

Crack Propagation Analysis in Asphalt Mixtures Reinforced by Fiberglass Paving Geosynthetics Using Digital Image Correlation

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The use of paving geosynthetics in the rehabilitation of flexible pavements has significantly increased in recent years, with the goal of extending pavement service life. The literature evidenced an improvement in fatigue and crack propagation resistance due to the stiff reinforcements, especially fiberglass products. However, the intrinsic bituminous viscous behavior and the different test methodologies available make difficult the interpretation of the cracking propagation phenomenon within the presence of the geosynthetic reinforcement. Hence, this study aimed at evaluating the impact of different fiberglass reinforcements on crack propagation and mitigation of reflective cracking in bituminous mixtures using Digital Image Correlation (DIC). The research involved testing three configurations of pre-notched beams made of double-layered asphalt slabs, both with and without paving geosynthetics (fiberglass paving grid and fiberglass paving composite), and an unreinforced configuration for comparison. The double-layered slabs were subjected to a four-point bending notched fracture test under cyclic loading at 5 Hz. The DIC technique was utilized to measure the strain patterns in the central length area of the specimens during crack propagation.

Results clearly demonstrated the impact of paving geosynthetics on mitigating cracking propagation through the beams. This was evidenced by the higher number of cycles endured by the reinforced beams compared to the control beam. The crack growth curves obtained during the tests allowed the identification of three main phases of crack propagation: Initiation: The crack begins to propagate from the pre-notch. Interface Interaction: The crack reaches the interface, and if the interface bonding strength is insufficient, crack growth may damage the bond between layers. Upper Layer Propagation: As the loading increases, the energy of propagation exceeds the system's capacity, causing the crack to propagate into the upper layer, ultimately leading to failure. The crack height analysis exhibited a discontinuity at the interface, indicating that crack propagation in the upper asphalt layer was delayed due to the presence of reinforcements. The reinforcement

dissipates propagation energy at the interface and reduces stress concentration at the crack tip. However, this effect depends on the specific characteristics of the geosynthetic used.

The second stage is when the geosynthetic begins to be mobilized at the interface. Even after the crack crossed the geosynthetic interface, the reinforcements remained highly capable of supporting the load. The crack was able to propagate over 25 mm beyond the interface before failure. The interlocking mechanism of the geogrid was evident during the tests. The non-linearity observed in horizontal strains as a function of crack height was attributed to the influence of the reinforcements. DIC analysis provided clear insights into how reinforcement retards crack propagation in asphalt layers.

Shear strain analysis revealed increased strains at the reinforced interfaces compared to the control sample. After the crack reflected into the upper layer, the control specimen (without reinforcement) and reinforced specimens exhibit similar shear strain levels. This strain similarity might be due to the fact that once the crack surpasses the interface, the effectiveness of the shear bond diminishes, and the crack propagates more freely in the upper layer. However, specimens have already endured superior number cycles before reaching this stage, indicating that the interface shear bond, combined with the reinforcement, initially delayed the crack's progress, but once the crack reflected, the strains equalized.

In conclusion, this study demonstrated the effectiveness of fiberglass paving geosynthetics in mitigating crack propagation and delaying reflective cracking in asphalt mixtures. DIC analysis provided valuable insights into the strain distribution and crack tip progression, highlighting the significant impact of geosynthetics on enhancing the structural integrity of bituminous pavements. The findings emphasize the critical role of interface shear bond and reinforcement characteristics in prolonging pavement life under cyclic loading, showing the potential of paving geosynthetic as a reliable reinforcement method in flexible pavement rehabilitation.