Al-Nahrain J. Eng. Sci. 29(1) 26-34, 2026
Review Article

Impact of synthetic fibers on the performance characteristics of asphalt concrete mixtures: a comprehensive review

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DOI: http://doi.org/10.29194/NJES.29010026

Received: Jan 10, 2025 **Revised:** April 26, 2025 **Accepted:** June 26, 2025 **Published:** March 20, 2026

Abstract
The properties related to Synthetic fibers such as significant strength, ductility, and durability lead the fibers to be adequate in enhancing the mechanical properties of asphalt concrete mixtures and that indicated by several studies. This paper aims to deliver an overview about the reinforcing influence of synthetic fibers on the mechanical and performance properties of asphalt concrete mixture.
This paper surveys the literature on synthetic fibers and their applications in enhancing the mechanical features of asphaltic mixtures. It could serve as a reference for prospective modification and development of asphalt pavement by synthetic fibres. The characteristics of prevalent synthetic fibers are introduced, and their usage in asphalt mixtures is evaluated. A review of fiber surface treatment techniques demonstrates that they can enhance the performance of synthetic fibers in asphalt concrete mixtures, especially on the chemical surface. The article debates how synthetic fibre inclusion influences asphalt concrete mechanical performance, including rutting resistance, tensile strength, water susceptibility, and cracking resistance. The review indicates that using fibers such as aramid, glass, polyester, polyamide, and carbon improves asphalt pavement resistance to permanent deformation.

Keywords: *Synthetic Fibers, Fiber Properties, Mechanical Performance, Hot Mix Asphalt, Rutting, Tensile Strength.*

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1. Introduction

The Marshall techniques were commonly used to design hot mix asphalt in Iraq. As the country's economy has grown, traffic loads have increased significantly. The rapid rise of heavy load traffic puts a great strain on the rations.
The highway network is mostly paved with hot mix asphalt concrete. Adding additives to the asphalt mix improves its performance and efficiency Chen et al [1]. Asphalt pavements deteriorate over time due to vehicle loads and harsh weather conditions, causing rutting and fatigue cracks Chen et al [2]. Numerous modification procedures have been proposed to enhance asphalt durability. Pavements protect against these deteriorations. Some options include employing a higher grade asphalt binder, altering it with other chemical materials or polymers, or adding rubber crumb, and join in fibers into the asphalt mixture Li et al., Motamedi et al [3] [4]. Fiber modification differs from other approaches as it adds fibers straight to the materials that are already there, requiring little changes to production, engineering, or handling operations. Fiber modification is becoming more popular due to its effectiveness. Research shows that fiber-modified asphalt concrete improves tensile strength and ductility. The asphalt mixture's fatigue microcrack, rutting, raveling, and thermal cracking were all decreased by the addition of fiber components Aliha et al Shu et al [5] [6]. Fiber inclusion enhances road stability and longevity, reducing the cost of maintenance Scorz et al Stempiha et al [7] [8]. Currently, there are two forms of fibers used in the construction of pavement: 1) natural fibers, including plant fibers Jia et al [9]. fibers made of minerals [10] , and fibers from animals [11]. 2) Synthetic fibers including carbon, polyamide, polyacrylonitrile, polyester, and glass fibers. Natural fibers, a renewable and non-hazardous material, can improve the mechanical qualities of asphalt concrete [12]. Shanbara et al [13] studied the interaction between synthetic fibers (polyester and polyacrylonitrile) and natural fibers (lignin and basalt).and the fibers were employed in the asphalt mixture. The study found that polyester fibers effectively improved the mechanical properties such as drainage, resistant to rutting and fatigue cracking. Because of its poor tensile strength, lignin fiber exhibited the least enhancement. Synthetic fiber-reinforced asphalt mixes have a greater stiffness modulus than natural fiber-reinforced mixes, according to modulus of stiffness obtained by indirect tensile test.

Al-Nahrain J. Eng. Sci. is a Scopus indexed **open access Journal** with **ISSN 2521-9154** and **eISSN 2521-9162**

2. Adding artificial fibers to asphalt concrete mixtures

2.1 Glass fiber:

One type of synthetic fiber is glass fiber made from glass, a material known for its strength and flexibility Mrema et al [14]. Fibers have a 100% elastic recovery rate.

Elongation ranges between 3 and 4 percent. Glass fiber has a Young's modulus of 70 GPa, 20 times greater than (HMA), and a tensile strength of 1700 MPa. Table 1 shows that the glass fiber employed in the asphalt mixture has a density range of 2.50-2.68 g/cm3 and a long of approximately 6 -12 mm. Glass fiber starts to breakdown at temperatures over 840oC, resulting in a reduction in strength. The temperature is around 315 C. Both chemically and thermally, glass fiber is steady at 165oC for the building of asphalt pavement. Figure 1(a) shows a glass fiber. A study investigated the impact of glass fiber vs natural fiber on an asphalt mixture's mechanical properties and moisture susceptibility. The cold asphalt mixture performance properties, such as resistance to crack propagation, water susceptibility and stiffness, were improved by adding glass fibre to reach its tensile strength of about 1600 MPa. Using glass fiber of lengths starting from 4mm to 10mm in porous asphalt (PA) mixtures enhances its tensile strength to be from 2000 and 3000 MPa. The use of glass fibers reduced air spaces and permeability in asphalt concrete, but improved tensile strength. Glass fibers enhance by establishing a network framework for asphalt mastic. In HMA with thick gradation, glass fibers have been used to enhance mechanical performance. PA mixes reinforced with glass fiber will be the subject of future studies. However, in PA mixes containing fiber, moisture damage, aging, and air void content are significant issues.

2.2. Aramid fiber:

Because of their superior strength, stiffness, and thermal resistance, aramid fibers are frequently used in heat protection, aeronautical engineering, and composite materials. Table 1 shows that the fiber has a density of 1.44-1.45 g/cm3 and a length of 19 mm. Tensile strength ranges between 2760-3000 MPa, with a temperature of breakdown above 450. Figure 1(b) illustrates the use of aramid fiber in asphalt concrete. Slebi-Acevedo et al[15] A mixture of polyamides was mixed with aramid and polyolefin fibers. The researchers found that the PA combination performed better when aramid fibers were added. They upgraded Tensile strength stiffness and crack The asphalt's vitality concrete mix under dry circumstances. Aramid fiber is used in polyethylene-aramid composites. to strengthen asphalt mixtures, while polypropylene enhances fiber dispersion and adherence to binder and aggregate. The study found that polyolefin-aramid blend fibers improve the mixture's resistance to fatigue cracking. In other research.

2.3. carbon fiber:

Carbon fibres are synthetic fibres that have several characteristics, such as being thin, flexible, and conductive Oret al. al [16]. Carbon fibers deliver outstanding qualities, including high tensile strength, thermal tolerance, resilience to chemicals and light weight , thermal expansion Liu and Kumar [17]. Table 1 shows that asphalt concrete's carbon fiber has a low density (1.37-1.78 g/cm3) and a 4-12 mm length. Because of its high decomposition temperature (over 1000 C) and robust tensile modulus (4300-6067 MPa), carbon fiber may be used in asphalt mixes. Without losing its qualities, it can withstand production temperatures. Figure 1(c) shows the carbon fiber. The study looked at how Carbon fiber percentages of 0.5% and 1.0% in an asphalt mixture had an impact on Marshall stability, performance in bending , porosity and the strength in tension. The study found that fiber-reinforced asphalt mixes outperformed non-fiber mixtures in terms of mechanical performance. Research suggests that adding carbon fiber to asphalt concrete increases heat conductivity and decreases electrical resistance. Fiber-strengthened asphalt mixture's microwave-healing capabilities have been improved by the use of carbon fiber. Fiber-strengthened asphalt concrete mixture had exceptional healing characteristics, according to the study. Muhammad Pirmo [54] examined the influence of carbon fibers on the durability of asphalt concrete using the semi-circular bend test. The optimal carbon fiber length and concentration for asphalt concrete, according to the researchers, are 8 mm and 3%, respectively Kim et al [18]. Carbon fiber has good tangible qualities, Electrical and thermal conductivity , making it a suitable reinforcement material for asphalt concrete. Due to its high cost, this fiber is not as commonly used as other fibers.

2.4. Polyester fiber:

At least 85% of polyester fiber is made of long-chain synthetic polymers. It is frequently utilized in the automotive, aerospace, and textile industries Bunsell [19]. The polyester fiber This material has outstanding mechanical qualities, minimal moisture absorption, and high resistance against abrasion and light. Table 1 indicates that the polyester fiber employed in the asphalt mixture has a density of 1.36-1.40 g/cm3 and a length of 6-14 mm. Polyester fiber has tensile strengths ranging from 500 to 1147 MPa and can decompose at temperatures over 240 C. Figure 1(d) shows The fibers of polyester utilized in asphalt mix. The study examined how varied levels of polyester fiber content has an impact on asphalt concrete's fatigue life and dynamic modulus. The outcomes of the test exhibited that the dynamic Adding 0.3% fiber content to asphalt concrete raised its modulus value, lowered phase angle, and improved cracking resistance at various stresses Wu et al [20].

2.5. Polyamide fiber:

Nylon fiber is frequently utilized as a reinforcing material in construction and in the furniture industry. strong tensile strength, excellent water absorption, and resistance to wear. The furniture industry and civil engineering both make extensive use of nylon fiber as a reinforcing material. [21] Noorvand et al. strong tensile strength, excellent water absorption, and resistance to wear. The furnishing industry and civil engineering both make extensive use of nylon fiber as reinforcement. According to Table 1, nylon fiber has a strength range of 810–2760 MPa and a decomposition temperature of 158–222 C. Because of the large temperature range—which may sometimes exceed 165 C during manufacture—using nylon fibers in (HMA) might be difficult.

. The fiber of nylon material used in the asphalt mixture has a density of 0.92-1.45 g/cm3 and a length of 12-19 mm. Form 1(e) shows the polyamide fibers utilized in concrete with asphalt.

2.6. Polyacrylonitrile fiber:

One type of synthetic fiber with great mechanical strength is polyacrylonitrile fiber., smaller profile, and reduced weight SlebiAcevedo et al [22]. Polyacrylonitrile fiber may absorb oil from asphalt binder, increasing viscosity and improving adhesive performance. Asphalt mastic exerts a force on mineral materials. Table 1 shows that the polyacrylonitrile fiber has tensile strength of 500-980 MPa and a decomposition temperature of above 220 C. The polyacrylonitrile fiber utilised in the composition of asphalt is 4–12 mm long and has a density of 1.18 g/cm3. Figure 1(f) shows the polyacrylonitrile fiber utilized. The study compared Polyacrylonitrile fiber was shown to improve stiffness, rutting resistance, and fracture resistance at low temperatures when used with asphalt concrete mixture modified with high percentage of SBS polymer. The study found that using a polyacrylonitrile fiber with a 0.15% content increased fatigue life. Synthetic fiber's physical and chemical qualities make it a reliable reinforcing material for asphalt pavements. Fibers can build networking structures. Improve asphalt mixture resistance to wear and tear and rutting during service life. However, there are major environmental and financial costs. J. Traffic Transp. Eng. (Engl. Ed.) 2023; 10(3): 331–348 335 Collaboration in research. Carbon fiber has a limited cost, but polymer fibers (polyacrylonitrile, polyamide, and polyester) contribute to contamination of the environment.

3. Surface treatment techniques for synthetic fibers

The road performance of the fiber is greatly influenced by its physical, thermal, and chemical characteristics. fiber-modified concrete made of asphalt. Fiber surface treatment for asphalt concrete enhances fiber dispersion and interfacial adhesion. Physical and chemical methods are used in fiber surface treatment to improve roughness, decrease water absorption, and improve the behavior of The contact between the fiber and the mixture Xiang et al [23].

3.1- Medical care

Actual therapies , including elongation, coating, and thermal modification, enhance the functioning of fiber interfaces and surfaces Phan et al [24]. utilized (WMA) to create a coating. The approach improves The ability of aramid fiber to disperse in asphalt concrete. The functionality of asphalt concrete roads with altered fibers was evaluated using indirect tensile, rheological, and fatigue tests. The study found that adding 0.05% WMA coated fiber significantly improved the fatigue life and rutting resistance of asphalt concrete. The asphalt concrete's fiber dispersion improves the interaction between particles and increases its resistance to cracks. Figure 2 displays the coating. The glass fiber surface was improved using therapy with chilly plasma with argon, oxygen, and nitrogen. The treated fiber was then surface functionalized. Fourier transform infrared spectroscopy was used to conduct the tests. Figures 3 and 4 demonstrate The plasma therapy method and spectroscopy in the infrared findings. The nitrogen plasma treatment resulted in the formation of the N-H groups, whereas the oxygen plasma treatment produced the O-H groups. Argon plasma treatment of glass fibers improves interfacial adhesion, improving composite bending resistance and reducing damage from force Yan et al [25].

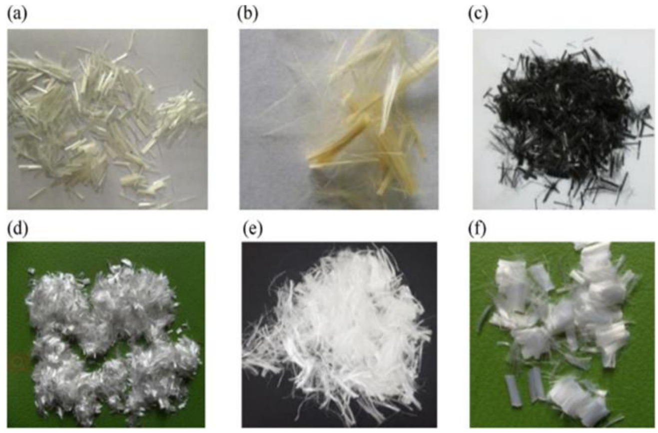


Figure 1. The pic of types of fibers discussed above. (a) glass fiber. (b) aramid fiber. (c) carbon (d) Polyester fiber. (e) Polyamide. (f) Polyacrylonitrile fiber.

Table 1. Shows the physical properties of commonly used artificial fibers in mixtures of asphalt.

Fiber	Tension resistance (MPa)	Disintegration T (C)	densenes s (g/cm3)	Long (mm)	Citation
Glass fiber	2000 2000 3100- 3400 3100- 3400 1700 3445	NA NA 840 >1500 860 NA	NA NA 2.58 2.50 2.58 2.68	10.0- 15.0 6-12 12.0 12.0 12.0	Fakhri and Hossein [50] Morea and Zerbino [51] Aziminezhad et al [52]
Aramid fiber	2758 3000 2758 3000	-- 450 -- >450	1.44 1.44 1.45 1.37	19.0 -- 19.0 19.0	Mirabdolazimi and Shafabakhsh [53]
Carbon fiber	4900 4300 6067	1000 NA NA	1.37 1.76 1.78	12.0 4-12 6.0	Pirmohammad et al [54]
Polyester fiber	531 550 NA 500 1147	NA 259 240 258 256	NA NA NA 1.40 1.36	6.0 10-14 6.0-12 6.0 6.0	Anurag et al. [49]
Polyamide fiber	2758 2757 800 800	157 260 220 260	1.44 0.94 1.14 1.16	19.0 NA 12.0 19.0	Qian et al. [55]
Polyacrylonitrile fiber	>910 >780 >500	NA NA >200	NA 1.18 1.18	4.0-6.0 4.0- 12.0 6.0	Xu et al[56]

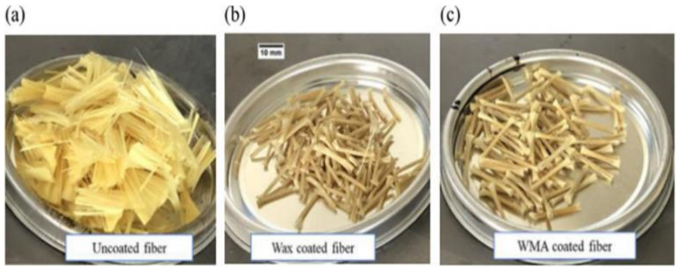


Figure 2. shows that the fiber surface is covered with three types of materials Phan et al [24].

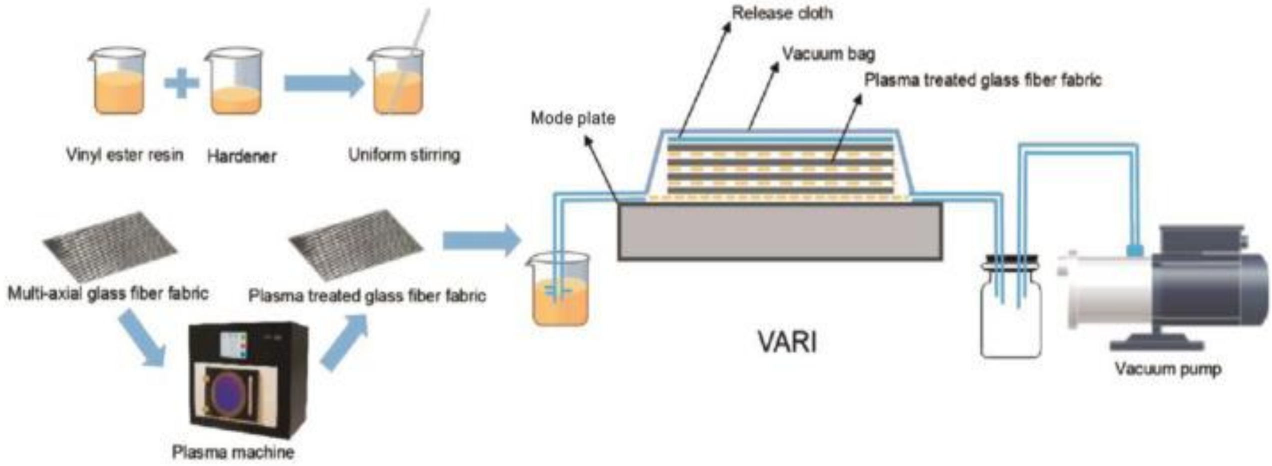


Figure 3. shows the glass fiber treatment method [25].

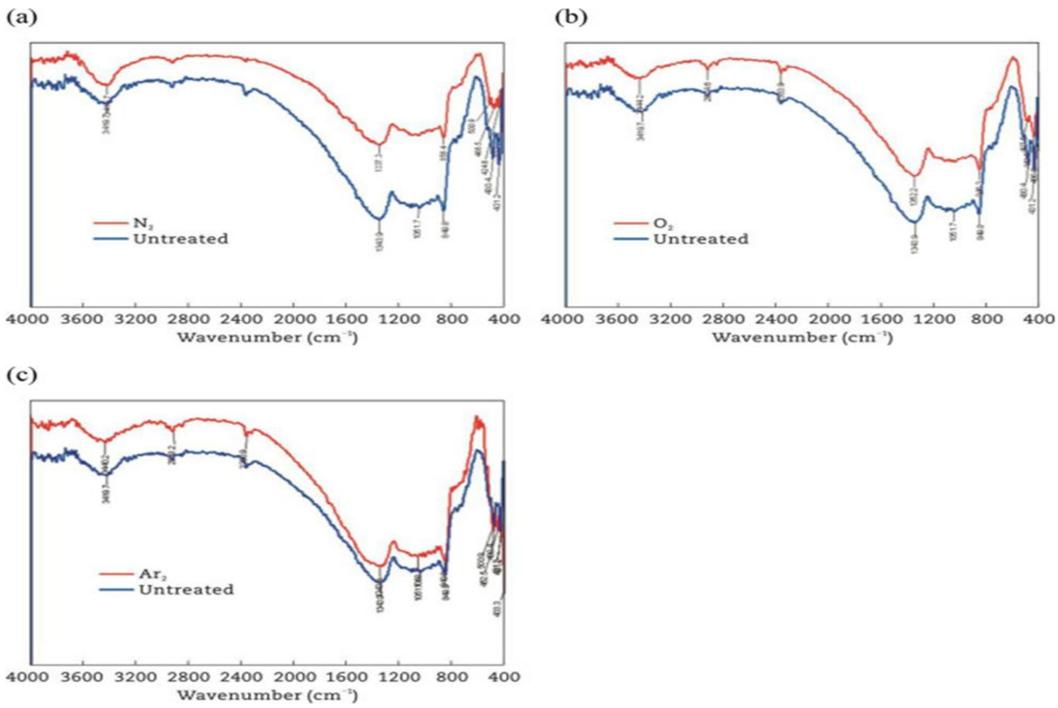
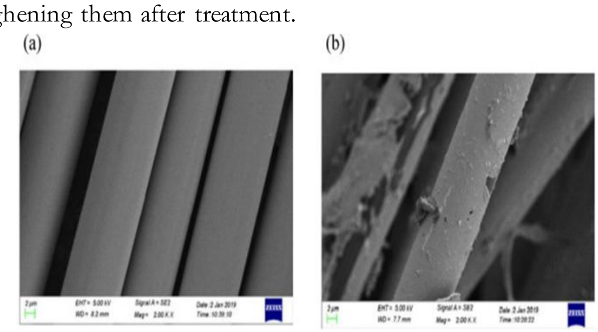


Figure 4. FT-IR Diagrams used for fiber composite characterisation. (a) Nitrogen plasma. (b) Oxygen plasma. (c) Argon plasma. Yan et al [25]

3.2. Chemical treatment

Chemical processing improves interfacial bonding and fortifies fiber-matrix interactions. Chemical therapy includes, for example, silane and alkali treatment. Sulfuric acid was applied to glass fibers in order to examine the effects of coupling, bleaching, and acetylation. Techniques for Treating Fibers of Fourier-transform infrared spectroscopy, SEM, rheological, Surface tension, tensile strength, and contact angle tests were used to assess fiber-reinforced emulsified asphalt. Fernandes et al [26]. Xing et al. [27] The study found that the fiber-reinforced emulsified fiber's breaking strength and binder-fiber adhesive energy. The glass fiber treatment increased the quantity of asphalt cement. Treated aramid fiber with an agent that couples silanes and examined the characteristics of the fiber-strengthed produced asphalt binder. The process of surface coating of fiber, the agent that couples silanes improve the surface fiber's roughness and hydrophobicity, and consequently amplifies. The connection with bitumen. A Scanning electron picture of the patient fiber is displayed in Figure 5. It Because of its flat surface, after treatment, it is challenging to disseminate the fiber. The fibers' dispersibility in asphalt concrete is improved by coating and roughening them after treatment.



Figurer 5. scanning electron microscope image of fiber surface. (a) Untreated fiber (b) Fiber treated with silane coupling agent [27].

4. Mechanical characteristics of asphalt mixes with artificial fibers.

4.1. Resistance to Rutting

One of the main causes of pavement deterioration in hot climates is rutting, which Does the asphalt pavement's longitudinal depressions bring on by vehicle loads Javilla et al; Ren et al[28] [29] [30]. Vehicle load leads to permanent deformation of asphalt pavements at temperatures over 40°C, with the asphalt mixture playing a key role. Building (aggregate, gradation, and asphalt) and environmental factors (climate and loading) [31]. The wheel tracking device test is a standard way for determining its permanent performance. Asphalt mixes are deformation resistant. The sloppy mixture of asphalt is placed in a 300 mm x 300 mm x 50 mm mold and compacted 24 times with an impact hammer. The specimen is then rolled using roller compactor equipment to attain the required height. After 5 hours at the specified temperature, the specimen is exposed to 42 cycles/min of wheel load at 0.7 MPa. The roller is loaded for 60 minutes and has a travel range of 230 ± 10 mm. The rutting resistance of asphalt mix is predicted using dynamic stability (DS) Shanbara et al [13]. Rutting and cracking caused by car wheels can deteriorate asphalt pavements and reduce their service life. Some study suggests that using synthetic fibers can prevent rutting. Cracking occurs due to the formation of a 3-dimensional fiber network in asphalt mix Kim et al [18]. The study examined the addition of 0.5% and 1.0% nylon, carbon, polypropylene, and polyester fibers to concrete with asphalt. We investigated fiber-reinforced asphalt concrete's resistance to rutting. Figure 7 the carbon fiber-reinforced mixture showed minor increase in dynamic stability compared to HMA, whereas polyester and nylon fibers significantly improved (HMA) Tanzadeh and Shahrezagamasaei [32]. The study examined the rutting resistance of a PA combination of styrene butadiene styrene (SBS) and hybrid artificial fibers (made of glass fibers and polypropylene). The Adding 3% polypropylene fibers and 2% glass fibers reduced permanent deformation and rutting depth by 5%,respectively. The use of synthetic fiber improved the permanent deformation asphalt concrete's resilience as compared to virgin concrete. Additionally, adding glass fibers and polyacrylonitrile to the asphalt mixtures enhanced their resistance to rutting significantly. Refer to Figures 8(a) and (b) [33].

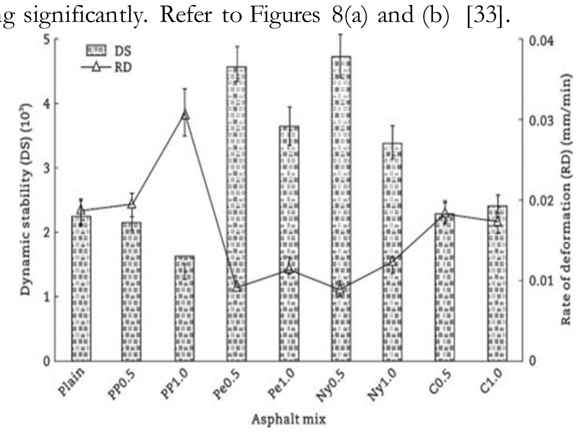


Figure 7. evaluates the long-term deformation of different fiber-containing asphalt mixes, including carbon fibers, polyester, polypropylene, and nylon Kim et al [18].

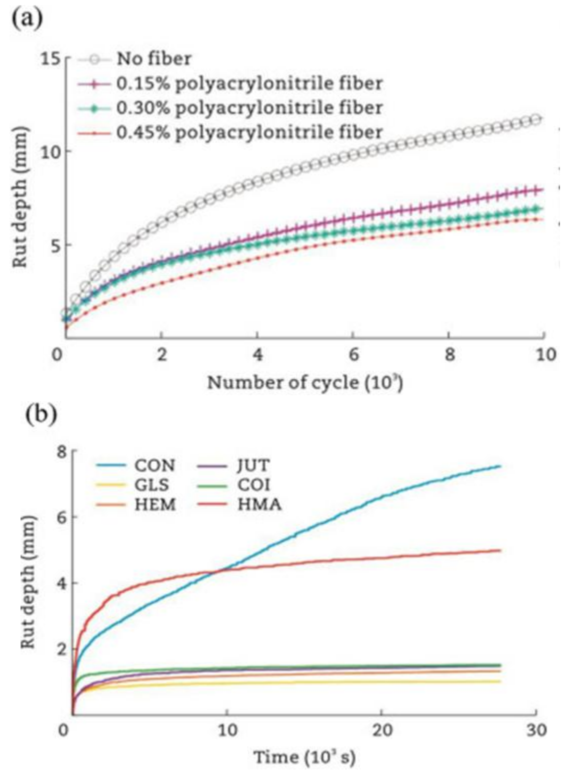


Figure 8. The rut depth of asphalt mixed with fibers. (A) Polyacrylonitrile. (b) Glass fibers

4.2. Characteristic of tensile strength

In a multidimensional network, fibers enhance the hardness and The asphalt binder tensile strength. (SCB) tests and strength of indirect tensile The (ITS) test evaluates asphalt concrete's resistance to cracking Sheng et al. [34]. The Superpave gyratory compactor (SGC) produces SCB specimens measuring 150 mm in diameter and 120 mm in height. Semi-discs of 32 mm in thickness and 75 mm in radius are created by cutting the cylindrical specimens both longitudinally and vertically. Fracture toughness and shattering at low temperatures are tested using a 3-point bending pressure equipment with two rollers (0.8 times the diameter). SCB specimens are stored for 12 hours at the desired temperatures before being tested at a continuous rate of 5 mm/min using a three-point bend loading fixture machine Song et al. [35]. Specimens undergo an 8-hour conditioning period at the proper temperature in order to undergo the ITS test. The break The asphalt mixes' hardness cracking is then investigated. A constant displacement rate of 50 mm per minute and a maximum load capacity of 100 kN are features of the material testing system (MTS). Guo et al [36] We looked into The engineering properties of asphalt mortar reinforced with synthetic fibers. Asphalt mortars with fiber contents of 0.1%, 0.2%, and 0.3% We conducted indirect tensile tests at -15°C, 0°C, and 15°C. According to the study, fibers became stronger at low temperatures (-15 C). The inclusion of fiber increases asphalt mortar's fracture energy. Figure (9) shows that polyolefin-aramid fibers (content of 0.2%) and fibers of polyacrylonitrile (0.1% and 0.3% content) modestly elevated ITS values at 15°C. Besides [15]. Nylon and polyester fibers significantly increase the strength of asphalt concrete in contrast to polypropylene and carbon. fibers, as seen in Figure 10 (a). The study examined the use of synthetic fibers in PA mixes and found that they improve ductility and toughness, as illustrated in Fig. 10 (b). Improved indirect tensile strength test results were obtained by mixing recycled hot-mix asphalt concrete with baton glass fibers and spherical fiber powder. Asphalt mixes treated with fiber had a 1.5-fold improvement in their ITS value Park et al. [37]. The SCB investigated the low-temperature fracture resistance of asphalt mixtures containing polyester fiber. test. The study found that lower heat resistance to breaches of asphalt mixes increased by 35.65%, 36.37%, and 45.95% at -20, -10, and 0 degrees Celsius [38] Hong et al. The SCB test was used to evaluate the cracking behavior of asphalt mixtures containing glass fibers at -16, 0 and 15 degrees Celsius. According to the findings, adding 0.13% glass fiber enhanced the asphalt mixes' resistance to breaking at low temperatures. Ziari et al [39]. The study examined fracture resistance at low temperatures in asphalt mixtures incorporating natural and synthetic fibers. The study found demonstrated, in comparison to control mixes, both fibers increased the asphalt concrete's resilience to fracture. At lower temperatures, the synthetic fiber fared better. Aliha et al. [40].

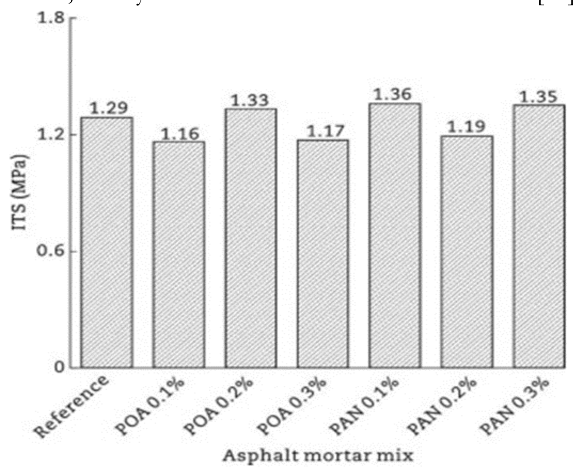


Figure 9. shows the ITS number of poly-ara fiber and polyacrylle fiber reinforced mixtures Slebi-Acevedo et al [15].

4.3. Performance of Water Stability

The main factor contributing to the breakdown of pavement is damage from water, which is brought on by a reduction in the contact between asphalt and particles Rainy regions Wang et al [41]. Damage from moisture causes raveling, peeling, as well as softer. Asphalt and aggregate production involve physical processes such as stripping and raveling. Via loss of adhesion. Softening occurs when the binder cohesiveness decreases, causing the asphalt concrete to lose stability and rigidity Cui et al., Goli and Latifi [42] [43]. The Marshall Integration Exam evaluates asphalt concrete's resistance to moisture degradation through the computation of the absorption residual. MSR, which mean Marshall Stability Ratio. The compaction of Marshall technique was used to make ready a specimen measuring 63.6 mm in height and 100.5 mm in circumference. The entrance and rear After 75 crushing, the sides are allowed to cool at room temperature for a full day. The asphalt concrete's moisture damage is measured by the tensile strength ratio (TSR). The test specimen was placed in a vacuum environment. placed for 16 hours at 18 degrees Celsius in a conditioning chamber. For a whole day, the water is submerged in the sample at 60°C. At 25°C, the sample is submerged in water. for two hours following the freeze-thaw cycle. To compute the TSR value, test the indirect tensile strength of the moisture-damaged specimen and divide it by the ITS value of the specimen. Moisture degradation in road pavements occurs when bitumen and aggregates lose adhesion due to harm by moisture, particularly to the PA mixture. In the SMA, cellulose fibers perform better than polyester fibers in terms of water stability [44]. Additionally, cellulose fiber was typically utilized to decrease the drainage of binder in the PA mixture [45] [46]. Gupta et al [47] The addition of aramid and glass-hybrid fibers to the PA combination resulted in moisture susceptibility test results. Glass fiber enhanced the PA combination's water stability, but there was no discernible improvement in aramid fiber. Kassem et al. [48] Polyolefin and aramid fibers enhance asphalt concrete's water stability performance. Test results revealed that fiber did not significantly improve moisture resistance in asphalt mixture. Anurag et al. [49] examined how polyester fibers with per cent of 0.35% and 0.50%, as well as lengths of 6.35 and 12.70 mm, influenced the resistance of asphalt to moisture damage. Regarding utilizing the ITS test, the study found that adding polyester fiber to asphalt concrete improves its water stability.

5. Conclusions

This study presents the characterisation of synthetic fibers and recommends appropriate lengths for usage in mixtures of asphalt and pavements. Furthermore, to the Fiber surface treatments, particularly chemical treatment, improve the mechanical qualities of asphalt mixtures. This paper examines how Synthetic fiber enhances asphalt mixtures' mechanical properties, such as their capacity to withstand high temperatures, their tensile strength, and their water stability. Previous research has demonstrated that synthetic fiber-modified mixtures outperform traditional mixtures in terms of mechanical qualities. Different synthetic fibers are advised for different asphalt blends. Below is a summary of the findings.

• The tensile strength, modulus of elasticity, specific weight, deterioration temperature, and dimensions of synthetic fibers were examined for usage in fiber-modified asphalt concrete mixtures.

• The suggested lengths for G&C fibers in asphalt mixtures are 6-12 mm and 5-12 mm, respectively. C fiber has outstanding physical and thermal qualities. Consider electrical conductivity, as well as building costs.

• The recommended lengths for poly, aram, poly, and polyacryl in asphalt mixtures are 6-14mm, 19mm, 12-19mm, and 4-12mm, in turn. But long-term ecological damage from polymer fibers should be addressed during pavement building.

• Aram, polye, and glas fibers are commonly utilized to enhance The opposing breaking properties of asphalt on streets. Poly, carb, and polyr fibres have Asphalt pavement has positive resistance to persistent deformation. Adding glass, nylon, and polyester fibers to asphalt mixtures increased water stability and tensile strength.

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