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| | **authors** | • Bayrak, M. Birkan<br>• Ceylan, Halil | **abstract** | acterize the layer properties as inputs into available numerical or analytical programs, backcalculation of pavement layer properties is a very useful tool. Most backcalculation procedures estimate pavement properties by matching measured and calculated pavement surface deflection basins. There are many advantages to using FWD tests in lieu of or to supplement traditional destructive tests for pavement structural evaluation. Most important is the capability to gather data quickly at several locations while keeping a runway, taxiway, or apron operational during these 2-to 3-min tests, provided the testing is performed in close coordination with air traffic control. Without FWD-HWD testing, structural data must be obtained from numerous cores, borings, and excavation pits on existing highway or airport pavements. This can be very disruptive to highway and airport operations. FWD tests are economical to perform and data can be collected at up to 250 locations per day. FWD-HWD equipment measures pavement surface deflections from an applied dynamic load that simulates a moving wheel (1). The elastic modulus of the portland cement concrete (PCC) slab, E PCC , and the coefficient of subgrade reaction, k s , are the backcalculated layer moduli parameters for the jointed plain concrete pavement (JPCP) systems. Over the years, researchers have developed several different methodologies for backcalculation of concrete pavement layer moduli from FWD measurements, including the AREA method for rigid pavements (2-4), ILLI-BACK (5), graphical solution by using ILLI-SLAB (6), use of regression analysis to solve the AREA method for rigid pavements (7, 8), use of a best-fit algorithm to find the radius of relative stiffness (á‰ ) (8, 9) , and many others. The primary focus of this study is the backcalculation of the rigid pavement parameters with high accuracy by using artificial neural networks (ANNs), particularly the determination of the elastic modulus of the slab and the coefficient of subgrade reaction of the pavement foundation that are used in the analysis and design of the rigid pavements using FWD data. FWD deflections and the PCC thickness of the test section are the only information needed for backcalculation of the rigid pavement parameters with developed ANN-based models. There is no need for the provision of seed moduli in this approach. The use of the ANN models also results in a drastic reduction in computation time compared with other methodologies. ANN-based analysis models can provide pavement engineers and designers with state-of-the-art solutions, without the need for a high degree of expertise in the input and output of the problem, for rapid analysis of a large number of rigid pavement deflection basins needed for project-specific and network-level pavement testing and evaluation. This paper focuses on the development of backcalculation models based on artificial neural networks (ANNs) for predicting the layer moduli of the jointed plain concrete pavements, that is, the elastic modulus of the portland cement concrete (PCC) layer and the coefficient of subgrade reaction for the pavement foundation. The ANN-based models were trained to predict the layer moduli by using the fallingweight deflectometer (FWD) deflection basin data and the thickness of the concrete pavement structure. The ISLAB2000 finite element program, extensively tested and validated for more than 20 years, has been employed as an advanced structural model for solving the responses of the rigid pavement systems and generating a knowledge database. ANN-based backcalculation models trained with the results from the ISLAB2000 solutions have been found to be viable alternatives for rapid assessment (capable of analyzing 100,000 FWD deflection profiles in a single second) of the rigid pavement systems. The trained ANN-based models are capable of predicting the concrete pavement parameters with very low (<0.4%) average absolute error values. The ANN model predictions and closed-form solutions were compared through the use of the FWD deflection data, and the results are summarized in the paper. In addition, a sensitivity study was conducted to verify the significance of the layer thicknesses and the effect of bonding between the PCC and the base layer in the backcalculation procedure. The results of this study demonstrated that the ANN-based models are capable of successfully predicting the rigid pavement layer moduli with high accuracy. Falling-weight deflectometer (FWD) and heavy-weight deflectometer (HWD) testing have become the main nondestructive testing (NDT) techniques to evaluate structurally in-service pavements over the last 20 years. FWD testing is often preferred over destructive testing methods because FWD testing is faster than destructive tests and does not entail the removal of pavement materials. In addition, the testing apparatus is easily transportable. Pavement properties are backcalculated from the observed dynamic response of the pavement surface to an impulse load (the falling weight). To evaluate the structural condition of in-service pavements and to char-Today, a variety of finite element (FE) programs are available for the analysis and design of pavement systems. The two main categories of FE programs are (a) programs specifically designed for the analysis of pavement systems and (b) general-purpose programs. FE programs such as ABAQUS, ANSYS, and DYNA3D are powerful generalpurpose programs with three-dimensional (3-D) nonlinear dynamic analysis capabilities. In several research studies, these programs have been used successfully for pavement analysis. A number of FE models built by means of these programs have been reported in the literature (10-12). In contrast, considerable computational resources and time needed for analysis of a structural system are among the limitations of the general-purpose FE programs. FE-based programs developed specifically for analysis of concrete pavement systems include ISLAB2000 (13-15), DIPLOMAT (16) , KENSLABS (17 ), WESLIQID (18), J-SLAB (19), FEACONS-IV (20), KOLA (21), and EverFE (22) . Most of these programs can analyze multiwheel loading of one-or two-layered medium-thick plates resting on a Winkler foundation or elastic solid (ISLAB2000, KENSLABS, WESLIQID). EverFE can analyze multilayered pavement systems by means of a 3-D-continuum brick element for the PCC and base layers. ISLAB2000 contains many advanced features that distinguish it from other pavement programs based on plate theory. In addition to the FE programs, Westergaard (23) solutions (plate theory) for PCC pavements are also used to analyze the rigid pavements. ANN trainings are also used for interpreting results from databases of deflection profiles to estimate pavement properties (24-26). Although there are different FE programs and other approaches to analyze the rigid pavements, all methods do not produce exactly the same results. For better understanding of the results produced by different programs, a sensitivity analysis was performed as part of this study. | | |
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| | **abstract** | This paper focuses on the development of backcalculation models based on artificial neural networks (ANNs) for predicting the layer moduli of the jointed plain concrete pavements, that is, the elastic modulus of the portland cement concrete (PCC) layer and the coefficient of subgrade reaction for the pavement foundation. The ANN-based models were trained to predict the layer moduli by using the falling-weight deflectometer (FWD) deflection basin data and the thickness of the concrete pavement structure. The ISLAB2000 finite element program, extensively tested and validated for more than 20 years, has been employed as an advanced structural model for solving the responses of the rigid pavement systems and generating a knowledge database. ANN-based backcalculation models trained with the results from the ISLAB2000 solutions have been found to be viable alternatives for rapid assessment (capable of analyzing 100,000 FWD deflection profiles in a single second) of the rigid pavement systems. The trained ANN-based models are capable of predicting the concrete pavement parameters with very low | | | | | |
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