Bulletin of the *Transilvania* University of Braşov
CIBv 2014 • Vol. 7 (56) Special Issue No. 1 - 2014

IMPLEMENTATION OF MECHANISTIC EMPIRICAL PAVEMENT DESIGN GUIDE ME-PDG IN ROMANIA

E-L. PLESCAN[1] **C. PLESCAN**[1]

Abstract: *This paper describes the most important aspects of the implementation of Mechanistic Empirical Pavement Design Guide – ME-PDG method, developed in United States. After a short presentation of the advantages of this method, in comparison with actual ones used in roads design practice, the main concepts and criteria of this method are described in detail. The specific climatic and traffic conditions of Romania public road network, characterized by sever winters and very hot summers, are tacked into consideration at creation of specific climatic and traffic database that is proposed. Finally specific recommendations for implementation of the methodology in Romania are considered.*

Key words: *pavement structural design, concrete pavement, long lasting rigid pavements- LLR, traffic loading, climate conditions.*

1. Introduction

There is an attempt to harmonize the design method of pavement structures at the European level by taking into account the traffic loads and the climatic conditions existing in Europe, as well as the new types of pavement structures [1].

Pavement engineers are continually looking for an effective analytical tool to assist in analysing pavement structures, taking into consideration the in-service condition of the road. Such a tool will facilitate the establishment of a performance-based design, capable of extending the service life of roads. An ideal design tool consists of a structural model capable of predicting the state of stresses and strains within the pavement structure under the action of traffic and environmental loading. To carry out such analysis effectively, the design tool should be equipped with material models capable of capturing the mechanistic response of the various materials used to construct the road structure. Such a model is considered a mechanistic model [2].

The concept of sensitivity can be defined function of various parameters that are taken into consideration at the structural design of pavements: traffic loads, climate conditions, failure criteria and design life. The objective of pavement design is to select pavement features, such as slab thickness, joint dimensions, and reinforcement and load transfer requirements, which will economically meet the needs and conditions of a specific paving project.

---

[1] Department of "Civil engineering", *Transilvania* University of Braşov.

Our research activity is based on a comparative study, which aims to examine various structural design methods for rigid pavement, currently used in road practices, and to identify the parameters that significantly influence their sensitivity. In addition to the issues presented above, a study regarding the implementation and the development in the specific traffic and climatic conditions of Romania (severe winters and hot summers), and a new design method for rigid pavement is proposed.

Traditionally, concrete pavement design has focused on slab thickness. A more integrated approach to pavement design considers all components of the pavement system (Figure 1) that affect performance.

Pavement performance is generally described in terms of structural and functional performance [2]:
Structural performance of concrete pavements is influenced by many factors, including design-related variables for structural

→ Performance at a given level of traffic is slab thickness, reinforcement, concrete strength, elastic modulus, and support conditions.

→ Functional performance is thought to consist of ride quality and surface friction, although other factors such as noise and geometrics may also come into play. Functional distress is generally represented by a degradation of a pavement's driving surface that reduces ride quality.

Nowadays, the new structural design methods for pavements are adopting a more integrated approach, which considers key pavement features as well as durable concrete mixtures, constructability issues, and it is reflected in the long-life pavement concepts. This integrated approach can also be observed in the thickness determination concepts incorporated into the Guide for Mechanistic-Empirical Design of New and Rehabilitated Pavement Structures [3].

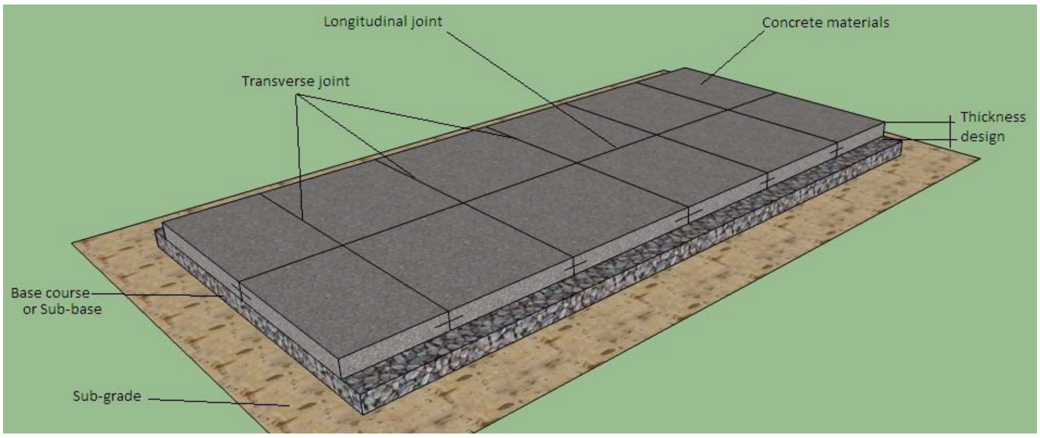

Fig. 1. *Components of the pavement system*

2. Mechanistic Empirical Pavement Design Method

The new design methodology, commonly termed the Mechanistic-Empirical Pavement Design Guide (M-E PDG), is based on mechanistic-empirical principles. Structural responses (i.e., stresses, strains and deflections) are mechanistically calculated (using multilayer elastic theory or finite element methods) for given material properties, environmental conditions, and loading characteristics. Thermal and moisture distributions are also mechanistically determined. These responses are used as inputs to empirical models for predicting permanent deformation, fatigue cracking (bottom-up and top-down), thermal cracking, and roughness [4].

A benefit of M-E analysis is that it predicts specific distress types as a function of time or traffic. Cracking, faulting, and changes in smoothness are estimated. Threshold values for each distress type are input by the designer based on experience, policy, or risk tolerance.

The major components of the mechanistic-empirical pavement design are as follows:

- → Inputs—Materials, traffic, climate, structure;
- → Structural response model – to compute critical responses;
- → Performance models or transfer functions – to predict pavement performance over the design life;
- → Performance criteria – to set objective goals by which the pavement performance will be judged;
- → Design reliability and variability.

M-E design procedures typically start with a trial design with an initial set of inputs. The inputs are fed into structural models to predict pavement responses of interest to the design process.

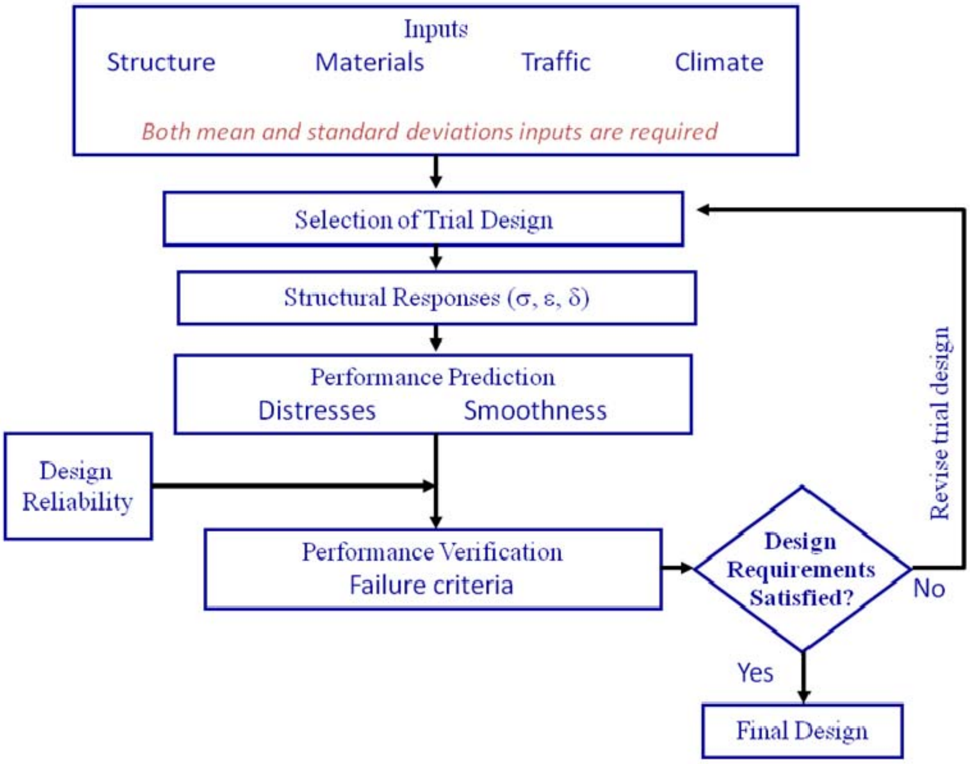

Fig. 2. *Design chart for ME-PDG [3]*

The choice of the critical responses to be evaluated is directly related to the performance indicators of interest—pavement distresses, smoothness, and so on—to the design procedure being adopted [4].

3. The advantages of mechanistic-empirical pavement design procedure

The basic advantages of a mechanistic-empirical pavement design procedure over empirical approaches are as follows [3]:

→ Direct consideration of axle types, tire types and pressure, axle weights, and changing traffic load types (also ability to consider “special” loadings);

→ A better utilization of available materials (often substandard materials);

→ The ability to accommodate new materials;

→ The improvement of reliability of design for design extrapolation;

→ More consideration of construction effects and variations;

→ Material properties that relate better to actual pavement behaviour and performance;

→ An improved definition of existing pavement layer properties;

→ Direct consideration of seasonal and aging effects on materials and designs;

→ More adequate consideration of rigid pavement joints, reinforcements, base course support, and thermal/moisture effects on slab curling;

→ Direct consideration of key distress types as primary performance indicators.

Based on the discussion presented, it is obvious that adopting a mechanistic approach for pavement design will help agencies adapt better to the ever-changing highway environment among other advantages.

The major components of the mechanistic-empirical pavement design are as follows:

→ Inputs—Materials, traffic, climate, structure;

→ Structural response model – to compute critical responses;

→ Performance models or transfer functions – to predict pavement performance over the design life;

→ Performance criteria – to set objective goals by which the pavement performance will be judged;

→ Design reliability and variability.

4. Implementation of ME-PDG in Romania

The Mechanistic Empirical Pavement Design Guide (MEPDG) is a significant advancement in pavement design, but requires significantly more inputs from designers. Many data sets need to be pre-processed before their use in the MEPDG procedure, such as Weigh-In-Motion (WIM) traffic data [6].

The adoption of the M-E PDG by Romanian will have significant ramifications for material testing and pavement design procedures. The mechanistic-empirical procedures upon which the ME- PDG is based will require greater quantity and quality of input data in four major categories: traffic; material characterization and properties; environmental influences; and pavement response and distress models. The new M-E PDG provides agencies the greatest possible flexibility for applying and calibrating the design procedures to local conditions and approaches. Local material properties and traffic characteristics in particular are expected to receive significant attention. Local calibration of distress prediction models is also being considered by many agencies. The Romanian agencies will need to evaluate the quality and quantity of existing historical data for use in the new procedures. This will undoubtedly require establishment of a data collection program to ensure that any gaps in current material, traffic, environmental, and other data are addressed during the implementation of the new M-E PDG [4].

In table 1 is presented a summary of proposed ME-PDG implementation activities.

Summary of proposed ME-PDG implementation activities Table 1

No.	Activity
1	Compile existing Romanian WIM data
2	Collect supplementary traffic data
3	Develop catalogue of typical traffic load spectra for the New M-E Pavement Design Guide
4	Romanian Climate Data for the New M-E Pavement Design Guide
5	Develop procedure for better reflecting benefits of M-E design procedure
6	Compile existing unbound MR data
7	Catalogue of Material Properties for Mechanistic-Empirical Pavement Design1
8	Develop database of PCC design input data
9	Evaluate suitability of Romanian PMS data for local calibration of M-E PDG
10	Perform local calibration of M-E PDG
11	Develop M-E design criteria
12	Monitor/evaluate future M-E PDG enhancements and software releases

The corresponding major components to implement this mechanistic-empirical pavement design methodology are [6]:

→ Inputs—traffic, climate, materials, others.

→ Pavement response models—to compute critical responses.

→ Performance models or transfer functions to predict pavement performance over the design life.

→ Design reliability and variability—to add a margin of safety for the design.

→ Performance criteria—to set objective goals by which the pavement performance will be judged.

→ Software—to implement the mechanistic-empirical models and calculations in a usable form.

Currently, the MEPDG includes empirical distress models that have to been calibrated using a national database. Most of the data used for the national calibration were obtained from the Long Term Pavement Performance (LTPP). It is therefore necessary that calibration of the MEPDG models be undertaken using local pavement condition data. In order to successfully calibrate and validate the MEPDG procedure to local conditions, pavement performance data are required.

The process involves the replacement of the of the national calibration coefficients in the empirical distress prediction models with values more suited to local conditions. The calibration process usually requires the selection and identification of a set of experimental pavement sections; MEPDG inputs, such as traffic, environment, and material properties, can be well quantified and for which a history of pavement performance data, such as rutting, fatigue cracking, and roughness, are available. All of the above mentioned pavement distresses need to be calibrated to local conditions. Studies have shown that local calibration of the MEPDG procedures can be very beneficial in improving pavement performance predictions for local conditions [7].

Database tables proposed for the implementation of the new ME-PDG method for pavement design are as follows:

→ General tables;
→ Traffic tables;
→ Climate data;
→ Water table depth;
→ Elevation;
→ Material: asphalt concrete, Portland cement concrete, stabilized base, unbound, subgrade and bedrock.

Conclusion

The Mechanistic-Empirical Pavement Design Guide (MEPDG) is an overwrought method for pavement distress, but it is computationally difficult to evaluate.

Analyses requiring large numbers of MEPDG evaluations, such as sensitivity analysis and design optimization, become impractical due to the computational expense. These applications are important in achieving robust, reliable, and cost-effective pavement designs.

The adoption of the M-E PDG for Romanian pavement design will have significant ramifications for material testing and pavement design procedures. The mechanistic-empirical procedures upon which the M-E PDG is based will require greater quantity and quality of input data in four major categories: traffic; material characterization and properties; environmental influences; and pavement response and distress models. The new M-E PDG provides agencies the greatest possible flexibility for applying and calibrating the design procedures to local conditions and approaches.

References

1. Elena Loredana Puslau, "*Studies concerning the sensitivity of various structural design methods of rigid pavements*", The Young European Arena of Research, 2010
2. Peter C. Taylor, Steven H. Kosmatka, Gerald F. Voigt, et al." *Integrated Materials and Construction Practices for Concrete Pavement: A State-of-the-Practice Manual* " Federal Highway Administration, Washington, D.C., 2007, pp. 7-22
3. "*Introduction To Mechanistic-Empirical Design of New and Rehabilitated Pavements*", National Highway Institute, March 2002
4. Charles W. Schwartz, " *Implementation of the NCHRP 1-37A Design Guide*", Final Report, University of Maryland, 2007
5. Andrei R., Boboc V., Puslau E., Boboc A., "*Actual status and implementation of the risk management on roads in Romania*", International PIARC Seminar on Managing Operational Risk on Roads, 2009
6. Osman Ali, "*Evaluation of the Mechanistic Empirical Pavement Design Guide (NCHRP 1-37A*), 2005
7. George Dzotepe, Khaled Ksaibati, " *Implementation of the Mechanistic-Empirical Pavement Design Guide (MEPDG)*", 2010.