

## ABSTRACT

Subgrade characterization in terms of resilient modulus is an important aspect of mechanistic pavement design methods. The resilient modulus is analogous to the Elastic modulus; however, repeated loads are applied instead of monotonic load and is expressed as the ratio of deviatoric stress to the resilient strain. The most commonly used laboratory method to determine resilient modulus is the Repeated Load Triaxial Test (RLTT). However, the test is complex, requires expensive test setup, skilled personnel and is time-consuming. Therefore, an alternate simple and cost-effective method for subgrade resilient modulus characterization using the simple CBR apparatus has been explored in this study. This study aims to characterize the subgrade resilient modulus using the Repeated Load CBR (RLCBR) test and compare it with the field modulus. It combines numerical modelling of the CBR test, with laboratory studies using the Repeated load CBR (RLCBR) test to propose methodologies and predictive models to characterize the subgrade resilient modulus using the RLCBR test. A 3D Finite Element Model of the CBR test was formulated in the commercial package LS-DYNA® to understand the mechanics of the test. The objective was to obtain mathematical relationships between the octahedral shear stress and the bulk stress with the plunger stress, which can be measured experimentally. Results showed that a linear relationship between the bulk stress and octahedral shear stress with the plunger stress can be assumed under elastic conditions. A total of twelve soils were tested in the laboratory in the present study. RLCBR tests were conducted on all twelve soils in deformation-controlled mode and five soils (out of twelve) in load-controlled mode. The deformation-controlled RLCBR tests were used to standardize the test and propose a predictive model which estimates the subgrade resilient modulus at stress levels typical of a subgrade soil element. Results showed that the proposed RLCBR model agreed with the modulus calculated at the recommended stress levels using the MEPDG model. Further, statistical analysis of the proposed model showed that the model could capture the effects of moisture on the resilient modulus. In contrast, the load-controlled test results were used for stress-based non-linear elastic characterization of subgrade soils. The results showed that the proposed methodology predicted the MEPDG model coefficients with an  $R^2 > 0.8$  for all the cases. Further, the model coefficients were validated with those obtained from empirical correlations and showed promising agreement. The proposed methodology can be cost-effective in characterizing resilient moduli for MEPDG Level 1 applications. The laboratory resilient modulus was compared with the field resilient modulus determined using the Light Weight Deflectometer and the Dynamic Cone Penetrometer (DCP) tests. The laboratory-resilient modulus was much higher than the field modulus obtained using the DCP and the LWD due to variations in field and laboratory moisture-density conditions. However, it was also observed that as the

moisture and density conditions were nearer to the laboratory conditions, the RLCBR and field modulus approached each other. The comparison assessment of the field and RLCBR test results suggest that a reference modulus from the laboratory RLCBR test can be used to evaluate the construction quality in the field in terms of modulus in addition to traditional density checking. Hence the resilient modulus prediction model developed using RLCBR, a quick and simple test, could provide more inputs to design and quality control characteristics in the field for constructing subgrade soils.

**Keywords:** RLCBR, LWD, DCP, Finite Element Modelling.

