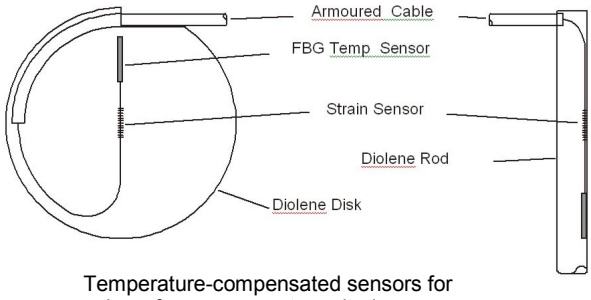
Road Pavement Monitoring

Project	Development of a mechanism for monitoring compressive strains in road pavements for detection of pavement deterioration, and for possible weigh-in-motion
Client	Kellogg, Brown and Root Ltd
Date	2002, 2004
Location	Leatherhead, England
Sensors	Custom packaged sensors
Attachment	Pavement Embedment
Interrogator	OFSSSI
Images	 Temperature-compensated sensors for sub-surface pavement monitoring  FWD test Instrument
Results	Road pavements have a multilayered structure, with each layer having different depths and relative proportions of hardcore and bituminous material. Models relating the load behaviour of the road surface to the stiffness of these layers and the integrity of the interfaces between them may be used to predict the condition of the roadway from measurements of surface deflections in response to an impulse load. However, the verification of these models, particularly over the long term as the roadway degrades, has proved difficult due to the unavailability of stable, sensitive strain transducers, rugged enough to survive long-term embedment in the pavement. In a collaborative project with Kellogg, Brown and Root Ltd., Smart Fibres developed packaged FBGs for retrofitting into an existing road. Two types of sensor were produced: a disk configuration for measuring horizontal strains and a rod configuration for vertical strains. The material of the sensor bodies, Diolene (polyester yarn) fibres in a polyester resin matrix, was chosen because it had a similar modulus to the roadbase material (4.4 to 5.2 GPa, depending upon fibre orientation). The roadway was instrumented by removing 170 mm diameter cores and backfilling with a cold-curing road repair mix for the disks, or drilling holes for rods. In both cases, the sensors were bonded in position with a cold-curing epoxy grouting compound. Two forms of controlled loading were performed to test the performance of the sensors. Transient loads were applied with an instrument known as a Falling Weight Deflectometer (FWD), a standard piece of equipment for estimating the state of the sub-surface structures of bituminous roads. This machine simulates the passage of a vehicle at speed over the road surface by dropping a known weight from a known height and measuring accurately the deflections of the road surface at several points up to 3 m distant from the impact point. The models mentioned previously are then used to derive sub-surface elastic moduli and hence calculate residual life. Data were also recorded as a bus, unladen weight 12760 kg, was driven over the sensors.

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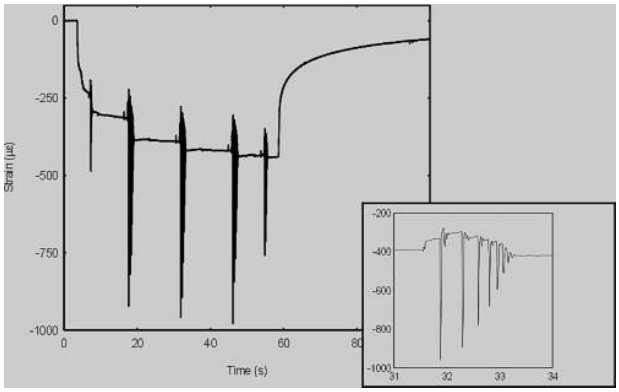
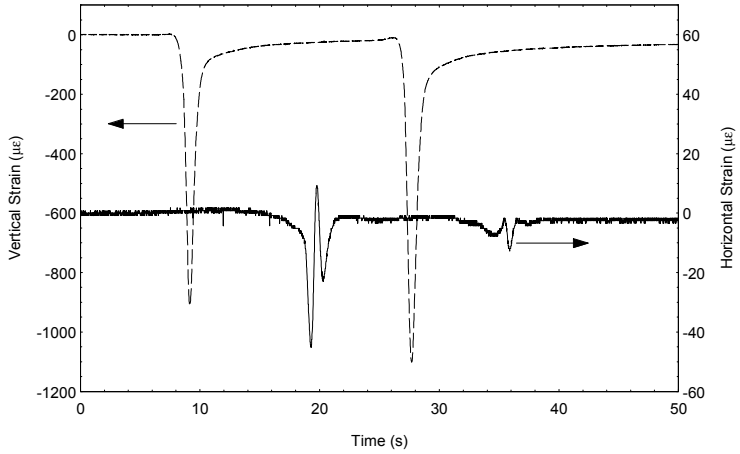
Results

Shown below is a time history of vertical strains measured by a rod sensor during a series of FWD tests. At the start of the test, the FWD machine was lowered onto the road surface, giving a compressive strain of approximately 250 □□. Five impacts followed, a small one to settle the machine, then three larger ones of 130 kN and one of 50 kN. Finally, the initial compressive strain was recovered as the machine was raised and moved off. The inset figure displays a single impact event in detail, showing the primary impact followed by rebounds of decaying energy.



Response of rod sensor to five successive FWD tests. Inset: detail view of third impact at 32 seconds

Shown below are time histories of the response of the sensors to the passage of the bus. The vertical sensor shows the expected compression, lower for the front wheel and higher at the rear, and the hysteresis of the pavement. The response of the disk was more complex, displaying compressive strain as the wheel approached, extension when the wheel was above the disk and compression again as the wheel moved away. The rear wheels may not have tracked straight over both sensors, causing the second peak in the horizontal strain trace to be smaller than the first.



Response of rod (dotted line, left y-axis) and disk (solid line, right y-axis) sensors to the passage of the bus at walking speed

The trials have indicated that, as well as being used to validate models of pavement behaviour, data from embedded sensors could be used for long-term health and traffic monitoring.

Plans are currently being discussed to now increase the scope of the trials to instrument a large (multi-km) length or motorway road pavement.

Further information

Contact us