

# Construction of arch bridges: An indigenous approach

S.M. Khorshed Alam & Sushanto Kumar Saha

*Dienco Ltd. Dhaka, Bangladesh*

**ABSTRACT:** A dual carriage way 60m long Arch Bridge over the Moyur river at Khulna and a four lane single span Arch Bridge over a canal at Uttara have recently been constructed. The Bridge at Khulna is 7.3 m high and it has dual arch to hold the deck. The bridge at Uttara is 9 m high, 12.6 m wide and the deck slab is resting on arch. Indigenous approach has been adopted to build the two bridges by using available local resources and practice. Incremental construction method with few modifications is adopted for Arch construction. These are presented in this paper. The bridges are aesthetically beautiful, pleasant and best in looking for urban areas.

## 1 INTRODUCTION

Construction of two Arch Bridges was completed in recent dates. One of which is at Khulna the southern district of Bangladesh over the river Moyur and the other one is over a canal in Dhaka at Uttara Residential Model Town. Both the water ways are flowing round the year at different stages. The Arch Bridge at Khulna over the Moyur River is at the periphery of the city and the bridge approach road has been given a new connectivity to the city with the existing city by-pass. The city dwellers were feeling the necessity of a new connectivity in a decorative way for the aesthetic beauty of the area that would keep pace with the nature. The Arch Bridge at Uttara Residential Model Town is built for the purposes of communication network within the proposed city extension. As it is over a canal within the residential area, it would harmonize the beauty of canal and attract the city dwellers for recreation at leisure.

Span of Arch Bridge over the Moyur River is 60 meter and height of Arch is 16.16 meter. It is under the category of Tied Arch Bridge. The clear span of Uttara Arch Bridge is 60.0 meter and it is in the category of Deck Arch Bridge. Construction of both the bridges was done by local indigenous method that has been evolved by closing the total water way and place the scaffolds on the adequately firmed built bed. Due to resources limitation it was difficult to build the arch without partial closing of river/channel. And finally the dumped soil was removed from the bed of river/canal and the desire section of the river/canal was brought back. The water flow of river/canal was kept open throughout the year by providing large diameter RCC pipes.

## 2 LOCATION & MAJOR GEOMETRIC DIMENSION

### 2.1 Location

Bridge over the river Mayor is situated in the district of Khulna at longitude  $89.536007^{\circ}$  E and latitude  $22.812271^{\circ}$  N and bridge at Uttara Residential model town is at longitude  $90.359891^{\circ}$  E and latitude  $23.868906^{\circ}$  N.

### 2.2 Geometric and Structural Description

Arch Bridge over the river Moyur is consisting of two arches and holding the deck by 3 intermediate stringers at both sides. The abutment at both sides are made of triangular viaduct of 15 meter length at each sides and the decks are resting on the grid of two long girders and cross beam at an interval 3.0 meter. Design concept of Uttara Arch Bridge is different. The deck of Uttara Arch Bridge is resting on the main arch of clear span 36.0 meter, and the rest of total 60.0 meter Bridge are supported from the inclined wall leafs at both end. The inclined wall leafs are finally resting on the abutment wall. The total Bridge looks like a combination of one big and many small Arches. Detail dimension of both the bridges are given in Table 1.

Table 1. Detail geometric description of Moyur and Uttara Arch Bridge.

| Description          | Bridge over Moyur                                 | Bridge at Uttara                                   |
|----------------------|---|--|
| Total Span of Bridge | 60 m  | 60 m   |
| Clear Span of Arch   | 45 m  | 36 m   |
| Height of Arch       | 16.16 m   | 9.85 m   |
| Long girder          | 30.0 m  | -  |
| Steel hangers        | 3 + 3 = 6 Nos                                     | -  |
| Piles Size           | 1000 mm Dia 48.0 m Long                           | 900 mm Dia. 28.0 m Long                            |
| Pile Cap             | 13.10 m x 8.0 m x 1.2 m                           | 11.3 m x 8.4 m 1.8 m                               |
| Width of Bridge      | 11.10 m   | 12.60 m  |
| Dimension of Arch    | 2470mm x 750 mm at bottom<br>500mm x 750mm at top | 8000mm x 1200mm at bottom<br>8000mm x 600mm at top |

### 2.3 Construction Methods

Arch Bridges at Khulna and Uttara were built on bored pile foundation and the numbers of pile were 102 and 104 respectively. Piles were built by following percussion method with tripod. For both the bridges same indigenous approach was followed in construction of RCC Arch. When the water level of river/canal was at the lowest stage it was closed by a coffer dam and the river/cannel bed was dried up. Then it was filled by local dredged sand up to the level of pile cap, i.e. up to the starting toe of the RCC Arch. Before placing of local dredged sand the top slushy soil of river/canal was removed. The fill was compacted adequately almost layer by layer. The bearing capacity of soil was brought to one tsf as per requirement for load distribution during the concreting, for temporary works and the live loads over the sand bed through supports. Each support was placed on steel U channel resting on the concrete blocks. A solid steel frame was fabricated and fixed as the shape of an Arch. It was tied with each and every member from different direction.

A frame made from steel hollow section was placed with polythene sheathing at the top over the scaffolding work. Rebar was placed and the concreting was started from the two ends covering suitable length of the arch. After completion of RCC Arch concreting the deck supported leaf walls were constructed and the formwork of arch was kept in place. When the bridge was completed the coffer dam was removed and the river/canal was commissioned with its natural stream flow. Dumped earth was removed from the river/canal bed and the canal section was brought back into its original shape. River/canal section was lined with block mattress for protection of slope and abutment. The photographs during construction of these bridges are shown in Figure-1.

### 2.4 The Project Cost

The cost of bridge over the river Moyur is BDT 10.47 crore and which is equivalent to USD 1.30 million. The cost comes at BDT 1.60 Lac / m<sup>2</sup>; equivalent USD 2,000 / m<sup>2</sup>. The cost of Bridge at Uttara Residential Model town is BDT 15.90 core and which is equivalent to USD 2.04 million. The cost comes at BDT 2.10 Lac / m<sup>2</sup>; equivalent USD 2,625 / m<sup>2</sup>.

## 3 PROJECT IMPLEMENTATION

### 3.1 Foreseen and Unforeseen Challenges

The Bridge over the river Moyur was built on two groups of pile, length 48 meter and diameter 1000mm. Its abutment wall was thick and inclined. It was a challenge to keep the inclined abutment in its position during construction. The soil bearing capacity of Moyur river bed was not enough to withstand the load from props and scaffolds. The SPT value was close to zero up to a depth of 5.0 meter. All these were considered in false work design. Same situation was faced in construction of RCC Arch Bridge at Uttara.

The construction period was limited to 18 months for both the bridges and unfortunately two monsoons had to face within this short period. The water flow of river/canal was kept open by providing large diameter RCC pipes throughout the year considering the actual flow in the river/ canal. In monsoon the water level in the river/canal was high and it was a constant threat for the construction. The river/canal water was diverted by small channels in adjacent sides of the abutments to reduce the water pressure. The water flow was regulated and constant watch was provided for the safety of ongoing construction of superstructure. The risk

of unforeseen challenge was minimized during construction by taking care of all the Engineering aspects. Both the bridges on soft ground and those were a threat for super structure construction.

Khulna



Uttara/Dhaka



Forms & Scaffolds in Main Arch Portion

View of Arch & Abutment

Figure 1. The photographs during construction of these bridges are shown

### 3.2 Social Dimension

It is obvious to say that every engineering structure is contributing something to the society. Particularly the RCC Arch Bridges those were built to fulfill certain social needs. Moreover it is a structure within the proposed township and another is on the periphery of town. The main social dimension of these two RCC Arch Bridge is to give pleasant look to the city dwellers and some aesthetical beauty in the mind of them at leisure.

## 4 LESSONS LEARN FROM THE PROJECT

### 4.1 Planning

From planning point of view both the structures are found appropriate with the present time and it could be efficient if some thoughts would be given to make the river/ canal more beautiful and harmonized with the structure like walkway along the canal bank. Boating facility near by the bridge and illumination could make the structures more attractive to the people.

### 4.2 Design

From designing point of view the bridge over the river Moyur had the great opportunity to review. After completion of bridge both the arches give a disproportionate view. Both the arches could be increased in size that would be more proportionate and stringer could be thicker for a better look of total structure. Again for

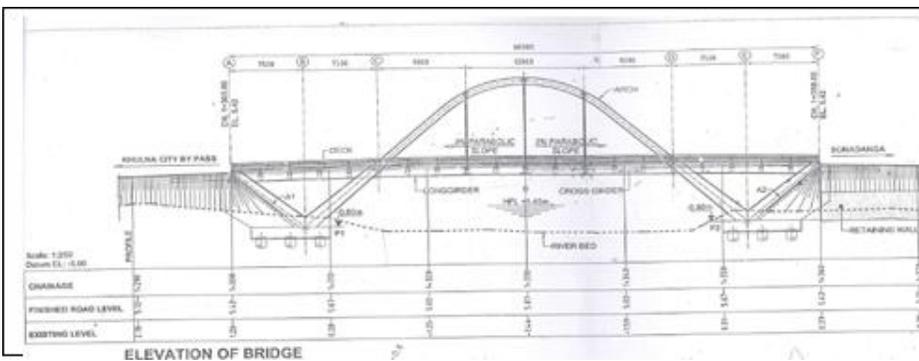
the Arch Bridge at Uttara seems to be a complete structure from the top but from the canal side it seems that the opening of small arches could be wider and if so the boating facility in the canal could play more comfortably. The thickness of leaf walls of bridge over the arch should be reviewed. This could be made more thin and smart.

#### 4.3 Construction

The most difficult task in construction of two arch bridges was designing and placing of form work and scaffolds over the filled earth on river/canal bed. Progressive concreting of Arch increases the dead load on formwork and as well as on river/canal bed. And during submerged condition bearing capacity of river/canal bed soil was reduced so improvement of bearing capacity of soil was necessary and it was done properly. It would not be possible to construct the whole thing if the temporary works would not be designed at every stage. The false work design of props and scaffolds everything had been given due priority and as a result construction was easier.

### 5 MAINTENANCE AND MONITORING IN FUTURE:

A complete as built drawing was prepared for both the RCC Arch Bridge and handed over to the employer. It is Khulna Development Authority KDA for bridge over the river Moyur and Rajdhani Unnayan Katripakha RAJUK Dhaka for bridge at Uttara. It is necessary to prepare a maintenance manual for every structure. It would be effective for both the KDA and RAJUK to prepare a maintenance manual for the structure with reference to the as built drawing of the structure. The periodic maintenance of the structure shall enhance and improve its life and as well as the performance of the structure.



Elevation of Bridge at Khulna



Figure 2a. Drawing and photographs of the completed bridges

## The Complete Bridge as Built – Khulna

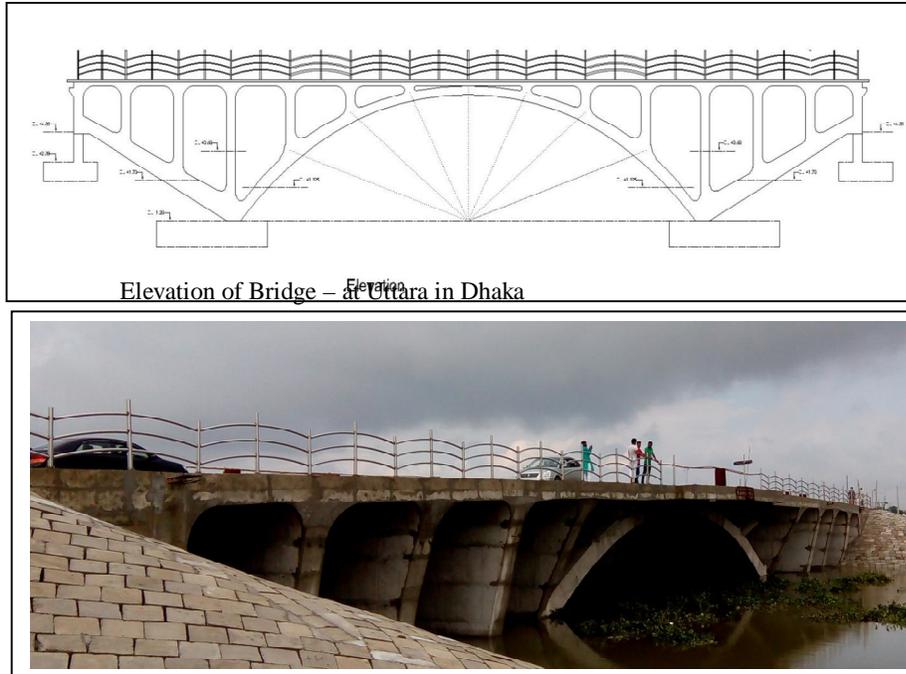


Figure 2b. Drawing and photographs of the completed bridges

## 6 CONCLUSIONS

RCC Arch Bridge is not new in Bangladesh. But it is not popular to the designer due to requirement of heavy equipment, formwork and difficult in construction. Now a day's few RCC Arch Bridges are found in many areas over the country especially in the city areas. These were built for serving both the purposes of communication and beautification. For ease in construction builders have to come up with indigenous local approach. If the effort from designer and builder continues there may be found many more Arch Bridges all over the country and that will meet the Architectural demand in structures, a bit.