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Title and Abstract below

Characterization of Subgrade Resilient Modulus for MEPDG and the Effects on Pavement Rutting

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Rutting is one of the most important asphalt pavement distresses because it is responsible for both the functional and structural condition degradation of the flexible pavement. There are limited studies on the effect of Resilient Modulus (M_R) of subgrade on pavement rutting in the Mechanistic-Empirical Pavement Design Guide (MEPDG). Therefore, subgrade M_R has been characterized and the effects of subgrade M_R on pavement rutting have been studied. Firstly, pavement performance evaluation models have been developed in this study using data from primary and interstate highway systems in the state of South Carolina, USA. Twenty pavement sections are selected from across the state, and historical pavement performance data of those sections are collected. A total of 9 models were developed based on regression techniques, which include 5 for Asphalt Concrete (AC) pavements and 4 for Jointed Plain Concrete Pavements (JPCP). Five different performance indicators are considered as response variables in the statistical analysis: Present Serviceability Index (PSI), Pavement Distress Index (PDI), Pavement Quality Index (PQI), International Roughness Index (IRI), and AC pavement rutting. Annual Average Daily Traffic (AADT), Free Flow Speed (FFS), precipitation, temperature, and soil type (soil Type A from Blue Ridge and Piedmont Region, and soil Type B from Coastal Plain and Sediment Region) are considered as predictor variables. Results showed that considering soil type, Type A soil produced statistically higher PDI and PQI ($p < 0.01$), and lower rutting ($p < 0.001$) compared to Type B soil on AC pavements; whereas, Type A soil produced statistically higher IRI and lower PSI ($p < 0.001$) compared to Type B soil on JPCP pavements.

Then, resilient modulus (M_R) of subgrade soils for different geographic regions in South Carolina has been characterized in this study. Shelby tube samples of subgrade soils were collected from existing pavements in different regions: SC-93 in Pickens county (Upstate Area), US-521 in Georgetown county (Coastal Plain), and US-321 in Orangeburg county (Coastal Plain, near the fall line). Resilient modulus model parameters were obtained using both the bulk stress model and the generalized constitutive resilient modulus model. Statistical analysis was

performed to develop M_R estimation models for undisturbed soils using soils index properties. A correlation between laboratory measured M_R with the modulus from Falling Weight Deflectometer (FWD) tests was also developed. The effects of M_R on subgrade rutting were also studied using MEPDG. Results showed that the developed models offer higher reliability than the universal Long-Term Pavement Performance models in estimating the resilient modulus of undisturbed soils and predicting subgrade rutting for South Carolina.

Finally, California Bearing Ratio (CBR) tests and laboratory M_R tests were performed on remolded samples of soils collected from different regions in South Carolina. The samples were prepared at moisture contents above and below the optimum moisture content (w_{opt}). Correlations between the results from the two tests were developed as a function of moisture content and statistical models were developed to correlate generalized constitutive M_R model parameters with soil index properties. Furthermore, pavement rutting was studied using the resilient modulus determined for the subgrade soils compacted at w_{opt} and $\pm 2\% w_{opt}$. Statistical analysis showed that soil moisture content and density played an important role for the subgrade soil M_R. A slight change in moisture content during compaction has a significant effect on pavement rutting. The peak value of both CBR and M_R was found on the dry side of optimum and at a dry density less than the maximum.