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Construction of deepwater pile caps for Dapdapia Bridge over the Kirtonkhola river

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ABSTRACT: Construction of bridges, especially construction of deepwater pile caps, on major rivers is a challenging task when water depth and water velocity are high. Traditional cofferdams approach of pile cap construction is not suitable under such circumstances. Recently, Project Builders Limited (PBL) has made a breakthrough in modern bridge construction in Bangladesh by successfully implementing the "pile cap lowering technique" for the construction of deep-water pile caps and piers of the Dapdapia Bridge over Kirtonkhola River on Barisal –Patuakhali Road. This method involves casting of a pile cap above water on temporary soffit shutter, lowering it to the desired level under water through precise synchronized operation of hydraulic jacks, and finally connecting the pile cap with the piles deep under water. This is an important milestone for local Contractors involved in bridge construction in Bangladesh. The experience gained by Project Builders Limited (PBL) through the construction of Dapdapia Bridge could be successfully utilized in the construction of bridges over any major river, using solely local expertise.

1 INTRODUCTION

Construction of bridges on major rivers is a challenging task. This is particularly true for construction of bridges in deep waters, which is common for many rivers in Bangladesh where water-depth remains very high, even during the dry season. Among the bridge components, construction of pile cap and pier is particularly challenging in deep water. 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.

Among the state of the art construction of techniques used for construction of pile cap and pier in deep water, the "pile cap lowering technique" or the "jack-down method" has been successfully used for bridge construction in many countries. The "jack-down" method has been successfully used for the construction of Bhairab Bridge (Bangladesh-UK Friendship Bridge) over Meghna River during 1999-2002 by Edmund Nuttall, a reputed UK Contractor (Collings et al. 2003). However, local Contractors lacked expertise and experience in such construction techniques, which was a major drawback that prevented them in undertaking major bridge construction on their own, without the support of foreign Contractors.

Recently, Project Builders Limited (PBL) has successfully implemented the "pile cap lowering technique" for the construction of deep-water pile caps and piers of the Dapdapia Bridge over Kirtonkhola River on Barisal –Patuakhali Road. This paper describes the "lift slab technique" used by Project Builders Limited (PBL) for the construction of pile caps and piers for Dapdapia Bridge on Kirtankhola River.

2 OVERVIEW OF DAPDAPIA BRIDGE

Figure 1 shows the location map of Dapdapia bridge. It is located at the 3rd km on Barisal –Patuakhali Road (N8) over Kirtonkhola River. It also shows the Khairabad bridge, which is being constructed by PBL over Khairabad river under the same project. The total length of Dapdapia Bridge is 1390 m and that of Khairabad Bridge is 274 m. The total width of Dapdapia Bridge is 10 m with footpath; the two-lane carriage way is 7.5 m wide. The project also involves construction of 9.3 km approach road. The project is being implemented by the Roads and Highways Department (RHD) of the Ministry of Communications. Kuwait Fund (KFAED) is

providing 80% funding for the project; the KCIC (Kuwait)-ACE (Egypt)-DDC (Bangladesh) is the consultant for the project. Table 1 shows some important features of Dapdapia Bridge.

Figure 1: Location of Dapdapia bridge on Barisal-Patuakhali road

Table 1: Important features of Dapdapia Bridge

Sl. No.	Name of Item	Description
1	Structure Type	Pre-stressed Concrete Segmental Box Girder
2	River Type	Category A
3	Vertical Clearance	18.30 M
4	Horizontal Clearance	76.20 M
5	No. of Spans	26 Nos. @ 30 M 2 Nos. @ 48.5 M 6 Nos. @ 85 M 34 Nos.=1390M
6	Foundation Type	R.C.C. Pile Foundation of Diameter 1.00/1.20 M
7	No of Piles	244 nos.
8	No of Piers	33 nos.
9	Width and Lane	Width-10 meter with foot path at each side; Carriage way-7.5m (2-lane)

As noted earlier, pile caps and piers for bridges are constructed by erecting large diameter sheet pile cofferdams, which provide the dry environment needed for construction works. Usually cofferdams consisting of two rows of sheet piles are used. The infill material between the two rows of sheet pile is provided to withstand the hydrostatic pressure and to limit the water seepage from the dam's wall. Usually a thick mass concrete water plug is used to limit the water seepage from the bottom of the working space and also to contain the riverbed during construction. A continuous de-watering system is run to keep the working space dry during construction.

However, as noted earlier, this method is workable only for relatively shallow water depths and not suitable for deep water pile cap/pier construction. As water depth and water velocity increases, this method becomes unsuitable both from technical and cost considerations. The depth of Dapadapia River exceeds 13 m and water velocity often exceeds 2.5 m/sec. Therefore, the traditional cofferdam approach cannot be used for construction of Dapdapia Bridge.

Based on the field condition and experience (Collings et al., 2003; Hinch et al., 1984; Candler et al., 1984), the "lift slab technique" or "jack-down method" or "lowering method" was considered suitable for pile cap construction of Dapdapia bridge. This method has certain advantages, e.g., it is quicker and more economical than traditional method; it is also safer and could be implemented with minimum disrupting navigation. However, local contractors never implemented this method/ technique on their own and therefore it a major construction challenge.

3 CONSTRUCTION OF DEEPWATER PILE CAPSE

The "lift slab technique" involves casting pile cap and pier above water and incrementally lowering them down the piles using hydraulic jacks. For this purpose, the steel pile casings were specially extended above water level (minimum 500 mm above HWL). The casings were filled with sand from the top of concrete level up to about the water level (see Fig. 2). On top of the sand fill within the steel casing, steel section were erected with concrete, on top of which the lifting beams (steel I beams) were fixed (see Fig. 2).

The pile cap was then cast (in two stages) above water level on temporary soffit shutter. During casting, portions of the pile cap around each pile were boxed out (that is not concreted) for: (i) keeping sliding gaps (for sliding the pile cap) around each pile, and (ii) keeping space for structurally connecting the pile cap with the piles. Lifting rods were set in the pile cap for connecting it to the lifting jacks. The lifting jack system, fitted with hydraulic pump, was installed on top of the lifting beams; these lifting jacks were connected to the pile cap through the connecting rods. Once the pile cap has been cast and cured and the hydraulic lifting jack system is in place, the pile cap was lifted off the shutter, and the soffit shutter system was removed from underneath. At this stage, the pile cap, held entirely by the lifting jacks, was ready for lowering.

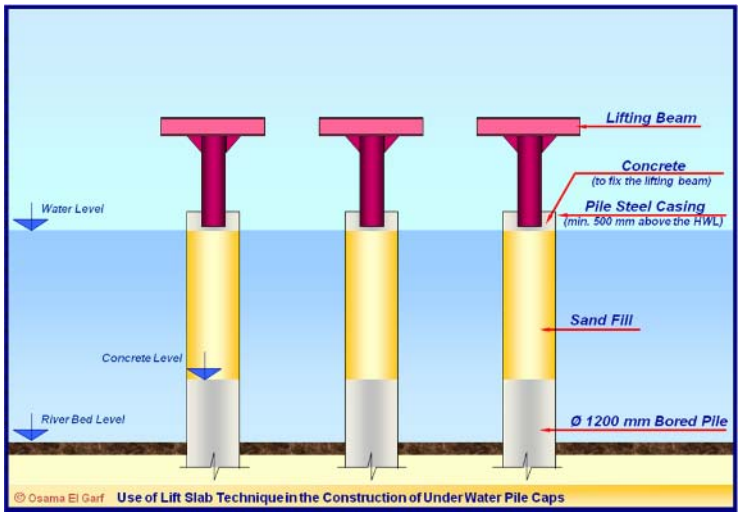

Figure 2: Fixing of lifting beam on top of steel pile casing (schematic view)

The pile cap was then lowered in water down the piles through precise synchronized operation of the hydraulic jacks up to a depth so that the top level of the pile cap remains above water (see Fig. 3); this reduced the effective weight of the pile cap. In order to create a dry environment underwater for making structural concrete connections between the piles and the pile cap, large diameter (2500 mm) steel watertight caissons were fixed and sealed to the top of the pile cap around each pile. Considering the safety of people who would work deep under water within the caissons, extreme care were taken in quality control and quality assurance of all works.

Figure 3: Lower of pile cap in progress through precise synchronized operation of hydraulic jacks

At this stage pier construction on the pile cap commenced; the piers were constructed in stages. As the pier construction progressed, the pile cap together with the steel caissons was lowered gradually using the hydraulic jack system, always keeping the top of the pier above water level. Following this process, the pile cap was lowered up to the desired level; the top of the steel caissons remained above the water level.

Once the pile cap was in place, the sliding gaps between the pile cap and the pile casings were sealed and water was pumped out from within the steel caissons to create a dry working space. Arrangements were then made to transfer the load of the pile cap to the piles, so that the hydraulic jacks, which still held the weight of the pile cap, could be released. The lifting jacks were then removed and the pile cap rested on the piles. The sections of steel pile casings above the concrete level were also removed at this stage to create working space at the base of the pile cap below water level. A de-watering system was run to keep the working space within the caissons dry. Reinforced concrete works for connecting the pile cap to the piles were then completed in stages. The steel caissons around the piles were then removed and the pile cap construction reached its completion.

4 CONCLUSIONS

The construction of Dapdapia bridge is near completion. The experience gained by Project Builders Limited (PBL) through the construction of Dapdapia Bridge could be successfully utilized in the construction of bridges over major rivers anywhere in Bangladesh or elsewhere, using solely local expertise.

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