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Minimizing The Phenomena of Reflection Cracks. A Review

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Abstract

Reflective cracking is a serious issue that Adversely influences the performance and longevity of asphalt overlays over deteriorated pavements. This review Looks for the Technologies which used to reduce the reflection cracks propagation by insert a new Strategies and different design materials. This research dealt with many treatments such as: increasing the layer thickness of Hot Mix Asphalt (HMA), creating modified asphalt by adding polymers to asphalt, rubberizing asphalt, carbon black, sulfur and other different materials. Geosynthetic materials were studied and analyzed to evaluate their ability to increase the layer tensile strength and minimize the effect of reflection cracks such as geotextiles, geogrids, and Stress Absorbing Membrane Interlayers (SAMI). The research shows that the increasing of overlay asphalt layer thickness leads to durability development. On the other hand, using developed materials like Polymer-Modified Asphalt and Stress Absorbing Membrane Interlayers (SAMI) Strategies leads to increasing the service life of the repaired pavement. The conclusion indicated that the development of overlay asphalt layer thickness and layer reinforcement and applying advanced environmental systems can be improving the pavement performance. These Strategies can produce a perfect solution to prevent or reduce the reflection cracks in rigid and flexible pavement.

Keywords: Reflection Cracks, Geosynthetic, Geogrids, Stress Absorbing Membrane Interlayers (SAMI).

التقليل من ظاهرة الشقوق الانعكاسية. ورقة بحثية

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الخلاصة:

يعد التشقق العاكس مشكلة خطيرة تؤثر سلبًا على أداء وطول عمر طبقات الأسفلت على الأرصفة المتدهورة. تبحث هذه الورقة في التقنيات الحالية التي تحاول تقليل انتشار الشقوق الانعكاسية من خلال استخدام استراتيجيات ومواد تصميم مختلفة. يبحث هذا البحث في فعالية زيادة سمك طبقات الأسفلت الساخن (HMA)، باستخدام الأسفلت المعدل بالبوليمر، والإسفلت المطاطي، والكربون الأسود، وإضافات الكبريت، وغيرها من المواد الجديدة. يتم إجراء تحليل على المواد (geosynthetic)، مثل الجيوتكستايل، والشبكات الجيوفيزيائية، وطبقات امتصاص الاجهاد (SAMI)، لتقييم قدرتها على تعزيز قوة الشد للطبقة وتقليل حدوث الشقوق العاكسة. تشير الأبحاث إلى أن استخدام طبقات أكثر سمكًا قد يعزز المتانة، ولكن استخدام مواد متطورة مثل الأسفلت المعدل بالبوليمر وأنظمة (SAMI) له إمكانات كبيرة في إطالة عمر السطح المستصلح. تشير النتائج إلى أنه من خلال تطوير سمك الطبقة، وتعزيز المادة، وتنفيذ أنظمة الطبقات البينية المتقدمة، يمكن تحسين أداء الأرصفة بشكل كبير. وهذا يوفر حلولاً عملية لمعالجة المشكلة الشائعة للتشققات العاكسة في كل من الأرصفة المرنة والصلبة.

1. Introduction

Reflection cracking is a significant kind of damage that has been seen in Hot Mix Asphalt (HMA) overlays for many years. Cleveland [1] defined reflection cracking as the phenomenon by which fractures and damage from old pavement layers propagate into and through fresh asphalt overlays. The primary elements that contribute to the deterioration of the pavement are the wheel loads caused by traffic and the changes in temperature throughout the year, which affect both the overlays and the underlying layers [3]. Reflection cracking is an intricate phenomenon that involves two

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main phases: fracture [4]. In addition, there is no one option to halt the propagation of cracks and protect the HMA overlays. Nevertheless, there exist several methods to limit the propagation of cracks for a significant period, consequently significantly improving the durability of the overlay [5],[6],[7].

Asphalt pavement, supported by a somewhat flexible foundation, has the benefits of excellent durability, cost-effectiveness, and consistent performance maintenance. Consequently, it is extensively used in top-quality road surfaces worldwide [8],[9]. Under the weight of traffic, fractures in the somewhat flexible base layer will quickly spread to the top layer, causing damage to the road surface and creating pathways for rainfall. This will exacerbate other sources of anxiety, thereby reducing the road's lifespan. Hence, the mitigation of reflective cracking is an urgent issue that has to be addressed during road maintenance.

Reflective cracks wider than 6 mm may cause several performance issues, such as insufficient load transmission at the joints, and heightened tensile stress is seen in the lower portion of the (HMA), resulting in an augmented roughness of the road surface. [10],[11]. Water may easily seep into the pavement layers via the many reflecting cracks, deteriorating the base, subbase, or subgrade layer and eventually separating the aggregate from the HMA [12],[13],[14]. In addition, there may be inadequate interlocking between the particles of the aggregate and localized deterioration of the pavement along the fracture [15],[16]. Reflective cracks may also give rise to secondary cracks, which may eventually result in fatigue cracking [17]. One of the main considerations when choosing HMA overlays with stabilized bases is the presence of serious fissures on the present surface. Asphalt mixes intended for use over a cracked foundation should be assessed for their resistance to reflective cracks to guarantee the pavement performs at its best for its whole duration.

Reflective fractures may spread quickly over the pavement surface, often expanding by around 1 inch each year on average. These fractures on the surface become noticeable after almost three years.

Two distinct phases characterize reflective cracking: first, the cracks start in the lower layer of the overlay, and second, the cracks spread to the upper surface of the overlay. Reflective distress in an overlay may be caused by two different things. One typical way that HMA overlays might be damaged is via thermal loading. It occurs when temperature changes cause the underlying, rigid pavement to shift both horizontally and vertically.

Another factor to consider is traffic loading, as shown in Figure 1. While thermal loading is also important in the development of reflective cracks, traffic-induced loading may have a greater impact. However, A critical factor in the propagation of the fracture from the overlay's base to its surface is the thermal load [18]. The load from traffic on a crack in the pavement creates three important pulses: one with the highest amount of bending stress and two with the highest amount of shear stress.

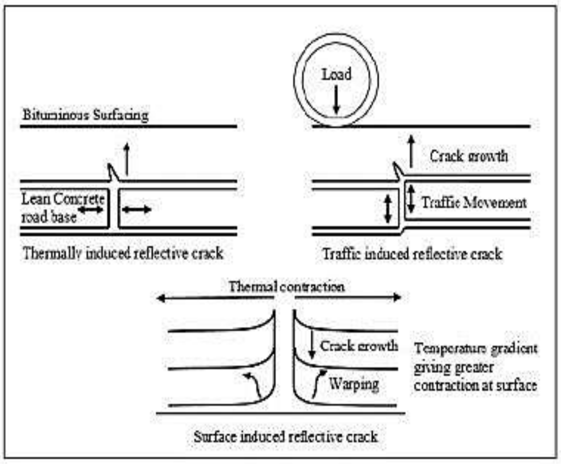

Figure (1): The mechanism of reflecting cracking occurs as a result of two distinct types of loading [19].

Typically, pavement construction is subjected to two types of loads, which are applied in an assemblage of three different modes, as seen in Figure 2. These modes are the most extreme moving conditions that might lead to fractures [19]. Mode 1 encompasses the typical stresses exerted on the fracture plane, which occurred due to heat and traffic loading. Mode 2 refers to the occurrence of shear loading within the same plane, causing the crack surfaces to slide against each other in a direction perpendicular to the front edge of the crack, this type of movement is a result of the weight of traffic. Mode 3 involves the application of shear forces in a direction parallel to the foremost edge of the fracture. This moving process is often known as the tearing mode. Nevertheless, the precise influence of this particular phase on the formation of reflective fissures in the composite pavement remains unknown.

External effects such as (temperature and load) lead to generate movement between the pavement layers, especially in the joint area and between fracture. This continuous movement leads to the emergence of failure cases on the overlay layer as a result to generate stresses during this process.

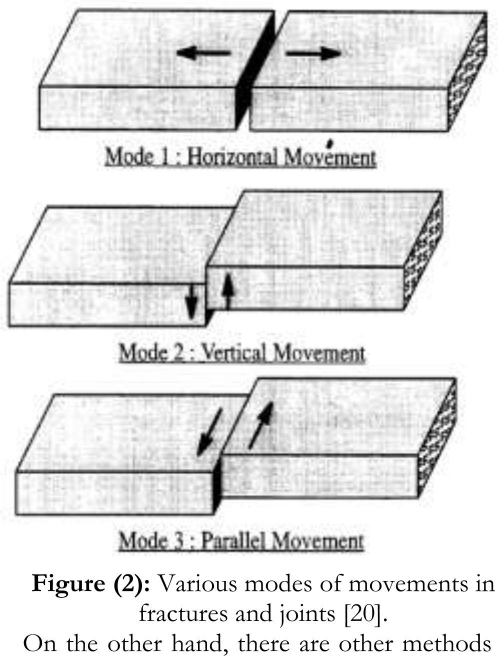

Figure (2): Various modes of movements in fractures and joints [20].

On the other hand, there are other methods that rely on past experience to reduce or postpone the spread of cracks. These methods include thickening the overlay, adjusting the asphalt's characteristics, or incorporating a stress-absorbing interlayer between the two layers of pavement.

Nonetheless, the preexisting fissures extend to the newly laid pavement, hastening the whole pavement's demise and increasing expenses for both highway authorities and drivers. Consequently, it is crucial for road maintenance to create an overlay design process that incorporates reflective cracking criteria.

To account for reflective cracking in design, one must think about the current pavement's discontinuity, which is caused by the cracks. Finite element analysis and other specialized numerical methods related to fracture mechanics ideas are required to represent this cracking state [21]. It's a complex path because we need to study the physical characteristics and behavior of cracks and how to describe it in numerical models, many factors need to be examined and studied such as (type of mesh, type of discontinuity, geometry model and materials properties). The type discontinuity describes if Pre-existing crack or Potential crack that means the crack position can be estimated.

This review aims to provide a wide description of the factors that cause the formation of reflection cracks, the most important effective treatments that reduce this phenomenon, and to clarify the extent of their effectiveness and methods of application.

2. Minimizing reflection cracks propagation procedures

2.1. Types of Overlay System

Asphalt overlays serve the purpose of enhancing the functional performance of deteriorated inflexible pavement. Additionally, they may be used to minimize noise, enhance skid resistance, and better ride quality. Asphalt overlays may be applied to pavements that are at different levels of deterioration, and the effectiveness of the overlay relies on how well the previous pavement is prepared. The primary advantage of asphalt overlay is its Efficiency in terms of cost as a solution for restoring an existing highway. Another notable advantage of the asphalt overlay is its accelerated building rate and ease. Asphalt concrete (AC) overlays may be applied to either flexible or stiff pavement with little disruption to traffic flow or the need for redirection. However, using the overlay instead of more expensive options, such as full-depth repair, is an additional advantage. While costly alternatives may provide the necessary structural functionality, often a significant restoration that includes a straightforward AC coating of the specified thickness can be a more efficient and cost-effective solution. One advantage of using asphalt overlay is its adaptability, since it may be used for both maintenance purposes, such as fixing damage caused by environmental factors or heavy traffic, and for rehabilitation purposes, to prolong the durability of an existing pavement.

2.1.1. Modify the HMA Overlay Design

2.1.1.1. Modify Structural Design (Increasing Thickness)

The strategy to raise the thickness of (HMA) overlays to minimize the occurrence of reflected distress has mostly depended on statistical relationships drawn from local knowledge and experience. [22]. The thickness of the overlay is Impacted by many variables, including the kind of pavement (HMA or Rigid), the distress type, the meteorological circumstances, and the traffic loadings [23]. Barksdale [24] revised the results of Synthesis NCHRP 92 [23] and presented the subsequent data on the thickness of HMA overlays.

The assessment of rigid pavements [24],[26] revealed that a 150 mm overlay saw 20 percent area cracking over a period of six years, while a 100 mm overlay exhibited the same level of cracking within two years. Reflective cracks manifested promptly after the completion of a 2-inch overlay.

Predoehl [27] has shown that a minimum of 122 mm of overlay is necessary to effectively mitigate reflective distresses over ten years. The Georgia investigations [25],[26] yielded comparable findings when using a 102 mm overlay, under the condition that the preexisting pavement is structurally solid and well maintained. If there is alligator cracking, it is advised to have at least 50 mm of overlay. For base failures, the overlay should be more than 50 mm. In the case of block cracking, a minimum of 75mm (90 mm inches is preferable) of overlay is recommended.

According to McLaughlin [28], the most severe instances of reflected cracking occur When constructing airport pavements, a thin overlay (less than 50 mm) is applied above the heavily cracked HMA or rigid pavement. The analysis found that when a 100 mm overlay was gradually reduced to 50 mm, reflective cracking only occurred in the sections with the slimmer hot mix asphalt (HMA).

Ajool Y. [29] created samples of Asphalt Concrete (AC) slab in three different thicknesses: 4 cm, 5 cm, and 6 cm. The specimens underwent testing using an overlay test machine to determine the number of cycles and loads required for the propagation of reflection cracking in the asphalt concrete mixture at three different temperatures (20, 30, and 30°C) and found that the development of asphalt thickness increases the resistance to crack propagation.

For the purpose of studying the impact that the thickness of the asphalt overlay has on the fracture resistance of the pavement structure, Han. [30] and his colleagues carried out fatigue tests on cement concrete pavement that had an asphalt overlay. They discovered that the fatigue life of the pavement greatly rises as the thickness of the asphalt overlay grows, even when the thickness of the asphalt overlay is less than 10 centimeters. Furthermore, they observed an approximate Linear correlation between the thickness of the asphalt overlay and the fatigue life.

Nevertheless, if the thickness surpasses 10 cm, the pace at which the anti-fatigue load increases decreases. Furthermore, when the thickness reaches 15 cm, the effectiveness of the resistance to thickness remains unaltered. Furthermore, it was shown by [31] that the development in AC mix thickness improved the lifespan of the AC overlay in terms of resistance to reflection distresses. Furthermore, it was shown that the quantity of fracture initiation and failure cycles escalated with rising temperatures. Conversely, the elevated temperature reduced both the load needed to initiate cracking and the load necessary for failure in the sample.

2.1.1.2. Modify Mixture Design of Overlay

- **Polymer-modified asphalt**

The study evaluates the effectiveness of reinforcing strategies in polymer-modified asphalt mixes for reducing reflection distresses in standard asphalt pavement overlays. A multitude of polymer Reinforcing materials such as a polypropylene film vinyl and a grid were chosen and used in conjunction with fiber as asphalt modifiers. Polymer-modified asphalt exhibits significant improvement in crack resistance within asphalt mixtures [32]. The practice of modifying asphalt binders with polymers to enhance their qualities, such as resistance to cracking and deformation, has been more prevalent in recent decades [33],[34].

Asphalt mixes that have been treated with polymers, with a polymer content of 2-3%, have shown improved durability when used as overlays. Moreover, it is postulated that asphalt mixes with a polymer percentage over 6% may produce further benefits for flexible and composite repaired pavements exposed to significant and/or slow-moving traffic loads [33],[34],[36]. This approach utilizes a new SBS polymer structure at an increased rate, without producing any production issues such as clogging of the binder pump or lower workability of the mixture [37]. The disadvantages of this type is that it needed a complex strategy in blending, high cost of polymer, and limited workability.

- **Rubberized asphalt**

The rubblization of degraded concrete pavements, followed by a hot mix asphalt (HMA) overlay, is a very successful rehabilitation technique that may be used for all forms of rigid pavements. Rubblization refers to the procedure of breaking the existing pavement into smaller pieces and then overlaying it with Hot Mix Asphalt (HMA). The text is enclosed in the tags [38]. The rubblized Portland Cement Concrete pavement functions similarly to a high-grade granular base layer. The rubblized layer acts as a tightly connected layer without any binding agent, resulting in the existing (Portland cement concrete) being transformed into a substance that is akin to a high-quality aggregate base course. The HMA overlay design thickness must include the loss of structure [39]. This procedure is Comparable to crack and seat, with the exception that the resultant concrete fragments measure 50-75mm at the surface of the rigid layer. Rubblizing, a process that breaks down the slab, compromises its structural integrity and prevents weight transmission between the individual pieces [40]. Using it as a pre-overlay treatment for pavements with insufficient subgrade support is not recommended [41].

Following the rubblization process, it is necessary to compact the pavement before applying the overlay. This step is comparable to the process of stabilizing damaged pavement in the crack and seat operation. It is used to provide a firm and secure foundation for the application of asphalt concrete. Both procedures include the crushing of the previous concrete slab into tiny fragments before the overlay is applied. The disparity between the two procedures lies in the dimensions of the resultant concrete fragments. The concrete is further broken to lower the chance of reflective cracking, which is directly associated with the reduction of crack spacing. This approach is effective because using tiny concrete pieces results in fewer gaps between them, which in turn reduces deformation caused by temperature variations. As a result, the level of crucial stressors at the lowermost layer of the asphalt overlay is decreased [42].

Multiple investigations have shown that the strength of the rubblized layer is 1.5 to 3 times higher than that of a high-quality thick graded crushed stone foundation. The cracked slab approach mitigates the incidence of reflective distresses in HMA overlays by reducing the thermal distresses of the Portland cement concrete slabs [42],[38].

- **Carbon black**

Rostler [43],[44] conducted research on the use of carbon black for asphalt modification. Carbon black has been discovered to function as a reinforcing ingredient for asphalt, reducing its temperature sensitivity and slowing down the solidification process of the asphalt during manufacture. The use of carbon black enhances the tensile strength of the HMA mixture. Enhancing the tensile strength of (HMA) may effectively postpone the development of reflected cracking.

Yao and Monismith [45] conducted laboratory experiments to study the influence of HMA mixes with carbon black reinforcement. The test findings indicated that including carbon black, namely Microfill, in quantities ranging from 15 to 20 percent by weight of the asphalt, mitigated the impact of temperature on the physical properties of the mixture. At elevated temperatures, the creep behavior significantly improved during extended loading durations, however at lower temperatures, the creep response remained unchanged compared to mixes without reinforcement.

According to Yao and Monismith [45], if the behavior of asphalt in service is comparable to that seen in this investigation, using soft asphalt might help reduce low-temperature cracking while also offering better resistance to rutting under high pavement temperatures. The research also proposed that incorporating carbon black micro filler into reasonably rigid asphalts might be beneficial in mitigating the propensity for rutting in extensively used pavement portions, particularly in hot regions.

The advantages of modified asphalt with carbon black are increase resistance for rutting, fatigue life, thermal properties and improved stability and strength. The disadvantage of this modification are brittleness at low temperatures and impact on workability.

- **Sulfur Asphalt**

Various additives may be used to enhance the rheological qualities of asphalt. By including sulfur, it is possible to regulate the formation of reflecting fractures and decrease the overall cost of Hot Mix Asphalt (HMA) by substituting part of the more expensive asphalt with more affordable sulfur [46]. Hignell [47] described the HMA modified with sulfur its a suitable component to high and low temperatures environment. Poon [46] shows that blending sulfur with asphalt produce improvement in stability and stiffness at high temperatures while keeping the asphalt properties at low temperatures. Sulfur asphalt leads to modified soft point at low temperatures and hardness at high temperatures, so that the sulfur asphalt resists the cracks propagation at low temperature and minimizes the rutting at high temperature, and the rigidity of the product depends on the sulfur amount that blended with asphalt. Fromm [48] observed that the sulfur asphalt combination had superior resistance to heat cracking and rutting when compared to a typical asphalt mixture without sulfur, based on the performance of test sections. However, the research did not include the phenomenon of reflective cracking. According to the research by [48], sulfur fumes might pose an issue when the temperature of the paving mixture exceeds 266°F (130 °C). Although their quantities were much below the hazardous limit, hydrogen sulfide and sulfur dioxide were identified as the primary constituents of the vapors. The disadvantage of this modification are compatibility issues, cracking potential, limited workability and long-term performance issues.

- **Other Additives**

Additional substances such as asbestos fibers, shingles, and metal additions have also been discovered to effectively alter asphalt. The majority of the research examined the use of additional additives including assessing the attributes of mixtures in a laboratory setting. Only a small number of these experiments included analyzing field performance data, and out of those, only a few specifically examined reflective cracking. The use of an asbestos-reinforced HMA mix was Demonstrated as one of the five procedures that successfully reduced reflective distress in Arizona [48]. Nevertheless, the use of asbestos in HMA overlays has been discontinued because of its classification as a hazardous chemical.

Kennedy [49] discovered that the introduction of a minute quantity of metal may initiate the process of polymerization in asphalt, leading to enhanced performance of (HMA). This alteration resulted in an improvement in the temperature susceptibility, indirect tensile strength, and bending strength as shown by the laboratory testing. According to Kennedy [50], the addition of manganese metal to the HMA mixture resulted in enhanced stiffness, strength, and stability at high temperatures, while reducing stiffness at low temperatures. At low temperatures, the modified combination exhibited a reduced tensile strength compared to standard mixes.

2.2. Applying Interlayer System

The HMA overlay reinforcement, represented by geosynthetics, is used to effectively minimize reflecting fractures. The overlay reinforcing technique is used to augment the tensile potency of the overlay and firmly unite any potential cracks.

2.2.1. Geotextiles

Geotextiles, often known as geo fabrics, may be essentially categorized as either woven or nonwoven. Typically, it consists of thermoplastics like polypropylene or polyester, however, it may also include other polymers, organic compounds, and fiberglass. Nonwoven textiles often have their filaments bound together using either mechanical means, such as needle-punching, or through chemical and heat processes, such as spun-bonding [51]. Various design and construction parameters influence the comparative effectiveness of geotextiles available on the market [52].

The research on the efficacy of geotextiles in reducing reflection distress found that the connection between the existing pavement and the new layer was considered a major factor. The interfacial adhesion's strength is determined by the composition and application of the tack coat. Overlay rutting may occur when there is insufficient bonding strength at the interface of the hot mix asphalt (HMA) layers, leading to lateral displacement of the HMA due to distresses of the traffic. This phenomenon has been shown in a model developed by [53].

Manufacturers recommend utilizing a minimum 37 mm thick overlay when installing an interlayer system. Additionally, if the surface has undergone machining, it is necessary to apply a leveling course [54].

Geotextile layers serve many fundamental purposes, including reinforcement, separation, filtration, drainage, fluid barrier, and protection [55]. Multiple factors influence the Efficiency of the geotextile or paving fabric. The investigation of these factors may be based on the geotextile's mechanism as an interlayer system. Reflective cracking propagates due to the accumulation of stresses in the area around the crack or joint. Fabrics were used in several heavy-duty pavement projects to alleviate the occurrence of reflecting fissures and safeguard the underlying layers from water-induced harm. Thomas, who is 59 years old, documented various uses of artificial textiles on both state roads as well as interstates, as well as on airport runways. Textiles were positioned on top of a layer of adhesive to hinder the formation of reflecting fissures in a hot mix asphalt overlay applied on aging in flexible pavements. Typically, regular repairs and maintenance were carried out to enhance the function of these overlays.

Additional research has similarly shown limited outcomes on the effectiveness of geotextiles in slowing down the formation of reflecting fissures. Amini recently provided research on the efficacy of pavement textiles in mitigating reflecting fractures, both in the United States and abroad [56]. One of his discoveries was that using paving cloths offers fewer benefits for thin overlays measuring less than (50 mm). Nevertheless, larger overlays have consistently shown satisfactory performance.

2.2.2. Geogrids

Geogrids originated in the 1980s. These materials may be made by weaving or knitting glass fibers or polymeric filaments, such as polypropylene or polyester. Alternatively, they can be produced by cutting or pressing plastic sheets and then applying post-tensioning to increase their strength and modulus. Geogrids are elongated items with rectangular apertures ranging from 1/4 to 2 inches (6 to 50 mm) in width.

Geogrids prevent cracks by adding tensile reinforcement to the Hot Mix Asphalt (HMA) layer.

Geogrids may be used as a method to minimize the occurrence of reflective distresses, as stated in [57]. By spreading out the horizontal tensile stresses that develop above the concrete joints, reinforcing geogrids improve the tensile strength of the (HMA) overlay.

Allen and other researchers [58] used the Texas Transportation Institute's Overlay Tester and computer simulations to reproduce the propagation of fractures resulting from heat contraction. The laboratory experiment showed that adding the reinforcing geogrid improved the HMA mixture's resistance to fracture that was measured. The study explained the principles behind the improved Efficiency of reinforced overlays and proposed that the use of high-stiffness geogrids and textiles enabled the interception and horizontal redirection of crack energy. By reorienting the fracture, it is transformed into a horizontal plane below the geogrid, thereby preventing reflective distress from occurring as long as suitable construction techniques are followed, further emphasizing the need to use a consistent definition and measurement of stiffness for geosynthetics when assessing the suitable reinforcing material. This ensures an accurate comparison of materials.

Cook [59] conducted a study on the use of geogrid reinforcing materials at different military airfields in the United Kingdom (UK). The geogrids utilized in the study consisted of a polyester grid with a mesh size of (40 mm), a fiberglass grid with a mesh size of (12.5 mm), and a galvanized hexagonal steel mesh. The geogrids, when correctly positioned in the HMA overlay, have effectively mitigated the impact of reflecting fissures on the performance of the overlay. To achieve optimal performance when using geogrids as reinforcement for HMA overlays, it is crucial to carefully choose the appropriate geogrid shape, implement effective construction techniques, and use materials that can withstand the stresses generated by traffic and thermal loads.

Safavizadeh [60] used the digital image correlation approach to quantify displacements, stresses, and fracture lengths. The findings suggest that using a robust adhesive layer and a mesh with wide apertures has the potential to enhance the ability of a grid-reinforced interface to withstand shearing forces. Nevertheless, it is crucial to acknowledge that the influence of these two elements might differ depending on whether the loading conditions are monotonous or cyclic. The results from the cyclic shear, beam fatigue, and monotonic displacement-controlled shear tests demonstrate that the grid aperture size plays a critical role in influencing the performance of interface shear fatigue.

2.2.3. Stress Absorbing Membrane Interlayer (SAMI)

An interlayer is a thin material that is inserted between a lower pavement layer and an HMA (Hot Mix Asphalt) overlay. The objective is to absorb and disperse motions and stresses that arise at a fracture in the bottom pavement, so preventing them from inducing damage to the overlay. SAMIs consist of a spray treatment with rubber or polymer-modified asphalt, which is used to alleviate stress. Subsequently, the aggregate chips are placed and seated [61].

In order to address and avoid the occurrence of reflective cracking, a technique known as a stress-absorbing layer has been created [62],[63]. This method utilizes the addition of a material layer that has the ability to Assimilate the pressure and tension resulting from the displacement of the existing layer. As a result, it delays or prevents the development of reflective cracks [64],[65].

Ogundipe [66],[67], and Chen [68] investigated the efficacy of an interlayer (SAMI) in resisting reflection cracking under traffic load. Their findings indicate that the SAMI may effectively postpone the occurrence of reflective cracking. Li [69] conducted experiments To assess the level of resistance of six different asphalt overlays to cracking caused by reflection. The evaluation of the performance was conducted via the use of bending and shear testing methods The findings indicate that SAMPAVE (Stress Absorbing Mixtures Pavement), a stress-absorbing mixture created by Chang'an University, has exceptional resistance to fatigue-induced cracking.

Baghel [70] Constructed a three-dimensional finite element model to replicate the inverted pavement's load response using two separate interlayer types: aggregate and stress-absorbing membrane. Stress and strain in the asphalt concrete layer of the stress-absorbing membrane interlayer pavement were found to be lower than those in the aggregate interlayer pavement, according to the findings.

Vespa [71] studied the effect of using three types of interlayer stress-absorbing composite (ISAC) PavePrep, Roadtac, and Sand Anti-Fracture (SAF). The results show that the (ISAC) improves the resistance to the reflection cracks more than PavePrep and Roadtac. Also, (ISAC) tends to delay in formation reflection crack by about two years compared to SAF. Vespa [71] concluded that the import of an interlayer system to the pavement structure leads to improvement in the reflection crack resistance depending on the type of materials and interlayer stiffness and other properties.

Furthermore, Palacios [72] used the fiber-reinforced in the interlayer structure, it's used to reinforce the (SAMI) to minimize the formation of reflection cracks. The results show that this strategy was effective in reducing the effect of the reflection cracks and no reflected distresses were noticed during the test.

In another study, Moses OO [73] studied the effect of reinforcing the interlayer with fiberglass, the results showed improvement in resistance to reflected distress while noticed that the variation in temperature leads to variation in interlayer efficiency, the increase in temperature leads to reduced the interlayer ability to resist the reflection crack due to drop the interlayer stiffness.

Zeng [74] studied the bonding force and resistance to reflection distresses into interlayer SAMI reinforced with glass fibers made of asphalt rubber (AR) and SBS asphalt (AS). Also, researchers looked at how well SAMI fiber reinforcement asphalt rubber resists those reflected cracks. They used finite element (FE) analysis. The results show that FAR-SAMI sticks well at temperatures of 15 and 40 degrees. Adding glass fiber makes the composite samples even more durable. When they compared it to SAMI asphalt rubber, they found that the fracture energy of SAMI fiber reinforcement asphalt rubber goes up by 23, this type of asphalt rubber is great for stopping reflection fractures from forming and helps it last longer when under stress.

3. Conclusion

To minimize the effect of crack propagation in the overlay asphalt pavement layer. Many strategies were studied and analyzed in this review that can be applied to produce the best performance of overlay asphalt pavement against crack propagation.

- Provide an appropriate overlay layer thickness: the increase in overlay layer thickness leads to the development of the resistance of fatigue cracks, the suitable thickness of overlay layer thickness should produce a balance between cost and performance. Polymer-modified asphalt and rubberized asphalt produce an effective strategy to mitigation the reflection cracks with significant development in flexibility and resistance to deformation. Carbon black and sulfur also produce development in asphalt mixture properties by improving the tensile strength and the economic advantage.
- Interlayer systems, such as geotextiles, geogrids, (SAMI), these strategies provide an appropriate solution to minimizing the effect of reflection cracks by distributing the stress in the pavement structure. Geogrids and geotextiles have the ability to support the pavement layer against the tension effect and that leads to reducing the crack propagation to the pavement surface. The (SAMI) absorb the stress that is formed due to the traffic load and reduce the crack initiation.
- Advanced solutions: use various materials to improve the functional role of asphalt pavement overlay such as: carbon black, sulfur and rubber, these materials when blended with asphalt produce development in asphalt performance like increasing to tensile strength of the mixture and developing the durability by increasing the resistance to moisture damage and other climatic conditions. These strategies lead to noticed expansion in the pavement lifespan.

To minimize the effect of reflection cracks many strategies should be used like increasing the asphalt Layer thickness or importing polymer materials to bitumen to develop the rheological properties of the mix, on the other hand; using interlayer strategies like geotextiles, geogrids, and SAMIs, can produce good resistance to reflection cracks and extend the service life of the pavement without repairing cost.

Finally, to mitigate the effect of reflection cracks, the modified asphalt with polymers and fibers and increasing the overlay layer, these strategies are easier techniques to minimize the reflection cracks.

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