

Instrumentation and monitoring: Early warning hopes

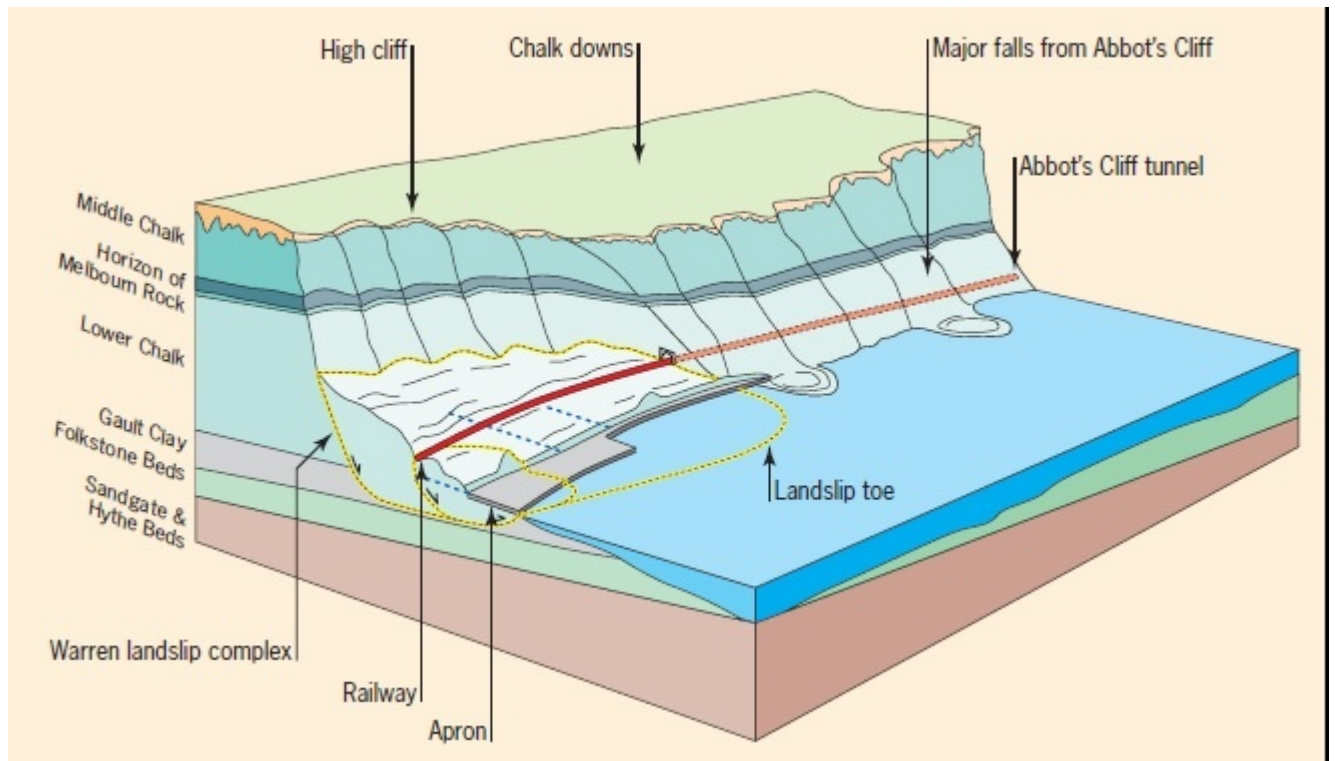
25 JANUARY, 2016 BY [CLAIRE SMITH](#)

Predicting movement on a known landslide complex is not a simple task but Network Rails hopes that a new monitoring system in Kent will provide some early indications.

Rail services between Folkestone and Dover are currently suspended but the reason is not the same one that has led to £1M of investment in monitoring and surveying in the area. Failure of a sea wall next to the rail line near Dover is the culprit for the lack of rail services this time, rather than the landslide complex at Folkestone Warren.

Ground movement of the landslide has led to many closures since the line was first opened in 1844, with the longest being four years, and catastrophic failure still remains a real risk (see box). However, Network Rail hopes that work currently underway will provide an early warning system that will allow it to suspend rail services ahead of any failure.

The landslide complex within the Chalk and Gault Clay deposits is 1.7km, so stabilisation is not an option and neither is re-routing of the rail line. Normally the rail line carries 50 train services a day including high speed services.



Ground movements have affected the rail line since it opened in 1844

Various monitoring systems have been installed at the site in the past but none have given clear detail about ground movement at depth.

“In the 1980s the risk was managed by basic surface monitoring,” says Network Rail route asset manager for geotechnics on the south east route Derek Butcher. “We dabbled with electrolevels and tiltmeters but none of them proved to be long-term solutions as the wires were often broken by tamping operations. We still carry out expert walkovers once a year, track monitoring and earthworks monitoring but it is more of a watching brief.”

In the last 10 years £10M has been invested at Folkestone Warren with much of the money spent on maintaining and improving the rock revetment and the toe weighting apron to minimise movement in the coastal margins. Network Rail came to the end of a 10-year management plan for the landslide complex last year and started to

look at how the issue could be better managed or monitored which has led to the current installation work.

Network Rail's main contractor Costain is overseeing installation of monitoring equipment at the site in two phases with ESG undertaking the drilling work and Getec carrying out the monitoring elements. This forms around £550,000 of the £1M investment with the remainder being spent on laser scanning of the landslide complex to help identify geomorphological changes.



Boreholes are being constructed next to the rail line in the first phase and will be followed by a second phase on the back scar of the landslide

“The first stage involves constructing two 70m boreholes close to the rail line and Getec is installing a Shape Array Accelerometer (SAA), supplied by Geotechnical Observations, into the first hole,” says Butcher. “The second borehole will contain four vibrating wire cable extensometers and four piezometers located within the different geological horizons to measure heave and settlement. At the surface there will be a weather station to monitor the rainfall, temperature, wind speed and direction to aid a better understanding of how the weather impacts the extent of landslide movement.”

The second part of the work involves installation of two 8m long horizontal tilt arrays, also supplied by Geotechnical Observations, which will be installed in trenches outside of Network Rail’s land at the top of the landslide back scar and crossing a tension crack.

“The system at the top of the cliff will be linked to the Folkestone East signal box as it is movement in this area that could signal catastrophic failure,” says Butcher. “The trackside monitoring equipment will feed data to Getec’s online system that will be checked periodically as movement here is expected to be slower but could still cause issues for track alignment.”

When GE visited the site, the first borehole had been completed and installation of the monitoring equipment was about to start. The second phase of the work can only get underway once planning permission has been granted.

“Wireline casing was used to enable core recovery from the first borehole and this showed the expected progression from Chalk rubble through the Gault Clay and into the Folkestone Beds,” says Butcher. “Groundwater was encountered at 10m and two slip surfaces were also observed – one at 23.3m below ground level at the boundary of the Chalk and Gault and the other at 55.75m in the sulphur beds between the Gault and Folkestone Beds.”

ESG had a full time geologist on site to log the cores and CH2M associate director Colin Warren also visited the site to help identify the slip surfaces and other features. Warren has also provided advice about where to locate the piezometers and extensometers in order to gain the most useful data.

According to Getec project engineer Justin Roffey, the SAA being installed at Folkestone Warren is probably one of the deepest vertical installations of this type in the UK.



Two 70m boreholes are being installed to hold the monitoring equipment

“The borehole for the SAA was drilled to just over 71m and will be grouted over the bottom 15m to allow the SAA to be anchored at its base,” says Roffey. “The orientation of the array is key to getting the best data and Colin Warren has been providing us with guidance on this. The array is much better than inclinometers as it is more flexible.

“The piezometers in the second borehole will provide pore water pressure data within the Folkestone Beds, Gault and Chalk. These are formed by silicon cables with a nylon tube on the outside due to concerns over shearing or slack cables and better allow for the expected movement.

“The deepest of the extensometers will be placed at 65m to provide baseline data and all will be anchored into position. Movement will be measured by gauges in the headworks, which are normally used in the mining sector as conventional transducers would not be able to cope with the ground movement here.”

The tilt array planned for the second phase of work is also unusual, according to Roffey. “The tilt array is a new instrument that is formed from three sets of accelerometers joined by Kevlar rope, which will be installed at 1.5m below ground level,” he says. “Bespoke-designed horizontal wire extensometers will also be installed.”

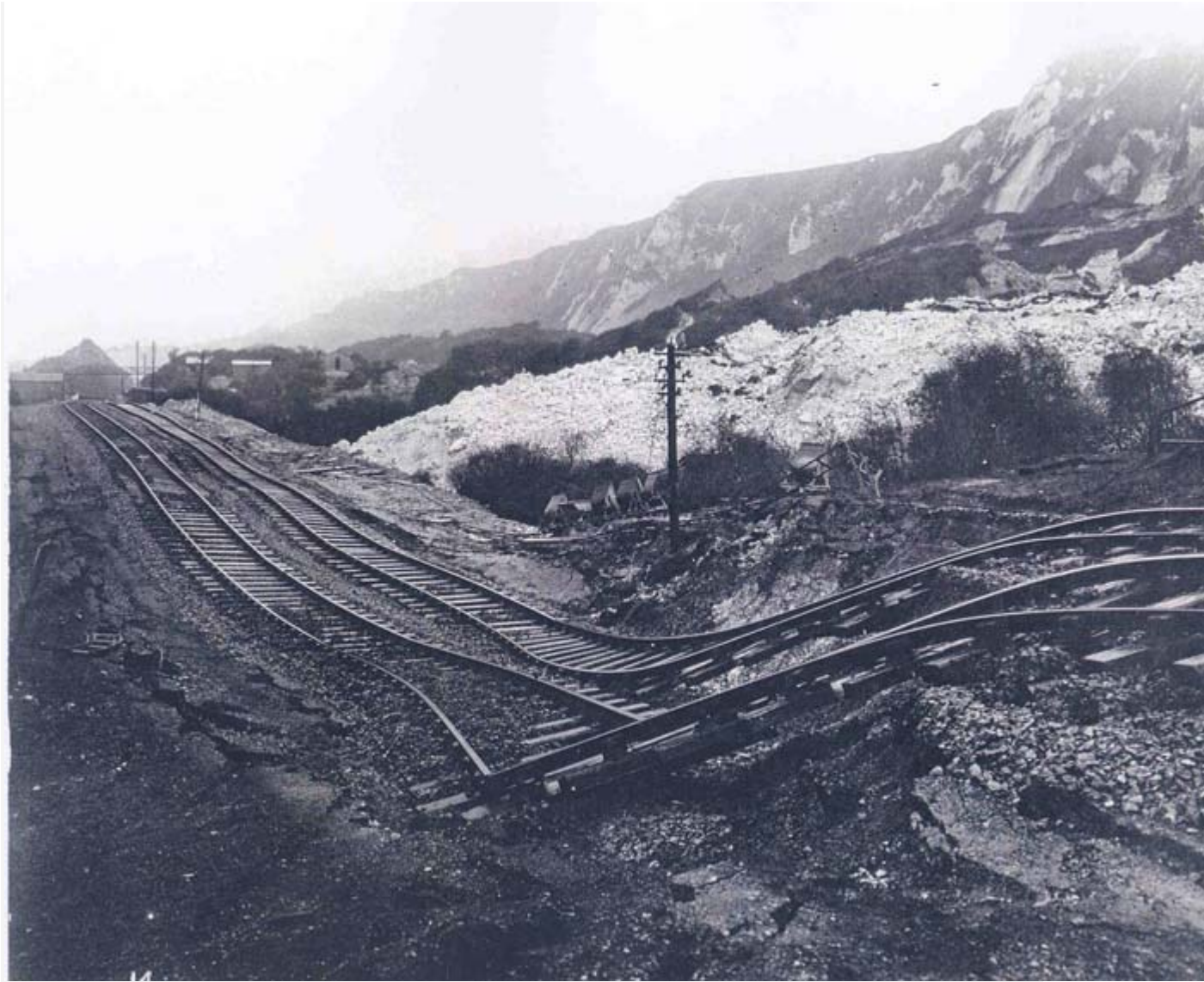
Once the equipment is in place, Butcher says that there will be a period of observation before trigger levels are set to minimise the risk of false alarms and implementing unnecessary speed restrictions or service suspensions on the rail line.

“A good correlation between rainfall and ground movement was observed over the winter of 2013/14 with movements of up to 150mm observed at ground level,” explains Butcher. “The ground is currently saturated so further movement is expected between now and March, which will allow us to develop a monitoring action plan over the next 12 months.”

Unstable past

From west to east, the rail line through Folkestone Warren passes through three tunnels – the Martello Tunnel at the western end, the Abbots Cliff Tunnel in the middle and the Shakespeare Tunnel at the eastern end near Dover.

After the rail line was built there were some small slope failures but larger movements occurred in 1876 and 1896 that both caused disruption to the tracks. The 1896 failure is recorded to have cracked the Martello Tunnel, resulting in part of the tunnel being demolished and the portal being rebuilt further westwards to prevent a future landslide shearing the structure.



Ground movement in 1915 caused significant damage to the track close to where the current instrumentation is being installed.

In 1915 a major failure occurred resulting in rail lines being buried under up to 20m of debris and creating a debris flow 70m out to sea. A train was already on the section when the failure occurred but fortunately there were no serious injuries. However, the damage took four years to repair.

Drainage was installed in the 1950s and stabilisation work then focused on constructing sea defences, including a concrete toe-weighting apron, coastal protection and adit improvement, but the area has continued to experience stability problems.

