Some problems of foundation construction for second Thane Creek bridge

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Construction of open foundation for the second Thane Creek bridge was indeed a challenging task. Some major problems were encountered during the construction of foundations for pier No. P22 and P19 of this bridge. The paper describes these problems briefly and also highlights how they are resolved.

The contractor for the second Thane Creek bridge, Messers U.P. State Bridge Corporation Ltd., in their lumpsum offer, proposed open foundations for the bridge, excepting the Bombay side abutment, for which well foundations were proposed.

The general scheme of constructing open foundations broadly consists of the following steps :

1. sinking cofferdams of required height and diameter (varying from 1 1 m to 13m) upto hard strata

2. dewatering the cofferdam

3. carrying out further excavation in the hard strata under dry condition.

The above scheme was adopted successfully for a majority of the foundations. However, for pier No P22 and P19, major problems were encountered during execution. These problems are highlighted here along with an account of how they were resolved.

Foundation problem for pier P22

The contractor started the work for pier P22 in September 1987. When the contractor started building island for the cofferdam by dumping murum on the soft bed the island got damaged very often during high tide and also due to the slippage of weak underlying strata. Probably, the contractor underestimated the fact that the underlying strata at this location comprising soft to dense marine clay extends upto 14m to 15m depth. They had to repair the island many times, even after adding dead load of earth-filled gunny bags around the island, to control heaving. Two concrete cofferdams, each of 12.9-m diameter and 0.3-m thick steining, were cast and sunk. Sinking of cofferdams was done mainly by grabbing. During the process of sinking, cofferdams tilted and shifted considerably towards north-east direction.

When the cofferdams were sunk to a depth of about 9m, an attempt was made to de water the south cofferdam to facilitate further sinking. It was found that the inner ring beam (7th from top) of the cofferdam had cracked on north and south sides, and the cofferdam had been distorted. The diameter at the top had increased in east-west direction. When checked at bottom, the diameter was also found to have increased in north-south direction. The cofferdam was thus badly deformed.

Vertical cracks, as wide as 15 mm to 20 mm, were also observed on east and south-west locations near the top of the north cofferdam. The second inner beam from top was damaged. A number of diagonal cracks on the surface of the north cofferdam were also observed.

Excavation by chiselling and grabbing with the help of a crane continued in the south cofferdam. When about 3-m deep sump was excavated below the cutting edge level, soil and sand started flowing into the sump from north-east side as cleaning of the foundation continued by grabbing.

An attempt was made to seal the blow point by dumping gunny bags filled with a mix of dry concrete inside the cofferdarn and also by dumping tree branches, and earth-filled gunny bags on the outside face. Cleaning of the foundation by grabbing and airlift pump was attempted, but without success.

The south cofferdam had already shifted at base by about 1 m

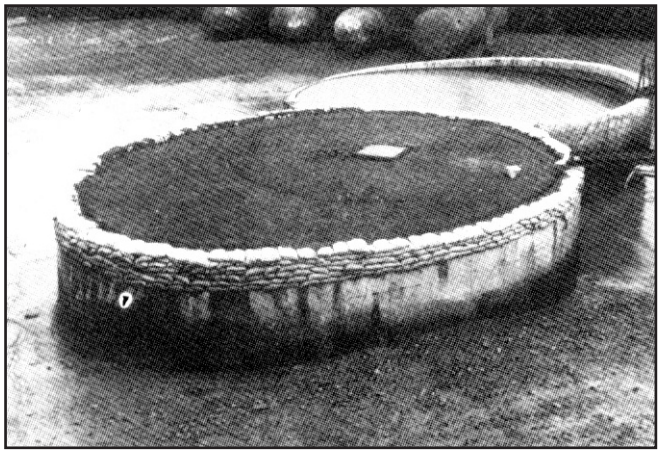

Figure 1. Deformed and cracked cofferdam of pier P22 filled with sand. This island of sand was used for sinking well foundation

and 1.75 m towards the north and cast respectively and had also tilled towards the south-east. Similarly, the north cofferdam had also shifted to the same extent and in the same direction, but had tilted towards the north-east.

The work of cleaning of south cofferdam was again taken up in September 1988. But, the flow of soil and sand continued to occur from the east side. Some sheet piles were sunk, outside the cofferdam opposite to blow point. Gunny bags filled with dry mix of concrete were dumped inside, under the cutting edge at the blow point and in the annular space between the cofferdam and sheet piles. After some time, sheet piles were removed and shifted to the north cofferdam. Cleaning of the cofferdam was continued, but after a few days the blow occurred again and the flow of material continued.

Both the concrete cofferdams were badly deformed and cracked.

When further sinking of concrete cofferdams could not materialise by conventional methods of sinking such as chiselling, grabbing, etc., a new scheme was devised. It envisaged construction of sheet-pile cofferdam inside the concrete cofferdam to carry out further excavation. As and when, more and more excavation and dewatering was done inside the sheet-pile cofferdam, steel ring trusses were inserted inside, at a spacing of about 2-m on centres, to strengthen the sheet pile cofferdam and to protect it from collapse.

This scheme was adopted for the north cofferdam. Two steel ring trusses were fixed and dewatering was again tried. When it was dewatered to a depth of about 4 to 5m, a loud cracking sound was heard from sheet piles and further work was abandoned.

The consultant ultimately changed the scheme of open foundation for pier P22 and adopted the well foundation.

Both the cofferdams were filled up with stone dust and were used as an island for well foundation, Figure 1. Wells of maximum 8-m outer diameter could be accommodated along the alignment in the badly-deformed and shifted cofferdams, Figure 2.

The work on north well was started in October 1989 and after casting for 22.5-m depth it was plugged in October 1990. Similarly, the work on south well was started in February 1990 and the well was finally plugged in November 1990 after sinking to 20.36-m depth.

Due to the proximity of the north well with its cofferdam on south-west side, the cutting edge of the well got stuck over concrete ring of the cofferdam and got tilted towards northeast. It was rectified by providing 2 props of 300 x 300 mm

Figure 2. Cracked and deformed cofferdam for pier P22 filled with sand and stone dust. Well steining is also cast to a certain height. Tilt and shift of the cofferdam can be seen from the eccentricity of the placement of well

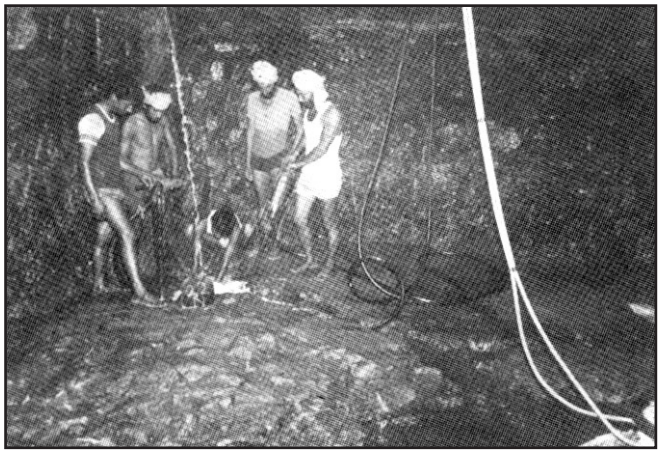

Figure 3. Rock excavation for socketing of well for pier P22 in progress

H-piles to the well from the opposite side and resting against the ring beam of the cofferdam. Kenteledge was also provided on the south-west side. Water jetting in the annular space on south-west side was also attempted to reduce friction. At one time, the contractor fixed 32-mm diameter wire rope around the well, and tied it to pulleys. These pulleys were, in turn, fixed to a winch by 32-mm diameter wire rope to hold back the north well from tilting. Further sinking by cutting rock with jack hammer was continued. Once the well penetrated in the rock strata, it was possible to dewater the well and work in open. Further sinking the well upto the required depth in the rock then became easy. 4.5m socketing of well was provided in the rock, Figure 3. As per the design requirement, 4.5-m deep socketing of the well in the rock was essential since diameter of wells was restricted to only 8 m.

Foundation for pier P19

As usual, 0.300-m thick concrete cofferdam, 4m in height, was placed in position with the help of a gantry and steel shell cofferdam was erected over this and lowered to the bed at pier P19 location.

Chiselling and grabbing operations were carried out for sinking. When the cofferdam was seated in the hard strata by about 150 mm to 200 mm, dewatering was tried.

When the cofferdam was almost dewatered, a big blow occurred from the east side. Sheet piling was done all around the cofferdam, maintaining an annular gap of about 1 m. Airlift pump was used to remove slush initially from the annular space and this was followed by the grabbing operation. About 1-m deep concrete was poured into the annular space and then dewatering was tried after about 15 days. However, full dewatering could not be achieved.

In the meantime, a labour problem cropped up and the work was held up for about 3 months, that is, from January to March 1993. It took some time to mobilise the labour again to start the work in full swing. The work was started in late August 1993. Vibro- hammer was used to sink the sheet piles deeper. However, no worthwhile progress could be achieved. Dewatering was again tried with 4 pumps of 20-HP each, but without success.

The concrete in the annular space was broken by chiselling. The sheet piles were removed from the eastern-half periphery and were resunk a little further away, keeping wider annular space on the east side. This annular space was again grabbed to deeper level, including the concrete filled earlier. About 1-m height of concrete was again filled up in the annular space along the eastern half periphery at a slightly deeper level than the earlier concrete. The cofferdam could be dewatered now with three 20-HP pumps in about 12 hours.

After a gap of about 5 hours, a big blow again occurred from the east side and the cofferdam was flooded. When divers were sent in the under-water annular space on the east side, it was found that a big hole was formed in the concrete within the annular fill, in which the diver could enter with his hands stretched.

By this time, that is, by December 1993, completion of pier P19 had become a critical activity in completing the north carriageway. All concentration was therefore focused on this foundation and further excavation was done under water by divers till the strata was reached upto the required founding level. During this period, the hole in the annular space was also filled up by dumping gunny bags filled with lean dry mix of concrete. Excavation in rock was carried out to about 2.00 m depth below the cutting edge of the cofferdam. The diameter of the pit was about 0.6m smaller than the diameter of the cutting edge.

Before concreting of the plug, 16 holes, about 1.5-in deep were drilled in the rock and 6 numbers of 12.7-mm strands, 4m in length, were inserted in each hole and these holes were grouted with a cement slurry. In addition, six numbers of 100-mm diameter pressure relief pipes were also provided. Concreting for the plug was then done under water with the help of a tremmie. Plug concreting was done upto about 0.3m above the cutting edge level of the cofferdam. Concreting for the plug was usually started when the high tide level just started receding.

It was, however, observed that during the subsequent high tide, the water level inside the cofferdam was not affected. This helped to a great extent in achieving good quality of concrete for the plug, though it was done under water.

The foundation was then dewatered after about 20 days. No excessive seepage was observed anywhere through the plug concrete. Further work of reinforced concrete footing and pier stem could be done in dry condition.

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