

Mechanistic-empirical pavement design guide: features and distinctive elements

Mechanistic-empirical pavement design guide: características y elementos distintivos

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Abstract

This paper is aimed at describing the most distinctive features of the pavement design method known as Mechanistic-Empirical Pavement Design Guide and to compare it with other renowned methodologies, while emphasizing its advantages and disadvantages. The MEPDG can accurately predict damage evolution, thus helping to choose the most appropriate design for new pavements or to schedule the conservation of the already existing ones. After analyzing different pavement design and management methods, the MEPDG stands out as the most comprehensive one as it takes into account and properly combines the greatest number of factors that affect the pavement. Therefore, some countries outside the USA have already imported and calibrated this method, what, at the same time, allows the scientific community to carry out comparative studies and improve its small deficiencies.

Keywords: Pavement, design, management, incremental damage, optimization.

Introduction.

Pavement design constitutes one of the essential aspects of any road, not only because it is directly related to its functionality and users' safety, but also because of its cost-related implications. The existence of new materials and production methods, as well as the new requirements that current traffic imposes, make necessary the development of innovative methods for the design of road pavement structural sections or for the management of the already constructed ones. Most of the methods used to date only take into account a small part of the parameters that affect pavement throughout its useful life. Thus, certain designs are therefore accepted without considering other possibilities that could provide a more desirable response to external loads and better recoup the allocated investment. The innovative and comprehensive design method known as Mechanistic-Empirical Pavement Design Guide (MEPDG) has been developed in the United States to change this trend. It also allows the user to predict the evolution of existing pavements, what helps to propose actions to extend their useful life and to avoid failures otherwise unexpected. This paper discusses the advantages of this method, studies its most distinctive features and analyzes its differences with respect to other methodologies of pavement design or management, especially comprehensive in the case of the HDM-IV, and mainly focusing on the case of flexible pavements. It also highlights those aspects in which the MEPDG could be further improved.

Background.

Until the mid-20th century, American engineers designed pavements simply on the basis of their experience. This procedure started in 1950, when the American Association of State Highway Officials (AASHTO) deliberately carried out

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Resumen

El objetivo de este artículo es describir los rasgos más característicos del método de diseño de firmes conocido como Mechanistic-Empirical Pavement Design Guide, así como compararlo con otras metodologías de renombrado, destacando sus ventajas y desventajas. El MEPDG puede predecir con precisión la evolución de los deterioros, ayudando por tanto a elegir el diseño más adecuado para el caso de firmes de nueva construcción, o a programar la conservación de los ya existentes. Tras analizar diferentes métodos de diseño y gestión de firmes, el MEPDG destaca como el más completo al ser el que tiene en cuenta un mayor número de factores que afectan al firme. Por ello algunos países fuera de EEUU ya han importado y calibrado este método, lo que al mismo tiempo permite a la comunidad científica llevar a cabo estudios comparativos y mejorar sus pequeñas deficiencias.

Palabras Claves: Pavimentos, diseño, administración, daño incremental, optimización.

various tests on a track in Ottawa, Illinois. By using regression models, they developed empirical equations based on the results, which were compiled in the AASHTO Guide for the Design of Pavement Structures in 1993 (AASHTO, 1993). As time passed, it was noticed that this purely empirical design system could not handle new traffic (about 30 times higher), new materials or boundary conditions of other regions. The lack of accuracy in the designs led to the expenditure of more than \$20 billion per year to improve the national pavement network (Ali, 2005). In addition to this method and other merely empirical procedures, diverse analytical design methods have been developed since 1940. The pavement is modeled as a multilayer structure whose layers show a certain behavior (linear-elastic, plastic, linear or nonlinear-viscoelastic, etc.) assigned in accordance with their nature. These methods predict the response of each layer depending on traffic loads and some factors related to climate. They first calculate the stresses, strains and displacements to which pavement will be subjected. Then, by means of the numerical resolution of a series of equations based on the multilayer theory (Burmister, 1945), they determine the number of applications of the pattern load that the structure can bear until failure. Commercial programs such as Alize, Kenlayer, Chevron, Etoym, Bisar, etc. are based on these models. Among analytical or rational methods there are some which use finite elements and others which utilize finite differences, such as Axidn, Abaqus, Cesar, Michpave, Nottingham, etc.

The problem is that the expected results derived from the individual application of empirical or analytical methods do not always agree with those obtained in the field. That is the reason why the MEPDG was developed between 1996 and 2004 (with its subsequent revisions) in the frame of the American National Cooperative Highway Research Program (NCHRP Project 1-37A). It includes a guide to carry out the design and the mechanistic-empirical analysis, the software (DARWINME) with its corresponding manual and additional documentation

Mechanistic Empirical Pavement Design Guide

Qiang Li



Mechanistic Empirical Pavement Design Guide:

Mechanistic-empirical Pavement Design Guide American Association of State Highway and Transportation Officials,2008
Mechanistic-empirical Pavement Design Guide ,2015 *Mechanistic-empirical Pavement Design Guide* ,2021 This addendum provides the additions and revisions to 3rd edition of the MEPDG including methods and inputs to the fracture based top down cracking model **Mechanistic-empirical Pavement Design Guide Implementation Plan** Todd E. Hoerner,2007 As AASH is expected to eventually adopt the MEPDG at its primary pavement design method it is critical that the SDDOT become familiar with the MEPGD documentation and associated design software The research conducted under this project was a first step toward achieving this goal **Implementing the Mechanistic-empirical Pavement Design Guide** Brian Coree,2005 *TRC-0702, Database Support for the Mechanistic-Empirical Pavement Design Guide (MEPDG)* Kelvin C. P. Wang, Kevin D. Hall, University of Arkansas, Fayetteville. Civil Engineering, Arkansas. State Highway & Transportation Department,2009 Database Support and Modeling for the Mechanistic Empirical Pavement Design Guide (MEPDG) Qiang Li,2009 *Characterization of Unbound Materials for Mechanistic-Empirical Pavement Design Guide (MEPDG)* Jeyakaran Thavathurairaja,2017 **Mechanistic-Empirical Pavement Design Guide** Meng Chong Lee,2004

Enhancement of Mechanistic-empirical Pavement Design Guide for Roadway Design, and Construction in the State of Wyoming Melake A. Brhanemeskel,2017 The Wyoming Department of Transportation WYDOT has been working to fully implement MEPDG as their pavement design guide To facilitate this implementation many research works have been completed Similarly this thesis was completed to evaluate the relationships between subgrade resilient modulus M_r and the dynamic cone penetration DCP and the standard penetration test SPT results select three best subgrade M_r predictive models based on both M_r and distress estimations determine the sensitivity of the pavement design parameters on pavement distresses in Wyoming and facilitate implementation of the MEPDG in the state of Wyoming Two resilient modulus M_r predictive models were developed from the dynamic cone penetration DCP and the standard penetration test SPT results To enhance the prediction of pavement performance distresses 11 subgrade M_r predictive models were evaluated and three best models were identified and selected Sensitivity of pavement distresses to influential variables was assessed All pavement distresses were found to be sensitive to asphalt concrete thickness and most of the distresses were found to be non sensitive to asphalt concrete AC grade base thickness and base M_r Finally pavement design comparisons were made between the WYDOT 2012 user design guide and the recommended design guide based on locally calibrated properties The average overall cost per square yard of the pavement structure designed using the WYDOT 2012 user design guide was found to be 21% higher than that based on the recommended design guide **Calibrating the Mechanistic-empirical Pavement Design Guide for Kansas** Xiaohui Sun (Writer on roads), University of Kansas. Civil, Environmental and Architectural Engineering Department,2015 The Kansas Department of Transportation KDOT is moving toward the implementation of the

new American Association of State Highway and Transportation Officials AASHTO Mechanistic Empirical Pavement Design Guide MEPDG for pavement design The MEPDG provides a rational pavement design framework based on mechanistic empirical principles to characterize the effects of climate traffic and material properties on the pavement performance as compared with the 1993 AASHTO Guide for Design of Pavement Structures Before moving to the MEPDG the nationally calibrated MEPDG distress prediction models need to be further validated and calibrated to the local condition The objective of this research was to improve the accuracy of the MEPDG to predict the pavement performance in Kansas This objective was achieved by evaluating the MEPDG predicted performance of Kansas projects as compared with the pavement performance data from the pavement management system PMS and calibrating the MEPDG models based on the pavement performance data In this study 28 flexible pavement projects and 32 rigid pavement projects with different material properties traffic volumes and climate conditions were strategically selected throughout Kansas The AASHTO ME Design software Version 1.3 was used in this study The comparisons between the MEPDG predicted pavement performance using the nationally calibrated models and the measured pavement performance indicated the need for the calibration of the MEPDG models to the Kansas conditions For new flexible pavements the MEPDG using the nationally calibrated models overestimated the rutting due to the overprediction of the deformation of the subgrade layer Biases also existed between the predicted top down cracking thermal cracking and International Roughness Index IRI and the measured data The relationship between the measured and the predicted IRIs was more obvious than that for the cracking Using the coefficients determined through local calibration in this study the biases and the standard errors were minimized for all the models based on the statistical analysis For new rigid pavements very low mean joint faulting was measured in actual projects as compared with the default threshold of the MEPDG The type of base course had a minor effect on the pavement performance The traditional splitting data method was adopted in the process of local calibration After the local calibration the biases between the predicted pavement performance mean joint faulting and IRI and the measured pavement performance were minimized and the standard errors were reduced

Preparation of the Implementation Plan of AASHTO Mechanistic-empirical Pavement Design Guide (M-E PDG) in Connecticut Iliya Yut, James M. Mahoney, Scott Zinke, 2014 **Recommended**

Mechanistic-empirical Pavement Design Guide and Software National Cooperative Highway Research Program, 2004

This digest announces the availability of key products from NCHRP Project 1-37A Development of the 2002 guide for the design of new and rehabilitated pavement structures phase II for evaluation Page 1 excerpt *Mechanistic-empirical Pavement Design Guide Calibration for Pavement Rehabilitation* R. Christopher Williams, 2013

Guide for the Local Calibration of the Mechanistic-empirical Pavement Design Guide, 2010 This guide provides guidance to calibrate the Mechanistic Empirical Pavement Design Guide MEPDG software to local conditions policies and materials It provides the highway community with a state of the practice tool for the design of new and rehabilitated pavement structures based on

mechanistic empirical M E principles The design procedure calculates pavement responses stresses strains and deflections and uses those responses to compute incremental damage over time The procedure empirically relates the cumulative damage to observed pavement distresses

Mechanistic-Empirical Pavement Design Guide (MEPDG) Method Implemented to Estimate Damage in Flexible and Rigid Pavements Tenzin Gusto,2016 The implementation of the Empirical Mechanistic Pavement Design Guide MEPDG method for flexible and rigid pavements requires numerous input parameters Most of these parameters can be easily determined while some require best estimates that are usually extracted from available literature This thesis identifies the most critical input parameters in terms of their effects on the damage of pavements and their influence on the determination of the number of corrective maintenance cycles to be performed during the design life of pavements It was found that for flexible pavement change in the average monthly temperature by as little as results in large differences in the number of corrective maintenance cycles Also consistently with simple mechanics concepts pavements on stiffer foundations performed better under the load and hence required fewer number of the corrective maintenance cycles than those founded on more flexible soils Also variations in truck weights affected the outcome in terms of the estimated number of corrective maintenance cycles for flexible pavement Hence better estimates of the number of corrective maintenance cycles can be obtained when the analysis was based on larger numbers of truck samples On the contrary no significant difference in the final estimation of the number of corrective maintenance cycles was found for rigid pavements even when the average monthly temperatures were increased or decreased by as much as Moreover no major difference was observed when a larger sample of trucks was used as input for the analysis Similarly change in ambient temperature which is directly related to the differential temperature on the top and the bottom of the slab that may lead to the curling of the slab and faulting was found not to be critical Similar to the results obtained for flexible pavements rigid pavement with stiffer foundation properties performed better in terms of the number of corrective maintenance cycles as they required fewer corrective maintenance cycles

Implementing the Mechanistic-empirical Pavement Design Guide for Cost Savings in Indiana Tommy E. Nantung,2010

Implementing the AASHTO Mechanistic-empirical Pavement Design Guide in Missouri ,2009 Volume I summarizes the entire research effort and documents findings from a review of MEPDG related literature an assessment of MoDOT s MEPDG input data needs MoDOT s laboratory and field testing efforts sensitivity analysis using MoDOT specific inputs and model validation and calibration tasks In addition Volume I also discusses the steps MoDOT could undertake in the future to fully implement the MEPDG Volume II presents a section by section comparison of the predicted and measured distresses for MoDOT specific LTPP and State Pavement Management System sections for HMA pavements and JPCP

Draft User's Guide for UDOT Mechanistic-empirical Pavement Design Michael I. Darter,Leslie Titus-Glover,Harold L. Von Quintus,2009 Validation of the new AASHTO Mechanistic Empirical Pavement Design Guide s MEPDG nationally calibrated pavement distress and smoothness prediction models when

applied under Utah conditions and local calibration of the new hot mix asphalt HMA pavement total rutting model were recently completed as documented in UDOT Research Report No UT 09 11 Implementation of the Mechanistic Empirical Pavement Design Guide in Utah Validation Calibration and Development of the UDOT MEPDG User s Guide dated October 2009 This Draft User s Guide incorporates the findings of the model validation and local calibration report and provides information for use by UDOT s pavement design engineers during trial implementation of the MEPDG This information includes an overview of the MEPDG procedure information on installation of the software guidelines for obtaining all needed inputs guidance to perform pavement design using the software for new and rehabilitated HMA pavement and jointed plain concrete pavement JPCP and pavement design examples for new HMA pavement and new JPCP using the MEPDG software

Implementation of the AASHTO Mechanistic-Empirical Pavement Design Guide and Software ,2014

Unveiling the Magic of Words: A Review of "**Mechanistic Empirical Pavement Design Guide**"

In some sort of defined by information and interconnectivity, the enchanting power of words has acquired unparalleled significance. Their ability to kindle emotions, provoke contemplation, and ignite transformative change is truly awe-inspiring. Enter the realm of "**Mechanistic Empirical Pavement Design Guide**," a mesmerizing literary masterpiece penned by a distinguished author, guiding readers on a profound journey to unravel the secrets and potential hidden within every word. In this critique, we shall delve to the book is central themes, examine its distinctive writing style, and assess its profound impact on the souls of its readers.

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