Kansas Department of Transportation

TECHNICAL SUMMARY

Determining an Acceptable California Bearing Ratio (CBR) Value for Kansas Subgrades Based on Pavement Distress Data

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Introduction

Pavement is a composite structure that consists of several layers, which are made from different materials, including a surface layer, base layer, and subgrade layer. The performance of pavement depends on the behaviors of all these layers. Notwithstanding, Schwartz et al. (2013) showed that the performance predicted by the American Association of State Highways and Transportation Officials (AASHTO) Ware (AASHTOWare) Pavement Mechanistic-Empirical ME Design shows low or no sensitivity to inputs from unbound and subgrade layers. Specifically, they found that total rutting in flexible pavements was only marginally sensitive to the resilient modulus of subgrade layers and non-sensitive to the thickness of unbound layers.

Total rutting is a pavement surface depression in a wheel path that is a consequence of a permanent deformation accumulated within all pavement layers. Rutting affects both the riding quality and structural health of flexible pavements. Consequently, it is considered to be a major failure mode of flexible pavements. Waseem and Yuan (2013) performed a local calibration of Mechanistic Empirical Pavement Design Guide (MEPDG) rutting models for flexible pavements and proposed percentage contributions from different pavement layers to the total rutting. Orobio and Zaniewski (2011) found that the resilient modulus of subgrade has the largest effect on rutting predicted from MEPDG. Baus and Stires (2010) suggested that the resilient modulus of subgrade layers had a significant effect on pavement roughness, total rutting, alligator cracking, and longitudinal cracking for a number of pavements in South Carolina. Thus, subgrade soil appears to have significant effects on the accumulation of different types of distress in flexible pavements.

Project Description

California Bearing Ratio (CBR) of subgrade soils, which can be used in design of flexible pavements, can be obtained from Dynamic Cone Penetrometer (DCP) tests through a statistical correlation. The main objective of this study was to determine an acceptable CBR value based on the use of statistical pavement performance evaluation models. To this end, actual DCP tests, along with the thickness of unbound layer and traffic data in the form of Average Annual Daily Truck Traffic (AADTT) were used as predictors for statistical analyses conducted in this study. Distress indicators of in-service pavements including total rutting, fatigue cracking, transverse cracking, roughness, and quality of pavement cores were the outcomes of the analyses.

All data were collected from 21 sections of largely flexible pavements of interstate and major highways across the state of Kansas. Only four pavement sections were composite pavements whereby the surface layer, which was made of asphalt concrete (AC), was underlain by a cement concrete layer. Four types of statistical analyses were performed including: Principal Component Regression Analysis (PCRA), Regression Analysis (RA), Multivariate Principal Component Regression Analysis (MPCRA), and Multivariate Regression Analysis (MRA).

Project Results

Multiple statistical analyses were performed to arrive at scientifically based recommendation for acceptable CBR values, for flexible pavements in the state of Kansas. Different statistical models were employed to predict pavement performance. Primary emphasis in these analyses was on effects of subgrade soil on pavement distresses, while secondary emphasis was on the effects of thickness of unbound layer and traffic volume. The predicted distresses included: 1) total rutting, 2) fatigue cracking, 3) transverse cracking, 4) pavement roughness, and 5) pavement core condition.

The statistically significant correlations that involve DCP or CBR are the correlations between DCP and total rutting, DCP and fatigue cracking code one (FC1), DCP and the percentage of good core, and DCP and the percentage of poor core. All correlations are functions of a single variable, except the percentages of good and poor core, which depend on both DCP value and thickness of unbound layer. To help with selection of acceptable CBR values two sets of x-y graphs have been constructed. In the first set, there is only one graph that provides the number of years needed to increase rutting code by one unit versus DCP or CBR value. The second set of graphs shows the percentage of good, poor, and fair cores versus DCP or CBR values for different thicknesses of unbound layer. In addition to these graphs, the correlation equations that relate fatigue cracking code one (FC1) and alternative relationship for rutting, which relates the average rutting rate to DCP values from the top 12.5 inches of subgrade, can be used when determining the acceptable CBR value.

Project Information

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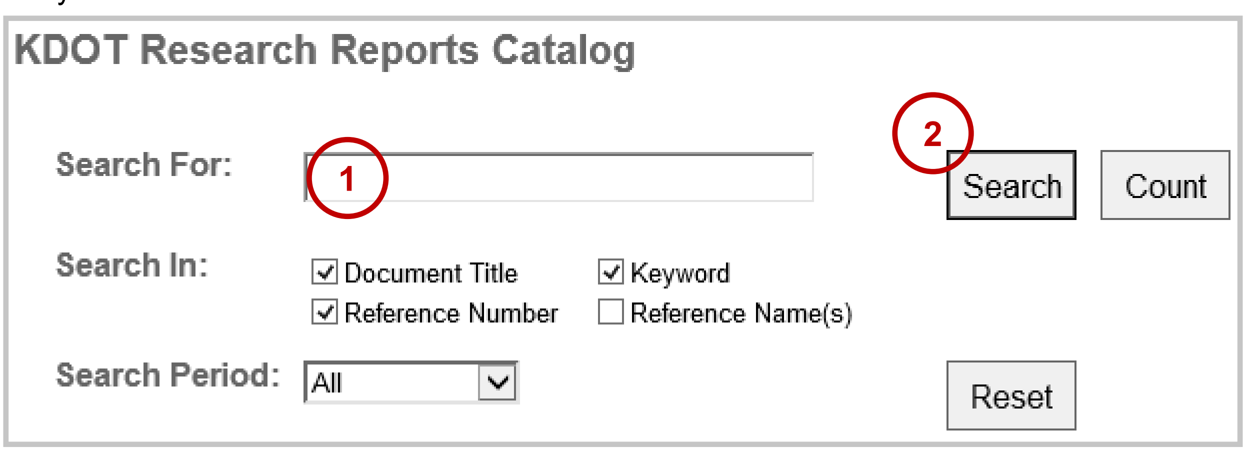

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