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UTILIZING THE FALLING WEIGHT DEFLECTOMETER IN EVALUATING SOIL SUPPORT VALUES OF PAVEMENT LAYERS

PROBLEM STATEMENT

The Florida Department of Transportation (FDOT) manages 39,780 lane miles of highways. More than 2,200 lane miles of asphalt pavement of the Florida highway network are rehabilitated every year. To manage rehabilitation efforts and efficiently allocate resources, FDOT pavement evaluation engineers and technicians rely increasingly on nondestructive testing (NDT) techniques to assess the structural integrity of the existing highways and provide the data base needed for improving design and construction techniques of a new generation of pavements and pavement overlays. Among the primary parameters needed for pavement evaluation are the soil support values of pavement layers.

FDOT has been using various NDTs, including Dynaflect and the Falling Weight Deflectometer (FWD), which differ mainly in the type and magnitude of applied loads. These techniques utilize the deflection basin of the pavement surface produced by dynamically applied loads to predict elastic parameters of the pavement layers. Accordingly, in the deformation methods, appreciable surface loads are applied to induce measurable deflections in the pavement layers. Large deflections can be attained from large impact loads. In many cases, it is preferable to apply forces comparable to those of the actual service loads on pavements.

The popularity of the FWD method over other testing techniques is due to various factors, which include technical aspects of the procedure and the acceptance of the technique as a research and production tool. Several studies have shown that impact loads produced by FWD are similar to those produced by actual traffic loads. Additionally, knowing that pavement material properties are a function of the deflection amplitude, light load applications of some NDT techniques such as seismic and Dynaflect methods may not convey the actual pavement parameters. Another aspect for selecting the FWD is the wide acceptance of the testing technique as an important tool for research into pavement design for more than a decade. Also, the device has earned a major role in pavement management. The Strategic Highway Research Program (SHRP) adopted the FWD as a key piece of equipment for assessing the structural capacity of long-term pavement performance (LTPP) test sections. Under the LTPP program, FWD testing is used at all General Pavement Studies (GPS) and Specific Pavement Studies (SPS) test sites. Most sections are tested about once every five years. At selected sections, FWD tests are performed 12 to 14 times a year, every second year, to check for seasonal changes in the pavement strength.

Recent research studies found that back calculated subgrade resilient modulus values should be adjusted by a correction factor C that is between 0 and 1.0. The AASHTO design guide recommends that the values of C should be adjusted to reflect local soil conditions. The adjusted resilient modulus values will be consistent with those values obtained at the AASHO road test. FDOT has replaced the Dynaflect units with the DYNATEST FWD units which can better simulate the traffic loads. Therefore, a research study is needed on the FWD to insure that reliable modulus values can be obtained with the FWD for typical soil conditions in Florida. In addition, the effect of the water table level and temperature on deflection measurements and back calculated resilient modulus values can be evaluated. The ultimate goal is to fully implement the FWD to obtain resilient modulus values for subgrade layers.

OBJECTIVES

For about two decades, the FDOT utilized the Dynaflect test for back calculating resilient modulus values of subgrade. Currently, the FDOT as well many other state highway agencies have replaced their Dynaflect systems with the FWD. As compared to the Dynaflect, the FWD can better simulate the actual traffic loads on pavement. Shifting the emphasis in pavement evaluation from using the Dynaflect method to the FWD method requires that the vast amount of measurements that were taken using the Dynaflect be converted to the FWD method. The simplest procedure to convert the Dynaflect measurements to those of the FWD is to establish a direct correlation between measurements obtained at the same pavement sections and under the same conditions. If a rational relationship does not exist, more parameters such as the geometry of the layers have to be considered in the analysis. Also, to include parameters to such correlation requires a large amount of measurements from both techniques. A study was recently performed at the State Materials Office to statistically correlate modulus values obtained with the Dynaflect and the FWD [1]. That study resulted in an evaluation procedure which produces FWD modulus values consistent with those obtained with the Dynaflect.

The main objectives of this study are to further refine the developed procedure and to insure that the back-calculated modulus values are consistent with the AASHTO design guide.

FINDINGS AND CONCLUSIONS

In this study, several sources of FWD and Dynaflect data were pursued. Among these sources were, field tests on selected sites, data from previous studies such as the SAP project, the FDOT 300 mile test sites, the LTPP database, and the FDOT water table and moisture study. Data from these resources were analyzed using AASHTO, MODULUS, and Dynaflect methods. Moduli values from these methods were compared with each other. The C factor was obtained from all of these tests and found to be in the range of 0.28 to 0.3 for the FWD tests. The characteristics of the deflection basins were investigated and relationships was obtained to predict the FWD deflections from any dropping load. These relationships are site specific, which means each site has its own parameters that are different than the others and these parameters have to be used in these relationships. The water table was found to greatly affect the moduli values of the subgrade. Shallow ground water tables resulted in lower moduli values. The same was found for the effect of moisture content. The higher the moisture content is the lower the moduli values. An analytical model was developed in this study to signify these effects. The finite element analysis gave a close look at the pavement behavior during FWD testing.

FEA was found to be a useful tool as a back-calculation analysis. It is a genuine mechanistic approach for estimating the moduli values. However, it is not a simple approach and not practical for frequent use by non-specialists. The FEA results indicated that the stiffer subgrade moduli values required shorter sensor distances. Selecting the deflection values of D6was found reasonable for most of the pavement sections in Florida. The FEA suggested lower distances in cases of higher stiffness values or shallow bedrock depths. The LTPP database holds a large mount of entries on pavement testing. It contains about 98,000 FWD deflection basin. These basins were used in the study to develop the relationship between the FWD deflections and the dropping load for each testing section. The α, β, , and ζ parameters signify the section properties. These parameters varied based on the geometry and properties of the pavement layers.

The FWD deflection measurements were found to be sufficient to obtain MR values, providing the selection of the proper back-calculation method. The AASHTO formula, after correction, and the EVERCALC, were found to be reasonable methods for estimating the MR values. Unlike widely used MODULUS 5.0, the EVERCALC method has better sensitivity of the selected seed values. Also it notifies the user of any irregular FWD deflection measurements. The repetition of these irregularities is a good indiction of the need for sensor calibration. Also EVERCALC can be used with different operating systems. The lack of history records from the FWD has confined the use of this device to the estimation of the moduli values. If the time-amplitude records are captured, there is a great chance that other pavement parameters can be estimated. The analytical techniques to estimate these additional parameters are available; however, the capability of the current FWD units has to be upgraded more to capture and store all of these records.

In general, the FWD testing technique is suitable for most of the pavement cross sections in Florida except for the thick and rigid surface layers. A great caution must be exercised when back-calculating the moduli values of these sections. It is recommended that more than one back-calculation method be used for these cases. Also the current back-calculation methods are not sensitive enough to predict the effect of temperature variation and the depth of the bedrock. The database that is being gathered from all around the state along with the use of DCP will be of great benefit to provide necessary information about the temperature and layering setup of the Florida pavements. This database should supplement the results of the back-calculation analysis.

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