume roads. Brown (1992) observed that many number of factor influenced the performanceof SMA mixtures, as change in binder source and grade of mix, types of aggregates, environmental conditions, production and methods of construction etc. The FHWA SMA Technical Working Group defined SMA as "A gap graded aggregate hot mix asphalt which will maximize the binder content and coarse aggregate fraction and provides a stable stone- on-stone skeleton that is held together by a rich mixture of filler, binder and stabilizing additives".

LITRATURE REVIEW :

Nura Shehu Aliyu Yaro et al. [2022] Asphalt pavement in tropical countries like Malaysia faces severe distresses. Thus, the use of more resistant and stable asphalt mixtures on the surface layer like stone matrix asphalt concrete (SMAC) is encouraged. The performance-related properties of asphaltic concrete are highly influenced by the mixing process and the asphalt mixtures homogeneity and segregation are pivotal issues affecting asphaltic concrete production. Malaysian palm oil industry generates a large amount of waste palm fiber (WPOF) which are largely discarded. This study investigates the feasibility of utilizing WPOF as a stabilizer in SMAC and evaluates the influence of two different mixing processes (traditional and sequential) on its properties The SMAC mixtures were reinforced with various content of WPOF, 0– 0.6% by weight of the total mix and evaluated for volumetric and mechanical properties.

Several standard laboratory test methods were used to examine the mixtures: Marshall properties, drain down test, Cantabro, stiffness modulus, moisture damage test.

Jing Luo et al. [2021] The mechanical performance characteristics of bitumens and mixtures can be mixture design factors. The fracture evaluation was done based on stress and energy. So critical stress intensity factor (KIC) and critical fracture energy (Gf) were used as fracture evaluation parameters. After conducting the tests and analyzing the results, it was found that 6.09 % binder with Ndesign = 78 leads to a design with a desirability of 0.869, which passed all the NCHRP 9–8 criteria of the mixture design in line with the maximum fracture performance.

Jiasheng Zhu et al. [1] Since 2020 COVID-19 was declared a global pandemic, the production, consumption, and discard of personal protective equipment (PPE), such as face masks, have been rapidly increasing. The massive amount of face mask waste poses a severe threat to the ecology, environment, and public health. Alleviating the adverse effects of mask waste requires the cooperation of professionals from various fields. To reduce the epidemic- generated waste and improve the performance of stone

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mastic asphalt (SMA) mixes, in this study, comprehensive laboratory experiments, including volumetric assessment, Marshall stability and flow, resilient modulus, dynamic creep, moisture susceptibility, and binder drain-off test were carried out on SMA specimens prepared with 0.3%, 0.5%, 0.7%, and 1.0% of mask fibre (MF) by weight of asphalt mixture. The results were compared with the control SMA specimen (i.e., SMA mixed with 0.3% cellulose fibre (CF)) that complied with the road industry regulations and standards. The results of the study illustrated that the introduction of MF into the SMA mix improved the stability, resilient modulus, indirect tensile strength, resistance to permanentdeformation, resistance to moisture damage and binder drain-off performance. Experimental results indicated that the inclusion of 0.3% and 1.0% MF in SMA complied with industry requirements and suggested that MF could be used instead of virgin CF as a fibre additive. Considering the available supply, performance and industry standards, SMA containing 0.3% MF demonstrates more potential for pavement applications. Hong-Hu Chu et al. [2020] Many distresses occur in the pavement due to the increase in traffic and changes in weather conditions through the year (hot to cold). Asphalt binder modification is the best way to control these stresses. On the other hand, utilization of warm mix asphalt additives has significant environmental benefits. This research investigates the influence of simultaneous usage of two waste material (ground tire rubber (5%, 10% 15%, and 20% by weight of asphalt binder) and natural bitumen (10%, 20%, 30%, and 40% by weight of asphalt binder)) on performance behavior of asphalt binders and mixtures containing warm mix asphalt additive. Performance behavior of binders and mixtures were evaluated by several tests such as; conventional asphalt binder tests, linear Amplitude Sweep (LAS), Multiple Stress Creep Recovery (MSCR), Bending Beam Rheometer (BBR), Dynamic Shear Rheometer (DSR), storage stability, resilient modulus, indirect tensile strength, dynamic creep, hamburg wheel track, and four point beam fatigue (FPB) tests. The statistical analysis was performed to investigate the additives have significant effect or not. Results revealed that fatigue and rutting performance of samples were improved by combination of waste materials. Addition of waste natural bitumen led to decreases the low- temperature behavior of asphalt binder, while addition of waste ground tire rubber improves the resistance against low-temperature cracking. Addition of natural bitumen up to 10% has positive impact on storage stability of binder and by adding more content of additive, phase separation occurred. Chen, H., Zhang, Z., & Li, N. (2020). Evaluation of stone mastic asphalt mixtures incorporating waste rubber and high-density polyethylene. Journal of Cleaner Production, 262, 121328.

1. This study investigates the use of waste rubber and high-density polyethylene in SMA mixtures, highlighting the environmental benefits and improved performance characteristics. Zhu, J., Ma, T., Dong, Z., Huang, X., & Zhang, D. (2019). Performance of stone mastic asphalt mixtures modified with basalt fiber and waste polyethylene terephthalate. Construction and Building Materials, 204, 774-782.

a. The research explores the use of basalt fiber and waste PET in SMA mixtures, focusing on mechanical properties and environmental impacts.

2. Liu, Q., Schlangen, E., & van de Ven, M. (2019). Self-healing capability of asphalt mixtures with induction heating and rejuvenation. Construction and Building Materials, 225, 915-922.

a. This paper presents innovative self-healing SMA mixtures using induction heating and rejuvenators, aiming to extend the service life and reduce maintenance needs.

3. Wang, Y., You, Z., Mills-Beale, J., & Hao, S. (2018). Laboratory evaluation on high-temperature performance of SMA mixtures with various stabilizers. Construction and Building Materials, 163, 437-447.

This study evaluates the high-temperature performance of SMA mixtures with different stabilizing additives, such as fibers and polymers, to enhance rutting resistance.

Jing Li et al. [2019] Asphalt mixtures has a long history of usage as pavement due to its economic efficiency. Asphalt mixtures have various modes of failure as they go through various temperature profiles and loading stresses over time since they are viscoelastic materials. Three different forms of distress, including rutting, fatigue cracking, and low-temperature cracking, are frequently seen in pavements composed of HMA. Such troubles limit its service life and lead to unsatisfactory service conditions. One of the most popular additives to modify bitumens is polymers. Numerous disadvantages prevent the widespread use of polymers in asphalt concrete (AC) mixture modification for the building of roads. Research on using complimentary materials, including nanomaterials, to counteract the detrimental effects of polymers while improving the performance of the AC combination has recently drawn a lot of interest. Recent years have seen pavement specialists reach the conclusion that modifying asphalt usingcomposite material is the best way to address the issues with binder additives and meet requirement for asphalt mixture. So, in the current research, original asphalt binder was modified using nano-CuO, nano- Al2O3, carbon nano tube (CNT) as a conductive material, and HDPE.

Lekhaz Devulapalli et al. [2018] Over the years stone matrix asphalt (SMA) mixtures have evolved significantly and research works have presented some promising results. This made the paving industries to increase the usage of SMA mixtures in the pavement construction. However, SMA mixtures have certain challenges or setbacks, which require comprehensive understanding. The aim of the review paper is to present some of the challenges in SMA mixtures and their mitigations measures. It is observed that several challenges (i.e., aggregate gradation, stone-on-stone contact, drain down and stabilizing agents) related to SMA mixtures are addressed by the researchers. Many agencies have suggested their own aggregate gradation based on their experience, location, climatic conditions and available manufacturing facilities, and they are working exceptionally. Stone-on-stone contact is achieved with proper aggregate gradation and failure to meet the same will reduce the performance. Drain down is major concern in the SMA mixtures since it controls overall mixture performance. Therefore, researchers shown out the most importance to curtail the same. Several researchers followed ASTM D6390 and National Cooperative Highway Research Program (NCHRP No. 424) procedure to evaluate the drain down and concluded that drain down should be less than 0.3% (by weight of mixture). Apart from that, researchers are trying different stabilizing agents to reduce the drain down. Especially, stabilizing agents such as fibers and polymers have a positive impact. Recently, suitable waste and recycle products are used as stabilizing agent to reduce drain down and environmental pollution. Out of which coconut fiber has shown some promising results, however, comprehensive research is required in this regard. On the other hand, 0.3% of cellulose fiber is working as a good stabilizing agent and can be used without conducting drain down test. The review paper provides a complete knowledge about different stabilizing agents used in SMA mixtures to minimize the drain down.Jiaqing Wang et al. [2016] With the sustainable development of infrastructure construction materials, the use of renewable biomass resources in asphalt mixtures could contribute to better sustainability. The bamboo fibers and corn straw fibers with lengths ranging from 1.5 to 12 mm were produced in the laboratory through the proposed crushing, steaming, and grinding processes. A surface treatment with the phenolic resin copolymer modifier was utilized to reconstruct the micro-surface of biomass fibers. The surface treatment effectively reduced the oil absorption multiplier and mass loss of proposed biomass fibers by about 0.6 and 2 %, respectively. The FI-IR absorption peak and change of micromorphology also validated the effective surface reconstructive. Afterward, the virgin asphalt (70#) mixtures and SBS- modified asphalt mixtures with/without biomass fibers were produced for road performance tests and fatigue resistance tests. The results showed that the proposed biomass fibers contributed to about 20 % to 30 % improvement in the high-temperature performance, while the low-temperature cracking resistance was also obviously increased. In addition, the moisture damage resistance and fatigue life were also improved after the addition of biomass fiber modifier, in which the residual stability and tensile strength ratio were increased by about 9 % and 6 % by comparing that with fibreless mixtures, respectively. By comparing the effect of different types and lengths of fiber modifiers, the long bamboo fiber with surface treatment represented the optimized strengthening efficiency. The enhancement mechanism of proposed biomass fiber modifiers was revealed through the microstructure observation. The feasibility of using proposed biomass fibers with surface treatment for producing high-performance SMA has been verified, which can be utilized in the field application for replacing the lignin fiber modifiers for achieving better sustainability.

L. Traseira Piñeiro et al. [2014] This paper aims to quantify stone loss mitigation due to the action of architected cellular particles that can absorb impact energy. The architected cellular particles presented in this paper are additives for asphalt that have been designed to absorb impact energy through an internal porous structure filled with a bitumen compatible liquid that controls their strength. The experimental programme is divided into four phases: Cellular particle manufacturing and morphological analysis; optimization of asphalt mixture performance by selecting the cellular particle content based on mass loss, rutting and skid resistance testing; study of mass loss with varying compaction energy and asphalt gradation and microstructural and energy absorption analysis. It was concluded that (i) the asphalt's mass loss linearly decreased as the cellular particle content was increased, (ii) up to 1% of architected cellular particle content by total weight of the mixture reduced mass loss without producing adverse effects in the asphalt, (iii) architected cellular particles deformed during testing, absorbing the impact load energy.

Seyed Ali Sahaf et al. [2013] In this research, the fracture properties and low temperature cracking of stone matrix asphalt)SMA(mixture containing reclaimed asphalt pavement)RAP(were evaluated. To achieve appropriate gradation of SMA with a nominal maximum aggregate size (NMAS) of 12.5 mm, 30 % dense graded RAP was used. Evaluation of fracture properties was done based on stress and energy approaches. To evaluate the fracture properties of the SMA mixture containing 30 % RAP and compare it with the non-RAP mixture, semicircular bending (SCB) test was performed at −10 °C. Air void in the mixture (Va), loading rate, and combined mode parameter (Me) was considered as research factors. The results showed that the critical stress intensity factor (KIC) of mixtures containing 30 % RAP was higher than the non-RAP mixture. In both types of mixtures, with increasing Me, KIC first decreased and then increased. In pure mode I (Me = 1) with increasing air void, KIC decreased. Regardless of the effect of RAP, in all fracture loading modes with increasing loading rate and air void, the fracture energy (Gf) decreased.Therefore, the presence of RAP did not affect the energy absorption of the mixture at low temperatures. The presence of RAP and coarse aggregate skeleton structure causes the brittle fracture of the mixture at low temperatures. The effect of RAP on the crack path only in samples with low air voids and high loading rate caused the crack path through coarse aggregates with smaller size and mastic to show a more share compared to non-RAP samples.

CONCLUSION:

Physical properties of all the materials was checked and it satisfies all the requirements specified on MoRTH code of practice.

The optimum binder content of 7.07% is obtained after the addition of 10% stone dust as filler.

The optimum binder content of 6.99% is obtained after the addition of 5% of stone dust

and 5% of bagasse ash as a filler.
The ptimum binder content of 7.25% is obtained after the addition of 5% of stone dust and 5% of POFA as a filler material.
The study concluded that among the above observations the optimum binder content for the addition of 5% stone dust with 5%

REFERENCES:

Ashish Talati, Vaishakhi Talati (2014). "Study of Stone Matrix Asphalt for theFlexible Pavement" IJEDR 2014, vol.2, pp 789-792.
Dr. A. Ramesh, Teja TAllam, Katasani Swetha "Assessment of Stone Mastic Asphalt Performance withthe Inclusion of Fiber Material on Resilient Characteristics", IIT- Bombay
Gazia Khurshid Khan, Er. Jyoti Narwal (2017). "A review study on stone matrix asphalt using a natural fibre", LILREC 2017, vol.5, pp 95.97.
Gummadi Chiranjeevi (2018). "Analysis of Stone Matrix Asphalt (SMA) with Interactive Properties of Gradation" JMTST 2018, vol. 4, pp 83-87.
IRC:SP:79-2008. "Tentative Specifications for Stone Matrix Asphalt", Indian Road Congress.. IS 73-2013. "Paving bitumen specifications" (Fourth revision), Bureau of Indian
standards. 7. Ministry of Road Transport and Highways (MoRTH) Specifications (2002), Government of India, Vol.6 January 2002.
Raghuram Bhadradri Kadali (2013). "Performance evaluation of stone matrix asphalt (SMA) using low cost fibres" Indian Road Congress, pp. 159-173.
Rosli Hainin, Wasid Farooq Reshi, Hamed Niroumand (2012). "The Importance of Stone Mastic Asphalt in Construction" EJGE 2012, vol. 17, pp 49-56.