

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 renombrada, 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 traffics (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 (AASHTO, 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, Elsym, Bilar, 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 Axdin, 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

**American Association of State
Highway and Transportation Officials**



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 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* Meng Chong Lee, 2004 **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 *Independent Review of the Mechanistic-empirical Pavement Design Guide and Software* Transportation Research Board. National Cooperative Highway Research Program, 2006 **Database Support and Modeling for the Mechanistic Empirical Pavement Design Guide (MEPDG)** Qiang Li, 2009 **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 *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 *Evaluation of the Mechanistic Empirical Pavement Design Guide (NCHRP 1-37A)* Osman Ali, Institute for Research in Construction (Canada), National Research Council Canada, 2005 *Implementation of the AASHTO Mechanistic-Empirical Pavement Design Guide and Software* , 2014 **Mechanistic-Empirical Pavement Design Guide** , 2020 This 2020 3rd edition includes the following revisions and updates from the previous 2015 2nd edition new fracture mechanics based model for reflective cracking in AC overlays over flexible semi rigid and rigid pavements new mechanistic empirical model for short jointed plain concrete pavement SJPCP overlays of flexible pavements new flexible and semi rigid pavement global calibration coefficients addition of non structural preventative maintenance treatment consideration for flexible and rigid pavements addition of five level 3

default distributions for normalized axle load spectra NALS updated climate discussion for Modern Era Retrospective Reanalysis MERRA and North American Regional Reanalysis NARR data incorporation of crack load transfer efficiency LTE for flexible pavements expanded guidance for creep compliance and indirect tensile strength inputs for asphalt wearing surface layers and updated standards references *Implementation Plan for the New Mechanistic-empirical Pavement Design Guide* Y. Richard Kim, 2007 *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 Changes to the Mechanistic-empirical Pavement Design Guide and Software Through Version 0.900, July 2006 Transportation Research Board. National Cooperative Highway Research Program, 2006 Review of the New Mechanistic-empirical Pavement Design Guide - a Material Characterization Perspective, 2005 Characterization of pavement materials in the three hierarchical design levels of the proposed mechanistic empirical pavement design MEPDG guide involves application of the dynamic modulus technique for asphalt concrete and the resilient modulus for unbound materials This approach if adequately implemented is expected to improve the road design processes The advance design level recommends using actual laboratory test data of the dynamic and resilient modulus determined under simulated environmental and traffic loading conditions To circumvent the need for conducting the mechanical test in lower design

levels predictive equations and correlations established with physical properties are used to estimate the mechanistic properties needed as input to the design software This paper examines the simplifications incorporated in the model using results of dynamic and resilient modulus tests performed at the National Research Council Canada NRC For the covering abstract of this conference see ITRD number E211426 **Implementing the Mechanistic-empirical Pavement Design Guide for Cost Savings in Indiana** Tommy E. Nantung,2010

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