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Case Study of Special Case of I-Foundation at Harris Bridge in Pune

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Abstract - *Pune is called Oxford of Asia because of its number of educational institutes and research centers. Also, the district has an important Military Base and a famous IT Hub in the country. All this makes the city very busy and congested. Hence, the construction of the Metro Rail System in a very congested city like Pune, where there is already a lot of infrastructure development going on, is challenging. This paper describes the challenge and the ideal and scientifically creative solution by the Metro Rail Corporation in Pune. The objective of this paper is to focus on one of the challenges that the team of Metro faced during the execution of the foundations between Harries Bridge and Dapodi Bridge at Dapodi, Pune. Harris Bridge is 125 years old Masonry Bridge constructed in the British era. In 2016, PCMC placed Harris Bridge under scrutiny. Hence, the challenge was not only to execute foundations in the riverbed but also to safeguard the old foundation of the Harris Bridge while executing the metro viaduct foundations. To protect the old foundation of Harris Bridge from scouring, micro piles were used. Pune City is gifted with rich rainwater; therefore, construction was not possible in the rainy and winter season. Hence, it was done only in the summer season with the help of an earthen cofferdam. An innovative solution of double eccentricity was opted to overcome space constraints due to the decks of the two bridges. My quest is to dive deep into the innovative solutions implemented by the Metro Team to overcome the mentioned challenges with high precision in planning, design, and execution.*

Key Words: **Metro Rail, Harris Bridge, PCMC (Pimpri Chinchwad Municipal Corporation), Cofferdam, Micro Piles, HFL (High Flood Level), GWL (Ground Water Level).**

1. INTRODUCTION

Site conditions always play a vital role in deciding the type, shape, and design of the foundation. In this case, the site conditions lead to the "I" shape of the open stepped foundation. This foundation is located between the two foundations of the old structures, where space availability is very limited. Also, the foundation of Harris Bridge is very old, so it requires special attention. There are two important challenges, the first is to construct a foundation in a limited or a very little space and the second is to give alert attention to the old structure. Also, the water level in the river and the moisture content create a lot of impact on the execution of the construction process. This influences seepage of water in the construction pit which, causes difficulty in construction activity.

1.1 Harris Bridge

Harris Bridge is a 125-year-old and 402-meter-long masonry structure located on the Mula River in Dapodi, Pune. This bridge was constructed during the British era. In 2016 it was inspected by the PCMC authorities and, the maintenance was done in 2017.

1.2 Soil investigation in Riverbed

The average depth of the hard strata was found to be at 4.65 meters and, the bearing capacity was found to be 250m/T2 which leads to the selection of an open foundation. The hard strata available was Basalt Rock.

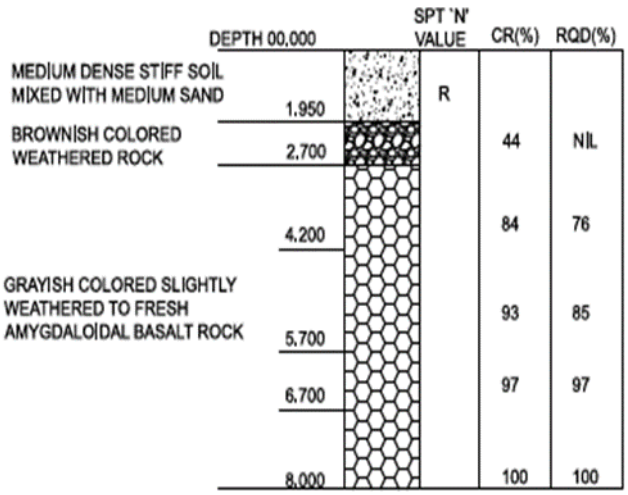

Fig -1: Soil Investigation in Riverbed

1.3 Special Foundation

The I-shaped foundation was constructed between the foundations of the two bridges, namely the Harris Bridge and the Dapodi Bridge. This was done because the running waterway of the river should not get disturbed. It is a stepped type of an open foundation of "I" shape. Available HFL and GWL are 553.434 and 543.185 respectively, which is too high, i.e., 10.25m. Therefore, to protect the foundation from high seepage and to keep it in a stable condition, the self-weight of the foundation had to be increased by keeping higher dimensions (12m×9m×4.5m). The quantity of the concrete used for this footing is almost three times more than the quantity of concrete used for the footing anywhere in this project. This foundation is located in between the existing foundations of the two bridges, this resulted in an inadequate area. Hence, the team came up with the solution of the "I" type of foundation.

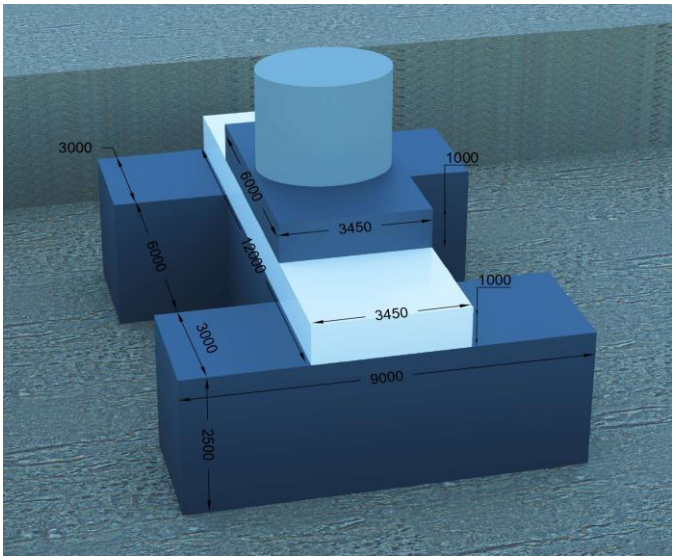

Fig -2: Special Foundation

1.4 Double Eccentric Pier

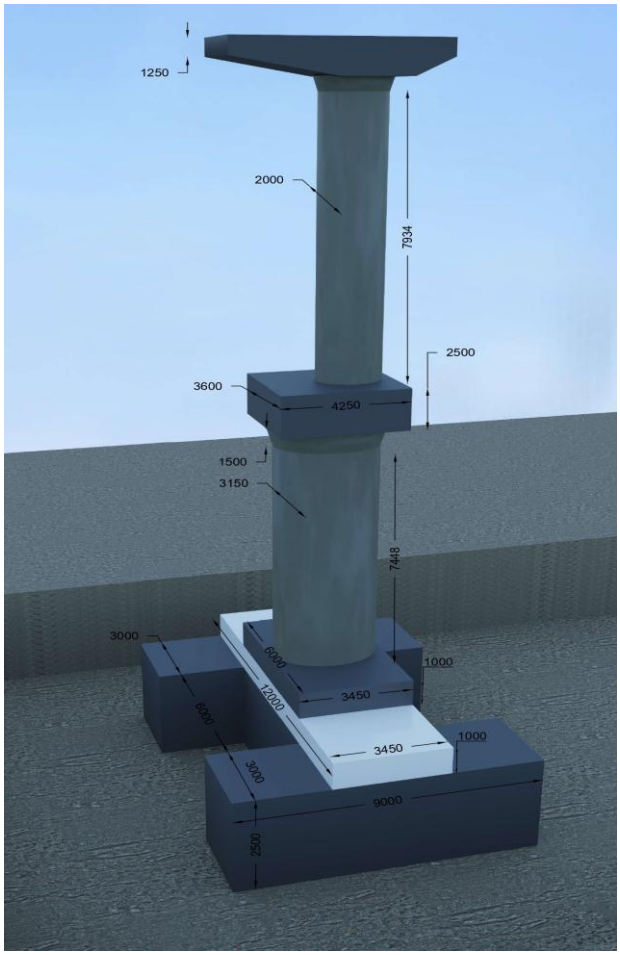

Fig -2: Double Eccentric Pier

The pier constructed here is a "Double Eccentric Pier". The centerline of the pier below and the centerline of the pier above the intermediate pier cap is not common. The centerline of the pier above the intermediate pier cap and the centerline of the segmental girder is also not common. This is called the "two eccentricities". The centerline of the alignment and the centerline of the pier above the intermediate pier cap are tried to be kept close so that the produced moment will be minimum. The distance between the Dapodi bridge and the pier above the intermediate pier cap is kept 100mm only. A total of five piers are constructed between the two bridges. The height of these piers is around 25meter. The shape of the pier is oval shape. The sizes of the lower pier and pier above the intermediate pier cap are (3150×2500) mm and (2500×2000) mm respectively.

2. Construction Methodology

Table -1: Construction Activity Sequence

1	Bed formation in River	9	Fixing of utility pipes
2	Micro Pilling for old structure	10	Construction of pier starter
3	Cofferdam	11	Shuttering for pier
4	Laying of PCC for footing	12	Concreting and curing of pier
5	Reinforcement fabrication for footing	13	Intermediate pier cap
6	Shuttering of footing	14	Constructing of pier above intermediate pier cap
7	Concreting & curing of foundation		
8	Reinforcement fabrication for pier	15	Final Coating

Even in the summer season, the Mula river is not completely dry. Hence, there is a need for the provision of a platform or solid bed of Morrum/ hard rock for the movement of workers, material, earthmovers, and carriers. But the complete river cannot be blocked. Therefore, the bed is built as per the requirement. As the Harris Bridge is very old, its base was provided with some support of micro piles of 250mm each. If this support would not have been provided, then there was a possibility of sliding or erosion of soil below the foundation of Harris Bridge. Which would've ultimately led to the collapse of the entire bridge.

Next, the survey is carried out and the points for cofferdam are marked with iron peds and total station and, after that, an earthen cofferdam is constructed at the location of the foundation. A cofferdam is an enclosure built within a body of water or river to allow the enclosed area to be pumped out. The pumping of water creates a dry working

environment so that the work can be carried out safely, this is constructed using sandbags. Later, fabrication of reinforcement is done as per the approved bar bending schedule. The Bar bending schedule is prepared with a reference of approved drawings. And then the reinforcement is placed and bonded using binding wire. Cover blocks of 75 mm size are placed at the bottom and sides of the foundation. While placing the foundation reinforcement, pier reinforcement must also be placed. Then steel shuttering is placed properly by coating it with shuttering oil. The verticality of shuttering is ensured by using the plumed bob. Jointed must be bolted properly with fill foam. Once that is done, impermeable concrete is placed using concrete chutes. The temperature must be checked of each batch before placing the concrete. The concrete mix used was M35 grade at a temperature of $32^0C \pm 20^0C$. The slum was maintained at 150mm ± 25mm. And then the slump was vibrated using a mechanical vibrator and, after 24 hours de-shuttering was done. Curing was done for 21 hours. Then a protective layer of coating was applied, which was done by a mixture of solvent-based coal tar epoxy coating and AC-DURCT (S) to protect the foundation. And finally, backfilling was done in well-compacted layers.

Then the construction of the pier commenced. Firstly, the fabrication and the placing of pier reinforcement was done and, then the pier starter was constructed. The purpose of the pier starter is to fine-tune the formwork of a column vertically to maintain a sufficient gap between the column reinforcement and the shuttering. Then the utility pipes like drainage pipes, etc. are fixed. Then the shuttering was erected by using clamps around the starter pier. A de-bonding agent was provided in the contact area of shuttering. And eventually concreting was done. The concrete mix used was M50 grade. Later with the use of wet hessian cloths and a sprinkling of water, curing was done. Then the intermediate pier cap was constructed. Similarly, the pier above the intermediate pier cap and the top pier caps were constructed.

3. CONCLUSIONS

Despite the challenges like space constraints, water percolation due to the river, old and fragile structures like the Harris Bridge, and maintaining the alignment through the two bridges. The construction of the special foundation and a double eccentric pier was designed to overcome the mentioned restrictions and implemented them successfully with the desired accuracy. Harris bridge's structure was not disturbed at all. Double eccentric pier is one of the iconic designs and construction in the world. Construction of foundation and the pier was done by achieving more than designed grades of concrete as per mix design.

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