Krzysztof Falkowski
BEng (Hons) GMICE

ADAPTING AN AGEING INFRASTRUCTURE FOR THE CHALLENGES OF THE FUTURE - SEVERN ESTUARY EARTHWORKS

Krzysztof (Chris) Falkowski is an Assistant Asset Engineer who started working on the railway in 2019 for his year in industry, where he quickly developed a passion for the railway. Following his degree in Civil Engineering from The University of Brighton, he joined the Network Rail (NR) graduate scheme in 2021. He was able to further his understanding of the railway through his time working on projects like the Severn Estuary Earthworks and various training courses including the PWI Track Engineering Diploma. He is currently working towards chartership with the Institution of Civil Engineers.

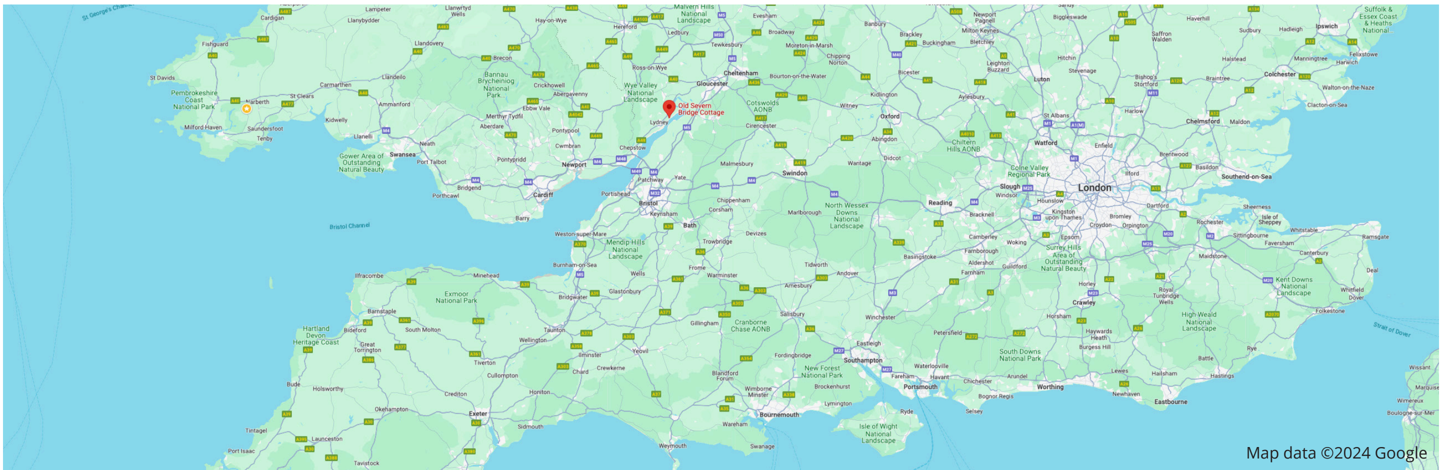

Figure 1: Location of site

1.1 SEVERN ESTUARY EARTHWORKS

The Newport-Gloucester railway line is a vital link between South Wales and the Midlands. **(Figure 1)**. However, while the South West Mainline 2 is vital and beautiful with its scenic sights of the Severn Estuary on the other side of the track there are hundreds of metres of cuttings with varying heights. The Severn Estuary cutting which scales up to heights of 40m has experienced many landslips in recent years, with 7 major incidents recorded between 2018-2021. This led to extended closures of the railway and temporary speed restrictions, delaying multiple trains which heavily impacted thousands of people travelling in and out of South Wales. Furthermore, with climate change the threat of further land slips and more delays keeps increasing over the years. Therefore, to prevent future long-term closures of the railway NR has embarked on a £25m investment scheme to protect the line.

This £25 million project is the biggest investment in this line since the 1980s. This landmark, multi-million-pound investment will protect the future of the Severn Estuary line as well as supporting the resilience of transport links within the area even against the projected changes from the most recent Climate Change figures. The importance of this route and NR's goal to put the passenger first cannot be understated, and this can be shown by the investment in this line of route. This investment is integral to continue the support of decarbonisation within the transport industry and to connect communities and businesses between Wales, the West Country, the Midlands and the North, for many generations to come.

This resilience programme is called the Severn Estuary Earthworks (SEE) and it consists of two phases. Phase 1 consisted of a 1.5 mile stretch of cutting which started on the lower mileage end of the overall resilience programme. The first phase of the programme was accelerated as the importance of protecting the safety of the railway and the passengers of the railway was paramount. The ground investigation was expedited and completed within a 4-month period and the design for the passive mesh system was completed within 6 months. Both phases were led by the in-house design and engineering team. The expedited completion of the project was only possible due to their prior knowledge of the site location and has allowed for learning, experience, and expertise of the site to remain consistent across all phases of the project. This unique expertise allowed for the engineering team to design the system in the most efficient and cost-effective way.

Phase 1 of the programme was delivered during a temporary closure of the line for seven weeks from 18 July to 3 September 2022. During this blockade the team had to plan, organise, and implement the running of 30 engineering trains. These trains were vital in the removal of more than 15,000 tonnes of material which was removed during regrading works within the two-mile extent of a steep cutting

Figure 2: Engineering Train stationary on site location while wagons are being loaded by excavators

Figure 3: Long reach excavator regrading topsoil from cutting face under NRDD guidance

near Lydney. **(Figure 2)**. While thirty engineering trains were planned, the strikes that were occurring during the blockade resulted in a lack of staff to crew them, causing cancellations. This necessitated a reduction in the overall number of engineering trains. The effect of this on the works required the team to think on their feet and change the project plan to ensure that while regrading the topsoil, space was left to temporarily store it prior to the engineering trains arriving on site. Alongside this, the team had to vary the initial plan as the reduced number of trains meant that there was less time to complete the task of regrading all the required sections within the cutting. The many years of knowledge within the team allowed for efficient and swift amendments to the removal of the regraded soil as the number of trains available to the team kept varying due to the strikes.

You might be asking yourself, how did the team manage to regrade so much soil, and how were they able to stabilise such a large amount of cutting? Well, for this project the team began by cutting existing mesh on the slope. This mesh was part of an old passive mesh system and was design life expired. This meant that the team had to use rope access trained operatives to cut through the existing layers of mesh on the slope to expose it, to allow for the regrading of the cutting topsoil. As you may already know, geotechnical projects always have a level of uncertainty about them. Unlike most other disciplines, when working on geotechnical projects the geology of the ground can easily vary from what is expected and it may not be possible to find certain details until the area has been excavated. For this project, the team could not be certain of the geology of the cutting until it was exposed, as the vegetation had already overgrown the whole cutting making it impossible to see the top soil. Therefore, for phase 1 while the topsoil was being regraded using excavators and rope access teams, the NR Design Delivery (NRDD) geotechnical team carefully guided the subcontractors to ensure that the final regraded slope was competent. This regrade of the topsoil was needed, as during landslips some of the most unstable sections of a slope is the topsoil. **(Figure 3)**.

Once the NRDD team were happy with the competency of the regraded cutting the rope access trained operatives placed the coir erosion control matting. The team installed circa 27,000 square metres of coir matting during phase 1. This was implemented by unravelling the roll from the top of the cutting to the bottom. This matting was then bound to the new competent topsoil using soil pins. This matting improves the stability of the topsoil and reduces the amount of ravelling that would occur following the regrading. Ravelling occurs as the topsoil is fresh and has not been consolidated and therefore, is more likely to ravel down the slope face. Once the coir matting was fully installed the rope access teams began the installation of a galvanised steel mesh and soil nails on the cutting. The steel mesh with the soil nails was installed to create a passive mesh system for the regraded slope sections. A passive mesh system works by pinning the mesh at the top, somewhere near the middle and finally at the bottom of the slope. The passive system works by allowing for larger rocks to ravel down the slope in a controlled manner as any rocks that break off would be contained by the steel mesh. The slack of the steel mesh allows for enough space for small to medium size boulders to move down the slope along the slope face without gathering too much momentum. Then at the toe of the cutting there is also some slack in the mesh which allows for any of the ravelled soil to build up over time. As the name suggests the system is a passive system and its implementation does not actively improve slope stability, however it does reduce the risks posed onto the railways from land slips and other general deterioration of the slope. The engineering team installed circa 27,000 square metres of galvanised steel mesh and over 750 soil nails to create the passive mesh system in the regraded sections. The soil nails at the toe of the slope were installed by using a rotary drilling rig installed on an RRV which drilled up to a depth of 7.5m, following which the soil nails were installed and grouted. The top and intermediate soil nails were installed using a rotary drilling rig which was suspended from the top of the cutting which drilled into the slope face to a depth of 7.5m and then the rope access teams installed the soil nails and grouted the holes to ensure that the system was secure with the slope. **(Figure 4)**. Once the grout had set the mesh was laid on top of the slope face and attached to the soil nails which created the passive mesh system.

Phase 1 did face a lot of difficulties during the works and the dedication and knowledge of the team was the main driver for the successful completion of the phase 1 works. As well as the multiple strikes during the blockade which reduced the number of available engineering trains, the team were also required to hand back the site for freight trains at night for the final week of the works. However, due to the strikes the team were unable to always regain their possession as the number of signallers was heavily reduced. This

Figure 4: Rope trained operative drilling into cutting face using a suspended drilling rig from the top of the cutting.

Figure 5: Regraded slope with coir erosion control matting installed as well as partly installed galvanised steel mesh

meant that the team had to proactively work with the contractor, Taziker, to ensure that the tasks which did not require a blockade continued during those days when the team were unable to regain their possession. Another challenge that the team faced was the remote location of the site. As the site was along the cutting slope of the Severn Estuary the local roads were not planned for such high traffic activity. Therefore, the team worked with the local council and residents to ensure that all parties were happy with the measures taken to reduce the impact on the local residents from the works. Some of the measures taken included implementing a minibus service for the works between the various site locations and the main compound, as well as removing all of the excavated material via train rather than using lorries. The use of minibuses meant that during shift handovers the number of additional vehicles due to the works was limited and the residents were not as heavily impacted. The use of the engineering trains meant that while the team excavated tonnes of soil the local community did not have to deal with the negative impacts of removing it from site. Additionally, as the roads leading to the site works are very narrow with many bends the team implemented a one-way system for the works traffic, and to ensure the safety of the residents a 20mph speed restriction for all site traffic was introduced to reduce the risks of the temporary increase in road traffic. Finally, to reduce the road usage Taziker hired a local caterer to provide packed lunches for the workers on shift. These packed lunches meant that the workers did not have to return to the main compound until the end of their shift. The team provided plenty of bins throughout the site as well as organising regular community litter picking clean-ups to ensure there was no major impact of the packed lunches onto the local community. Another challenge the team faced was the record-breaking temperatures during the works. During some of the days the temperatures rose to as high as 35-degrees Celsius at midday. This meant that the team had to actively manage the risks that the workers faced while working in this heat. The team provided the workers with hundreds of water bottles to ensure that they stayed hydrated, as well as SPF 50+ sunscreen which was available to all workers at the start of their shift in the main compound. The COSSs and welfare facilities also had sunscreen, and the workers were able to reapply it when required. The team implemented all these safety measures to ensure that no workers were caused harm during the works; the success and value of these measures can be seen by no worker sun-related incident occurring during the works.

The NR team alongside Taziker always had sustainability and the environment at the forefront of their mind, and this could be seen by the many implemented environmental and sustainability measures during the works. Some of these measures included but not limited to; all the welfare facilities being 100% solar powered, removal of soil utilising engineering trains, reusing existing timber bog mats for rail protection, re-using regraded topsoil for creation of working platforms, reusing existing soil nails bolts when possible, and repurposing coir erosion control matting. **(Figure 5)**.

All of these measures were implemented to reduce the overall environmental impact of the works, and they could have only been implemented with forward thinking about how to lessen the environmental impact of the project right from the beginning. When discussing sustainability within the industry it is easy to get entangled with the details of how to reduce the carbon impact of a project by trying to reduce the carbon footprint of all the materials used. However, the SEE Phase 1 project opened my eyes that not only does the material carbon footprint matter but also the footprint of the other aspects of the project, and how being proactive early on in a project's beginning can greatly reduce its carbon footprint. Therefore, while trying to reduce the material carbon footprint of the project the team realised they could improve the carbon footprint by utilising coir matting instead of the PVC alternatives. The team also reviewed all other materials being planned during the construction phase and how these could be altered to reduce their carbon footprint. When the team were unable to find any sustainable alternatives, they tried to implement as much previously used materials as they could. Furthermore, the environmental benefit of this project can be also attributed to the increased resilience of the route which in turn has an indirect environmental benefit to the community with the increased reliability of trains within the area, allowing for those who might have used alternative less environmentally friendly means of travel to choose to use the train for their commute. This increased resilience is fundamental to ensuring a better railway for the future with the increased risk and impact of the ongoing climate change crisis.

In conclusion, the SEE phase 1 project was a successful resilience project which improved the reliability of the South Wales Mainline. **(Figure 6)**. The success of this elaborate project is not only a success for NR but also for the wider railway community within the UK. Hopefully, with the upcoming phase 2 of the SEE the team will be able to deliver another successful project and further improve the resilience of the crucial connections between South Wales and England.

Figure 6: Picture of Severn Estuary from top of the cutting overlooking the worksite

If there is anything I hope you can remember about this project, it is that when focusing on being more sustainable in construction sometimes the small victories aren't celebrated enough. The minor changes projects can implement to be more sustainable consistently will help the industry move forward towards a more sustainable future. These small consistent changes make the railway industry a more environmentally friendly business and I am excited to see what the future holds for how everyday tasks can be more environmentally friendly.

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