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Construction of Hazrat Shah Paran (r) (2nd Surma) Bridge over Surma River at the North East Bangladesh – An innovation of temporary works for girder construction

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ABSTRACT: This paper describes the construction method and Techniques adopted for construction of Hazrat Shah Paran (r) Bridge (2nd Surma Bridge) over Surma River, particularly for construction of 43.50 meter I-Section Pre-stressed Concrete Girder in location, some innovative idea and methods were introduced. Instead of making traditional platform by inserting steel pipes in River bed and blocking the navigation, an alternative method was introduced and that worked successfully. This helped to complete the whole construction work on time by allowing all weather construction work and no hindrance to the normal navigation in the river.

1 INTRODUCTION

The 392.00 meter long Hazrat Shah paran (r) (2nd Surma) Bridge over Surma river is located on Sylhet-Tamabil-Jaflong Road Improvement Project (STJRIP) of Roads & Highways department (RHD). Fig. 1 shows the photograph of the completed bridge. The project has been completed during 01July 2003 to 31December 2005, under the financing of Kuwait Fund for Arab Economic Development (KFAED) and Government of Bangladesh (GOB). It contains total 9 spans having lengths for 2 end spans @ 43.125 meter (abutment backwall to centerline (C/L) of the 1st pier, and the 7 intermediate spans @ 43.55 meter center to center (c/c) piers.

Fig. 1 Photograph of the completed Hazrat Shah Paran (r) Bridge

The design and supervision consultants of the project were SARM Associates Ltd., et al Monico Limited, a reputed construction company of Bangladesh was the Contractor of the bridge project. The temporary works for the bridge were designed by Design Planning & Management Consultants Ltd. on behalf of Monico Ltd.

The Author as the then Director of Monico Ltd./Director-In Charge of the project, narrates the innovative, site specific and cost-effective method of construction of the superstructure. In discussion and conclusion he gives the lessons learnt and what's to be done for future bridge construction under such flashy rivers.

2 BRIDGE DATA

The deck girder bridge spans contain 7 nos. I-Section post-tensioned Prestressed Concrete (PC) girders of depth 2.25 meters par span. The bridge deck elevation at its mid-length along the bridge center line (C/L) of the parabolic bridge deck, is maximum 22.525 mPWD, where the corresponding girder soffit elevation over bearing is 22.449 mPWD. The longitudinal gradient of the bridge deck is 3.5% parabolic and its cross fall is 2.5%.The unsupported height of Pier from the top of pile cap to bridge bearing level was 16.674 meters at mid-length of the bridge.

The cast-in-place bored piles having diameters 750mm and lengths varying between 32.00 and 35.00 meters were used for Pier and Abutment foundations. The bottom of the Pier pile caps are placed at EL. 4.50 m PWD.

For PC Girders, the specified compressive cylinder strength at 28 days fc' = 35 N/mm^2 is used. Reinforcement of ASTM A615M – 88 Grade 60 deformed Bars, having minimum yield strength fy=415 N/mm^2 for all members are used. The prestressing cables composed of 7 Nos. of 12.7 mm nominal diameter 7-wire high tensile strands with minimum yield strength fy = 1580 N/mm2 & ultimate tensile strength (UTS) = 1860 N/mm^2 were used.

3 BACKGROUND OF INNOVATION

Monico Ltd. signed the agreement for the construction of this bridge and its approaches in 01 June 2003 with a targeted completion period of 30 months, i.e. the completion date was 31 December 2005. Out of this 30 months duration, 12 months are non-working period, considering the 3 flood/monsoon seasons, each of 4 months duration from June to August per year. This gives net working period of 18 months only, out of which a considerable period was required to construct the cast-in-place bored piles particularly for piers in flashy river.

The Contractor needed to adopt fast track construction for the bridge superstructure utilizing the monsoon season also. The methodology should be safe under the flash flood and under the cyclonic condition of the Sylhet area. The innovation adopted in the construction methodology of the bridge superstructure is described below.

4 RIVER HYDROLOGY AND BATHYMETRY AT BRIDGE LOCATION

Surma is a large size flashy river originated in the Manipur hills of the North eastern India. Its maximum and minimum discharges vary between 1,500 and 14 m^3/sec. The high water level (HWL) considered in design was12.00 mPWD , which corresponds to 2000 flood. During construction period the measured HFL on 11 July 2004 exceeded this design HWL by about 0.44 meter. The design low water level (LWL) was 4.156 mPWD, which corresponds to 09 December 2001 water level. At bridge location river bed elevation adjacent to deep water pier was 1.092 mPWD. The flash flood may exceed 1.00 – 1.50 meters in a day.

5 CONSTRUCTION METHODOLOGIES OF BRIDGE DECK GIRDERS

Several options were studied as follows:

5.1 *Conventional method of constructing deck girders*

For the Government of Bangladesh (GOB)-funded small and medium span river bridges, the conventional method is by erecting scaffolding in the river bed for the entire deck girders of one span, as shown in Fig. 2. The PC girders and reinforced concrete (RC) decks are then constructed cast-in-place over bearings below each girder end. This has a risk of prop settlement affecting the girder and deck concreting, and further, it's time consuming and expensive also.

Fig. 2 Traditional method of construction of bridge girders by erecting props

5.2 *PC girders are concreted as non-composite members at span level*

The scaffoldings are erected on river bed, as shown in Fig. 1, but for one PC girder only. The girder formwork and reinforcement are placed over the scaffolding nearer to the bearing level but away from their actual locations. After it gains adequate strength, by about 7 days, these are either partially or fully prestressed. These are then lifted and shifted to their actual positions over bearings, either before or after grouting. After all the girders are placed in position, the scaffolding is removed. The deck forms are then placed over inserts in the precast girders, and then deck concreting is done. The props are then removed for use in the other spans.

The non-composite girder is designed to carry its self weight and the weight of the deck concrete and some live load. The deck is shear-connected to the precast girders. The composite girder carries the live load. The prestressing losses are estimated considering the differential shrinkage along with the other losses.

This option also has the risk of prop settlement and therefore isn't preferred.

5.3 *Precast girders lifted and shifted by crane*

The girders are constructed adjacent to the span. After prestressing, these are lifted and shifted to the span locations and placed in position over the bearings. Deck concreting is done by providing supports over the PC girders through inserts.

This was found inconvenient, expensive and unsafe for the subject flashy river.

5.4 *Launching girder method*

This method is generally used for medium span river bridges. In this method the precast PC girders are constructed behind the abutment. After their partial or full prestressing these are lifted and shifted by using the launching girder and placed in the adjacent span. Deck concreting is done by supporting the formwork over the PC girders through inserts as before. The rest procedure is the same as before. Span by span construction is done sequentially thereafter.

For a single bridge mobilizing the launching girder was found expensive.

5.5 *Launching truss method*

The launching truss could be designed with nosing. The depth of the pair of main trusses becomes large. Besides, truss nosing is required at each end. For the high stream current of the subject flashy river (peak flow velocity > 2.0 m/sec approximately), mobilizing the launching truss arrangement under water was considered unsafe. For the single bridge of 9 spans this was found economically not viable under the contract amount.

5.6 *Innovative use of space truss for construction of non-composite PC girder*

5.6.1 *About the system*

After exploring many other options, finally developed the innovative form of space truss, as shown in Fig. 3. At the 2 ends, 2pairs of triangular arches were erected. In the middle third, one pair of normal arch was suspended from the tip of the 2 triangular arches. Additional members were then provided connecting the pairs of arches including the triangular arches to form the space truss. The erection of the whole system was done by mechanical method and jointed with nuts and bolts.

The pairs of the triangular arches were first erected up to about 150 mm above the HWL for all the river spans before the arrival of the monsoon floods. These were supported over the pier caps with holding down device and the control system to arrest the longitudinal and transverse movement of the truss support due to hydrodynamic and gravity loads. These trusses were anchored and fastened with the pier shafts also. The stream flow of the flash flood could pass through the truss openings without exerting unacceptable vibrations in the submerged trusses. The erection of the whole system was done by mechanical method and jointed with nuts and bolts. Fig. 4 shows the erected trusses during the monsoon season.

Fig. 3 Bridge girder construction by using triangular space truss support

Fig. 4 Photograph shows the system of erected truss supports during monsoon season

The spacing of the pairs of parallel trusses was designed to accommodate a suitable working platform of about 5.0 meter wide with adequate working space and movement of the workers. The steel I-sections and U-Channels were used to make the top platform.

On completion of one span the whole truss system was dismantled, lowered on the bed of a river vessel, brought forward to the next gap and erected on the pairs of the triangular trusses fixed earlier, as shown in Fig. 5.

Fig. 5 Erection / dismantling system of truss modules

5.6.2 *Analysis of the trusses*

The analysis model was developed in STAAD/Pro. The design of the truss members and their depths, particularly for the middle third, were designed so that the maximum deflection doesn't exceed 50 mm. The objective is to select the concreting sequence such that the integrity of the green concrete at plastic stage isn't affected. The trusses were designed as modules of uniform size so that these could be transported and re-used easily. With this truss the construction could be continued during all the seasons.

The system helped the contractor in faster construction of girders with almost no risk and hindrances. The system was found environment-friendly, safe and at the same time economical also.

5.7 *Comparison of the financial cost of the triangular truss system and propping system*

- The cost analysis between the conventional propping method and triangular space truss method showed that the financial expenses of truss per linear meter of girder length are 15% higher than the propping method.
- As regards salvage value of the materials, it is found that almost 40% length of props/pipes isn't salvageable. Besides, withdrawing the props from the river bed becomes practically uncertain; even if it's done it becomes costlier than dismantling cost of the truss. In case the props aren't withdrawn, it will create obstruction for the river navigation subsequently. Considering the above factors, the propping method is found 30% costlier than truss method.
- Comparing the repeated use and time savings of the truss system vis-à-vis the propping system the cost of the truss system was found about 10% cheaper than the prop system.
- Summarizing the comparative cost of the above 2 systems, propping method is financially about 25% costlier than the truss method. Besides, it contains the risk of prop settlement harming the structure.

6 LESSONS LEARNT AND CONCLUSION

The lessons to be learnt from the construction of the Hazrat Shah Paran (r) Bridge over Surma river (2nd Surma) is that the design of the temporary works for construction of the river bridges is as important as of the design of the permanent bridges.

The innovations in temporary works require studying different options of which some may appear not logical in the foresight but might be found logical in the hind sight. So, no options should be discarded from the initial scrutiny.

The environmental load effects should be considered in the realistic manner and adequate safety measures should be provided in design and detailing of the temporary works.

The specialized team of design engineers well-conversant with the scaffolding and temporary works design including the design codes and available local materials and their properties are very important.

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