



Seasonal Variation in the Layers of Highway US 20

tech transfer summary

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RESEARCH PROJECT TITLE

Iowa Case Study of Seasonal Variation in the Subgrade and Subbase Layers of Highway US 20

SPONSORS

Iowa Highway Research Board (TR-516)
Iowa Department of Transportation
PCC Center, Iowa State University

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The Partnership for Geotechnical Advancement (PGA) is part of the Center for Transportation Research and Education (CTRE) at Iowa State University. The mission of the PGA is to increase highway performance in a cost-effective manner by developing and implementing methods, materials, and technologies to solve highway construction problems in a continuing and sustainable manner.

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A better understanding of the influence of seasonal variation of pavement foundation layer properties in Iowa could potentially benefit pavement design, material selection, and construction specifications.

Objectives

The major objectives of the project were the following:

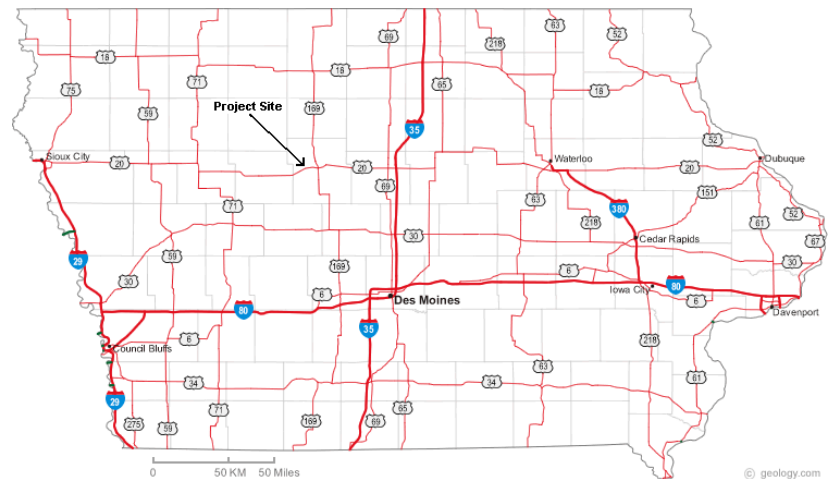
- Conduct field tests on a newly compacted subgrade to document spatial variation in stiffness parameters.
- Monitor changes in subgrade stiffness due to seasonal variation in moisture and temperature.
- Conduct field tests on the subgrade layer during freezing and thawing conditions.

Problem Statement

Seasonal temperature and moisture content variations within pavement subgrade and subbase layers influence pavement load carrying capacity. Loss of support conditions (i.e., a reduction in stiffness) in these layers can occur during thawing periods and/or saturated conditions and is one of the contributors to pavement distress. A better understanding of the influence of seasonal variation of pavement foundation layer properties in Iowa could potentially benefit pavement design, material selection, and construction specifications.

Research Description

The quality of a pavement subgrade layer depends on many factors, including spatial variation, initial compaction density, mineralogy, and impact from environmental factors.



Plan view of the US 20 project



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As a part of this study, in-situ testing was conducted and field instrumentation were installed to monitor the seasonal variations in temperature, moisture content, frost depth, and groundwater levels.

This research was conducted on a newly constructed PCC pavement on US 20 near Fort Dodge, Iowa. In-situ field tests included a dynamic cone penetrometer (DCP), nuclear density gauge, and Clegg hammer impact tests. Tests were performed at 64 test locations on the surface of compacted subgrade prior to placement of the aggregate subbase layer. Results provided a statistically significant dataset for spatial variability analysis. Approximately two years after construction, the subgrade soil was sampled for laboratory resilient modulus testing. In addition, DCP tests were also performed during two seasons of freeze-thaw cycles to observe the changes in subgrade stiffness.



Instrumentation installation

Key Findings

The average value of Clegg Impact Value was 14. CBR value and Mr-CBR Clegg were 21 and 222 MPa, respectively. The average DPI (mm/blow) for three sub-layers 0–1 ft, 1–2 ft, and 2–3 ft of the subgrade layer were 18, 20, and 18, respectively. CBR values estimated from these DPI values were 12, 11, and 12, respectively. The resilient moduli, Mr-CBR DPI (MPa), for three sub-layers 0–1 ft, 1–2 ft, and 2–3 ft of the subgrade layer were 120, 109, and 128, respectively. The average dry density and moisture content obtained from in-situ testing were 116.5 pcf and 10.2%, respectively. Relative compaction averaged 100% based on standard Proctor compaction energy. The ground water table under the pavement surface fluctuated from 9–13 ft.

Spatial kriging plots showed the variations of soil moisture content, wet density, Clegg Hammer, and DPI of the test section. The Clegg impact values showed that the northern lane had a higher stiffness, possibly resulting from more roller passes. The coefficient of variations of the Clegg impact values, moisture content, and dry density were 38%, 9%, and 2%, respectively.

The average values of resilient modulus in the subgrade layer estimated from the DCP two years after construction at depths 0–1 ft and 1–2 ft were 121 MPa and 159 MPa, respectively. The average value of resilient modulus obtained from laboratory testing was 47 MPa.

Long-term instrumentation was installed after in-situ testing and prior to paving to provide rainfall, moisture content, air temperature, ground water table, and frost depth information during the period of May 2005 to April 2008. Temperature in the subbase and subgrade layers could not be collected for the entire monitoring period because several sensors failed. Moisture content in the subbase layer remained relatively constant throughout the year except during freezing periods. The subgrade moisture content was lower in the winter season compared to summer. Moisture contents of the subgrade layer increased deeper into the layer and were affected by seasonal variations.

In the subgrade layer, freezing penetrated downward, but thawing occurred in both downward and upward directions. The PCC pavement experienced greater temperature extremes and it changed at a higher rate than the subbase and subgrade layers. The temperature gradient within one hour at PCC surface was up to 18oF.

Conclusions

In general, the testing and instrumentation of the tests section on US 20 near Fort Dodge, Iowa was successful. The in-ground instrumentation provided rainfall, moisture content, air temperature, groundwater location, and frost depth information during the monitoring period of about three years. In-situ testing prior to paving included moisture content, density, Clegg impact hammer, and dynamic cone penetration tests. Tests were performed on a six-by-six-foot test grid. The data provided statistically reliable information for spatial variation analysis and correlations to resilient modulus.