Superstructure for third Godavari Bridge : Construction problems and their solution

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A number of problems were encountered during the construction of the superstructure for the third Godavari Bridge. The article briefly describes these problems and also highlights the measures taken to solve the problems.

The sequence of construction of the superstructure for the third Godavari Bridge is as follows :

1. construction of two starting stubs, that is, end portions of the girders over one pier
2. erection of tower over stubs
3. concreting of 1st arch segment
4. concreting of the balance arch
5. concreting of closing segment to join the two halves of the arch
6. suspension of Dina hanger cables
7. concreting of tie girder
8. concreting of the balance items like footpath railing etc.

The article briefly describes the difficulties encountered during the above phases of construction and also highlights the solutions.

Starting stub

The starting stub was concreted in two pours; one pour for the vertical webs and bottom slab and other pour for top slab as shown in Figure 1. However, some modifications were made in the shuttering arrangements to cast the complete cross section of the starting stub in one pour, in order to gain time and avoid horizontal construction joints. For this, the strut which supports the soffit of the top slab was supported on channel beams which in turn are resting on the sides of inside web shutter as indicated in Figure 1.

Erection of tower

It was difficult to achieve the verticality of the tower because of matching of the joints of adjacent elements. Even a small problem of matching resulted in large deviation at top because of the height of tower. This was rectified by destressing the tower tie-down cables slightly and wedging the bottom element in the required directions by steel plates under the tower stub elements.

Arch construction

The construction of the arch involves delicate control of alignment of twin arches and the proper level of arches as per coordinates indicated in the drawing. The tolerance is 1 mm in either of the two geometries. The first span, that is, span no.28 is on the ground, that is, on the bank of Kovvur side. Therefore, it was possible to take the level of the arch soffit directly by a levelling instrument and also to control the alignment directly with the help of theodolites. Since the other spans were to be constructed in water, a permanent system was developed to control the alignment and level by making a parallel base line on the old bridge which is 54 m downstream of the third bridge. Since both the bridges are exactly parallel, the parallel line served an important reference line. This was cross-checked by measuring instruments placed on the ground and the theodolite for levelling and alignment respectively. The error in this system of 3-dimensional survey comes to around 2 seconds in angular measurement which when reflected over a distance of 100m, comes to 1 mm in linear measurement.

As per the sequence of construction, every element of the arch has to be supported by arch stay cables after casting totake up

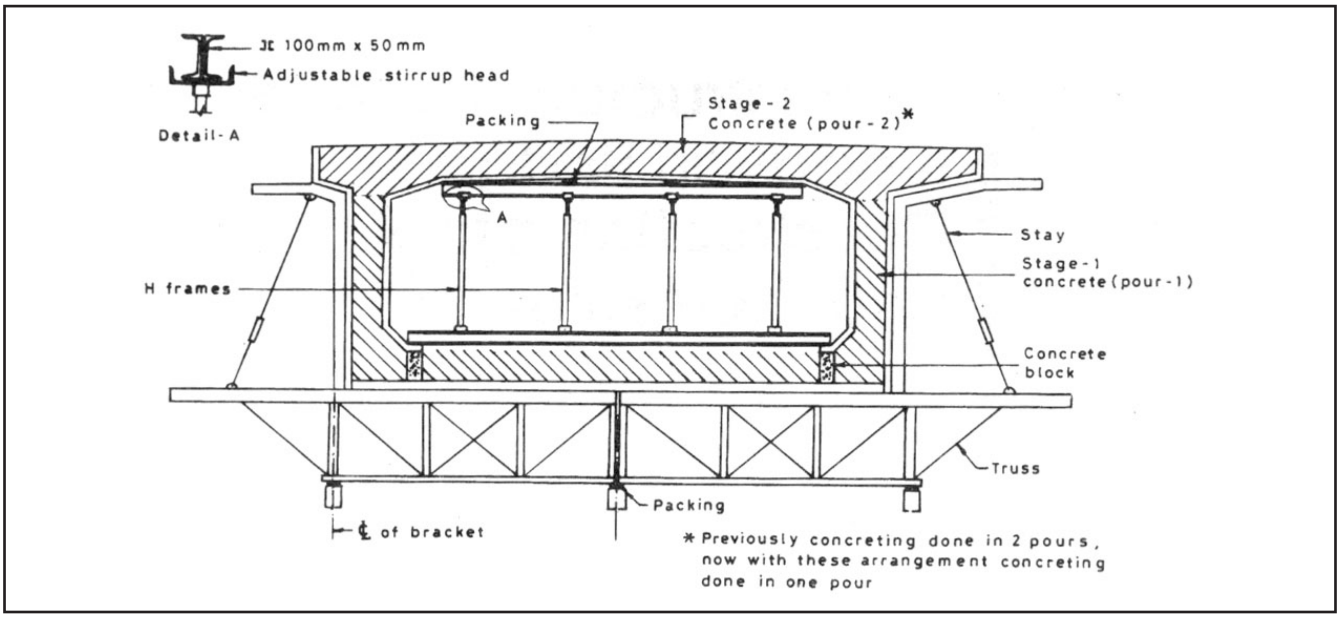

Figure 1. Shuttering arrangement for casting of the starting stub

the self weight. Before casting any element few stressing and destressing operations are to be executed in order to bring the previously-cast arch to the theoretical level and then to give a positive pre-camber before concreting.

It was observed that while the actual forces as per drawing were reached in the stay cables, the arch has not exactly reached its predicted level. This may be due to actual Ec (modulus of elasticity) being different from the theoretical Ec. Therefore, in order to solve this difficulty the capacity of each stay cable was evaluated with a view to check as to how much over-stressing can be done safely in order to attain the desired level. Priority was given to achieving the level since any deviation in level from theoretical would be a permanent feature while small deviations in the cable forces is a matter of temporary adjustment and does not reflect on the permanent aspects.

Alignment of tie-girder and longitudinal prestressing cables

As per the approved drawing the alignment of prestressing cables in the starting stub involves reverse curves for few cables. The cables which suffer reverse curves develop more frictional forces and result into less elongation. Accordingly, these cables were cut slightly more initially and the reverse curve was smoothened to reduce the friction forces. The reverse curve in the drawing showed that the cable becomes straight, 2m beyond the end of the starting stub. However, in practice, the cable cannot be kept in a curved position for a 2-m long portion which hangs freely in air and therefore, the cable used to take the resultant straight line shape. In order to solve this, the curvature was curtailed at the end of the starting stub, thereby the free cable is only to be kept in straight line which is practically possible.

Four cables, that is, cable nos., 2, 3 and 4 were provided in 200-mm diameter mild steel pipe in the starting stub to facilitate launching of four temporary cables along with the anchor heads. However, at the end of the starting stub 200-mm diameter duct is suddenly reduced to 85-mm internal diameter duct which is the sheathing diameter. The cable on the sharp corner during stressing and give high friction loss and less elongation. In order to solve this the cross sectional area of 200-mm diameter mild steel pipe was reduced to 85-mm diameter sheathing by means of a tapered cone thereby avoiding any sharp edge on which cable can rub and lose force.

Advancement of arch form carrier

The arch consist of 7 elements and every time the arch form carrier is advanced to a new position to facilitate the casting of the next element. The advancement of the arch form carrier involves sliding of the carrier on top of the arch surface by putting the steel plate, duly greased, on which the arch form carrier slides while getting pulled. The original method suggested had 25t capacity tirffors by anchoring the tirffors. However, because of excessive friction losses this system could not work as the balance forces were too less to pull the carrier. In order to solve this problem a system consisting of manual winch anchored to the starting stub by means of channels was developed. The wires are looped three times to increase the resultant forces and this has since been successfully used in advancing the carrier in a controlled manner without rubbing the frame on the side of the arch.

Temporary tie-girder cables for the arch construction

The half arches from adjacent piers need to be joined by a central segment called closing pour. Before casting the closing pour 4 tie-girder cables are launched to counter-act the forthcoming arch thrust which would develop in due course as the concrete of closing pour gains strength. The 200-mm diameter mild steel pipes for the four cables were provided for in the starting stub for this purpose as mentioned earlier. However, the launching of temporary cables and then

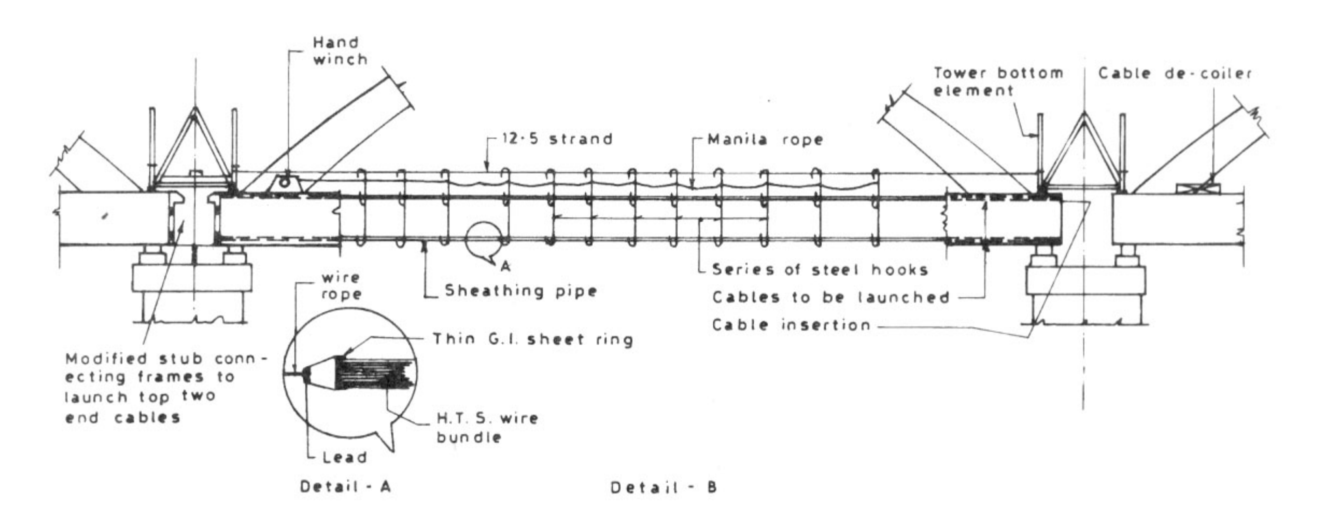

Figure 2. Catenary wire system for launching of tie girder cable and improved connecting frame

changing them with the permanent cables used to take more time which was a loss. This was solved by launching 4 permanent cables alongwith sheathing by developing a cantilever system of launching, thereby obviating any need of temporary cables. This also solved the problem of excessive friction loss due to sudden constriction of the area of the mild steel pipe from 200-mm to 85-mm as explained earlier.

Launching of tie-girder cables

The tie-girder cables are 95-m long and its weight is 2 t. These are to be launched in the prepared ducts for cable Nos. 13, 14, 15 and 16 since the T-frame obstructs these cables from launching during the construction of tie-girder. In order to launch these 4 cables a system was developed using launching cone (Figure 2) of 73-mm diameter. In this method, first the cone of 65-mm diameter is independently pulled by wire from one end to other end, thereby ensuring that the duct is clear to the extent of 65-mm diameter. Then similar cone of 73mm is also passed through it ensuring the clearance to the duct of 73-mm diameter. In case of blockades the ducts are cleared by rotating action. Then the cable wires are fed in the back of the launching cone fitting snugly and tightly and the launching cone is pulled from the forward pier by means of a power winch. In this manner the cables are launched in the concrete ducts.

Modification in the steel T-frame

Steel T-frames (2 numbers) are placed in between the starting stubs in the gap between the stubs as shown in Figure 2. The gap between the sides of T-frame and the back of stub is grouted. Then back to back stressing, pier tie-down stressing etc., are done.

However, these steel frames obstruct the launching of cable nos.13, 14, 15 and 16 during the casting of tie-girder because these frames are to be removed only after the tie-girder in the next span is cast and stressed. Therefore, the steel frames were modified duly making a recess which gives sufficient space to launch cables even during the casting of tie-girder. Thus after changing steel frame all the 16 cables are launched in the tie-girder before casting the tie-girder so that the question of launching cables in the concrete ducts (in which blockades occur on may occasions) does not arise.

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