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Mitigation of Reflection Cracking in Asphaltic Overlays Using Geosynthetic Interlayers

Varma S.[1]., Singh A.[2]., Gupta M.[3] and Chitra R.[4]
[1]*Scientist D, Central Soil and Materials Research Station, New Delhi*
[2]*Scientist E, Central Soil and Materials Research Station, New Delhi*
[3]*Scientist E, Central Soil and Materials Research Station, New Delhi*
[4]*Director, Central Soil and Materials Research Station, New Delhi*

ABSTRACT
Reflection cracking in asphaltic overlays remains a critical challenge in pavement rehabilitation. Reflection cracks are primarily caused by the upward propagation of existing cracks and joints present in the underlying distressed layers, due to repeated traffic loads and thermal stresses. The incorporation of geosynthetic materials has emerged as an effective mitigation strategy to retard initiation and propagation of reflection cracks thereby enhancing overlay performance and service life. The geosynthetic materials when installed between the existing pavement and the new overlay, act as an interlayer that helps in stress distribution, strain attenuation and reinforce the system. It absorbs the tensile stresses induced by differential movements and reduce stress concentration near the cracks. This controls further propagation of cracks limiting water ingress thereby reduces pavement deterioration. This paper studies about the effectiveness of the geosynthetic interlayers in reducing reflective cracks, the factors affecting and the choice of specific geosynthetic materials,based on relevant literature, case studies and through comparative analysis. The use of geosynthetic materials provides a technically viable solution for controlling reflective cracks in asphaltic overlays, contributing to improved structural performance of rehabilitated pavements.

Keywords: Reflective Cracks, Geosynthetic Materials, Asphaltic Overlays, Pavement Rehabilitation etc.

I. INTRODUCTION

The asphaltic overlays are normally provided to protect a flexible or rigid pavement surface. Reflection cracks are formed due to the existing discontinuities or distress conditions of the underlying layers, which can propagate through the asphaltic overlays due to triggers like thermal expansion, seasonal temperature variations and continuous traffic load etc. The pre-existed distress conditions shall appear on the overlay surface in the form of reflective cracks.Reflection cracking in asphaltic overlays is very important as they lead to early failure of the pavement structure, allowing water ingress through the cracks developed. The intruded water can strip off the overlay layer and also deteriorate the layers beneath, leading to premature failure of the whole pavement rehabilitation system. The average service life of a 1.5 inch to 2 inch thick overlay against reflection cracking is normally limited to 1 to 6 years only. Experimental studies have proven that a geosynthetic interlayer can be introduced to the system, to delay the propagation of reflective cracks as it reinforces the pavement structure and helps to well distribute the traffic load. The use of geosynthetic materials for reducing reflection cracking is studied in this paper. This method is in effect since 1960s.

II. OBJECTIVES

The objectives of the current study are:

1. To understand the mechanism of reflection cracking of asphaltic overlays and the factors governing its initiation and propagation.

2. To evaluate the effectiveness of the geosynthetic interlayers in controlling reflection cracking in asphaltic overlays through a critical review of existing literature and documented field and laboratory performances.

3. To perform a comparative analysis to assess the suitability of different geosynthetic materials such as geotextiles, geogrids and geocomposites with respect to their mechanical properties, installation characteristics and crack retardation efficiency and their long-term performance behaviour.

III. MATERIALS AND METHODS

Reflection cracking in asphaltic overlays is a common distress condition observed in pavement rehabilitation, where cracks from an existing underlying pavement layer propagate upward through a newly placed asphalt overlay and reappear on the surface. This occurs because the underlying pavement already contains discontinuities such as cracks, joints or weakened zones. When the asphaltic overlay is placed over such inherently weak points, these discontinuities are transferred to the overlay. The two primary mechanisms that govern reflection cracking are:

1. Traffic load induced stresses: Repeated vehicular loads cause differential vertical and horizontal movements, generating tensile and shear stresses in the overlay. The discontinuities in the existing pavement reduce the bending stiffness of the rehabilitated pavement section and creates a stress concentration. When the stress exceeds the fracture resistance of the overlay, a reflective crack can be initiated or propagated.

2. Thermal stresses due to temperature variations: The expansion and contraction of pavement layers due to diurnal temperature changes induce additional stress concentrations and leads to crack opening.

Over time, these stresses concentrate at the same locations as the underlying cracks, leading to crack initiation in the overlay, which then propagates upward until it becomes visible on the surface. The reflection cracks often appear as either longitudinal, transverse or block patterns mirroring the underlying pavement or the cracks that appear directly above the existing cracks.

As there are so many factors involved in the phenomenon of reflection cracking, no complete mitigation of the same is possible, only the retardation of crack propagation can be achieved. Reflection cracking decreases the useful life of asphaltic overlays and/or increases the need for cost-effective preventive maintenance techniques. Promising techniques include: increasing the overlay thickness, crack sealing, incorporating crack arresting granular layersand stress absorbing interlayer systems.

Commonly used interlayer systems are sand asphalt, paving fabric or geotextiles, geogrids, geocomposites etc into the pavement structure. Earlier investigations have proved that incorporation of geosynthetic materials as interlayer has significantly reduced the crack propagation and improves the service life of pavements. This is typically accomplished by attaching the geosynthetic product to the existing pavement (flexible or rigid) with an asphalt tack coat and then overlaying with a specified thickness of asphaltic overlay.

Fig 1: Reflection Cracking of Asphaltic Overlay

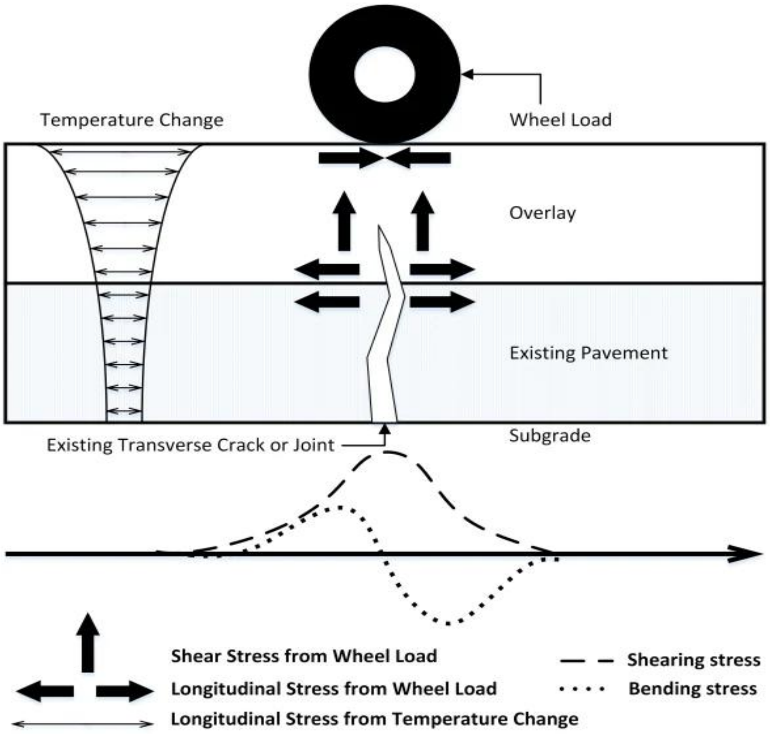

Fig 2: Mechanism of Reflection Cracking (Nithin et.al. , 2014)

GEOSYNTHETIC INTERLAYER SYSTEMS

Geosynthetic interlayer systems have emerged as an effective engineering solution for mitigating reflection cracking in asphaltic overlays by interrupting stress transfer mechanisms from underlying distressed pavements. Geotextiles, typically nonwoven polypropylene or polyester fabrics, function primarily as stress-relief interlayers. When installed with an appropriate tack coat, they create an itermediatelayer that absorbs tensile strains and redistributes stresses induced by traffic loading and thermal movements. Their relatively high elongation capacity allows them to accommodate minor substrate movements, thereby delaying crack propagation into the overlay.

Geogrids, in contrast, provide reinforcement through their high tensile stiffness and modulus, making them particularly effective in controlling crack opening and propagation. Manufactured from polymers such as polyester, fiberglass, or polypropylene, geogrids are designed with apertures that interlock with the surrounding asphalt matrix, creating a composite action that enhances load distribution. Their primary mechanism involves reducing stress concentration at crack tips by bridging existing cracks and limiting horizontal strain development in the overlay. Geogrids with high modulus and low creep characteristics are preferred for reflection cracking applications, as they maintain structural integrity over long service periods.

Geocomposites and natural geosynthetics combine multiple functional properties to optimize interlayer performance. Geocomposites typically integrate geotextiles with geogrids or geomembranes, thereby providing simultaneous reinforcement, stress absorption, and moisture resistance. This hybrid approach enhances bonding between pavement layers while maximizing crack retardation efficiency. Natural geosynthetics, such as jute or coir-based mats, offer an environmentally sustainable alternative with adequate tensile properties and biodegradability suited for low to moderate traffic conditions. While their durability is lower compared to synthetic counterparts, they can still provide short-term reinforcement and stress dissipation benefits.

Overall, the selection of an appropriate geosynthetic interlayer system depends on traffic intensity, climatic conditions, pavement distress type, and desired service life, with proper installation and bonding being critical to performance.

GEOSYNTHETIC INTERLAYER WORKING MECHANISMS

The design principles of the geosynthetic interlayer system for pavements can be categorised for unpaved and paved roads as given below:

a) For unpaved roads, the working principle is based on the membrane method (Giroud and Noiray, 1981). When ruts or cracks are formed on the surface, the geosynthetic interlayer acts like a tensioned membrane, which will create an upward force to resist further propagation of the ruts or cracks.

b) For paved roads, the working principle is based on both membrane method (Giroud and Noiray, 1981) and the bearing capacity method (Homly and Jewell, 1990). The stiffness of the geogrid and also the foundation material, both are important as deciding factors for load spreading capacity and stability of the geosynthetic interlayer system.

Two technical terms related to the geosynthetic interlayer systems when used for reducing reflection cracking are:

a) Efficiency Factor (E) :

$$\textit{Efficiency Factor (E)} = \frac{Nr}{Nu}$$

Where Nr – Number of load repetitions till failure of the unreinforced pavement and
$Nu -$ Number of load repetitions till failure of the reinforced pavement

From literature, it is understood that the value of E can be up to 16, which confirms the efficiency of the geosynthetic interlayer system for pavement rehabilitation purposes (Mounes et.al., 2011).

b) Percentage Reflective Cracking :

$$\textit{Reflective Cracking (\%)} = \frac{Length\ of\ cracks\ for\ a\ year\ afterconstruction(in\ ft)}{Length\ of\ cracks\ before\ construction(in\ ft)}\ X\ 100$$

The percentage reflective cracking can be calculated separately for the transverse, longitudinal and total cracks using the above equation.

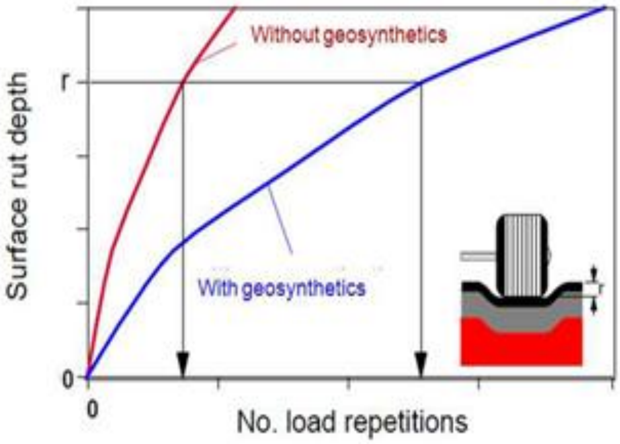

Fig 3: The Reduction in Surface Rut Depth with Incorporation of Geosythetic Interlayer (Mounes et. al., 2011)

As per the study conducted by Cleveland et.al (2002), the percentage reflective cracking variation over a time period of three years, for different geosynthetic products are summarised in Fig 4.

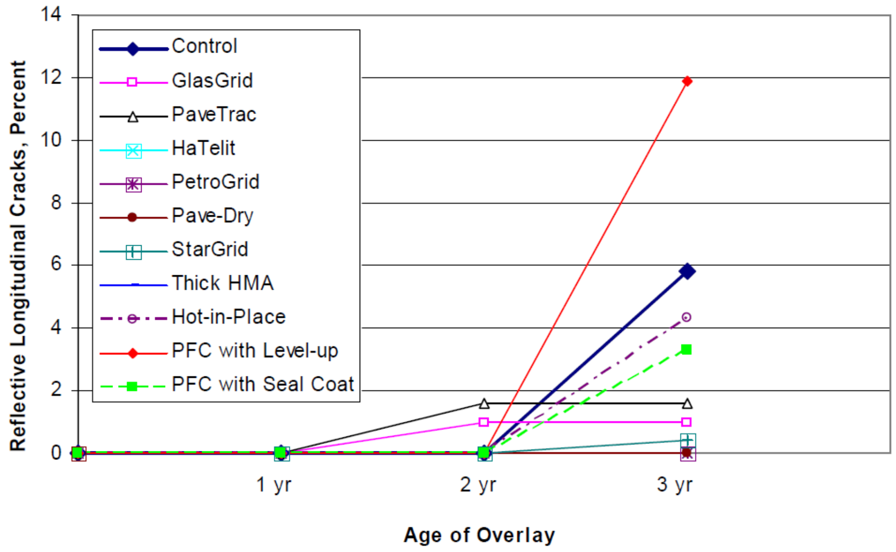

Fig 4 : Reflective Cracking (%) vs Time (Cleveland et.al., 2002)

The comparative analysis of different geosythetic materials that are commonly used for reducing reflection cracking in pavement rehabilitation is shown in Table 1 below**.**

Table 1: Comparative Analysis of Different GeosyntheticInterlayer Systems

Parameter	**Geotextiles**	**Geogrids**	**Geocomposites**	**Natural Geosynthetics**
Primary Function	Stress relief + moisture barrier	Reinforcement (tensile)	Combined reinforcement + stress relief + barrier	Stress relief (limited reinforcement)
Material type	Non-woven and Woven	Polyester, Fiberglass, Polypropylene	Hybrid (geotextile + geogrid/geomembrane)	Jute,coir, natural fibers
Tensile Strength	Moderate	High	High (due to composite action)	Low to moderate
Strain Tolerance	High (good flexibility)	Low (stiff material)	Moderate to high	Moderate
Stress Distribution	Moderate	High	Very High	Low
Moisture Barrier Capability	Excellent	Poor	Excellent	Moderate
Bonding with Asphalt Layer	Excellent	Moderate	Excellent	Moderate
Durability	High	Very high	Very High	Low
Environmental Impact	Non biodegradable	Non biodegradable	Non biodegradable	Eco friendly

On comparison, it can be understood that geocomposites generally provide the highest performance efficiency due to their multifunctional behavior, followed by geogrids, which excel in reinforcement. Geotextiles are effective as stress-relief systems but are less efficient in crack control compared to geogrids. Natural geosynthetics, while environmentally sustainable, offer limited long-term performance and are best suited for low-volume or temporary applications.

IV. CONCLUSIONS

This paper gives an overview of the use of geosynthetics in reducing reflection cracking of hot mixed overlays in pavement rehabilitation. The complete mitigation of reflection cracking is impossible, but the phenomenon can be delayed to desirable degree by incorporating geosythetic interlayer, which increases the service life of the pavement system. A comparative analysis of various geosynthetic materials are carried out for their suitability based on relevant parameters and is inferred that geocomposites provide the best performance due to the multifunctional behavior. The ultimate choice of the product primarily depends on the functional requirement.

REFERENCES

[1]. AASHTO M288-06, 2006, Geotextile Specifications for Highway Applications
[2]. Cleveland, G.S., et.al. (2002), Geosynthetics in Flexible and Rigid Pavement Overlay Sysytems to reduce Reflection Cracking, Research Report, Texas Transportation Institute, Texas
[3]. IRCSP59, 2002, Guidelines for Use of Geotextiles in Road Pavements and Associated Works.
[4]. Koerner, R.M., 2005, Designing with Geosynthetics, Pearson, Prentice Hall, NJ

[5]. Mounes, S. M., et.al. (2011), An Overview of the Use of Geosynthetics in Pavement
[6]. Structures, Scientific Research and Essays, Vol 6(11), pp 2234-2241