Performance Quantification of Interlayer Systems in Flexible Pavements Using Finite Element Analysis, Instrument Response, and Non Destructive Testing

Mostafa A. Elseifi
The Via Department of Civil and Environmental Engineering
Virginia Polytechnic Institute and State University
Blacksburg, VA 24061

Dissertation submitted to the Faculty of the
Virginia Polytechnic Institute and State University
in partial fulfillment of the requirements for the degree of

Doctor of Philosophy
In
Civil Engineering

Imad L. Al-Qadi, Chair
Scott Case
Gerardo W. Flintsch
Siegfried Holzer
Amara Loulizi
Kenneth L. Reifsnider
Antonio Trani

February 2003
Blacksburg, Virginia

Keywords: Steel Reinforcing Netting, Instrumentation, Finite Element, Geocomposite Membrane, Reflective Cracking

Copyright, Mostafa A. Elseifi

Performance Quantification of Interlayer Systems in Flexible Pavements Using Finite Element Analysis, Instrument Response, and Non Destructive Testing

Mostafa Elseifi

Imad L. Al-Qadi, Chairman

(ABSTRACT)

This study quantifies the benefits of two interlayer systems (steel reinforcing netting and a newly-designed geocomposite membrane) in different pavement applications. Steel reinforcing netting and geocomposite membrane have been installed at the Virginia Smart Road in four different sections. Ground penetrating radar (GPR) surveys and time domain reflectometer (TDR) validated the effectiveness of the geocomposite membrane in preventing water from infiltrating to the underneath layers. In pavement rehabilitation applications, based on finite element (FE) analysis, it was found that the geocomposite membrane would create a protective compressive field around the crack tip and separate the criticality of the stress field in the cracked area from the bottom of the overlay. However, if the crack passes through the interlayer, a faster propagation rate than in a typical pavement is expected. These results emphasize the importance of proper field installation. As to steel reinforcing netting, this study found that this interlayer system would be effective in new pavement systems in both the crack initiation and propagation phases when the cracks start at the bottom of the HMA layers. For the considered pavement structures, steel reinforcing netting was found effective to delay the initiation of the cracks. This delay depends on the stiffness of the hot-mix asphalt (HMA) layers, the reinforcing pattern, and the direction of the strain at the bottom of the HMA layers. After initiation of the crack, steel reinforcement contribute by delaying the rate of crack propagation to the pavement surface. In pavement rehabilitations, however, the crack is

already well established in the existing pavement, and steel reinforcement contribution is expected from the time of installation. In this case, steel reinforcement will delay the initiation of the crack in the overlay, and reduce the rate of crack propagation afterwards. Two models, to predict the overlay service life against reflective cracking from existing HMA layers, were developed.

To Aicha, Marwa, and Mohamed

Acknowledgements

I would like to acknowledge my advisor, Dr. Imad L. Al-Qadi; you have been my tutor, and my friend. You always had the patience and wisdom to guide me in every step of the way. You always took the time to listen to my problems, and advice me in every aspect of my life. I would like also to express my appreciation to my committee members: Dr. Gerardo Flintsch, Dr. Scott Case, Dr. Amara Loulizi, Dr. Siegfried Holzer, Dr. Kenneth Reifsnider, and Dr. Antonio Trani.

Thanks to my wife, Marwa, who was always by my side during every up and down of this long process. Thank you Marwa for your caring and unconditioned love. Thank you brother for your help and ceaseless support; you will always have a special place in my heart.

I would like also to acknowledge my friends who helped in different aspects of this research: Alexander Appea, Samer Lahouar, Raul Andruet, Didier Leonard of the Belgium Road Research Center, Samer Katicha, Edgar de León, William Hobbs, Stacey Reubush, Tim Tomlin, Brian Diefenderfer, Bragi Baldursson, Kenneth Taylor, Randy Orren, and Kevin Light. Laboratory testing used in this study was performed by William Hobbs, Samer Katicha, and Stacey Reubush.

Finally, thanks to my beloved mother. You endured so much to see this day, and the happiness it will bring to your heart is invaluable. I will always be in debt to you for all your sacrifice and love.