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COMPARATIVE STUDY OF STABILIZING ADDITIVES EFFECT ON BITUMINOUS MIXTURE: A REVIEW

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ABSTRACT

The two most common distresses that arise in road pavement are fatigue and rutting. These are mostly caused by rapid expansion and population growth, an increase in the number of cars, particularly those with high axle loads and stress on the pavement, which causes premature distress in structural systems in the form of excessive permanent deformation. Also, due to environmental factors, as well as building and design flaws. As a result, the service life of asphalt pavement is impacted and will be reduced. As a response, the service life of asphalt pavement is influenced and will be reduced. Several studies have reported the use of added materials such as various types of fiber in asphalt mixture. (AC) to enhance its performances and could be a solution to postpone the rehabilitations and decrease its maintenance cost. Recycling technology has been recognized as an efficient, cost effective, and environmentally friendly method to rehabilitate asphalt pavements. There remain many unclear issues related to the use of additives. Therefore, in this review paper aims to highlight previous research works conducted on the effects for utilized different types of additives materials to improving on fatigue cracks and rutting resistance of bituminous concrete mixtures. It was observed that fatigue and rutting resistance of AC mixture could be enhanced considerably by utilization of different types of additives such as fibers that can increase the amount of strain energy absorbed during fatigue and fracture process of the mix in the resulting composite.

Introduction

Asphalt concrete is still a common type for pavement, because it offers a good combination of stability, durability, and water damage resistance. Pavements are engineering structures placed on natural soils and designed to withstand the traffic loading and the action of the climate with minimal deterioration and in the most economical way. In flexible pavement construction, surface layer constructed of flexible materials (asphalt concrete) over granular base and sub base layers placed on the existing, natural soil [1], whose primary function is to hold the aggregates firmly and to act as a sealant against water [2]. Roads are getting damaged day by day which cause rutting, cracking and pot holes [3], they cause premature distress in pavement structures in the form of excessive permanent deformation. Also, due to the environmental effects and due to construction and design errors.
Most of countries have mainly warm temperatures with the rapid development and population, the increase in traffic volume and stress on the pavement. They cause premature distress in pavement structures in the form of excessive permanent deformation [4]. Fatigue is one of the main failure modes of pavement structures. Bituminous materials in roads are subjected to a load each time a vehicle passes. This causes in the long term to failure. This fatigue is of considerable importance in the field of roads and must be correctly understood to ensure good pavement structural design [5]. However, but it is a must to try to develop asphalt mixture to face all kinds of pavement distresses which increase the cost of road maintenance and affect the performance of the asphalt [6].
Over the past few decades, research into the creation of modified asphalt mixes has focused on enhancing the performance of pavement mixes. Nowadays, the field of developing asphalt mixtures has been improved so much rapidly, a lot of studies were done and theses were discussed trying to improve the mechanical properties of asphalt mixture in order to enhance some of its characteristics by using additives to beaded to the mix. The objective of this study is to give a comparative review of the suitability of additives for pavement based on many factors, including material, fatigue and rutting resistance, as well as trying to improve the mechanical properties of asphalt mixture.

Literature Review

Paving materials have been strengthened with fibers. There are many different of fibers types that can be added to asphalt paving mixtures. According to the literature review, fiber-reinforced bituminous mixtures have produced mixed outcomes. It was discovered that there is not a lot of published information on fiber-enhanced asphalt. Some fibers have higher tensile strengths as compared to bituminous mixtures, which suggests that they may be able to increase the cohesive and tensile strength of bituminous mixtures and improve resistance to cracking [7].
Published the study on the reinforcement of asphalt mixtures. The study concluded that the COPF content has a strong effect on COPF modified bitumen by increasing thestiffness, thus, making the binder less temperature susceptible and lead to highresistance to permanent deformation. The COPF was blended in ratio of 0.0, 0.2, 0.4, 0.6, 0.8, and 1.0% by weight of bitumen binder. The modified binder gave the best fatigue resistance at 0.4 to 0.6% COPF content, thus, making the binder less temperature susceptible and lead to highresistance to permanent deformation [8].
Fibre reinforcing effect increases initially with increasing fibre content in Asphalt mixture, but at high fibre content (more than 0.3%) induce coagulation and thus reduce its reinforcing effect, resulting in less stiff mixture with lower strength values. The test results converge to the conclusion that the best performance of the asphalt mixture is at 0.3% fibre content and with coir fibre. The presence of fibres in SMA mixtures gives the higher retained stability, tensile strength ratio and index of retained strength at 0.3% fibre content by weight of mix. Test results show that the optimum fibre content of the fibre stabilized asphalt mixture is 0.3% by weight of mixture and the coir fibre additive is the best among the fibres investigated. The higher amount of fibre in the mixture (over 0.3%) may not have any beneficial effect and may deteriorate its deformation properties [9].
Conducted a study of the performance of bituminous concrete with the addition of coir/coconut fiber. In this paper, the researcher conducted research to improve the performance of flexible pavements. Bitumen content is 5%, while fiber content ranges from 0.2 to 0.8 percent and ranges from 0.4 to 0.6 percent. The stability value of bituminous concrete began to rise up to 0.4 percent before significantly declining after that. The stability value peaked at 0.4 percent of fiber. The flow value of bituminous concrete was minimum at 0.8 percent of fiber content and increased up to 0.2 percent before declining again. VFB significantly increased from 0% to 0.8% at its highest value, which was 0.8% of fiber. VMA decreased marginally from 0 to 0.8 percent. By the addition of coir fiber, which considerably improves its performance of the mix [10].
Conducted a studying the effect of adding the natural fibers on properties of bituminous mixtures. In this paper, the purpose of the study was to enhance the performance of flexible pavements. It has been used in this research, coir nature cleaned and cut by hand into small lengths ranging from 25-50 mm to facilitate the process of mixing with asphalt. Founded in coconut fiber fine with different contents 0% .3% and 5% in the mixture using a wet process. The amount of coconut fiber fit inverse properties with voids filled with asphalt (VFA), note also in the flow shows that there are conflicting shuffle by adding 0%, 3% and 5% of the fibers in the mixture. The results showed that the coconut fiber could be used as an additional material in asphalt mixture. However, the use should not be more than 3%.Resulting in a decrease in cracking increasing its resistance to performing, longer lasting asphalt pavement [11].
This paper evaluated the Effect of adding glass fiber on the properties of asphalt mix. In this paper, glass fibers used as additives. GF was added to control mix at ratios 0.25%, 0.5%, 0.75% and 1.0% by weight of the total mix. Marshall Stability (MS) and flow tests were applied to the specimens. The optimum content of GF is 0.25% by weight of the total mix, producing improved mixtures of hot asphalt,

which provide higher stability value by 10%, adjusted flow value by reducing it with 13%, and more rutting resistance by reducing rutting value by 19.7% comparing with control asphalt mixture. Compared to the control mix, the loss of stability value increased when utilizing glass fiber at its optimal content. It nevertheless stayed within the permissible limit (25%). The 0.25% glass fiber content in the asphalt mixture falls short of the minimum VMA requirements. On the basis of the findings of this research, a mix was developed with 0.25 percent glass fiber by weight of the overall mix. For practically all mix qualities, this mixture displayed acceptable values [12].
This paper reports about the Fatigue and deformation properties of glass fiber reinforced bituminous mixes. In this paper, the fiber length in the mixture was preserved as constant parameter with a value equal to 20 mm and used 0.1%, 0.2%, 0.3%, 0.4% and 0.5% by weight of mix. The use of glass fiber showed consistent results and it was found the addition of fiber does affect the properties of bituminous mixes, by decreasing its stability and an increase in the flow value as well the voids in the mix. The tests results indicated that the fiber has the potential to improve structural resistance to distress that occur in road pavement as result of increased traffic loading. Addition of fiber improves fatigue life by increasing the resistance to cracking and permanent deformation of bituminous mixes [8].
2017 the performance of the glass fiber is studied at various percentages, ranging from 0.5% to 2.5%. Glass fiber is a type of material made up of a lot of fine glass fibers. The performance of Flexible Pavements is greatly enhanced by additive. Marshall Stability value is raised by adding glass-fiber up to 1.5%; however, adding more glass fiber will result in a drop. As compared to mixes without fiber, flow value dropped when glass fiber was proportioned, but flow value increased when 1.5% fiber was added. From results on the Marshall properties it was noticed that the glass fiber content 1.5% was found to be optimum, gives the superior results of bituminous mixes [13].
The asphalt mixture also contained glass fiber (12 mm). The effects of adding various percentages of glass fiber to the asphalt mix were examined using the Marshal mix design process. Glass fiber was tested at various weights (0.1, 0.2, 0.4, 0.6, 0.8, and 1%). Glass fiber content about (0.1%) is where the maximum stability value is found, and it thereafter drops as the GF percentage rises. The flow continues to rise as the GF modifier content increases to (1%). The bulk density decreases as the percentage of glass fiber increases. The low density of the additional fiber can be attributed to this drop. Va% steadily declines as GF content rises. Va % content in modified asphalt mixes typically falls within the aallowed range. The optimum fiber content to be added as a modifier of asphalt mix was found to be (0.27 %) of the asphalt mix's total weight [14].

Types of Additives and Its Impact

The use of fibers in asphalt mixtures is not a new technology. Researchers studying asphalt pavement are becoming more and more interested in how different technologies might be used to improve the pavement's performance. Flexible pavements have low to negligible flexural strength, and even under heavy traffic loads, their structural activities remain reasonably flexible. The constant loading brought on by traffic will cause the asphalt concrete to experience an increase in tensile and shear stresses, which will result in the loss of structural integrity.

As a result, fatigue cracks will develop as traffic-induced tensile and shear stresses approach the material's strength. Fibers have been utilized to reinforce paving materials for many years in most of the world's regions. Oriented fibers materials can be used or distributed randomly inside the material as a means of reinforcement [15]. Particularly fibers are typically employed to prevent binder drain-down from aggregate particles. The use of fiber to lessen rutting and increase resilience to cracking in dense-graded mixtures. however, is less common [16]. A wide variety of fiber types and forms have been used In asphalt mixes. The most commonly used types of fibers and their reported benefits and disadvantages are following:

Table (1) Published benefits and disadvantages of common fiber types [17]

Fiber Type	Reported advantages	Reported disadvantages
Cellulose	• Stabilizes binder in open- and gap-graded stone matrix asphalt (SMA) mixtures. • Absorbs binder, allowing high binder content for more durable mixture. • Relatively inexpensive. • May be made from a variety of plant materials. • Widely available. • May be from recycled materials such as newsprint.	• High binder absorption increases binder cost. • Not strong in tensile mode.
Mineral	• Stabilizes binder in open- and gap-graded SMA mixtures. • Not as absorptive as cellulose.	• Some may corrode or degrade because of moisture conditions.

	• Electrically conductive fibers have been used for inductive heating for deicing purposes or to promote healing of cracks.	• May create harsh mixes that are hard to compact and may be aggressive, causing tire damage if used in surfaces.
Fiberglass	• High tensile strength. • Low elongation. • High elastic recovery. • High softening point.	• Brittle. • Fibers may break where they cross each other. • May break during mixing and compaction. • Cost-effectiveness not proven/varies.
Polyester	• Resists cracking, rutting, and potholes. • Increases mix strength and stability. • Higher melting point than polypropylene. • High tensile strength.	• Higher specific gravity means fewer fibers per unit weight added. • Cost-effectiveness not proven/varies.
Polypropylene	• Reduces rutting, cracking, and shoving. • Derived from petroleum, so compatible with asphalt. • Strongly bonds with asphalt. • Disperses easily in asphalt. • Resistant to acids and salts. • Low specific gravity means more fibers per unit weight added.	• Lower melting point than some other fiber materials requires control of production temperatures. • Begins to shorten at 300°F. • Cost-effectiveness not proven/varies.
Aramid	• Resists cracking, rutting, and potholes. • Increases mix strength and stability. • High tensile strength. • May contract at higher temperature, which can help resist rutting.	• Cost-effectiveness not proven/varies.
Aramid and polyolefin	• Controls rutting, cracking, and shoving. • Combines benefits of aramid and polypropylene fiber types.	• Cost-effectiveness not proven/varies.

Some of the studies demonstrate the benefits of using fibers, including these [17]:
Reduced draindown in open- and gap-graded mixtures
Increased resistance to rutting and cracking.
Improved durability.
Increased toughness and stability.
However, documented benefit–cost ratios or costeffectiveness studies are lacking.

CONCLUSION

This review paper that we've done is reviews numerous research to evaluate the performance traits of bituminous mixtures with various naturally occurring additives serving as stabilizers. Some major findings can be given below:

1. The use of additives in asphalt applications helps asphalt pavements operate better by reducing noise from traffic and strengthening resilience to cracking and rutting.
2. When choosing a source for stabilizing additives, it is important to take into account differences in chemical composition, mechanical properties, durability, and surface properties of fibrous materials. These factors significantly affect the nature of the sorption processes at the interaction with bitumen.
3. A mixture's tensile strength can be improved by adding fibers. Theoretically, stresses might be transferred from the relatively weak asphalt mix to the strong fibers.
4. As asphalt experiences increased traffic and load expansion, especially from large vehicles, the use of fibers offers a chance to improve the elastic good and plasticity of the bituminous mixes.
5. The addition of fibers to pavement mixtures will be beneficial in enhances their engineering properties. It has been found that the fatigue and rutting resistance of AC mixtures can be significantly improved by using various types of additives, such as fibers.

6. Some fibers had high tensile strengths than bituminous mixes that indicates that they may be able to strengthen bituminous mixtures' cohesive and tensile properties.

Based on these conclusions, it is recommended that fiber be used as a sustainable additives component in the creation of asphalt mixtures. But more research needs to be done on this project. It would be wonderful to investigate the impact of fibers on the resistance of asphalt mixtures to rutting, fatigue cracking, and moisture-induced damage.

References

[1] V. M. Milind and Dr. K. N. Kadam "A Comparative study on rigid and flexible pavement: a review", IOSR Journal of Mechanical and Civil Engineering, vol. 13, no. 3, pp. 84-88, May- Jun. 2016.
[2] S. M. Nuha, H. A. Asim, R. K. Mohamed and A. Mahrez "A review on using crumb rubber in reinforcement of asphalt pavement ", The Scientific World Journal, vol. 2014, Article ID 214612, 21 pages, Abbrev. 30 January 2014.
[3] V. Astha, Dr. O. Netula and K, Faraz "A review on comparative study of natural fiber modified bitumen and conventional modified bitumen ," Journal of Huazhong University of Science and Technology, vol. 50, issue. 3. May, 2021.
[4] Y. A. Nura, B. N. Madzlan, H. S. Muslich, U. Aliyu and M. S. Saeed "Performance evaluation of waste palm oil fiber reinforced stone matrix asphalt mixtures using traditional and sequential mixing processes," Case Studies in Construction Materials, vol. 15, no. 14 November 2021.
[5] D. B. Herve, B. Hassan, C. Roche and A. C. Pronk "Fatigue of bituminous mixtures," Article in Materials and Structures, April 2004.
[6] E. Ahmed, H. Mahdi and K. Kandil "Utilization of Fiber Modified Stone Matrix Asphalt (SMA) Mixes in Egypt", Al-Azhar University Civil Engineering Research Magazine, 2020.
[7] A. Mahrez, M. R. Karim and H. Y. Katman "Fatigue and deformation properties of glass fiber reinforced bituminous mixes", Journal of the Eastern Asia Society for Transportation Studies, vol. 6, pp. 997-1007. January 2005.
[8] A.A. Md. Maniruzzaman, A. W. Hamad, A. M. Maleka and M. Elsergany "Rheological properties of cellulose oil plam fiber (COPF) modified 80-100 asphalt binder", Journal of Advanced Research in Applied Mechanics, vol. 7, no. 1, pp. 21-30. 2015.
[9] N. Kiran and A. Ravitheja "Characteristics of stone matrix asphalt by using natural fibers as additives", Materials Today: Proceedings, vol. 19, Part 2, pp 397-402, 19 August 2019.
[10] T. Ramit and S. Jaspreet "Study of performance of bituminous concrete with addition of coir/coconut fiber", International Journal of Mechanical Engineering and Technology (IJMET), vol. 8, no. 7, July 2017, pp. 1793-1799.
[11] A. Zaltuom, M. Muftah and A. Akhmira, "Studying the Effect of Adding the Natural Fibers on Properties of Bituminous Mixtures,"
[12] M. E. Eisa, M. B. Basiouny and D. I. Daloob "Effect of adding glass fiber on the properties of asphalt mix," International Journal of Pavement Research and Technology, vol. 14, no. 5, pp. 403-409, Abbrev.30 September, 2020.
[13] S. N. Pasha, Dr. M. Madhuri "Investigation of modified bitumen using glass fibre in bituminous concrete," International Journal of Advance Research and Innovative Ideas in Education, vol. 3, no. 6, pp. 298-311, 2017.
[14] S. Y. Matar "Studying the effect of adding glass fiber on the mechanical properties of asphalt mixtures," Master of Science in Infrastructure Management- Civil Engineering, The Islamic University–Gaza, February 2017.
[15] N. F. A. Musa, M. Y. Aman, Z. Shahadan, M. N. M. Taher, Z. Noanai "Utilization of synthetic reinforced fiber in asphalt concrete – a review ," International Journal of Civil Engineering and Technology (IJCIET), vol. 10, 05 May 2019, pp. 678-694. Access online on 15 June 2022.
[16] Y. A. Nura, B. N. Madzlan, H. S. Muslich, U. Aliyu and M. S. Saeed "Performance evaluation of waste palm oil fiber reinforced stone matrix asphalt mixtures using traditional and sequential mixing processes," Case Studies in Construction Materials, vol. 15, no. 14 November 2021.
[17] National Cooperative Highway Research Program "Fiber Additives in Asphalt Mixtures," Washington, D.C 2015 https://nap.nationalacademies.org/catalog/22191/fiber-additives-in-asphalt-mixtures.