TECHSUMMARY November 2021

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Quality Control/Assurance on Base Course and Embankment with the Dynamic Cone Penetrometer

INTRODUCTION

Current quality assurance/control processes (QA/QC) on base courses and subgrades are based on densities and moisture contents obtained from the Proctor Compaction test and the nuclear moisture-density gauge (NDG). NDGs utilize radioactive materials to determine the density and moisture contents. These gauges can be expensive to maintain and have extensive licensing and safety requirements. These requirements can often limit the number of staff available to operate them and add considerable time and costs (training, tedious paperwork, etc.) to the Department. Utilizing a simple tool, like the Dynamic Cone Penetrometer (DCP) that is not electronic or nuclear, could help save DOTD time and funds over the long term.

OBJECTIVE

The purpose of this project was to evaluate the Dynamic Cone Penetration Index (DCPI) stiffness against the NDG density results of unbound layers and embankments. The research will compare the DCP to the NDG for technical accuracy, precision, consistency, economical benefits, and ease-of-use. As a subtask, researchers evaluated two auto readers: 1) the Mag Ruler by Kessler and 2) the Smart DCP by Vertek for correlation amongst themselves as well as compared to standard DCP results without an auto reader. The research utilized intensive field tests to determine if there are benefits and implementation potential for DCP QA/QC applications within DOTD. In addition, a specification subpart for these applications was developed for DOTD.

SCOPE

The LTRC Geotechnical group visited sites with ongoing NDG QA/QC testing across south Louisiana. Stone base course, soil-cement base course, and embankment layers were tested with the DCP. Researchers were searching for a new relationship or correlation between the DCP and NDG to establish a DOTD test procedure for QA acceptance. Other elements including performance, cost, reporting, and training requirements were also evaluated.

METHODOLOGY

Researchers reviewed highway project lists to determine applicable sites for QA/QC testing. Each site had different soil properties, which were evaluated by the districts under their normal/current QA/QC specifications and operations. Field testing by the DOTD districts often includes an NDG per DOTD Method TR 401: Determination of In-place Density.

LTRC mobilized on available and compatible projects to conduct DCP tests. Tests included the stiffness determination by dynamic cone penetration index (DCPI) and shadowing nuclear density gauge acceptance testing locations on each site. Shadowing refers to the fact that the research DCPs will not affect construction acceptance, pay, or progress as determined by the district inspectors.

In this research, DCP testing was conducted adjacent to the locations of NDG tests performed at various construction sites. Conducting the DCP at nearly the same location as the NDG aided in the search for an acceptance correlation. Field data from both devices was compared and analyzed with the shadowing DCPI readings against the adjacent NDG QA density and moisture readings to determine correlations.

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District NDG testing determines acceptance (pass or fail) based if the required ranges of density and moisture content are met. The DCP can utilize this pass or fail method as well. The researchers compared and plotted multiple DCPI results against the NDG density and moisture readings to find effective relationships. The maximum DCPI for certain soil layers and types was determined and compared to other state DOTs' DCP acceptance requirements. A specification was proposed and implemented utilzing the DCP as an accepatnce tool for DOTD.

CONCLUSIONS

This research focused on evaluating a non-nuclear acceptance method, the DCP, as an alternative to the NDG during QA/QC acceptance testing. The main motivation for this study was to eliminate existing safety concerns and reduce the costs of tedious requirements associated with the NDG.

Based on collected data, test results, and analysis, the following conclusions are listed below:

- DOTD TR 645, a test method for utilizing the DCP, was modified to include a method (Method B) for compaction acceptance. The modification was developed in relation to other state DOTs specifications (MnDOT, InDOT, etc.) and based on field acceptance compaction test results from the NDG vs. DCP tests.
- Other state specifications (InDOT and MnDOT) are already established regarding the DCP as an acceptance tool for soil layers, and Louisiana field work correlates well with these existing specifications. To further improve on this, two DCP test may be taken for verification.
- The DOTD TR 645 Method B includes the acceptance criteria of a limiting DCP Index (mm/blow) parameter for each of the tested types of soil layers in this research, as seen in the table below:

DCPI ANALYSIS			
Layer Type	**Material Properties**	**ACCEPTABLE DCPI**	
		Top 6-in	**Full Layer**
Clay/Silty Embankment	MDD < 105; OMC 19-24%	**< 25 mm/blow**	**< 25 mm/blow**
	MDD > 105; OMC 8-18%	**< 22 mm/blow**	**< 25 mm/blow**
Subgrade	Lime Treated	**< 19 mm/blow**	**< 16 mm/blow**
	Cement Treated		
	Untreated		
Interlayer (< 6-in)	Class II Stone	**< 10 mm/blow**	**NA**
Base Course	Recycled PCC	**< 19 mm/blow**	**< 16 mm/blow**
	Class II Stone	**< 10 mm/blow**	**< 10 mm/blow**

- The costs of DCP were significantly less than that of the NDG. The NDG requires approximately $9,000 per year for thermoluminescent dosimeters and licensing certifications, roughly $9,000 - $25,000 for safety training classes during a 3-year training cycle. The DCP does not require these safety or training measures.
- Additional testing was conducted to compare the DCP with and without an auto reader. The Smart DCP was the more preferred auto reader due to its ease of utilization, instant data transferring, and visually appealing data interface smart phone application.
- A transition to the DCP and auto readers will likely entail an overlap of devices to ensure continuity until a possible phase out of the older test procedure of utilizing the NDG.

RECOMMENDATIONS

Based on the research work and conclusions, the following items are recommended for implementation:

- Researchers recommend the proposed specification TR-645 Method B as an alternative to NDG acceptance testing.
- Pilot projects should be selected to test and refine the draft specification and test method. In this case, the project could utilize the DCP for acceptance and pay and have the NDG shadow the DCP for research purposes.