Crossing India's Narmada River using HDD

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Punj Lloyd has laid over 92,295 m of pipelines under expressways, railways, rivers, shore approaches, creeks and canals using horizontal directional drilling. The company says that one of its most challenging horizontal directional drilling projects completed was the Narmada River crossing on India's East West Gas Pipeline.

Punj Lloyd was awarded part of India's East West Gas Pipeline project by Reliance Gas Transportation Infrastructure Ltd. The scope of work involved the construction of 302 km of 48 inch diameter gas pipeline, five mainline valve stations, three tap-off points including laying of high-density polyethylene (HDPE) duct for optical fibre, and river and canal crossings. The client also awarded six horizontal directional drilling (HDD) crossings with a cumulative length of over 3,300 m involving rivers, canals and highways to Punj Lloyd HDD-specialist subsidiary PLN Construction Ltd.

The purpose of the East West Gas Pipeline is to transport natural gas from Reliance's KG-D6 field in Krishna Godavari Basin on the east coast to various petrochemical and fertiliser plants in India. The pipeline originates near Kakinanda in the state of Andhra Pradesh, on the east coast, and terminates near Bharuch in the state of Gujarat on India's west coast.

The Narmada River crossing was one the most difficult HDD crossings in the East West Gas Pipeline, and involved the drilling and installation of over 1,400 m of 48 inch diameter pipeline.

The HDD crossing was carried out on the Narmada River at the village of Bhadbut, near Bharuch, in the state of Gujarat.

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Execution

The geotechnical information revealed that the river bed consisted of loose, grayish, silty sand, brownish, stiff and hard clay-like silt with a standard penetration test (SPT) N value of more than 80, 10 m below the river bed. Maximum scouring depth and the drilled-hole design and path were planned based on subsoil conditions.

The pilot bore was to be drilled 360 m away from the bank of the river to attain a maximum depth of 24 m below the river bed. The entry and exit angles of the crossing were taken at 7 degrees, while the radius of the curvature was taken as 1,500 m so as to ensure minimum stress on the 48 inch diameter carrier pipe as well as to minimise the pull force.

Mobilisation of the drilling equipment occurred immediately. The company's fleet of Maxi HDD rigs includes three 250 t rigs and one 400 t rig. The company also has one 250 t rig deployed in Kazakhstan and one 250 t rig in Malaysia for large-diameter crossings.

A 400 t rig was used to drill the pilot hole, which was started in the first week of project work. The pilot bore was drilled using a 9.875 inch milled tooth tri-cone bit with 1.5 degrees bend sub attached to a 6.625 inch drill string.

Navigation of the drilling head during the pilot bore drill was completed using a wire-line navigation system. A TruTracker system was used to triangulate the location of the advancing drill head prior to reaching the water line of the river. A relative measurement system was then used to steer the head to the opposite river bank. Here, the TruTracker system was used to steer the drill head to the desired exit location.

With a penetration rate of 250 m over 12 hours, the pilot hole was completed in five days. Extreme care was taken to ensure that the hole was drilled according to the final design, as any break in the radius of curvature would mean difficulties during the pipe-pulling operations.

The hole was then enlarged up to 66 inches in diameter by using various sizes of reamers and fly cutters. The 48inch diameter pipe was then successfully installed in the 66 inch diameter hole across the river.

Anti-buoyancy HDPE pipe insertion

The 48 inch diameter pipe with 25.4 mm thickness had a weight of 747.8 kg/m. However, due to its large surface area it had a positive buoyant force which acted when pulled into the Bentonite-filled hole. To counteract these buoyant forces on the pipe, two separate 20 inch diameter pipe strings of 1,400 m in length and 22 mm in wall thickness had to be installed inside the 48 inch diameter pipe.

In spite of the installation of two additional HDPE pipes inside the 48 inch diameter carrier pipe, the cumulative pipe weight was not sufficient to counteract the buoyant forces. Thus an additional 6 inch diameter conduit of 6 mm thickness had to be installed. This conduit served two purposes; it not only increased the cumulative weight of the 48 inch diameter pipe, but also helped in filling the annulus of 48 inch diameter pipe with water.

Due to space constraints and the carrier pipe not being in alignment with the HDD crossing, the conventional methodology for installation of HDPE pipes and conduit was not used (where a bundle of strings are pulled up – with the help of pipelayers/sidebooms – through the carrier pipe by using a heavy wire rope). Instead, a unique methodology was devised for this installation in which the second drilling rig, along with spare drill pipes was used for the installation.

At the other end of the 48 inch diameter carrier pipe, the HDPE pipes and the 6 inch conduit were welded in sections of 200 m each. The 250 t rig was then aligned and set up at an angle suitable for pushing and pulling drill pipes inside the 48 inch diameter carrier pipe. One by one the drill pipes were attached to the rig and, with a very slow rotation, they were pushed inside the 48 inch diameter carrier pipe until they reached the other end.

This task of pulling bundles of two 20 inch diameter HDPE pipe along with one 6 inch diameter CS conduit for 1,400 m inside a 48 inch diameter steel pipe required extreme care and optimum control to ensure the pulling without breaking any of the HDPE pipe joints.

Challenges

Apart from the large diameter and length of the pipe, executing the HDD process during the monsoon season was a major test.

For a pipe of 48 inch diameter to be drilled inside the soil, a 66 inch diameter hole was required to be drilled and kept open. In order to maintain this wide diameter hole, large volumes of Bentonite were pumped at a very high pressure using two mega pumps with a combined rate of 2,000 litres per minute.

The soft silt formation toward the exit of the crossing and the SPT N values as low as 18 in the last 300 m of the crossing added to the difficulties of maintaining the 66 inch diameter hole.

Environment protection

HDD technology is considered environmentally friendly as it causes minimum damage to the natural surroundings while laying pipelines beneath surface obstacles.

The Narmada River crossing required huge volumes of Bentonite to be pumped at very high pressure to maintain and clean the 66 inch diameter hole. A high pumping rate of Bentonite meant large amounts of soil cutting. Punj Lloyd deployed two complete sets of mud systems, one set on either side of the crossing to ensure that the total quantity of Bentonite and cutting slurry was re-circulated in the system, minimising soil cutting and hence reducing environmental damage.

Equipment used for two complete sets of HDD spreads

- HDD rig: Herrenknecht 400 t and Herrenknecht 250 t
- Four high-pressure mud pumps with pumping capacity ranging from 2,000-2,300 litres per minute
- Two mixing units with a capacity of 36 cubic metres each
- Two double deck recycling units
- Steering system: Paratrak
- Slurry pump: Sykes pump
- Six excavators each with 30 t capacity
- Six pipelayers/sidebooms of 90 t capacity
- Reamers ranging from 16-54 inch sizes
- Fly cutters ranging from 20-66 inch sizes