LMR Drilling UK Ltd.

"Avon Calling..."

Bath CSO Scheme, Somerset

Fig. 1: View from top of Drilling Rig looking towards Exit Side (beyond tree line)

Introduction

Trusted Horizontal Directional Drilling company, LMR Drilling UK Ltd., have recently completed works surrounding the installation of 313 metres of an 800 mm high performance polyethylene SDR 17.6 pipe in rock. This work was concluded with great satisfaction to all concerned.

Project Brief

Costain Ltd., a UK based construction company, were awarded the contract to expand the sewerage treatment plant at Saltford, just to the west of Bath, Somerset. This new extension has been designed to act as a combined sewer that will treat both sewerage and surface run-off to prevent any over-spill of sewerage into the River Avon during times of flooding. It forms part of a larger project including the construction of holding tanks, transmittal pipelines, tunnels, and, of course, the expansion of the current treatment works.

Between Bath and the current treatment works at Saltford, flows the River Avon. The transmittal pipeline needed to cross the river and so due to both environmental and economic factors, it was decided that horizontal directional drilling should be used to install the pipe. Due to LMR UK Ltd.'s reputation and high regard within the construction industry, they were awarded the sub-contract for not only installing the pipe, but for fabricating the pipe including all associated works, such as pipe welding and pressure testing.

Geology

Due to the design of the pipeline, the drilling rig was placed on the flood plain of the River Avon. This meant that there was several metres of clay overburden before the bedrock was reached. This clay was typical of those deposited on flood plains, in that they were soft and sticky with a certain organic content.

The rocks in this region are the Jurassic system, and more specific, are of the Lower Lias stages making them between 195 and 205 million years old. More specifically, the lithologies encountered were interbedded layers of limestone and mudstone with individual layers ranging from a few millimetres up to a couple of metres.

Between the overlying clay and the bedrock, it was noted that there was a layer of broken up bedrock that had the appearance of gravel. This layer was due to the weathering of the bedrock.

Drilling Engineering

Taking into account the above geological considerations and a designed drilled length of 313 metres, it was decided the drilling and hole opening should be done in four stages, these being 12¼", 24", 30" and 40" diameter. Between entry and exit side of the crossing, there was an elevation difference of 10 metres and this meant that care had to be taken to ensure hole stability through the elevated section of hole which was not supported by drilling fluid throughout the drilling operations.

Fig. 2: The 12 ¼" Pilot Bit Breaks the Surface
(the blue peg indicates the intended exit point)

Pilot Hole

The pilot hole was drilled with a 12¼" tungsten-carbide insert (TCI) tri-cone bit and a 8" mud motor. Although these are unconventional sizes to use in HDD generally, LMR have used them with great effect for the drilling of rock, both hard and soft.

Drill bit guidance for the pilot hole was enhanced by using the Tru-Track magnetic survey system. Two Tru-Track grids were constructed, thus minimising the distance that had to be drilled without this secondary system. This helped to ensure the necessary tolerance was maintained throughout the drill.

Opposite the rig on the other side of the river was a yacht club. Due to restrictions placed upon the design of the drilled hole, it was necessary to avoid drilling directly under the building of the yacht clubhouse, and so a horizontal curve was drilled taking the hole over five metres to the left of it. This was easily accomplished with no engineering difficulties encountered.

Prior to punch out, the topsoil was stripped at the exit point and a pit was dug so as to collect any bentonite escaping from the bore before the punch-out was complete. Drilling continued until the bit was out of the rock and the final accuracy was to within 2 metres of the intended exit point (see Fig. 2).

Fig. 3: The 40" Hole-Opener at the Start of the Pass

Hole Opening

After the pilot hole was completed, the pilot assembly was broken off the drill string and the 24" hole-opener was placed on the string. The types of hole-opener selected had three rotating

interchangeable cutters. As it was anticipated a certain shape of cutter would be better for reaming the limestone, and another shape would be better for reaming the mudstone, and that the layers of rock would be heavily interbedded, a compromise was needed to prevent any unnecessary downtime relating to tripping out the hole-opener to change the cutters. This was achieved by using tungsten carbide insert cutters with a “chisel” shaped profile.

Once the 24” hole-opening was completed, a 30” and then a 40” diameter hole-opener was used to provide a sufficiently large hole in which to install the 800 mm diameter pipe.

The approach of using cutters capable of reaming both the limestone and the mudstone proved to be worthwhile as indicated with a more consistent rate of penetration for the hole-opening in general, with each hole-opening pass taking 5 to 6 days to complete.

On completion of the hole-opening, a pass was done with a 38” hole-opener. This “cleaning run” was deemed necessary to confirm borehole integrity and to confirm that no large pieces of limestone had become dislodged that might have posed an obstruction during pullback operations.

Fig. 4: The 800 mm Product Pipe on Rollers

Drilling Fluid

Throughout the pilot hole and subsequent hole-opening, an extended bentonite drilling fluid was pumped to clean out the drilled cuttings. This fluid was constantly recycled as full returns were encountered throughout the whole job.

At times the mud was found to be increasing in density and viscosity due to the incorporation of drilled solids from the mudstone sections. This made it necessary to carefully monitor and adjust the mud properties to ensure optimum hole-cleaning efficiency was achieved whilst maintaining a mud system that was manageable by the surface equipment.

Product Pipe Fabrication

As drilling operations were conducted, the 800 mm product pipe was butt fusion welded together (see Fig.4). A 160 mm P.E. pipe was welded alongside the main pipeline and after the product pipe was finished the 160 mm pipe was pushed into the 800 mm pipe. This was then used to fill the product pipe with water during the pullback. This water is necessary to counteract the natural buoyancy of the pipe especially in the heavier weight drilling fluid, thus reducing the pullback force.

After the 160 mm pipe was in place, stub flanges were welded on either end of the product pipe and blank plates with valves were bolted on. A pressure test was then carried out to ensure the quality of the butt fusion welding. As no welds were found to be defective, the stub flange on the end of the pipe closest to the exit point was cut off and a pulling head welded on (see Fig. 5).

Fig. 5: Pulling Head Prior to Going into Hole During Pullback

Fig. 6: Shows Product Pipe Overbend Construction

Pullback Procedure

During the cleaning run with the 38" hole-opener, an overbend was constructed and this was designed to lift the product pipe to allow it easy entry into the hole. After the cleaning run the hole-opener was again attached to the drill string at the exit point.

Throughout the pullback, water was pumped into the pipe through the 160 mm ballast line and this was tethered and so was removed from the product pipe as pulling commenced. As a result, the pullback was completed in 6 hours with a maximum pull-force of 35 tonnes.

Post Pullback Operations

With the pullback successfully completed, de-rigging of the site could now take place. After the drilling equipment had been de-mobilised, a Type II pressure test was performed to confirm the integrity of the installed pipe. For this test, the pulling head was cut off and a stub flange welded on with a blank plate bolted on.

As the pipe was largely filled with water following the filling of ballast water during the pullback, little water was needed for the pressure test. The pipe was pressurised and the test was carried out over a 24 hour period. Once the test was completed, the pressure was then released and the pipe handed over to Costain.

Summary

With the river left undisturbed, the work was completed within the programmed timescale and all parties were satisfied with the outcome. This project has indicated that although there are several different trenchless techniques that can be employed, LMR Drilling UK Ltd. have proved that when the right kind of engineering knowledge is utilised, and when the project is co-ordinated correctly, horizontal directional drilling can be the most versatile and efficient method of pipeline installation.