## Alternatives to Nuclear Density Testing

The performance of pavements is highly dependent on compaction quality control of unbound subgrade and base/subbase layers beneath flexible pavements. Distresses in pavements can be directly linked to compaction defects within these layers. In current practice, the nuclear density gauge (NDG) is utilized for evaluating the compaction quality of these layers. Highway agencies, such as the New Jersey Department of Transportation (NJDOT), employ minimum density requirements, typically 95% of the Proctor maximum dry density (MDD), for evaluating the compaction quality of these layers. However, there are several concerns and safety risks associated with using the NDG. This study was initiated with the aim of replacing the NDG with non-nuclear alternative method(s) that can be used as acceptance tools during the compaction of unbound base/subbase layers. To achieve this goal, a laboratory procedure for compacting large samples was developed to facilitate testing using three non-nuclear devices: Briaud compaction device (BCD), light weight falling deflectometer (LWD), and dynamic cone penetrometer (DCP) on four types of aggregates, two subgrade soils, one dense graded aggregate (DGA), and one recycled concrete aggregate (RCA). Each device was evaluated for their sensitivity to moisture content, compaction effort applied, aggregate type, and testing time. Based on laboratory testing, a multiple linear regression model to predict DCP field measurements. The developed model was calibrated using data collected through field testing and used to determine the minimum recommended DCP values that would ensure satisfactory compaction of pavement layers in the field. Using the proposed acceptance criteria, a draft specification for use of the DCP was also developed within this report.

Based on testing results and analyses conducted subsequently, the following conclusions were made:

- The DCP was the most suitable device for capturing the change in moisture contents within the samples while all other devices showed mixed trends within their results, specifically when preparing samples at 2% below and 2% above OMC.
- The DCP prediction model developed was found to be adequate at predicting laboratory and field DCP measurements. The model was also found to be significantly dependent on moisture content, percent passing sieve No. 4, and percent passing sieve No. 200.
- The DCP prediction model, which was developed and calibrated as a part of this study, was used successfully for identifying a set of recommended DCP penetration rates that would ensure satisfactory compaction of unbound pavement layers in the field.
- A specifications for using the DCP as a compaction acceptance tool for natural soils and engineered aggregates was successfully developed.