EpsiMon
INFRASTRUCTURE MONITORING

HS2 Tilehouse Lane Cutting

Hertfordshire, United Kingdom

Monitoring sub-surface ground movement using a FO-instrumented geogrid

Tilehouse Lane Cutting (TLC) is located along a section of the UK's High-Speed 2 (HS2) railway. The cutting, which is approximately 710 m long and up to 13 m deep, connects the Colne Valley viaduct to the south with the Chiltern Tunnel to the north. The geology of the area consists of chalk and contains several dissolution features ranging from 0.5 m to 2.0 m in diameter. These presented a significant engineering risk, particularly during the construction of the railway, when TLC was being used as a haul road to transport very heavy loads of precast concrete segments.

As part of the mitigation strategy developed by the design engineers, Jacobs, and the main contractor, ALIGN JV, Epsimon installed a fibre optic (FO) instrumented geogrid at the base of the cutting. This was monitored continuously to detect and localise changes in strain anywhere within the instrumented area and thereby provide early warning of any movement that could occur beneath the haul road.

Challenges and solutions

One of the main challenges when using buried FO cables to monitor ground movement is **preventing slippage between the cables and the ground**. *Sensorgrid*, developed jointly by Huesker, Cambridge University and Epsimon, is a standard ground reinforcement geogrid in which some of the yarns are replaced with strain-sensing FO cables during production. This ensures that, when buried within earthworks, any ground movement that occurs beneath the surface is transferred to and can be measured by the FO cables.

Additionally, the FO cables have to be robust enough to withstand the localised pressure induced by fill material potentially containing sharp aggregate and rocks. **Extensive prototype testing** was carried out in the laboratory as well as field trials, in order to ensure that the steel armoured FO cables within the *Sensorgrid* can **detect ground movement from a very early stage up to complete ground failure**, without being damaged.

Project highlights

- Geogrid with integrated fibre optic cables placed at the base of a 13 m-deep cutting
- 20 parallel sensing lines at 0.5 m spacing, providing over 9500 measurement points across a 100 m-long x 10 m-wide area
- Continuous monitoring of vertical ground movement for 22 months
- Real-time data processing and visualisation helped the contractor ensure safe operation of the haul road throughout construction

Technology used

- Distributed temperature & strain sensing (DTSS)
- Brillouin optical time domain analysis (BOTDA) spectrum analyser

Monitoring objectives and solution

The purpose of the instrumentation was to provide **early warning of potential ground movement** beneath a 100 m-long x 10 m-wide section of TLC, where the highest concentration of dissolution features was known to be present. This would enable the contractor to implement targeted ground remediation measures before the movement could disrupt the construction. The monitoring system was required to:

- detect vertical subsidence from a very early stage;
- pinpoint the location and extent of the affected area;
- record the evolution of the ground movement over time, such that trends and rate of change could be used to inform decision making.

Two 5 m-wide strips of ***Sensorgrid*** were laid at the base of the excavated cutting, providing 20 parallel FO cables at 0.5 m spacing across the 10 m-wide haul road. **Distributed fibre optic sensing** (DFOS) technology transformed these cables into a network of sensors that could detect any ground movement occurring in their vicinity. A temperature-sensing FO cable was also tied to each strip, to enable temperature compensation of the strain measurements. The instrumented geogrid was sandwiched between two layers of non-woven geotextile for protection and subsequently overlaid with a 2m-thick layer of compacted chalk fill.

A BOTDA spectrum analyser was used to take **readings at 0.2 m intervals** along the buried FO cables every hour, **continuously for 22 months**. The measurements were automatically processed with Epsimon's cloud-based ***Real-Time Monitoring System*** (*RTMS*), which displayed the data graphically on an online dashboard within a few seconds of the measurement having been recorded.

Project details

- **Clients: ALIGN JV, Jacobs, Cambridge University**
- **Timeline: May 2022 to March 2024**

Scope of services

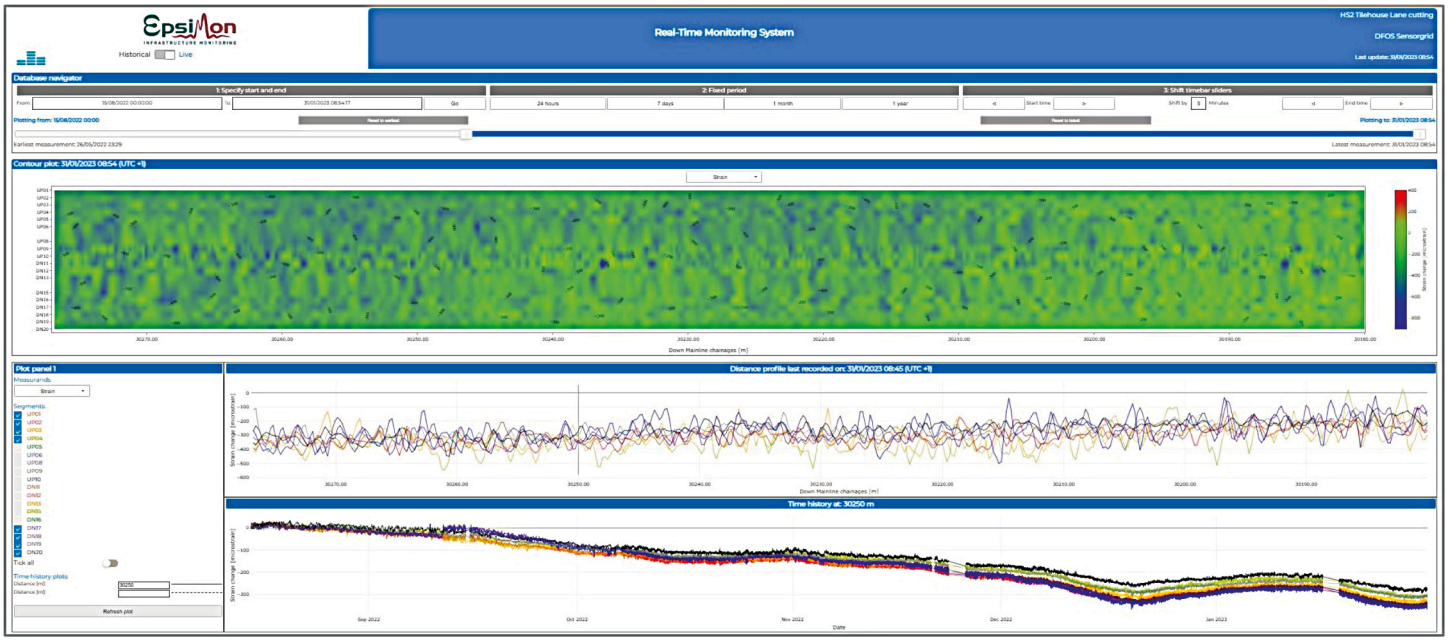
- **Installation of the FO instrumentation**
- **Development of bespoke data processing algorithms**
- **Operation of the monitoring system, including real-time data processing and visualisation**

Key outcomes and benefits

The monitoring data enabled the project engineers to **track any changes in sub-surface ground movement** and relate them to construction activities and seasonal effects. The back-filling of the cutting during the first few weeks of monitoring resulted in localised pockets of ground movement which were clearly observed on the data dashboard.

However, once the back-filling was completed and the cutting started being used as a haul road, the levels of strain measured across the instrumented area throughout the rest of the monitoring indicated that **no significant sub-surface movement was occurring**. The live data reassured the contractor that works could progress safely and that no additional ground remediation measures were required.

Scan for digital version



Screenshot of the *Real-Time Monitoring System* online dashboard displaying the live and historical monitoring data in various graphical formats.