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Construction of deep water pile and pile cap by using prefabricated steel coffer dam technique

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ABSTRACT: Construction of deepwater pile caps on major rivers is a challenging task when water depth and water velocity are high. Monico Limited has made a successful attempt to implement low cost technique in construction of deep water pile and pile cap of a bridge on the river Halda at Chittagong-Hathazari-Rangamati Highway. It is an alternate method of pile cap lowering technique for the construction of deep-water pile caps and piers. The river Halda is a tidal river and the average difference between maximum daily high and low tide is 4.20 meter. The maximum velocity of water during the monsoon is about 3 m/s. Moreover, the river is the breeding ground of many species of fishes. The proposed pile cap bottom for the piers is more than 9.00 meter below the high tide level HTL and the bridge had to be completed within 22 months. So construction had to continue even during the monsoon. Due to high velocity of water and tidal waves, the conventional methods of deep water pile and pile cap construction by using conventional coffer dam was very expensive and posed high level threat towards construction safety. That is why a new technique was required to overcome all those conditions including speed, safety, sustainability and environmental conservation. In this technique steel coffer dam was prefabricated and placed at the pier location. Deep water pile and pile caps were constructed by the help of prefabricated steel coffer dam. This method is presented in this paper.

1 INTRODUCTION

The Halda River Bridge is 102 meter long and 10.3 meter wide 3 span simply supported PC-I Girder Bridge. The river Halda is a tidal river and its depth of water is high twice in a day. In design pile caps are placed at the bed of river and construction of pile cap and pier at this level is difficult. Traditionally, cofferdams are used for construction of pile caps and piers in relatively shallow water. However, this traditional approach suffers from major drawbacks, both from technical and cost considerations, in situations where water depth is high and there is high difference between water levels at high tide and low tide. This approach is therefore not suitable for construction of pile caps and piers in deep waters.

The Halda River contains a significant flow even during the dry season, and the work had to be continued during monsoon; so the only solution was to construct a coffer dam or caisson for piling works. Usually a cofferdam or a caisson works where the river current is slow and the tidal waves are low. In this particular case, because of the high velocity current and the high tidal wave, traditional coffer dam could not prevent the water leakage. The high velocity of water would cause erosion in river bed and would make it impossible for the traditional coffer dam or caisson to sustain. Moreover, the difference between the maximum daily high tide level and low tide level was 4.2 m, which required high walls around the piling area that made the construction work nearly impossible on the water. So the construction methodology and techniques had to be modified. In this method steel coffer dam was prefabricated on dry land and joined on the river bed safely. It is reusable and it is easy to move from one pier location to other.

2 LOCATION AND STRUCTURAL DESCRIPTION OF HALDA RIVER BRIDGE

The location and long section of Halda Bridge is shown in Figure 1 and in Figure 2, respectively. The total width of this Bridge is 10.3 m with footpath; the two-lane carriage way is 7.3 m wide. The project also involves construction of 0.644 km approach road. Six number of 1000 mm diameter bored pile of 37 m length was used in each pier. The project is being implemented by the Roads and Highways Department (RHD) of the Ministry of Road Transport and Bridges and Japan International Cooperation Agency (JICA).

Figure 1. Location of Halda Bridge

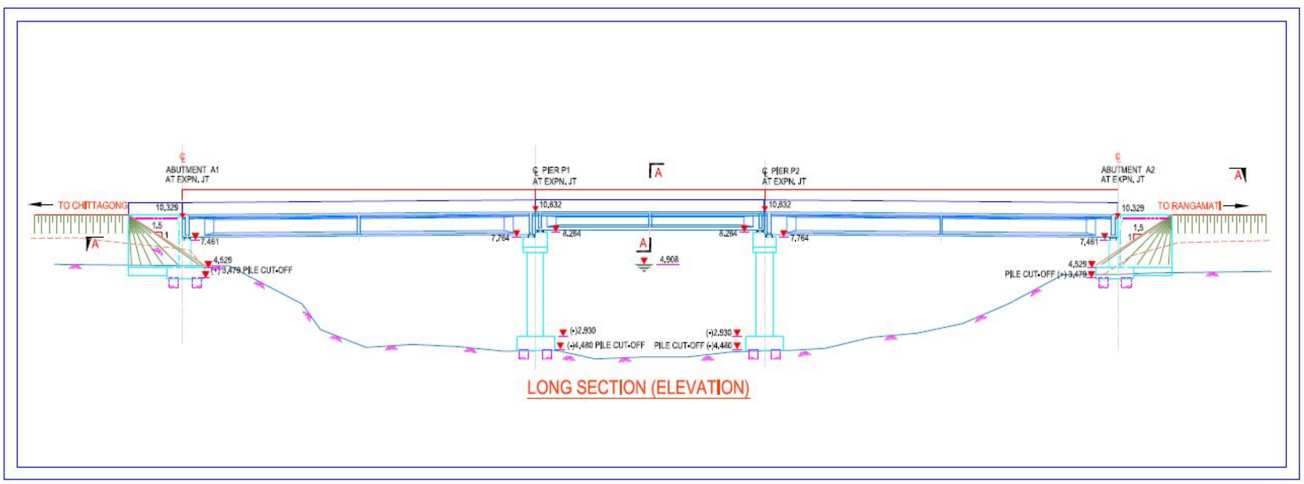

Figure 2. Long Section of Halda Bridge

3 PREFABRICATED STEEL COFFER DAM TECHNIQUE

In this method prefabricated steel coffer dam was made near by the bridge site. Then it was placed and anchored at the pier location. Deep water pile and pile caps were constructed by the help of prefabricated steel coffer dam. This are presented here briefly.

3.1 *Fabrication of Steel Coffer Dam*

The dimension of the coffer dam was 8.5 m x 5.5 m x 8.7 m which was constructed as a steel box with a bottom frame and side walls. The bottom frame and the side walls were made from 4mm thick M.S plate and 75 x 75 x 6 mm M.S angles. The bottom frame had six 1.2 m diameter holes at the pile points. To resist water pressure on the side walls, 5-layer I-beams were placed vertically and horizontally with the side walls. Six temporary casings were joined by continuous welding at the pile points from bottom frame to top frame. The coffer dam was divided in 23 frames and each frame was constructed separately in the riverside workshop. The coffer dam consists of two bottom frames, eighteen side frames and three top frames. The frames were later shifted to the erection point with crane. The top frames were placed on the top of the coffer dam for the convenience of installation of conventional rig for percussion boring. Three dimensional images of prefabricated steel coffer dam and adjacent pile casing are shown in Figure 3.

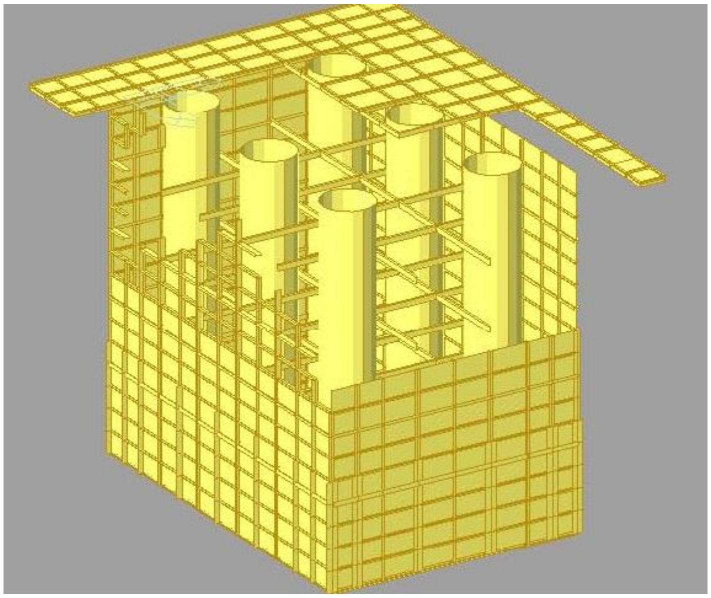

Figure 3. 3D image of prefabricated steel coffer dam and adjacent pile casings

3.2 *Placing of Steel Coffer Dam*

After fixing the center line of the pier and providing Layout of the cofferdam as per drawing, 150 mm diameter MS guide/anchor pipes were driven along the periphery of the steel cofferdam as per drawing up-to required depth so that the coffer dam cannot move in any direction and also to resist the upward thrust of coffer dam during dewatering process. The cantilever portion of the top of the coffer dam is rested on the additional steel pipe driven in the inside.

3.3 *Anchoring of Steel Coffer Dam*

Two bottom frames were placed on the level ground and welded into one component. Bottom frame is placed on the 150 mm diameter M.S pipe after welding. Six side frames were placed around the bottom frame. The height of sides is 2.2 m which is more than pile cap height. Two-layer bracing with I – beams was welded with the side wall. All joints were welded properly to prevent water leakage. This steel box was pulled very slowly by the winch & chain pulley and shifted to the pier location where 18 m long, 150 mm dia M.S. pipe was driven in two directions. The floating box was anchored with the MS pipes and filled with water to submerge the box partially. Six side frames were placed over the previously installed side wall and were joined by nuts and bolts with gasket, and welded vertically on both sides. Another two-layer bracing of I-beams (150 x 75 x 6 x 8 mm) was placed in this frame. The joined frame is filled with more water to submerge it partially. The remaining six frames were installed over this frame, joined by gasket, and the bracing was placed between the side walls. The remaining two sides of the coffer dam were surrounded by driving MS pipe. Six temporary casings (1200 mm diameter & 8m height) were placed and welded with the bottom frame at pile point. The bottom frame, layers of I-beams and temporary pile casings are shown in Figure 4.

3.4 *Pile and Pile Cap Construction*

The coffer dam was filled with water until it reached the river bed. The divers leveled the pier location using sand bags. Cofferdam was fixed at the specified level with the MS pipe. Prefabricated top frame was placed on the coffer dam using crane situated on a Barge. Additional pipes were driven around the cofferdam to carry the load of cantilever portion of the top frame. The Rig machine was installed on the top frame centering with one pile and its temporary casing. Permanent steel casing was inserted through the temporary steel casing and driven up to required level using drop hammer (2.5 ton). The cutter was lowered to the bed level for boring. After completion of boring and washing of bore hole, the High-Yield steel cage of the pile was placed at true level as per drawing and concreting work was done. The same operation was repeated for the other piles.

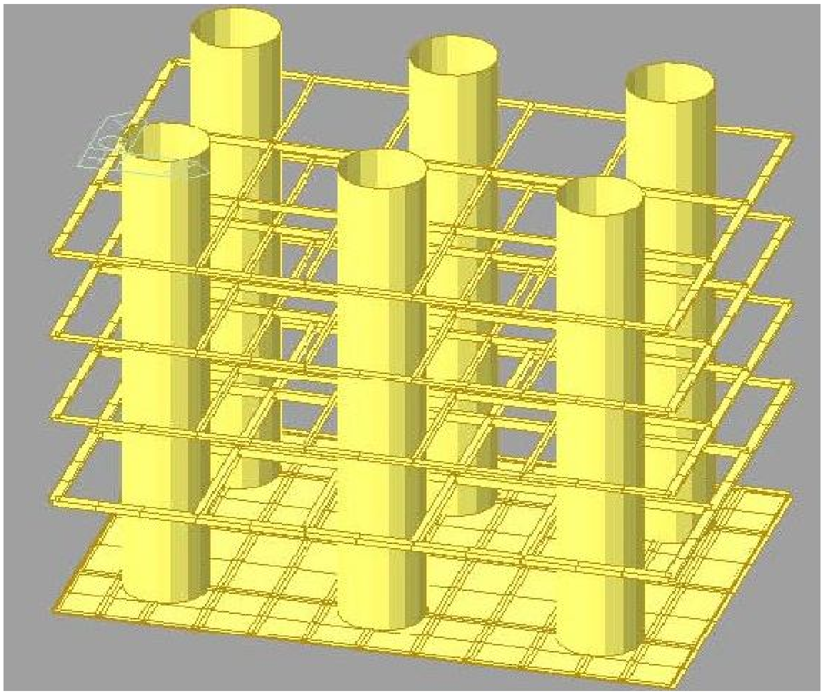

Figure 4. The bottom frame, layers of I-beams and temporary pile casings

After completion of all piles, top frame of cofferdam was removed but the cantilever portion was kept intact for the movement & installation of machinery. After dewatering, the gap between the temporary casing (1200 mm) and permanent casing (1000 mm) was sealed by the divers using steel gasket. Temporary casing was removed from cofferdam by the crane and all other casings were cut by underwater cutter at the bottom level. Under water CC work was made by the concrete pump. Again dewatering operation had been performed and pile head was broke by the electric hammer drill. All the garbage was removed from the coffer dam using crane & steel bucket. Pile cap rebar was placed as per drawing and design and concreting was done by concrete pump installed by the river shore. After completing the pile cap and pier shaft the upper part (remaining top frame & side wall up to 5 m from top level) of the cofferdam had been removed. Peripheral MS pipe was removed from river by boring and washing method. Photographs of prefabricated steel coffer dam, its placing, anchoring and deep water pile & pile cap construction are shown in Figures 5-8.

Figure 5. Photographs of prefabricated steel coffer dam

Figure 6. Placing of prefabricated steel coffer dam

Figure 7. Watering, De-watering & Anchoring of prefabricated steel coffer dam

Figure 8. Construction of Pile over prefabricated steel coffer dam

Figure 9. Construction of pier shaft inside prefabricated steel coffer dam

4 CONCLUSIONS

The construction of the Pre-stressed Concrete Girder Bridge over Halda River posed considerable challenges in terms of time, economy and construction safety, but the challenges had been overcome by using innovative construction techniques. A prefabricated steel coffer dam which has been constructed parts by parts on the workshop by the river shore and then pulling the parts to the river and joining those there not only made the work possible, but the new method and techniques used in the process saved significant amount of time and cost and provided a safe working environment to the workers. This method can be used in similar conditions for constructing bridges and underwater structures in future for economy, speed and construction safety.

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