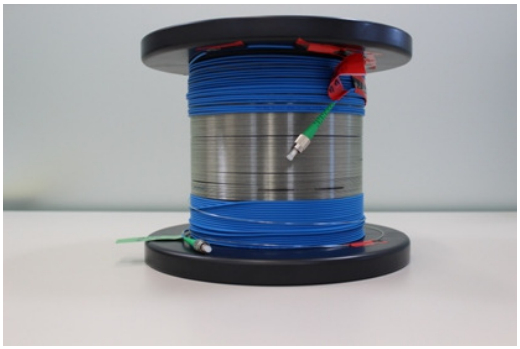
Dynamic monitoring of concrete structures using fibre optic sensing cables

Monitor Optics Systems (MOS) distributed strain and temperature sensing cables based on optical sensing technology, have been installed within concrete beams to demonstrate the resolution and range of the sensors with the view to using them on large scale concrete structures that require continuous monitoring.

The trial was undertaken to demonstrate to Network Rail (NWR) that the sensors were capable of monitoring dynamic strains to understand the 'structural health' of post tensioned structures. The use of MOS's strain sensing cables was seen by Datum monitoring (NWR's monitoring contractor) as the only viable system which could meet both the dynamic requirement and strain sensitivity required for long term continuous monitoring.

The sensor selected for this application was a standard 1mm diameter fibre glass sensing cable which can have large numbers (up to 40) of distributed sensors (Fibre Bragg Gratings-FBG's) on a single cable. The sensing cable was embedded into a 3mmx5mm groove in the beam using epoxy resin as shown below. A flat profile cable can also be adhered to the surface of a structure.



1mm strain cable

1mm cable embedded in 5x5mm groove

The aim of the tests was to prove that MOS FBG sensing cables are able to monitor a pre-stressed beam and detect failure of a reinforcing element within the beam. This was demonstrated by loading the beam using a hydraulic jack and pressure cell and monitoring the strain changes within the beam during this process. Whilst under load a reinforcement bar was cut so it could be seen that the sensors could detect the changes in strain within the beam during a failure scenario in real time.

Exposed reinforcement bar to be cut

Instrumented beam and test rig

Sensing Network

A total of two strain cables each containing three FBG sensors where installed in the beam with the sensors at equal spacing's along the beam. One cable was installed in the upper surface of the beam whilst the other in the lower surface, so compression and tension could both be measured. One MOS temperature sensor was also used to provide temperature compensation to the strain sensors.

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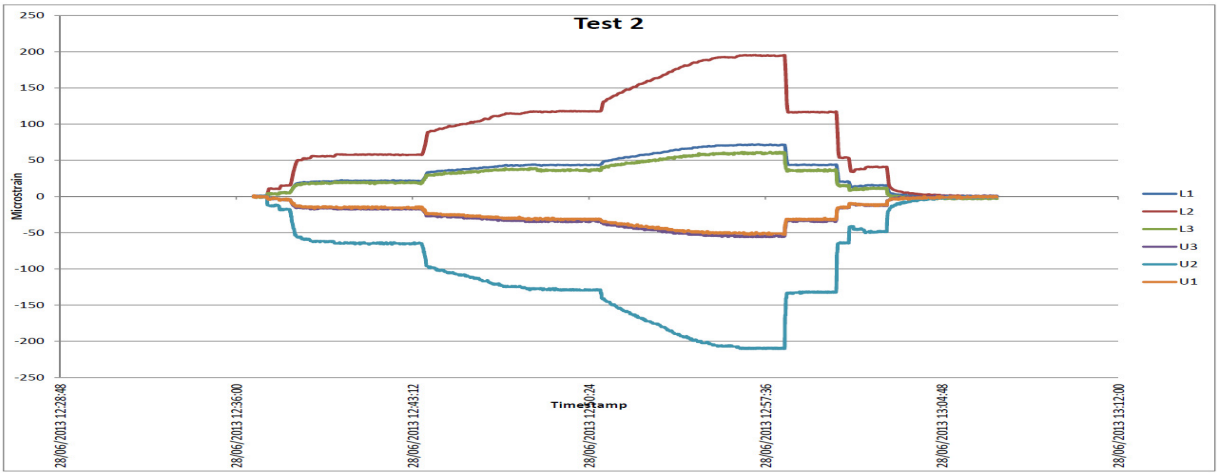
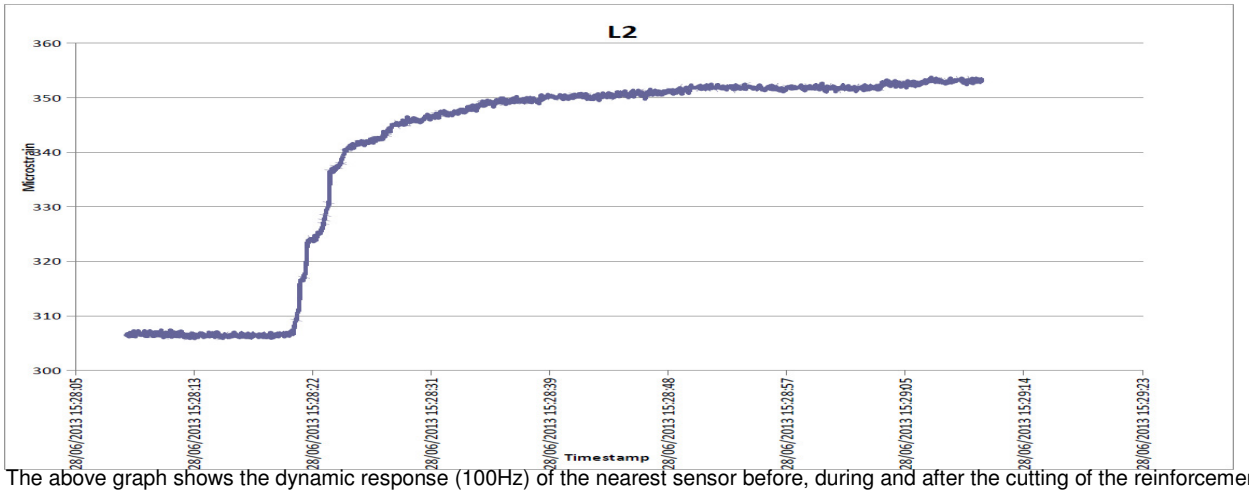


During the test a good relationship between applied load and measured strain was observed. The FBG sensors recorded a reduction in strain on the upper surface of the sleeper and an increase in strain on the lower surface.



The above graph shows the dynamic response (100Hz) of the nearest sensor before, during and after the cutting of the reinforcement

Data acquisition & processing

Demodulation of the FBG system was provided by a Micron Optics Inc (MOI) SM130 interrogator controlled via a TCP/IP connection by a process module running MOI Enlight software.

Data was acquired at 100 Hz (100 times per second) for the dynamic events. Analysis of the strain variations would allow an asset manager to understand the 'structural health' of the asset, assisting with inspection regimes, pro-active maintenance and asset life management.

Results

- MOS FBG strain cables, epoxy bonded into shallow groves in the surface of a reinforced concrete beam, are capable of detecting the failure of a reinforcement strand within such a beam.

- Long term monitoring of concrete beams by MOS FBG strain cables can provide data that can provide data sensitive to detect failures, detect when critical maintenance is required, assess the effect of structural repairs, determine the rate of structural deterioration, aid in the development of maintenance and access regimes and even determine rail traffic patterns.