

EUROFWD10
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Summary of presentation

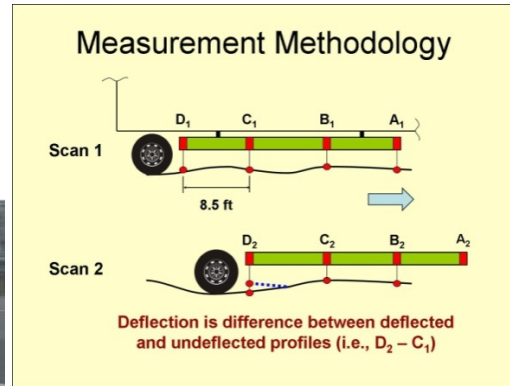
International developments in traffic-speed deflection measurement

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There have been many reviews of this subject over recent years. This presentation will attempt to provide an up-to-date summary of the most promising devices to measure pavement deflection response at traffic speed. It will, in particular emphasize the current status of the various examples of the Danish Traffic Speed Deflectometer.

The authors have had recent involvement in US studies on the subject as well as continuing involvement in UK Highways Agency sponsored developments. The US SHRP2 programme has awarded a two year study on this subject to the Virginia Transportation Research Council and the Transport Research Laboratory. The project is misnamed "Development of continuous deflection device". However the aim of the study is 'to critically assess the potential of existing continuous deflection devices as a practical and cost-effective tool for use in the development of optimum pavement rehabilitation strategies on rapid renewal projects'. It should be noted that the objective is not to develop a device as stated in the project title. The project comprises two Phases. The first, which has recently been completed, has reviewed the state-of-the-art of all available continuous deflection devices, interviewed a sample of US State Highway Departments to assess the demand for and potential value of such devices and prepared a plan for field evaluation of the most promising devices. The second phase will conduct field evaluations of the most promising devices and report the outcome, including recommendations as to what further development and refinement, if any, is needed in order to practically implement such devices in the USA and at what cost. The first Phase has selected two machines for further evaluation the Rolling Weight Deflectometer and the Traffic Speed Deflectometer.

The RWD is based on the spatially coincident method for measuring pavement deflections. Three lasers located in front of the dual-tires (away from the applied load and therefore deflection bowl) are used to measure the unloaded pavement surface, and a fourth laser, located between the dual tires and just behind the rear axle, measures the deflected pavement surface. Deflection is calculated by comparing spatially coincident scans as the RWD moves forward. The RWD applies a 40 kN (9 kips) load through 2 wheels spaced 330 mm (13 inches) apart and surveys at speeds up to 80 km/h (50 mph). The deflection profile is obtained by subtracting the profile of the deflected shape from that of the undeflected shape measured in the same location. The RWD surveys with a 2 kHz sampling rate, i.e. every 11mm (0.5 inches), and averages the deflection values over longer sections, typically 160 m (0.1 mi), to produce a single deflection measurement.



The Rolling Wheel Deflectometer (RWD) and its measurement principle

The TSD is an articulated truck with a rear axle load of 100 kN (22 kips) which, in its current form, utilizes four Doppler lasers mounted on a servo-hydraulic beam to record the deflection velocity of a loaded pavement. Three Doppler lasers are positioned such that they measure deflection velocity at a range of distances in front of the rear axle, (100, 200 and 300mm (4, 8 and 12 inches) and 100, 300 and 750 mm (4, 12 and 30 inches) in the two present prototypes). The fourth sensor is positioned 3.6 m (12 ft) in front of the rear axle largely outside the deflection bowl, acting as a reference laser. The beam on which the lasers are mounted moves up and down in opposition to the movement of the trailer in order to keep the lasers at constant height from the pavement surface. To prevent thermal distortion of the steel measurement beam a climate control system maintains the trailer temperature at a constant 20°C (68°F). Data is recorded at a survey speed of 70 km/h (45 mph) at a rate of 1000 Hz, i.e. a 20mm (0.8 inches) spacing of the raw measurements. These results are usually reported as averaged over 10 m (33 ft).



Picture of two TSD machines at the TRL test track and computer generated schematic

Status of the machines

At present the RWD is a working prototype with only one example of its type in existence. There are two working prototype TSD's with a third model under construction. The manufacturer's website, Greenwood A/S, currently designates the TSD as a production model.

Available interpretation methods

As yet fully developed methods of interpretation are not available specifically for either machine. However, in principle the RWD deflection should be usable as an input to any interpretation method that only requires a maximum deflection response as its pavement response input. As discussed earlier, it is claimed that the velocity measurements from the Danish machine configuration can be used to produce surface curvature index values that are akin to those measured by an FWD. Therefore they should be viable as input of any interpretation method that only requires SCI as its pavement response input.

In the UK the main method for interpreting pavement deflection response uses the maximum deflection measured by a slow moving Deflectograph to estimate residual lives and strengthening requirements. Research in the UK, reported earlier in this section has shown that equivalent Deflectograph values can be estimated from TSD measurements thus providing an approximate interpretation methodology for the English strategic road network. Routine network surveys of this network started in November 2009 and structural condition information will be circulated later in 2010 to the agents responsible for the various parts of the network to assist them with their management of the network.

The above information refers to just flexible pavements. For rigid and granular pavements there is as yet no explicit interpretation method for either machine.

Usage

The following two Tables summarize the current status of survey coverage for each type of machine. For the RWD most of this testing was conducted on flexible pavements with a total survey length of more than 12,100 km (7,500 miles). For the TSD, close to 100% is of flexible construction with a total surveyed length of over 13,000 miles (21,000 km) in the UK. The Danish machine has covered well over 10,000km (6,500miles) in Denmark. In 2010, the machine has been commissioned to cover 20,000km (12,500 miles) of the road networks in two Australian States. As yet little data has been explicitly used for specific pavement management activities so it is not possible to break down the usage of the data into whether for screening structurally deficient sections, defining rehabilitation strategies or designing rehabilitation treatments.

The presentation will conclude with an update on the latest TSD developments and plans for the future.

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Table 1. Summary of Tests Conducted in the U.S.

Location	Year	Month	Lane-Miles	FWD data availability?	FWD Sampling Frequency	Repeat Runs	Road functional class
Louisiana	2009	--	N/A	Good			
Kansas	2008	--	466	Good	0.1		U.S. and state
New Mexico	2008	September	443	Good	0.1		U.S. routes
Colorado	2008	October	230	Partial	0.1		Int., U.S., and state
New Hampshire	2007	July	712	N/A	N/A		Int., U.S., and state
Connecticut	2007	September	204	N/A	N/A		Int., U.S., and state
Kansas	2006	July – August	506	Good	0.1	Research sites	U.S. and state
Iowa	2006	July	278	Good	0.1		Int., U.S., and state
Oregon	2006	June – July	579	Partial	0.1		Int., U.S., and state
California	2006	June – July	685	N/A	N/A	Research sites	Int., U.S., and state
Virginia	2005	Oct	488	Partial	0.1	3 int., 2 prim.	Int., U.S., and state
New Jersey	2005	October	803	Partial	Varied		Int., U.S., and state
Minnesota	2005	September	*	Partial	0.1	MnRoad Sites	U.S., State, and county
Kentucky/ Ohio/ WV	2005	September	437	Good in OH	0.1		Int., U.S., and state
Indiana	2004	September	688	N/A	N/A	Yes	U.S. and state
Natchez Trace	2004	November	800+	N/A	N/A		U.S. Park Service
NCAT	2005	July	**	N/A	N/A	Yes	Test Track
Texas	2003	July	264	Good	***	Yes	38 Test sections; U.S. and state routes
TOTAL			7,583+				

* Testing on County Roads and MnRoad Facility - mileage not rerecorded

** Testing at varying speeds on 1.3 mile test track - mileage not recorded

*** FWD, MDD and RDD testing on specific spots - See Report for details (FHWA 2009)

Table 2. Approximate lane km/miles surveyed by the UK HA TSD by type of survey from September 2005 to February 2010

Survey description	Approximate length surveyed
European continent	350 km/220 miles
TRL track	1300 km/800 miles
Local roads	10,400 km/6,500miles
Scottish road network	800 km/500 miles
English trunk road and motorway network	8,200 km/5,100 miles
TOTAL	21,050 km/13,100 miles