CENTER FOR
PORTLAND CEMENT CONCRETE
PAVEMENT TECHNOLOGY

Fly Ash Soil Stabilization for Non-Uniform Subgrade Soils, Volume II: Influence of Subgrade Non-Uniformity on PCC Pavement Performance

Final Report
April 2005

IOWA STATE UNIVERSITY

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16. Abstract

To provide insight into subgrade non-uniformity and its effects on pavement performance, this study investigated the influence of non-uniform subgrade support on pavement responses (stress and deflection) that affect pavement performance.

Several reconstructed 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. Results of stiffness, moisture and density, strength, and soil classification were 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 and subgrade using the ISLAB2000 finite element analysis program.

A major conclusion from this study is that non-uniform subgrade/subbase stiffness increases localized deflections and causes principal stress concentrations in the pavement, which can lead to fatigue cracking and other types of pavement distresses. Field data show that hydrated fly ash, self-cementing fly ash-stabilized subgrade, and granular subbases exhibit lower variability than natural subgrade soils. Pavement life should be increased through the use of more uniform subgrade support. Subgrade/subbase construction in the future should consider uniformity as a key to long-term pavement performance.

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INFLUENCE OF SUBGRADE NON-UNIFORMITY ON PCC PAVEMENT PERFORMANCE

Final Report
April 2005

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EXECUTIVE SUMMARY

To provide insight into subgrade non-uniformity and its effects on pavement performance, the civil engineering and construction communities need to look at the whole pavement system to determine whether a more effective, economical solution exists for achieving long-term pavement performance. The purpose of this study was to investigate the influence of non-uniform subgrade support on critical pavement responses (maximum stresses, strains, and deflections) that affect pavement performance. This project set forth three objectives:

1. Generate field data from 10 to 12 local subgrade or pavement reconstruction projects in Iowa
2. Using the field data, develop numerical models to simulate pavement performance in terms of pavement stress and deflection responses
3. Conduct a statistical analysis of the results to determine whether a correlation exists between pavement life and subgrade non-uniformity

To achieve these objectives, 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 following: Dynamic Cone Penetrometer, nuclear density gauge, GeoGauge stiffness, and Clegg Impact Hammer tests. Tests were performed in a grid pattern (approximately 2.5 m x 2.5 m over an area about 7.5 m wide by 30 m long) 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. Results show that 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.

Field data show that hydrated fly ash (HFA), self-cementing fly ash-stabilized subgrade, and granular subbases exhibit lower variability than natural subgrade soils. This was determined by calculating and comparing the coefficient of variation (COV) for the stiffness of natural subgrade (COV up to 71 percent), fly ash-stabilized subgrade (COV about 22 percent), reclaimed HFA (COV about 20 percent), and granular subbase (COV about 16 percent). Results from analytical pavement modeling using the ISLAB2000 finite element program 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. A major conclusion from this study is that pavement performance is adversely affected by non-uniform pavement foundations. Pavement life can be increased and pavement performance improved through using more uniform subgrade/subbase support. Pavement subgrade/subbase construction in the future should consider uniformity as one of the key issues for long-term pavement performance.