CENTER FOR
PORTLAND CEMENT CONCRETE
PAVEMENT TECHNOLOGY

IOWA STATE UNIVERSITY

Influence of Subgrade Non-Uniformity on PCC Pavement Performance

tech transfer summary

RESEARCH PROJECT TITLE
Fly Ash Soil Stabilization for Non-Uniform Subgrade Soils, Volume II: Influence of Subgrade Non-Uniformity on PCC Pavement Performance (IHRB Project TR-461; FHWA Project 4)

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KEY WORDS
fly ash—long-term pavement performance—non-uniformity—stress and deflection responses—subgrade/subbase

The Center for Portland Cement Concrete Pavement Technology (PCC Center) is housed at the Center for Transportation Research and Education (CTRE) at Iowa State University. The mission of the PCC Center is to advance the state of the art of portland cement concrete pavement technology.

Objective

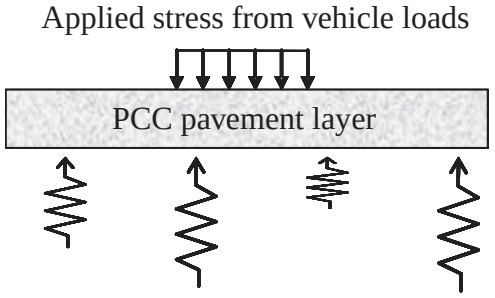
Improve the civil engineering and construction communities' understanding of the influence of non-uniform subgrade support on critical pavement responses that affect long-term pavement performance.

Research Description

Several reconstructed portland cement concrete (PCC) pavement projects in Iowa were studied to document and evaluate the influence of subgrade/subbase non-uniformity on pavement performance.

In situ field tests were performed at 12 sites to determine the subgrade/subbase engineering properties and develop a database of engineering parameter values for statistical and numerical analysis. Field tests included the dynamic cone penetrometer, nuclear density gauge, GeoGauge stiffness, and Clegg impact hammer tests. The tests were performed in a grid pattern to develop a spatial database of the subgrade/subbase engineering property values.

Results of stiffness, moisture and density, strength, and soil classification were then used to determine the spatial variability of a given property. Natural subgrade soils, fly ash-stabilized subgrade, reclaimed hydrated fly ash subbase, and granular subbase were studied. The influence of the spatial variability of subgrade/subbase on pavement performance was then evaluated by modeling the elastic properties of the pavement structure and the pavement foundation using the ISLAB2000 finite element model program.



"Spring" model used to simulate non-uniform subgrade/subbase stiffness

Key Findings

- Non-uniform subgrade/subbase support increases localized deflections and causes stress concentrations in the pavement, which can lead to premature failures, fatigue cracking, faulting, pumping, rutting, and other types of pavement distresses for rigid and flexible pavement systems.
- Natural Iowa subgrade soils were found to have more variability in moisture content, density, stiffness, and strength than self-cementing fly ash–stabilized subgrades, reclaimed hydrated fly ash (HFA) subbases, and granular subbases. Using improved subgrade/subbase support in the form of self-cementing fly ash stabilization, reclaimed hydrated fly ash subbase, or granular subbase will improve pavement performance.
- Wet subgrade soil conditions are sometimes created on old PCC pavement projects that had been placed directly on natural subgrade soil. In the absence of a drainage layer to facilitate water removal, the soils became saturated. Poor draining pavement foundations cause instability in the unbound base materials and intensify the pumping in the subgrade layer.
- Results from analytical pavement modeling show that when pavement foundations are modeled using a uniform subgrade, the maximum principal stresses and deflections are reduced in the pavement structure and thus the fatigue life increases.
- ISLAB2000 pavement modeling comparisons show a decrease in maximum bending/principal stresses and decrease in pavement deflection as the modulus of subgrade reaction increases.

Major Conclusion

Pavement performance is adversely affected by non-uniform pavement foundations. Uniform subgrade reduces critical pavement responses, such as stresses and deflections, leading to improved pavement life. In the future, pavement subgrade/subbase construction should consider uniformity as one of the key issues for long-term pavement performance.

Implementation Benefits

Pavement life can be increased and pavement performance improved through using more uniform subgrade/subbase support.

Implementation Readiness

Achieving uniformity in pavement foundation will require improvements to be made in construction methods and field quality control testing.

Dynamic cone penetrometer testing

Nuclear density gauge

GeoGauge for stiffness testing

Clegg impact hammer