FALLING WEIGHT DEFLECTOMETER (FWD)

PennDOT's Falling Weight Deflectometer

RITU performs Falling Weight Deflectometer (FWD) testing for the investigation of pavement structural capacity, performance, postings, and other special circumstances, typically as requested by District offices.

An FWD is a device that drops weight, of amounts controlled by the operator, onto a load plate positioned on the pavement surface (usually in the right wheelpath) and measures the deflection of the pavement with seven sensors. These sensors are spaced one foot apart in a series along the device with one sensor located directly over the point of loading. Deflection is measured in "mils," which are thousandths of an inch. The van that tows the test device is equipped with computer system electronics to control the testing and record the measurements. The deflection basin can be determined from these measurements.

Control PC and Camera Monitor

Based on the deflection measurements, mechanistic theory, elastic layer theory, finite element analysis, or other mathematical modeling techniques can be applied to estimate the resilient modulus, modulus of elasticity, or other factors for the pavement, subbase, and subgrade layers. These values can be used to estimate the remaining structural capacity of the existing pavement and determine required structural overlay depths.

On cement concrete pavements, deflection testing can also be used for determining transverse joint load transfer efficiency, and the potential for the presence or absence of subsurface voids. Other uses of deflection testing include the evaluation of maintenance and rehabilitation strategies, bearing capacity surveys, analysis of pavement failure, management of load restrictions, airport pavement design, testing and classification, fatigue tests, and compaction control.

Dynatest Truck Mounted Deflectometer (TMD)

The Department has been performing FWD testing since 1985. RITU currently owns two Falling Weight Deflectometer devices, both are manufactured by Dynatest.

The Dynatest units are model 8000 FWD's. These models are single mass systems capable of testing with weights between 1500 pounds and 27,000 pounds. There is a camera and monitor which allows the operator to view the load plate and properly position the device over the desired test location.

The system hardware consists of an IBM-PC compatible laptop computer system, printer and RS-232C Serial Interface. FWD test equipment is defined in ASTM D 4694; the test method is defined in ASTM D 4695.

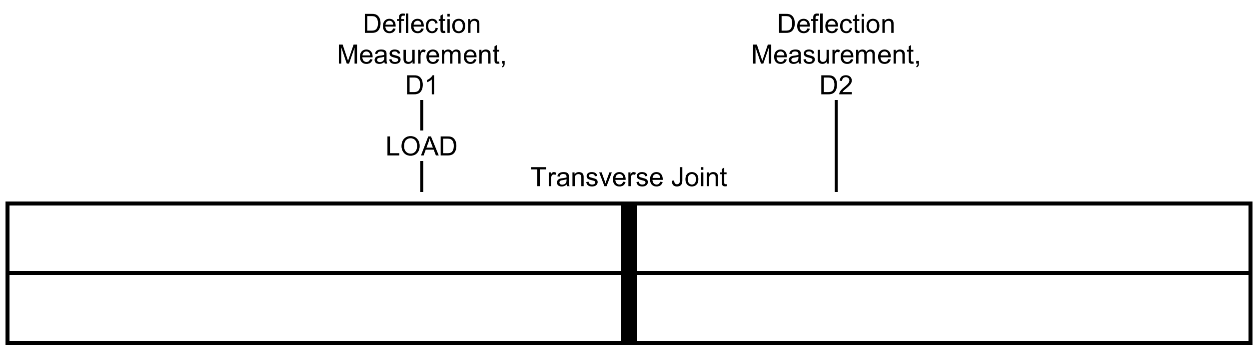
One person is needed to perform testing; the device is positioned at the required location, and testing is performed with the device in a stationary position. RITU performs the FWD testing programs with both a permanent Roadway Programs Technician 2, and a permanent Roadway Programs Specialist. Testing is typically performed during the months of March through November, but can vary depending on weather conditions. If the temperature is below 40 degrees (Fahrenheit) and/or the subgrade is frozen, test results may be misleading or invalid. Deflection testing for determining transverse joint load transfer efficiency or void detection should not be done if the temperature is above 70 degrees (Fahrenheit). At temperatures exceeding this value, the pavement expands and the joints constrict to a point that movement is restricted, leading to invalid test results.

Since the FWD is a device that is stationary during testing, road closure and/or maintenance and protection of traffic is usually required. The number of tests within a project varies, depending on the type of testing, the initial results, and the needs of the customer. The weight dropped during testing varies depending on the results being sought.
To determine resilient modulus, M_R, on flexible pavements, the weight of 9000 pounds is used, which equals the point load (at each tire) on the pavement under an 18,000 pound axle which is the standard load used as the basis for structural pavement design.

There are instances where dropping only 9000 pounds on a rigid pavement does not initiate deflection at any sensor location other than that directly over the load, causing invalid deflection basin results. Therefore, for M_R testing, or any other mid-slab testing on jointed concrete pavements, 16,000 pounds are dropped; the additional weight ensures a properly distributed deflection basin.

The determination of pavement material properties from FWD measurements is referred to as backcalculation. The Department uses DARWin software for this purpose, and for the structural design of pavements. This software embodies the methodology of the "AASHTO Guide for the Design of Pavement Structures". For more information, refer to that manual, the "AASHTOWare DARWin User's Guide", or the "Pavement Policy Manual" (PennDOT Publication 242).

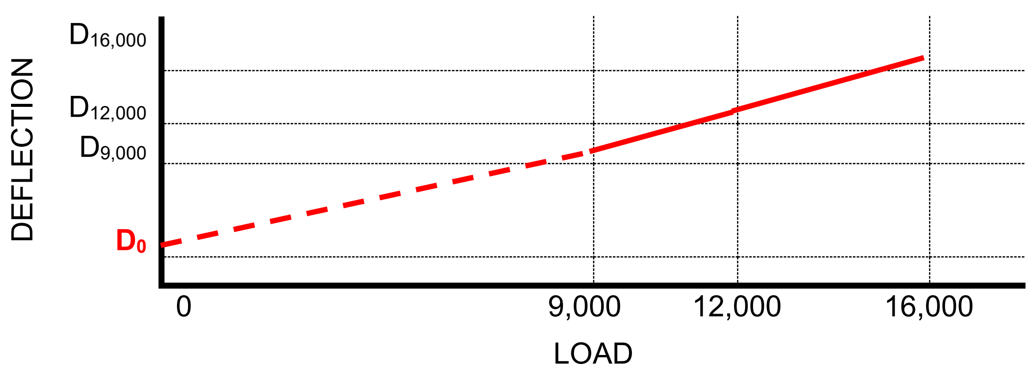
To perform testing of transverse joint load transfer efficiency on rigid pavements or concrete pavements, a weight of 9000 pounds is dropped approximately six inches from the joint, and the deflection at the sensors immediately on each side of the joint are compared, as follows:



The percentage of transfer joint efficiency is simply: (D2 / D1) x 100

Ideally, all of the load would be transferred across the joint, the deflections would be equal on both sides, and the transfer efficiency would be 100%. These tests can be performed by dropping the weight on the side before the joint, after the joint, or multiple tests can be performed by dropping the weight on both sides. In some cases, every joint is tested; in others every fourth or fifth joint is tested.

Void detection testing is usually performed at the same time as transverse joint load transfer efficiency testing. For void detection, deflection is measured at three different weight amounts: 9000 pounds, 12,000 pounds, and 16,000 pounds. By plotting the deflection versus the load, the potential for voids is determined as follows:



By extrapolating the line plotting the measured deflections, the y-intercept can be determined. The y-intercept represents a "deflection" value under zero load, D_0. If D_0 is greater than 3 mils, then the potential for the presence of voids exists.