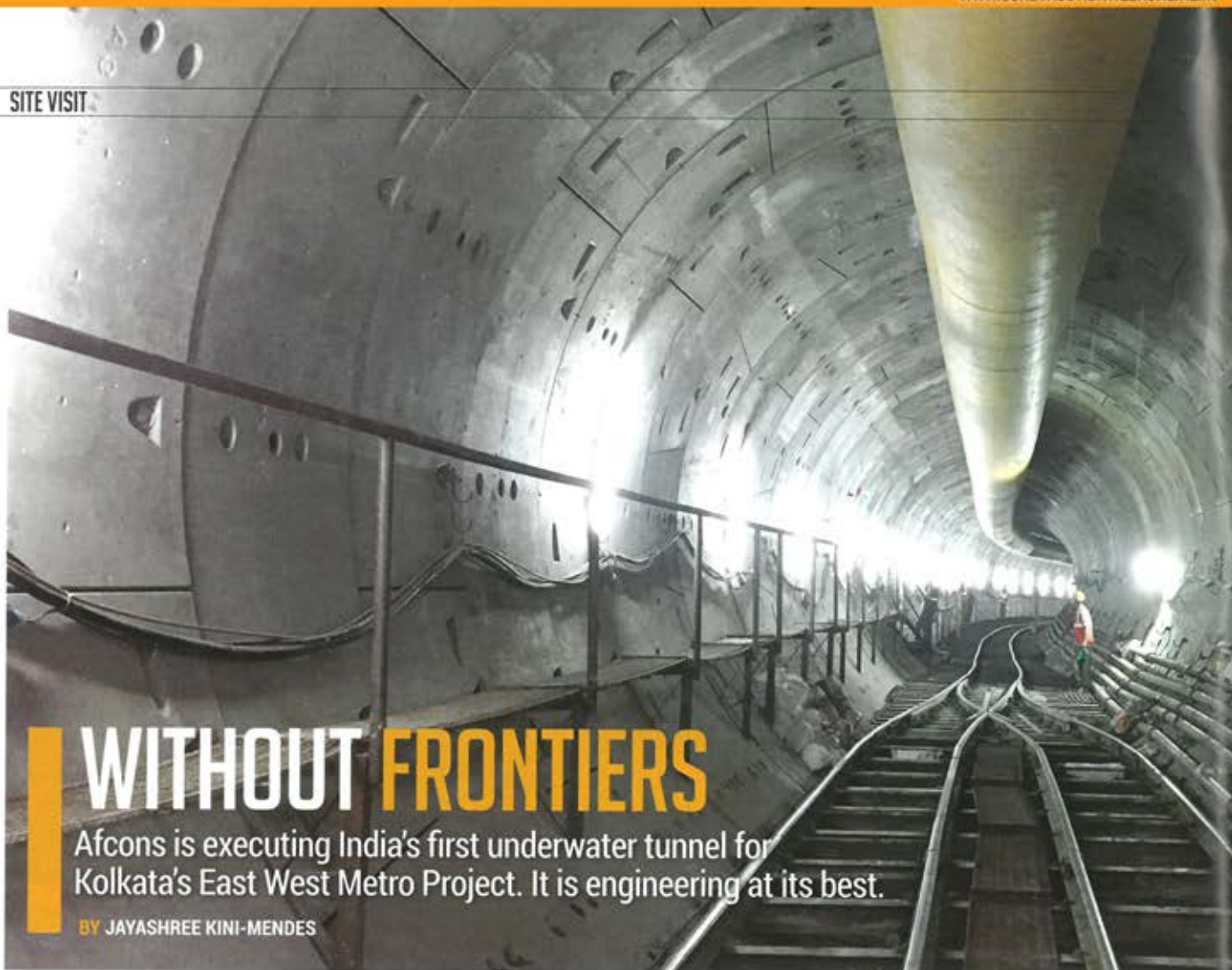


CONSTRUCTION WEEK

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SITE VISIT



WITHOUT FRONTIERS

Afcons is executing India's first underwater tunnel for Kolkata's East West Metro Project. It is engineering at its best.

BY JAYASHREE KINI-MENDES

Would you ever have thought that India could build a metro system that partly runs under one of India's most cherished river? Or that we would ply a tunnel boring machine (TBM) under the river and, in case of an exigency, one that would voluntarily shut down like a submarine?

Such are the marvels that one gets to see and hear at the East-West Metro Project executed under the guidance of the Kolkata Metro Rail Corporation (KMRCL). **Construction Week** took a trip to this historic city to see the progress of the much-awaited metro project and a part being executed by Afcons.

At a time when metro projects are increasingly popular in the country, with even Tier-II cities coming up with their home-grown metros, Kolkata is the only city in the country to have evolved with an underground metro way back in 1984. But that could not take the load off the now creaking transport system and it was not long before officials realised that it needs a modern system and one that is efficacious. As a metro city, Kolkata is no different than Mumbai or Bengaluru or Delhi. Most of the public transport may look dilapidated but it functions reasonably well. The roads are chock-a-block, people throng the streets, motorised rickshaws trundle along busy roads, and the incessant traffic can be maddening. In such a situation, a novel and modern metro concept was the only saviour.

GOING UNDERGROUND

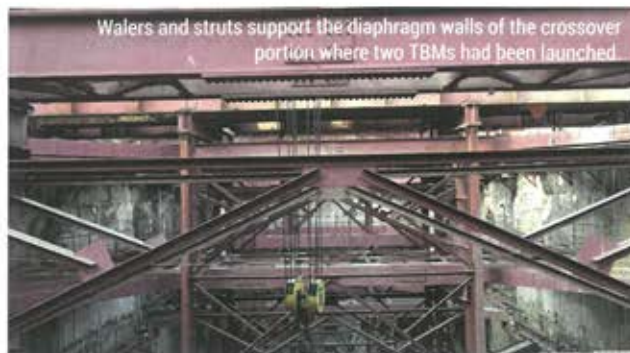
Afcons has bagged the toughest part of the project. The company's exceptional capabilities of executing intricate and complex engineering projects, naturally led KMRCL to plop the trickiest part of the project into Afcons' lap. The infrastructure company has bagged the contract to build India's first underwater transportation tunnel and also build three underground stations at Howrah Maidan, Mahakaran and a crossover (integrated with Howrah Maidan station) linking to Howrah station. The project, when complete, will lend itself to be one of the engineering marvels the country has seen. It must also be mentioned here that nearly all the equipment being used at the site are also owned by Afcons.

Although bedevilled by delays since announced in 2008, the East West Metro Project is meant to wean away a significant part of the population from the aging Howrah bridge.

At the project site in Howrah Maidan, work is on in full swing. Afcons has completed the roof slab and is now working on the concourse, which is 10m deep from the top. The work will go further one level down for construction of the base slab touching a depth of excavation of 20m. A crossover is also integrated with Howrah Maidan station resulting in a 326m long single underground box. It decided on a top down construction approach for Howrah Maidan station (226m of underground box),



Afcons has completed 1.2km tunneling for east bound and 850m west bound.



Walers and struts support the diaphragm walls of the crossover portion where two TBMs had been launched.

as excavating 20m into the ground meant careful consideration for the buildings nearby. The crossover portion (100m) of this underground box has, however, been constructed using bottom-up technique for launching the TBMs for tunneling. In the single underground box both the techniques (bottom up and top down) have been used. Walers and struts support the diaphragm walls of the crossover portion where two TBMs had been launched. At the time of the visit, Afcons was gearing up to plunge the TBMs 32m under the sea level, below the Hooghly river. Considering the tricky nature of the river, the 250 people employed at the site work round the clock with relooking design and poring over geo-technical surveys so that execution can go according to plan. So far, there have been no surprises.

The Herrenknecht TBMs deployed are the earth pressure balancing machines and these machines were the only choice for tunnel-boring under very soft clay to stiff clay strata. The EPB technique is suitable for boring under unstable terrain or under structures that are sensitive to ground disturbances.

Satya Narayan Kunwar, deputy project manager, Afcons' KMRCL project, says, "The Howrah Station is one of deepest stations constructed in India. The excavation depth of this station is nearly 30m. There is a stiff stricture on ground movement for this deep station due to its location in Howrah Railway Yard. The depth of excavation and requirement of strict control

over ground movement resulted into design of 1.5m thick diaphragm walls extending up to 42m depth. The barrettes and piles, meant for providing support during construction/temporary phase and also for preventing uplift of station box during operational/permanent phase, are extending up to a depth of 60m from ground level."

The TBMs were planned to pass through Howrah Station and required to cut through diaphragm walls. A big challenge was finding out a way to cut the concrete 1.5m thick diaphragm walls. Finally, for resolving this challenge, the Soft Eye using styrofoam was designed which is unique of its kind and done for the first time in India, says Kunwar.

The external diameter of the tunnel is 6.1m and internal is 5.55m. Reinforced concrete segments, 275mm thick, are used for tunnel lining. Six segments complete circular lining of the diameter. Afcons had to order specialised moulds from Korea for casting the tunnel segments. Length of the main TBM is 8.5m followed by back-up gantries extending up to 100m. The whole system runs on a large power backup of six gensets of 1010kVA for handling five motors exceeding 650HP and more than 35 other auxiliary motors. The TBM operation also characterises a complex hydraulics system actuated and controlled through the main TBM machine and back-up gantries. TBMs are expected to run 15m per day and will cover 2.9m of the twin tunnel. So far, the company has completed 1.2km tunneling for east bound and 850m west bound.

A project of such gigantic proportions calls for several innovations. Afcons' head of urban transport business unit, Anantakumar says that due to site constraints the TBM had to be driven through Howrah station in advance. "This is a delicate operation where the TBM can encounter difficulty in crossing the diaphragm walls. We designed a 'Soft Eye' of styrofoam replacing M-40 concrete. This has worked well."

Smooth execution of any project can happen if the design is right. The engineering conglomerate has created teams responsible for design, instrumentation, survey, execution - but, by far, it has set up the largest design team for a project of this size. At the outset, the company selected suitable designs and technologies for the successful delivery of the project. The designing of this project was entrusted to specialised world-class design companies such as Atkins, Systra and Tunnelconsult.



The casting yard where segments are cast for the tunnel.



Cured segments line up the yard.

THE DEAL BREAKER

As each tunnel is unique, care must be taken to ensure its strength. The inner walls of the tunnel are lined with precast elements called segments that will be put together with 4,150 rings. It is the rings that make the tunnel resistant against external pressure. The segments are cast at a casting yard set up specially for this purpose. Each ring of the segment weighs 19 tonnes and has a width of 1.4m. Afcons has created four types using M-50 grade concrete. The overall ring will contain six segments and the position of the shortest segment (called key segment) governs the positions of the other segments. Ring sides form an angle that allows the tunnel to bend according to the relative angular position of each segment. A major challenge during underwater tunnel construction is to seal the potential water inflow. A complex process called grouting is



A CHALLENGE WAS CUTTING THE 1.5M THICK DIAPHRAGM WALLS. THE SOFT EYE USING STYROFOAM WAS DESIGNED.

SATYA NARAYAN KUNWAR

adopted as an important measure for filling up annular spaces between tunnel ring and TBM shield/soil face at a fast pace. Batching plants set up at the site manage this process. Backfill grouting reduces ground permeability thus strengthening and stiffening the ground. Afcons has preferred two-component grout – a cementitious part (cement, water and bentonite) and the other is sodium silicate. The grout takes about 12-13 seconds to gel and is passed through the grout plant and then the grout car, which is then whisked into the tunnel through four TBM grout ports. They merge about 1.5m away from the grout port before grouting happens. The TBM only moves after the tunnel annulus has received its initial strength with grouting.

With under-the-river tunnelling, Afcons is taking no chances and has put in place an emergency protocol. It has increased the frequency of checking the machines and systems. It will not be easy to tunnel through soft clay and one cannot over mine. Precision is must. Tunnelling through soft clay calls for adjustments in application of face pressure because the soil face is totally supported by the head of the TBM, and losing hold on the face cause serious ground disturbances.

A control centre monitors the grout pressure, the TBM movement and also considers the earth pressure acting on the TBM, which on an average is 2.8 to 3 Bar depending upon depth of tunnel axis from ground level. Exhaustive analysis has been done for assessment of face pressure throughout the alignment and this serves as a guide for the crew during movement of the TBMs. The centre also has panels that oversees the thrust cylinder that pushes the TBM, the four ports, the curvature of the tunnel, and the controller feeds all the data into the VMT for smooth execution.

Considering the measures that Afcons is taking, by 2020, citizens will travel from Howrah to Kolkata with a feel of the Channel Tunnel that links UK and Calais in France. ■