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Calibration of Witczak and Modified Witczak Models for Prediction of Dynamic Modulus of In-Service Asphalt Layers

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ABSTRACT: One of the important input parameters of Mechanistic–Empirical Pavement Design Guide (MEPDG) for asphalt pavements is the dynamic modulus ($|E^*|$) that can be defined as the viscoelastic property of asphalt materials. For determination of dynamic modulus of in-service asphalt layers, MEPDG uses results of both Falling Weight Deflectometer (FWD) and laboratory dynamic modulus predictive models. This method in some cases lacks precision. Hence, it is needed to improve the current method and develop accurate predictive models. In this research, ten asphalt pavement sites, having various structure, age and conditions, were selected in Khuzestan and Kerman provinces in Iran. Field and laboratory testing were performed and dynamic modulus of in-service asphalt layers was determined. Developed predictive models for dynamic modulus of asphalt mixes including Witczak and Modified Witczak were calibrated and new models were constructed for predicting in-situ dynamic modulus of asphalt layers. These two calibrated models entitled "In-situ Witczak Model" and "In-situ Modified Witczak Model" could be directly used for prediction of dynamic modulus of in-service asphalt layers from volumetric properties of asphalt mixes and viscosity characteristics of extracted binders without any need for FWD testing. Performance evaluation and validation of new models showed high accuracy and low bias with very good correlation between predicted and measured values (R^2=0.93).

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1. INTRODUCTION

Asphalt dynamic modulus is measured in laboratory during expensive and time-consuming tests. Prediction models were developed to determine dynamic modulus with a few usual laboratories works based on mix volumetric properties and binder viscosity characterization. The objective of this study is to apply and evaluate two conventional dynamic modulus predictive models including Witczak and Modified Witczak in determining dynamic modulus of in-service asphalt layers with different characteristics in Iran. In addition, new in-situ dynamic modulus predictive models with high accuracy and low bias are developed.

2. EXISTING PREDICTIVE MODELS

Two conventional dynamic modulus predictive models for asphalt mixtures were investigated in this paper including:

- Witczak model [1];
- Modified Witczak model [2].

3. EXPERIMENTAL WORK

In this research, ten flexible pavement sites were selected in Khuzestan and Kerman provinces in Iran. The sites were selected from different roads having pavements with different characteristics with regard to their thickness, number of layers, age and types of base and subbase layers. Falling Weight Deflectometer (FWD) testing was conducted ("Fig. 1") and core samples were taken at each site. These were then tested for volumetric analysis. The results of the tests were used as input parameters in dynamic modulus predictive models.

Fig. 1. FWD testing on a site

4. PREDICTION OF DYNAMIC MODULUS OF ASPHALT LAYERS

Predicted dynamic moduli for all samples at different temperatures using original predictive models as well as FWD

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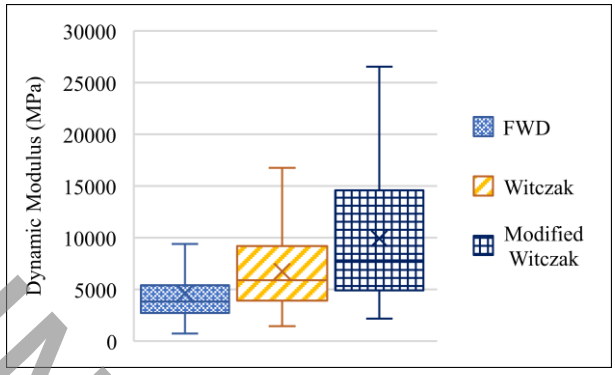

Fig. 2. FWD backcalculated and predicted dynamic moduli for all samples at different temperatures using original predictive models

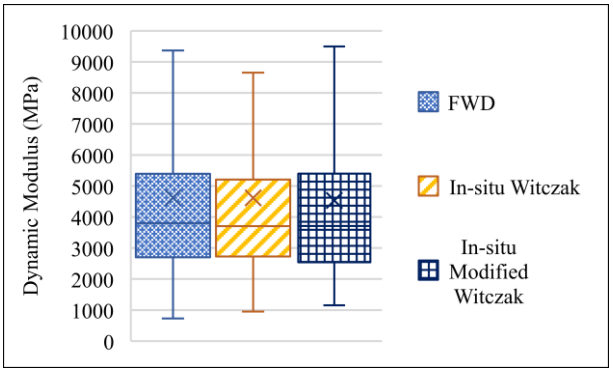

Fig. 3. FWD backcalculated and predicted dynamic moduli using new in-situ models

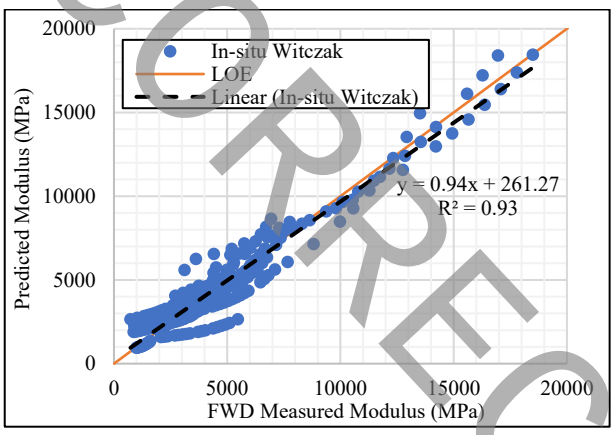

Fig. 4. Predicted dynamic moduli using In-situ Witczak model versus FWD backcalculated values

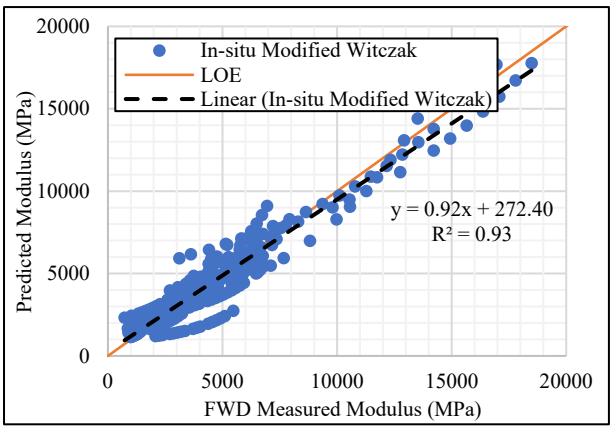

Fig. 5. Predicted dynamic moduli using In-situ Modified Witczak model versus FWD backcalculated values

backcalculated ones are shown in "Fig. 2". As it can be seen in this figure, the moduli predicted with Witczak and Modified Witczak models are greater than the backcalculated values. In addition, moduli predicted with Modified Witczak model has shown a large difference with the backcalculated ones.

5. DEVELOPMENT OF IN-SITU PREDICTIVE MODELS

Nonlinear regression analysis was employed and two new in-situ predictive models were developed based on calibration of the original models. New developed models were named "In-situ Witczak" and "In-situ Modified Witczak" models. The predicted dynamic moduli using these new in-situ models as well as FWD backcalculated ones are shown in "Fig. 3". As it can be seen in this figure, in-situ models could predict dynamic moduli at the similar range of the backcalculated values and this shows the capability of the new proposed models in predicting dynamic modulus of in-service asphalt layers.

6. PERFORMANCE OF NEW MODELS

Goodness-of-fit and bias were the two parameters that used to evaluate prediction performance of the new models. "Fig. 4" and "Fig. 5" show the predicted moduli versus FWD backcalculated values using In-situ Witczak and In-situ Modified Witczak models, respectively. As it can be seen in these figures, the new developed models could predict the dynamic modulus of in-service asphalt layers very close to the line of equality.

7. CONCLUSIONS

In this research, field and laboratory testing were carried out to predict dynamic modulus of in-service asphalt layers in some flexible pavements in Iran. Two conventional dynamic modulus predictive models were utilized and following findings were obtained:

- Feasibility investigation of using two dynamic modulus predictive models including Witczak and Modified Witczak models showed that it is possible to predict dynamic moduli of in-service asphalt layers using these models, although improvement of prediction accuracy is necessary.
- New in-situ predictive models with calibration of the above two original models were developed and their prediction performance was evaluated. Results showed that proposed models could predict dynamic modulus of in-service asphalt layers with high accuracy and low bias, especially in the temperature range of this study.
- Directly prediction of dynamic modulus of in-service asphalt layers using mixture volumetric properties and

asphalt binder characteristics without need for FWD testing, is the main advantage of new developed in-situ predictive models.

- The best prediction performance belonged to the "In-situ Witczak model" with R^2 of 0.93.

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