



TECHNICAL ADVISORY

Published as needed by the Construction and Bridge Divisions - June 2008

Frequently Asked Questions about the Falling Weight Deflectometer (FWD)

➔ WHAT IS A FWD?

The falling weight deflectometer (FWD) is a non-destructive testing (NDT) and non-intrusive device. The FWD has been widely used in pavement engineering to evaluate pavement structural condition. The FWD plays a crucial role in selecting optimum pavement maintenance and rehabilitation strategies. The FWD is a tool used to achieve rapid and repeatable in-situ characterization of the pavement layer stiffness.

TxDOT currently owns 15 FWDs. The first FWD was purchased in 1983. On average, each district utilizes the FWD to evaluate ~60 projects annually. Figure 1 shows a typical TxDOT FWD.



Figure 1. Typical TxDOT FWD

➔ HOW DOES AN FWD WORK?

The FWD applies dynamic loads to a pavement surface, simulating the magnitude and duration of a single heavy moving wheel load. The FWD loading system delivers a transient impulse load to the pavement surface. The pavement response (vertical deformation or deflection) at various distances from the loading plate are measured by a series (usually seven) of geophone sensors (see Figure 2).

The deflection sensors can be adjusted to variable distances from the load plate according to user’s requirement. For TxDOT, the typical spacing in pavement design and structural evaluation is 12 inches between each sensor.

A typical FWD test applies four different load levels at discrete locations; this test is completed in less than two minutes.

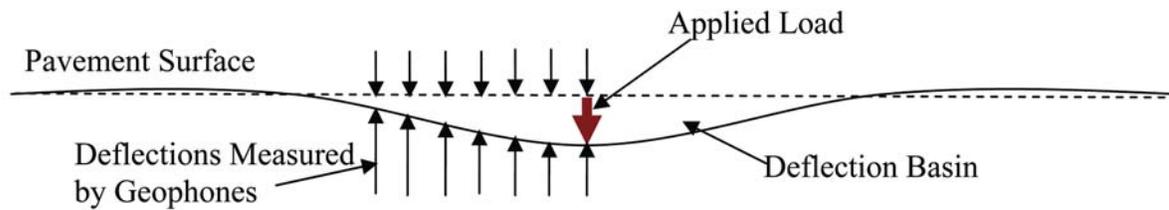


Figure 2. Schematic of FWD load and deflection measurement.

➔ WHAT ARE THE MAJOR COMPONENTS OF A TYPICAL FWD UNIT?

Control system, loading weight and plate, hydraulic system, and geophones (see Figure 3).

The FWD can either be mounted in a vehicle or on a trailer (see Figure 1).

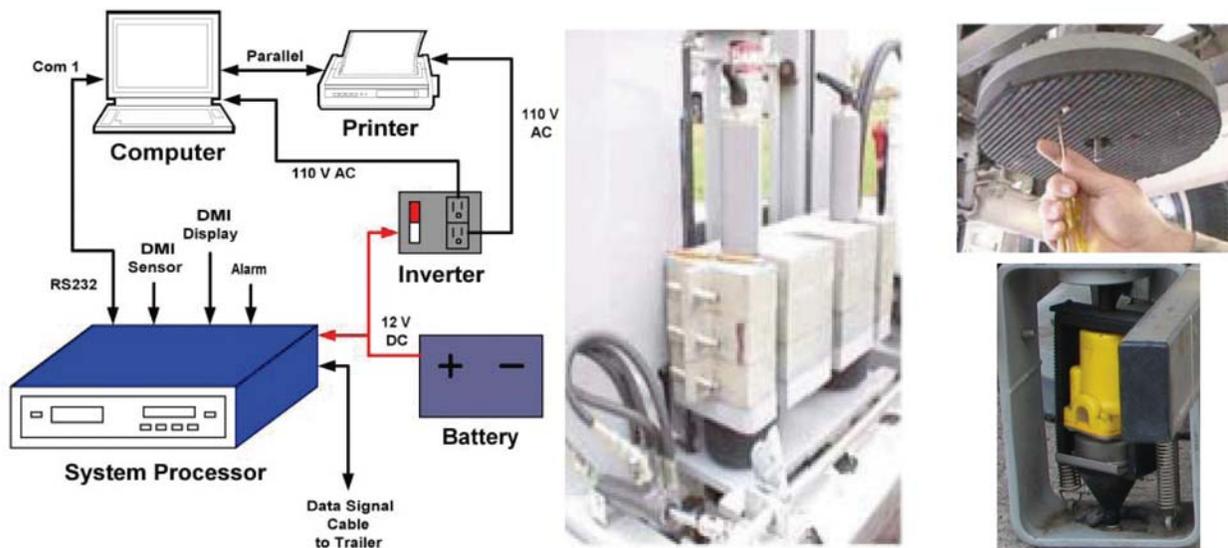


Figure 3. Major components of the FWD unit.

➔ WHAT IS THE PROPER SEQUENCE FOR CONDUCTING A FWD FIELD TEST?

Before conducting the FWD field testing, arrangements must be made for traffic control. The vehicle is at a full stop during testing.

Before starting field testing, a 10-minute warm-up test is strongly suggested to provide more consistent and reliable data.

FWD FIELD TEST PROCEDURE

STEP	ACTION
1	Stop the vehicle and position (lower) the loading plate over the chosen location.
2	Lower the sensors to the pavement surface.
3	Drop weight. NOTE: Multiple tests can be performed on the same location using different weight drop heights.

For project level testing, test a minimum of 30 points, so the results will be statistically valid.

NOTE: Preferably, tests are conducted every 0.1 mile to ensure sufficient data is collected to reflect changes in soil type and pavement structure. Sufficient data allows for irregular data readings to be removed.

In forensic studies, the test pattern should also include points where the pavement is in relatively good condition, and points where distress (the cause of which the engineers are trying to isolate) is present.

During the FWD testing, the air and pavement surface temperatures are measured; these factors can be taken into account later in the analysis.

➔ **WHAT ARE MAJOR FACTORS AFFECTING PAVEMENT DEFLECTION WHEN USING THE FWD?**

Pavement layer thickness, layer material types, material quality, subgrade support, environmental factors, pavement discontinuities and variability within the pavement structure.

➔ **CAN AN FWD BE USED ON BOTH FLEXIBLE AND RIGID PAVEMENTS?**

Yes, the FWD is used to evaluate flexible pavement to determine overall structural strength as well as individual layer stiffness. An FWD is also used on rigid pavement to evaluate the load transfer across slabs and can be used to detect large voids when significant erosion of the base material has occurred under the slab joints. An FWD is commonly used to determine the variability of overall deflection along the roadway alignment.

➔ **WHAT ARE THE REASONS FOR USING THE FWD?**

Support routine pavement design, aid forensic studies, select rehabilitation strategies, route superheavy loads and evaluate their effect on pavement, establish or remove load zones, and support pavement management activities at both project and network levels.

➔ **HOW ARE TXDOT FWDS MAINTAINED AND CALIBRATED?**

Maintenance. Consumable parts, such as buffers and neoprene pads, are checked and verified annually prior to calibration and replaced, if needed, in Austin (Construction Division – Pavements & Materials Systems Branch). Replacement of relays, switches and other easily changeable parts can be made in Austin by the Pavement Systems Branch or at the district location, as needed.

Calibration. FWD calibrations are performed annually. An operator takes the FWD to Austin for whatever mechanical or general system work is needed; the FWD functionality is checked and any repairs are made.

System calibration is performed at either TTI or UTEP facilities; services performed include calibration of the load cell, geophones, distance measurement instrument and temperature sensors.

➔ **WHAT IS BACKCALCULATION?**

Backcalculation is a complex iterative procedure in which the modulus of each pavement layer is determined.

Backcalculation is usually carried out using a computer program. Currently, TxDOT uses the MODULUS® program, developed by the Texas Transportation Institute, to perform the backcalculation of layer moduli and help determine the uniformity of the pavement sections.

The major inputs include surface deflection, structural layers' thicknesses, material Poisson's ratio and initial moduli estimates. NOTE: Temperature at the time of testing must be considered in estimating the initial modulus for any bituminous layers.

➔ HOW IS FWD-COLLECTED DATA USED?

One of the major applications of FWD-collected data is to determine the backcalculation of layer moduli for pavement design and analysis.

Data are usually provided to engineers performing the pavement design and/or the pavement engineer to perform the backcalculation analysis.

➔ CAN I USE THE FWD TO DETERMINE REMAINING LIFE?

Yes. Once the pavement layer moduli are obtained, the compressive strain at the top of the base layer and the tensile strain at the bottom of the asphalt layer can be calculated. These numbers are then used to calculate the remaining number of equivalent single axle loads (ESALs) the pavement can withstand before reaching its breakpoint of rapidly accelerated deterioration. The traffic data can then be used to determine approximately the remaining pavement life before a pavement rehab will be required.

An alternate analysis is provided in MODULUS to provide a simple method of grossly estimating remaining life based solely on the deflections measured.

➔ WHAT ARE THE MAJOR BENEFITS OF THE APPLICATION OF THE FWD IN TXDOT?

Knowledge of the existing pavement condition is vital to the success of any rehabilitation project. The FWD plays an indispensable role in evaluating the pavement structural condition. The goal of lower cost, improved pavement quality demands more precise assessment of the pavement layer qualities, making the in-situ measurement of design parameters like stiffness and modulus necessary.

By applying FWD test results, pavement analyses and design are carried out in a more rational and accurate manner than relying on simple assumptions or engineering judgment. This leads to millions of dollars in construction costs saved, annually, on TxDOT pavement projects.

CONTACT INFORMATION:

For any questions regarding FWD repairs and calibrations, please contact Randy Beck at 512/ 465-3064.

For any questions regarding FWD data collection and analysis, please contact:

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