ON TIME AND ON TRACK IN DOVER

The newly-laid twin track rail line and reinforced sea wall hugs Dover's Shakespeare Cliff. Image: Network Rail

Constant battering from an unrelenting English Channel poses a continuous challenge for operators of the Dover to Folkestone rail line along Britain's south coast. **Tareq Khodabacksh** relates how wireless condition monitoring technology has been used to bring speed and safety to the work of reinforcing a key stretch of track along Dover's sea wall

In 1597 the famous playwright William Shakespeare, accompanied by a group of travelling actors, came to Dover to perform some of his most famous plays. He was apparently struck by the beauty of the vast white cliffs of Dover and even mentioned them in *King Lear*. A cliff to the west of Dover has since been named in his honour and is now the site of a stretch of rail track that carries a Southeastern train service. This section of track hugs the cliff face from Dover to Folkestone, goes through three tunnels, runs along a shelf of cut chalk and even across a section of beach.

It was here, in 1849, that a picturesque timber trestle viaduct was constructed to go across this section of the line (Fig.1). Due to the constant battering from an unrelenting English Channel, Southern Railway thought it prudent to reinforce this viaduct, fearing cumulative erosion to the

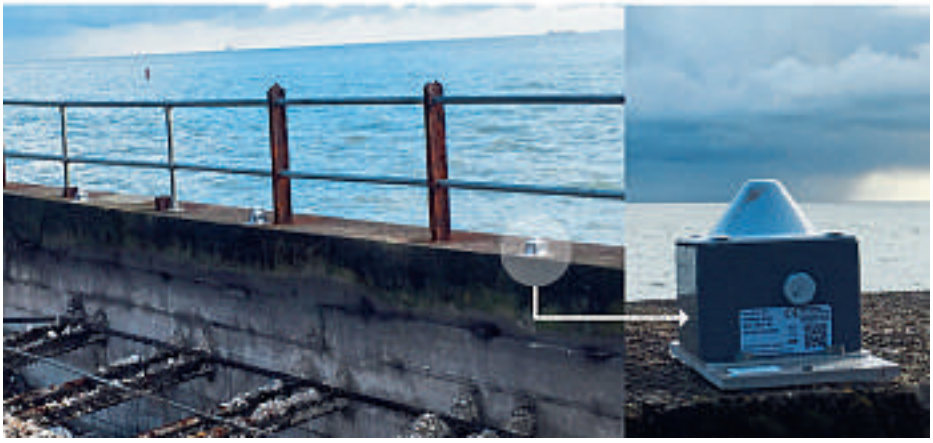
Fig.1: The original timber trestle viaduct (pictured) has since been buried up to the railway trackbed

timber material. In 1927 the Dover Sea Wall was constructed to protect the coastal-facing viaduct, and the voids between this and the cliff were filled with chalk material from the local tunnel works, ongoing at the time. The viaduct was effectively buried all the way up to the trackbed and this allowed the safe functioning of this busy rail service for 88 years.

Service suspended

After a huge storm in late 2015, large cracks appeared on the Sea Wall protecting Shakespeare Cliff and workmen also discovered sinkholes in the track formation. Southeastern train services between Folkestone and Dover Priory ground to a halt on 24th December 2015. The public footbridge to the Shakespeare beach was also structurally compromised and was shut to protect public safety. Massive disruption to travellers ensued, and the replacement bus service struggled to cope with the large number of customers who use this critical service.

Network Rail and Southeastern had to quickly assess and urgently resolve the situation. Unusually, local MP Charlie Elphicke came on board to represent the people of Dover and Deal and ensure that the vital train link was restored as



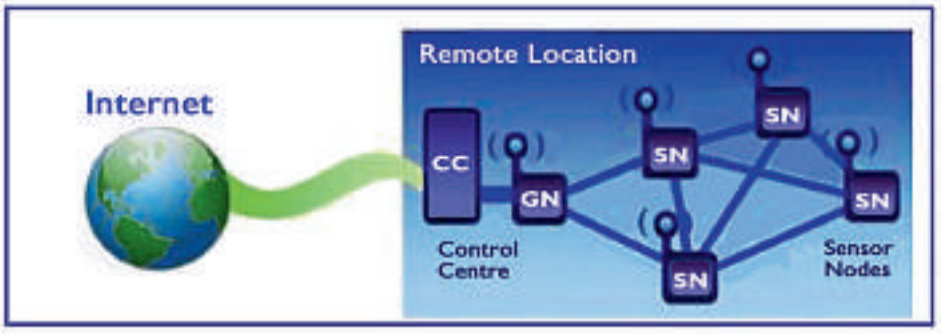


Fig.2: Top left and right. Some of the 178 Senceive nodes mounted to the Dover Sea Wall. Subsequently redeployed to monitor track bed movement, these continue to operate round-the-clock to ensure passenger safety on the busy line. Below: Linked to Senceive's FlatMesh wireless network, the sensors work co-operatively and intelligently to monitor complex layouts or challenging and difficult to access environments

quickly as possible. Costain was brought on board as the main contractor to survey the damage and also to design and carry out necessary remedial works.

Upon close inspection, it was quickly discovered that huge coastal storms, over the course of 88 years, had slowly eroded parts of the Dover Sea Wall allowing the salty sea water to dissolve the chalk infill which surrounds the old timber viaduct. This led to the visible sinkholes. Once the wall and chalk infill had been initially damaged it was only a matter of time before the cracks got bigger and the trackbed sinkholes became more pronounced and frequent.

Studying the options

Costain consulted Tony Gee and Partners LLP, who came up with five recovery options, some of which would keep the track closed for as long as two years. Costain and Network Rail finally opted to construct a reinforced raft supported by bored piling. This would still carry the two-line segment of track over 235 metres, but take only take a year to complete. This plan, championed by the local MP, involved completely removing the track and excavating behind the wall. It was also a project that would attract ministerial scrutiny and visits as it unfolded. But to proceed safely and speedily, Costain needed to monitor a 750m-long stretch of wall as piling repairs and reconstruction took place.

Based on several successful deployments elsewhere for Network Rail, Costain approached Senceive to provide its high precision wireless tilt sensors as a monitoring solution. The London-based company's system had the advantage of swift and easy installation, and carried a reputation for robustness and reliability in demanding environments, and this was a particularly challenging site. Senceive was tasked to monitor both the wall during excavation and also the newly-laid track once the wall was reinstated. This would ensure that it was stable and remained within operational guidelines for track geometry and stability.

Round-the-clock working

Senceive initially supplied 178 nodes, half of which were directly mounted to the wall using sacrificial mounting plates directly glued to the surface (Fig.2). The other half were screwed onto the inside of the wall using swivel mounts. Data was then relayed back to Senceive's WebMonitor system via the FlatMesh wireless GSM/GPRS Gateway, providing a totally wire and external power-free solution. The wireless system allowed accurate remote monitoring of the wall during a round-the-clock project that involved more than 200 workers from Costain and elsewhere. The ability to measure movements to sub-millimetre levels at extremely high reporting rates gave the workers peace of mind and security despite harsh costal conditions.

Fig.3: The reinforced Dover Sea Wall and reinstated rail track

Once the timber viaduct was exposed, it was decided to bore through 10 metres of the chalk infill and a further 20 metres into the bedrock so that the 134 reinforced concrete pilings could be installed to carry the rail track. To ensure continued stability and protection of the wall itself, sheet pilling was installed either side of the wall and 130,000 tonnes rock armour was also placed between sheet pilling and the sea. The eventual concrete raft for the reinforced viaduct was cast from 1,933m^3 of concrete from two local plants. It was then also decided to increase the height of the sea wall using this concrete to protect the track from sea spray caused by storms or high winds.

Once the remedial works were completed and the track reinstated (Fig.3), the Senceive wireless nodes were easily redeployed onto the rail sleepers to monitor cant and twist, with additional nodes supplied to provide sufficient monitoring coverage. This quick and easy redeployment saved both on time and cost during this tentative stage of the project.

Full steam ahead

Costain and Senceive successfully delivered the solution to the tight timeframes required, and the innovative reliable monitoring system allowed easy and cost-effective redeployment at the key transitional stages of the project.

The vital train line finally reopened a mere nine months after closure on the 5th September 2016, some three months ahead of schedule. The footbridge, which is famous in its own right as a launch base for Channel swimmers was formally reopened in March 2017. Nearly 18 months after monitoring began, the Senceive wireless system continues to keep a vigilant eye 24/7 and is constantly monitoring for twist and cant along the new track.

The Shakespeare beach is now once again accessible and clear from any signs of the intense construction that went before. Locals and dog walkers are once again able to enjoy breath-taking views of the white cliffs of Dover that inspired our greatest playwright over 400 years ago.

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