Use of Modern Technology on the Northern Line Extension

The Northern Line Extension (NLE) is a project on behalf of London Underground Limited (LUL). The project will extend the existing Charing Cross branch of the Northern Line from the Kennington Loop to a new terminus station south of Battersea Power Station. The NLE supports economic development and population growth within the Vauxhall, Nine Elms and Battersea Opportunity Area. The project will alleviate overcrowding on the Northern Line South of Kennington, and the Victoria Line north of Vauxhall. Majority of the tunnelling will be TBM (Tunnel Boring Machine) driven and the TBM's will be extracted from two shafts at Kennington. From the shafts, SCL (Sprayed Concrete Lining) tunnels were constructed to the start of the step plate junction works.

The step plate junction works involve challenging tunnelling works to connect into the existing Northern Line at the Kennington Loop. The construction works are being carried out while the Northern Line is operational. From the SCL tunnels the tunnelling works involved excavating firstly a 9.5m diameter tunnel followed 6.5m diameter tunnel with both tunnels incorporating an SGI (Spheroidal Graphite Iron) lining. Both these tunnels encompass the existing Northern Line tunnel within. The SGI lining for the 6.5m is a complete ring consisting of 12 segments a key. However the 9.5m SGI lining consist of only 10 segments sitting on a concrete invert (Figure 1). The concrete invert incorporates GFRP (Glass fibre reinforced plastic) reinforcement as an alternative to steel reinforcement. The change in type of reinforcement material made it possible to preassemble the reinforcement on the surface and place it in two halves due to the significant reduction in weight obtained through the use of GFRP. The installation of the 9.5m SGI segments presented a challenge as each segment weighed 230kg. Hence a specially designed and built segment erector was procured and used for the installation of these segments. As a result of the incorporation of the GFRP and the use of the segment erector, the project should be considered for the Application of Technology Award.

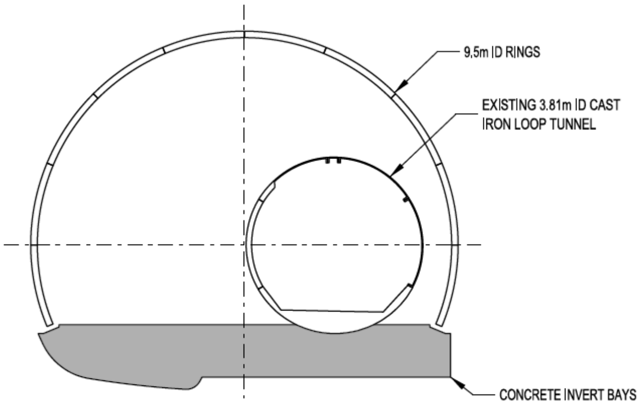

Figure 1: 9.5m SGI section of the Step Plate Junction

Incorporation of Technology

Invert Concreting Works

The invert concrete (Figure 1) was cast into two halves; firstly the invert under the Kennington Loop Tunnel was cast individually and was followed by the open section of the invert which was cast in larger sections which were equivalent to four individual single invert bays under the loop. Prior to casting the invert the GFRP cages were inserted into the bays with couplers. Once the remaining larger halve was ready to cast the couplers were exposed to link the second half of the GFRP cage.

Figure: Preassembled GFRP cage

The GFRP reinforcement weighs 75% less than normal steel reinforcement which presented the opportunity to preassemble on the surface prior to installation. The weight reduction obtained reduced risks associated with manual handling and lifting. The benefits of GFRP compared to steel including reduced carbon footprint and high corrosion resistance presented it as a material with significant benefits for the client and the project. As this was one of the first uses of GFRP on the London Underground network acceptance was obtained from the client as a result of the benefits accrued.

Figure: Invert concrete works from excavation to installation to concreting.

Incorporation of the Segment Erector

Once the envelope for the 9.5m tunnel was constructed the SGI segments were required to be installed as the permanent tunnel lining. There were various options for the installation of the segments. The options for installing the segments included building from scaffolding decking using lifting eyes, snatch blocks and winches, another option included using erector ring with scaffold decking and using winches to build and the final option was using an erector ring with a segment erector. The last option was chosen as the method of installing the segments due to the safe installation and opportunity to increase the rate of installing the segments. As there was restricted timescale for the completion of the 9.5m section of the tunnels, the segment erector would offer the opportunity to mechanise the installation of the segments using the technology commonly used in Tunnel Boring Machines (TBMs).

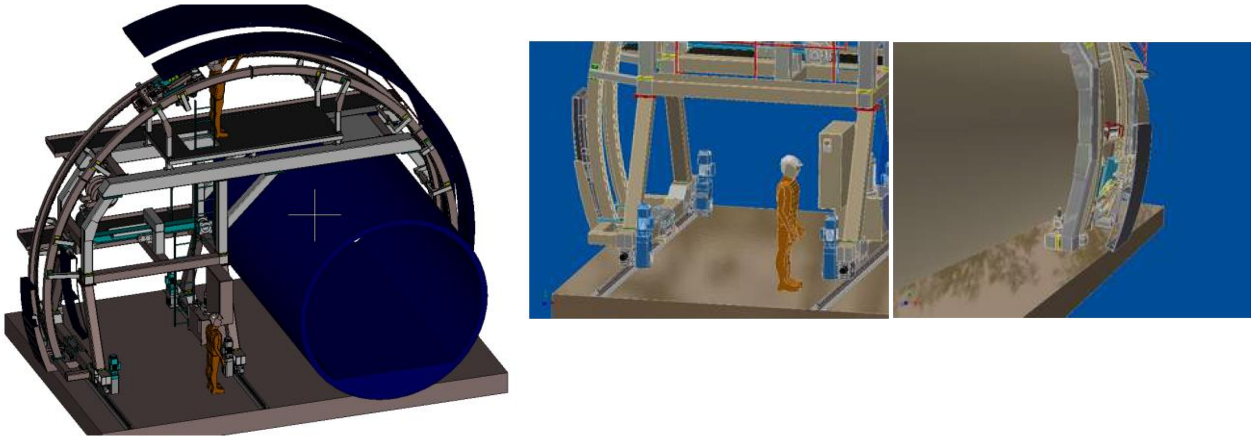

Figure: Erector for installing 9.5m SGI rings

The erector was manufactured in the UK by Tunnel Engineering Services for the NLE project in Oldham, Manchester and the erector ring was manufactured by Associated Polymer Services. The segment erector and the erector was manufactured in parts so that it could be assembled inside the tunnel. There were multiple visits to the manufacturers during commissioning to ensure the erector would work on site. Additionally 3D modelling was carried out to facilitate the commissioning and to undertake clash detection.

During the operation once the segment is loaded using the hydraulic arm into the loading frame the erector arm which positions and installs the segments is operated using a remote control. The only time the operative is part of the installation is to bolt the segments together. Once a full ring is completed the segment erector can move longitudinally to install the next set of rings. This process significantly removes manual handling in favour mechanised lifting. The erector facilitated the completion of the 9.5m SGI ring section of the step plate junction safely and at a quicker rate providing considerable time saving.

Conclusion

The continued push to use modern technology including GFRP and a specialised segment erector on the NLE provided the project and the client with significant benefits. The integration of modern mechanised technology and materials was a step forward compared to previous step plate junction works with intensive handworks.