CENTER FOR TRANSPORTATION RESEARCH
THE UNIVERSITY OF TEXAS AT AUSTIN

Project Summary Report 0-4357-S
Project 0-4357: Further Development of the Rolling Dynamic Deflectometer to Increase Test Speed

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# Improved Testing Speed of the Rolling Dynamic Deflectometer: A Summary

The Rolling Dynamic Deflectometer (RDD) is a nondestructive deflection testing device developed by researchers at The University of Texas at Austin in the 1990s. The developmental work was funded by Texas Department of Transportation (TxDOT) Research Project No. 0-1422. The RDD, which is used to measure continuous deflection profiles along highway and airport pavements, is an effective tool for identifying critical sections, cracks, or joints along a pavement test section that need repair. It is also an effective tool for monitoring deterioration in pavement sections over time. A schematic diagram of the RDD is shown in Figure 1.

During the last decade, the RDD has been used in many different project-level studies of highway and airport pavements. The continuous deflection profiles have often been used in making pavement rehabilitation decisions. The RDD uses a contact-type rolling sensor to measure dynamic deflections of the pavement. Currently, the first-generation rolling sensor limits the testing speed of the RDD to about 1 mph (1.6 km/hr). A photograph of the first-generation rolling sensor is shown in Figure 2. The limiting speed is controlled by the size of the wheels (6 inches or 152 mm in diameter) of the rolling sensors. If testing is performed at speeds faster than 1 mph (1.6 km/hr) using the first-generation rolling sensor, the sensor can decouple from the pavement and invalidate the measurements. To increase the testing speed of the RDD, TxDOT contracted with The University of Texas at Austin's Center for Transportation Research to develop a second-generation rolling sensor. This report summarizes the findings of TxDOT Research Project No. 0-4357.

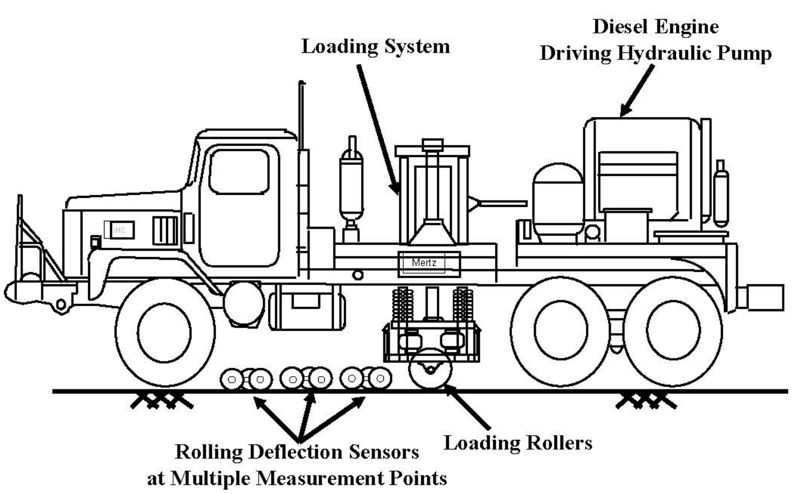



*Figure 1: Schematic Diagram of the Rolling Dynamic Deflectometer*

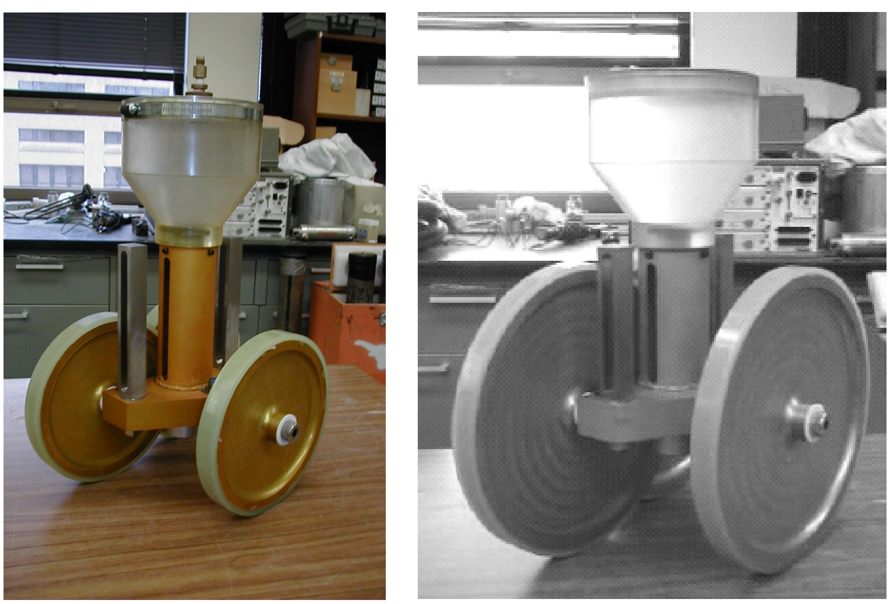
## What We Did...

The main objective of the research was to increase the RDD testing speed from 1.0 mph (1.6 km/hr) to 3.0 mph (4.8 km/hr). To achieve this, the research team developed new second-generation rolling sensors. There were two major factors involved in developing the second-generation rolling sensor. First, a hold-down force was added to the sensor so that the sensor does not decouple from the pavement when traveling at 3 mph (4.8 km/hr). Second, the level of rolling noise was decreased by enlarging the wheel size. After a number of rolling sensor design iterations, second-generation rolling sensors using the final design were constructed. This sensor design has an air spring system to apply a hold-down force on the rolling sensor. Application of a hold-down force prevents the rolling sensor from decoupling from the pavement surface when tested at speeds of 3 mph (4.8 km/hr). Furthermore, larger-diameter wheels (9 inches/229 mm and 12 inches/305 mm) were built to decrease the level of rolling noise. Both the decoupling performance and level of rolling noise were evaluated during field trials that were carried out at the Pickle Research Campus (PRC) at The University of Texas at Austin.


*Figure 2: Photograph of the First-Generation Rolling Sensor*

**Design and Construction of Second-Generation Rolling Sensor**

During the duration of the project, two rolling sensor designs evolved. The first design provides an additional hold-down force by adding a mass suspended on a soft spring, and the second design provides an additional hold-down force by pressurizing a "massless" air spring located on top of each rolling sensor. In the end, the second-generation rolling sensors were built using the second design, which uses an air spring to provide an additional hold-down force. This design was preferred because it allows a larger hold-down force to be applied, and the geophone is located lower in the rolling sensor assembly. Four rolling sensors were constructed using the second design. Due to space limitations beneath the RDD truck, second-generation rolling sensors with two different wheel diameters were built. Photographs of the second-generation rolling sensors are shown in Figure 3, with either 9-inch (229 mm) or 12-inch (305 mm) diameter wheels. Before the rolling sensors were tested in the field, each second-generation rolling sensor was calibrated on a shake table in the laboratory. The detailed design, fabrication, and laboratory calibration procedures of the second generation rolling sensors are discussed in Report 0-4357-1.



(a) 9-in. (229-mm) diameter wheels

(b) 12-in. (305-mm) diameter rolling wheels

*Figure 3: Photographs of the Second-Generation Rolling Sensors*

**Evaluation of Performance of Second-Generation Rolling Sensor**

The performance of the second-generation rolling sensor was evaluated and compared with the first-generation rolling sensor in a series of field trials conducted at the Pickle Research Campus. The rolling sensor is a critical component in RDD testing. The sensor is a contact-type sensor that rolls along the pavement surface and measures the dynamic deflections of the surface created by the dynamic loading from the RDD loading rollers (see Figure 1). During testing, the rolling sensor needs to stay coupled with the pavement surface to make correct pavement surface deflection measurements. Furthermore, the level of rolling noise that is generated as the rolling sensor moves along a pavement surface can affect the measurement accuracy. Based on these design considerations, the research team used two criteria to evaluate the performance of the second-generation rolling sensor: (1) level of rolling noise, and (2) speed at which the rolling sensor decouples from the pavement.

Preliminary field trials were carried out to evaluate the level of rolling noise and decoupling performance of the second-generation rolling sensor. Both the first-generation and second-generation rolling sensors were compared using these two criteria. Field trials were performed at the Texas Accelerated Pavement Testing (TxAPT) site at PRC using the RDD.

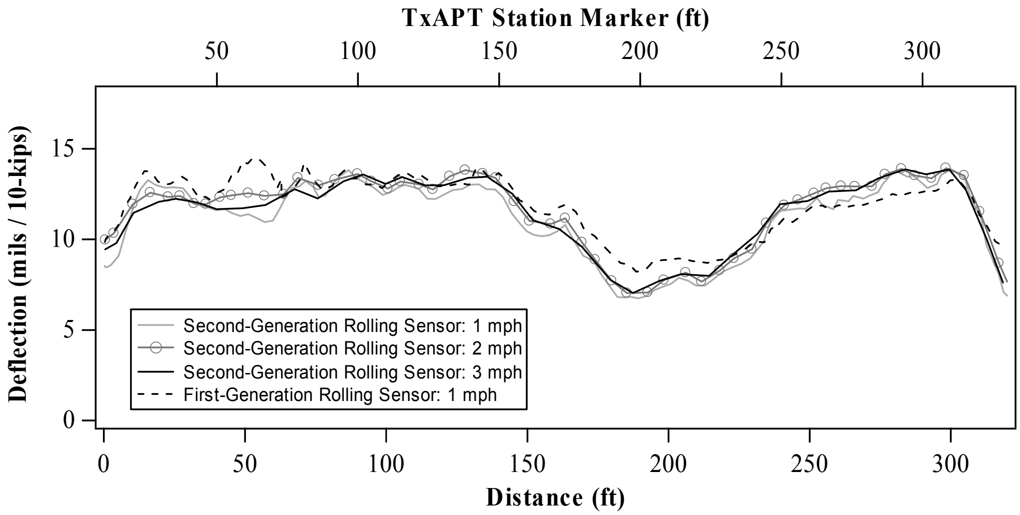



*Figure 4: RDD Continuous Deflection Profiles Collected Using the Second-Generation Rolling Sensor (After Temperature Correction)*

Continuous deflection profiles using the first-generation and second-generation rolling sensors were collected at different testing speeds. These deflection profiles are presented in Figure 4 to demonstrate the ability of the RDD to collect continuous deflection profiles at a testing speed around 3 mph (4.8 km/hr) using the newly developed second-generation rolling sensor.

## What We Found...

The second-generation rolling sensor was designed, built, and tested in a series of field trials at PRC. With this sensor, the RDD testing speed can be improved from 1 mph (1.6 km/hr) to 3 mph (4.8 km/hr). Several observations may be made regarding the second-generation rolling sensor.

First, the second-generation rolling sensor design with an air spring system allows significant hold-down force to be applied with small changes of air pressure in the pressurized air spring. This additional hold-down force effectively maintains coupling of the rolling sensor with the pavement surface at the target testing speed.

Second, the second-generation rolling sensor has a lower level of rolling noise when compared with the first-generation rolling sensor. This is primarily due to the larger-diameter wheels used in the second-generation sensor.

Third, the second-generation rolling sensor has a more uniformly distributed rolling noise spectrum than the first-generation rolling sensor. This distribution avoids having rolling noise concentrated in the RDD operating frequency range. This noise distribution also allows the digital filter that is used to extract the sensor output at the measurement frequency to be more successful in removing noise from the RDD measurements.

Fourth, the second-generation rolling sensor maintained coupling with the pavement surface at a speed of 3 mph (4.8 km/hr) during field trials. During the field trial at the TxAPT site, it was shown that the deflection profiles collected at 1, 2, and 3 mph (1.6, 3.2, and 4.8 km/hr) are consistent and repeatable (see Figure 4).

## The Researchers Recommend...

In this project, the research team developed a working design of a second-generation rolling sensor for RDD testing. This second-generation rolling sensor achieved the target test speed of 3 mph (4.8 km/hr) during field trials. However, due to time and cost limitations, the towing frame arrangement currently used with the first-generation rolling sensors could not be redesigned and constructed so that the second-generation rolling sensors have not been implemented in the RDD. A new towing frame needs to be designed and constructed which would have the following characteristics:
(1) position the second-generation rolling sensors at locations where the deflection basin is measured;
(2) have sufficient self-weight to provide the reaction force required by each air spring;
(3) have a raising and lowering mechanical system which would minimize: (a) the installation time of the rolling sensors in the field, and (b) the transfer time from one measurement path or location to the next path or location; and
(4) be of the proper configuration to fit within the limited space around the RDD loading-roller mechanism.

## For More Details...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The research is documented in the following report:

0-4357-1 *Improved Testing Speed of the Rolling Dynamic Deflectometer*

To obtain copies of a report: CTR Library, Center for Transportation Research,
(512) 232-3126, email: ctrlib@uts.cc.utexas.edu

## Your Involvement Is Welcome!

## Disclaimer

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