Short line matchcasting and erection of precast segments for DMRL

P.K. Prabhakaran, K. Senthilnathan and S. Balaji

The construction of the elevated viaduct from the west bank of the Yamuna river to Rithala was part of the first phase of the DMRL project. The authors describe the construction aspect highlighting the technology of segmental construction, involving precasting operations and the erection and launching procedures adopted.

The transportation sector is rapidly expanding in our country, with construction of projects like, "Golden Quadrilateral", North-South-East-West corridors and metro rail transport system (MRTS). There are, however, difficulties in introducing flyovers/bridges on existing roads, especially in metros, as these have to be constructed without blocking the present busy traffic. Such problems can be tackled only with the introduction of new technologies like segmental construction with centralised precasting. This technique has been successfully deployed by L&T in the construction of 2.64-km long Sirsi Flyover in the busy metro city of Bangalore, as early as 1996. Application of such new technology requires understanding of the enabling structures, which form the backbone of such construction. This was brought into sharp focus when, for Delhi Metro Rail Corporation (DMRC) projects in New Delhi, elevated viaducts had to be constructed over busy roads near Inter-State Bus Terminus without hampering traffic.

Salient features of the project

The first phase of DMRC project consists of an elevated viaduct connecting the west bank of Yamuna to Rithala. This will carry twin ballastless railway tracks for the Delhi Metro Rail Link (DMRL). Out of the total scope of DMRC project, the author's organisation was entrusted with the construction of elevated corridor between west bank of Yamuna and Tis Hazari section. This stretch has a length of 1800 m with a few curves. The scope of the work comprised construction of:

1. 66 piers including portals with their pile foundations
2. 57 standard spans by segmental construction
3. 6 obligatory spans which were longer and done by in-situ construction.

The superstructure consists of a single cell box girder with segments 9.1 m wide, 2.25 m deep and 2.5 m long. All segments were of the same depth. Pier segments were similar to span segments but with a slightly shorter length of 2.025 m. The length of segments varies slightly in the curved alignment. Span lengths were conscientiously chosen to fit integral

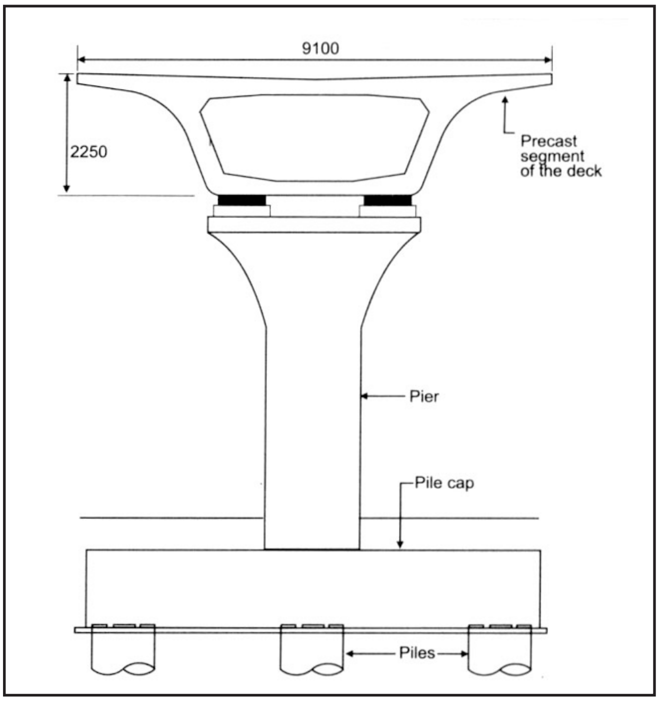


Figure 1. Typical cross section of the viaduct

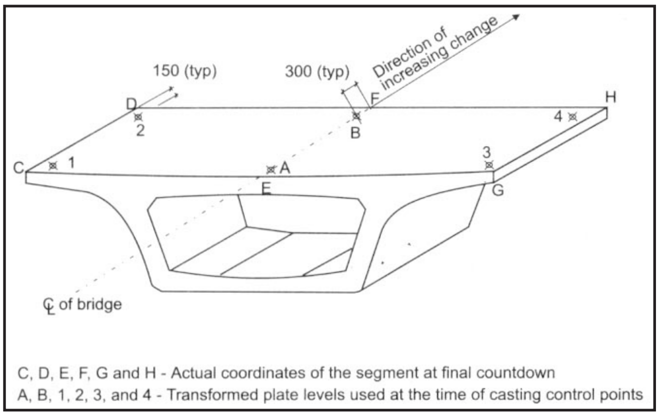


Figure 2. Control points on a segment

multiples of precast concrete segments. Spans for segmental construction thus varied between 24.1 m and 29.1 m. Maximum span in in-situ construction was 46.2 m. The viaduct had a radius of curvature in alignment of 402.05 m and had a maximum gradient of 1.89 percent.

A typical cross section of the elevated viaduct is shown in Figure 1. The total length of precast construction was sub-divided into four distinct stretches as was marked by interruptions at ISBT station, Morrigate crossing and Tiz Hazari Stations. Construction was taken up on two stretches simultaneously.

Precasting operations

Precast concrete segments had to be manufactured sequentially in a serialised 'mark by mark', procedure. Each segment was 'match cast' against the previously cast segment, for perfect fit. Segments thus had to be cast in the same order of their sequence of erection. Segments at portions of curved alignment were tapered in plan. Form /bulkhead was maintained at a stationery portion. The previously-cast segment was kept slightly rotated in plan orientation so as to get the correct length in inner curve. The mould shutters were lapping over the already-cast segment.

The layout geometry for the viaduct would give global coordinates for each segment, in its final erected position. Now, this had to be converted to local coordinates with reference to axis of bulkhead at the time of casting. This was specifically needed for segments in curved zones for accurate casting. Control points (in coordinates) were marked on six plates fixed at top of each segment (two on the centre line and one at each corners), Figure 2.The exact position of the control point as per calculations based on final alignment in the erected position, would have to be located on the mark plate and punched to cater to adjustments made in the orientation during casting.

Casting yard

Various components of the casting yard are enumerated below.

1. Segment casting moulds

    Six for span segments

Figure 3. A view of gantry and stacked segment

    One for portal segments

2. Curing tank of size 50 m x 10 m
3. Stacking yard
4. 28 m span and 60-t cap. gantry
5. Bay for reinforcement cage fabrication

The segments were cured in curing tank using sprinklers. They were stacked later in two layers, one on top of the other. Figure 3 shows view of the casting yard.

Moulds for precasting

The details of the mould used in precasting is given in Figure 4 (a) and (b). The salient features of the formwork system is highlighted below.

1. Mould for soffit was made out of 12-mm thick steel plates.

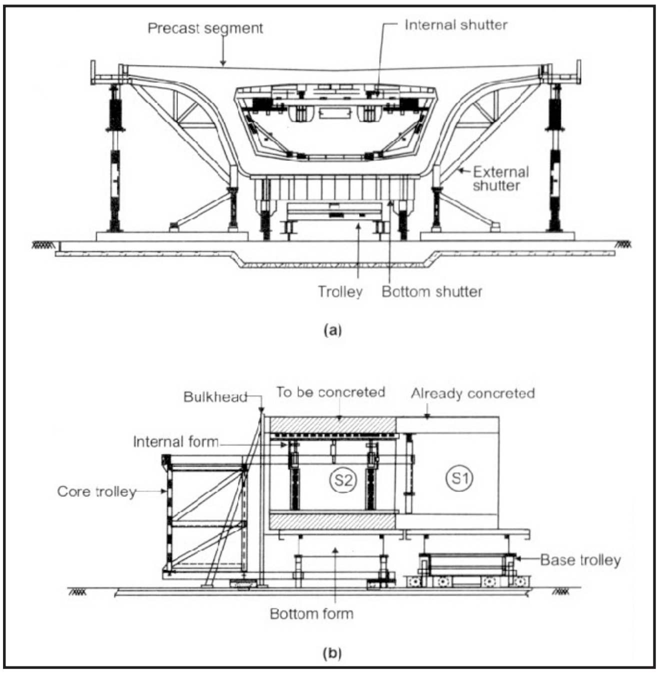


Figure 4. Details of mould used for precasting

It was fitted with screw jacks for vertical adjustments.

2. External form was also in steel and had screw and hydraulic jacks to align the shutter
3. Internal form was supported on a core trolley and moving inside the segment to be cast
4. Base trolley again equipped with vertical and horizontal hydraulic jacks to support and align previously cast segment
5. Bulkhead which is a stopper frame mounted on a structural steel framework.

Figures 5 and 6 show the view of the moulds and the precasting operation

Erection of segments

Precast segments were transported to site using special trailers. From there, they were lifted and erected in position using specially-designed launching tackles. Two separate launching tackles — an underslung one (where tackle was below segment) and an overslung one (where tackle was holding the segment from above) were deployed for erection at different stretches simultaneously. A slightly different arrangement was used for erection of segments at portals.

Underslung launching tackle consists of two pairs of structural steel I-girders placed 13 m apart on either side of pier. Each pair of I-girders was at 1.8 m on centres. The overall depth of the 65-m long launching girder was 2732 mm. The other accessories of launching tackle are described below.

1. Trolleys, also termed as bogies, carry the segment to be erected and roll on top of launching girder. These trolleys are equipped with screw jacks, both in vertical and horizontal direction for both directional alignments of segments.
2. An overhead gantry is equipped with strand jack arrangement at top that can lift 100 t of weight. This gantry can travel along the launching girder over a gantry beam attached to side of launching girder.
3. Supporting arrangement which provides support to launching girder consists of temporary trestles erected at pier locations only.
4. Nosing girder, a steel truss having 10m length, was attached to the leading end of launching girder for stability purpose. This would ensure a minimum of two supports at all stages during hauling of launching girder.

Over-slung launching tackle consisted of the following items.

1. Main truss was a tubular steel space frame having dimensions of 6.2 m overall depth, 5.65 m overall width. The 75-m long truss was supported with one end on completed deck and another support over a temporary frame erected at pier locations. The chord members of the truss were made up of structural steel box sections.
2. Truss nosing extended 16 m at the front. This provided storage and parking area for (idle) segment trolleys and also served as the nosing structure as hauling progresses.
3. A delivery crane picked up the segment from trailer. This crane moved on rails fixed to secondary beams attached to brackets on vertical bracing of truss. The crane was equipped with a cable winch, which was capable of raising or lowering a 70 t weight by around 6 m and could also rotate segments through 90^0.
4. Segment trolleys that run back and forth on skids were located on upper surface of the top chord. Segments were suspended from trolleys through Macalloy hanger rods during erection process.
5. Miscellaneous items like support beam, spreader and hanger beam, segment lifting beam etc.

Erection procedure

The erection process briefly consisted of the following steps.

1. Transportation of segments from casting yard to erection location by special trailers.
2. Lifting segments by gantry/crane.
3. Rotating the segments by 90^0 in the lifted position.
4. Hauling the gantry to location of parked trolleys.
5. Lowering segment on trolleys.

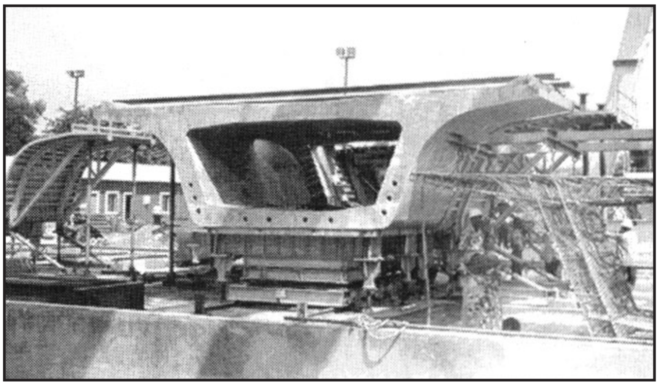


Figure 5. Cast segment on mould

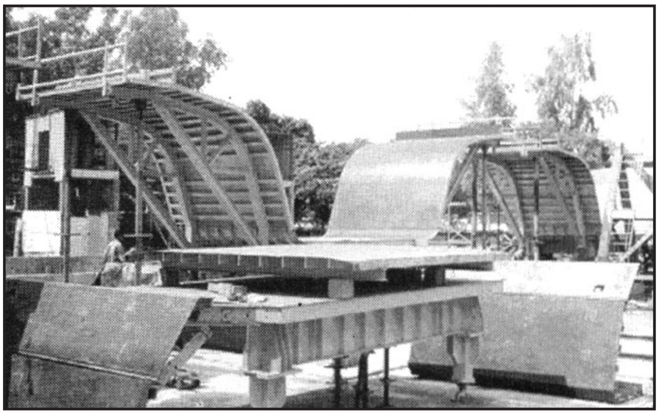


Figure 6. A view of the shortline mould

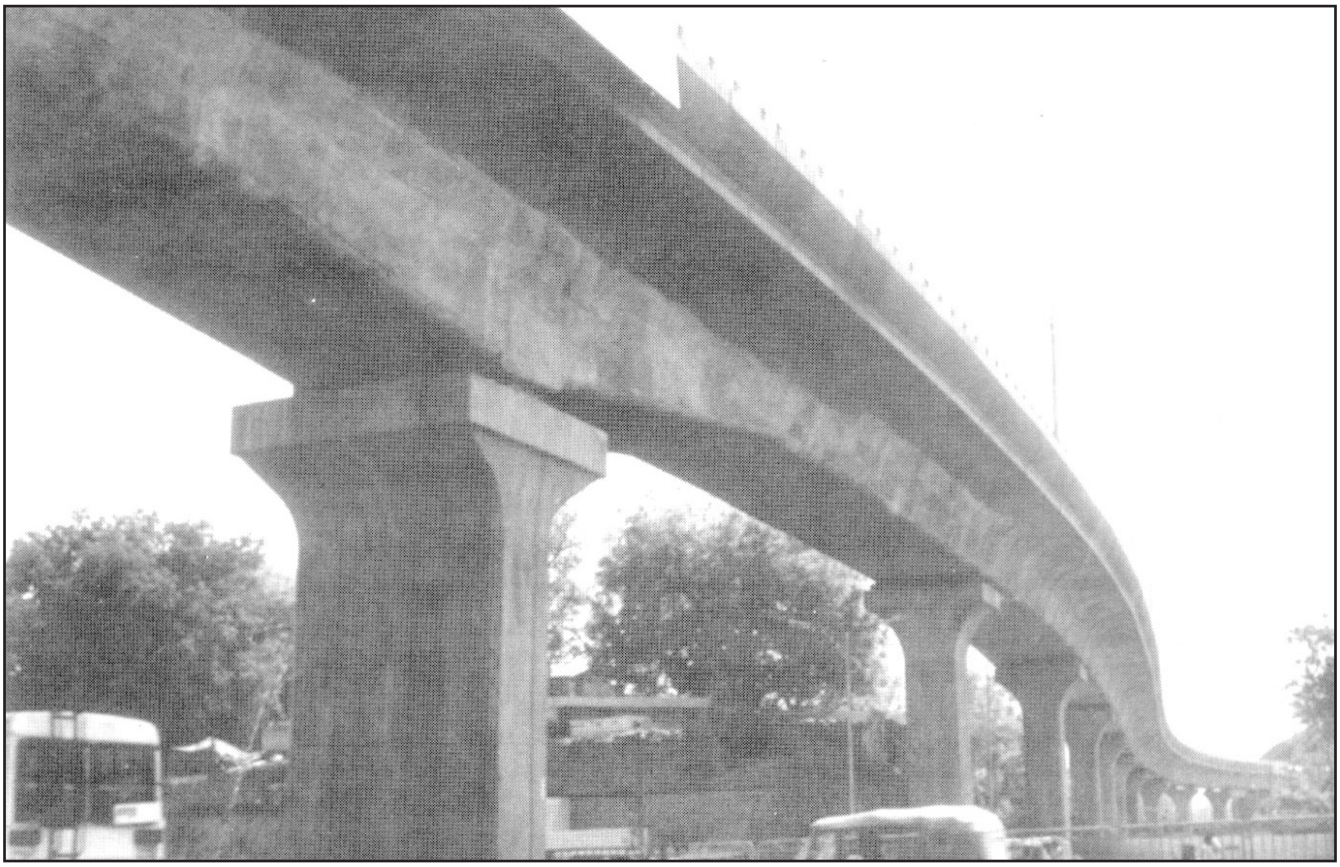


Figure 7. A view of the completed viaduct

6. Moving the trolleys carrying segment to its final erection location.
7. Aligning the precast segment in its erected position by operating jacks/suspender rods
8. Checking the coordinates
9. Drymatching the segments
10. Glueing the joint surfaces with epoxy glue over entire cross section.
11. Temporary stressing with Macalloy bars, attached to frames fixed at top of segments
12. Cleaning and removing the squeezed epoxy at the segment joints
13. Threading the prestressing cables through ducts left in the segments
14. Application of prestressing force
15. Lowering the segments on bearings
16. Grouting of bearings.

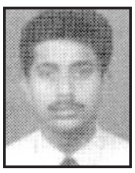
Fig 7 shows a view of the completed viaduct.

Conclusion

This project was completed successfully in 30 months. The completed view is given in Figure 7. Nevertheless, the attention given for the planning and execution of the whole project, including special and innovative new technique, paid in terms of quality and speed of construction. This also shows that new and innovative ideas will play a major role in the future of urban infrastructure construction in India.

Mr P.K. Prabhakaran is with Larsen & Toubro Limited (L&T) as joint general manager (bridges) in its ECC Division. A Master's degree holder in civil engineering from IIT Chennai, he has been responsible for the design of a variety of complex structures like cement plants, large span roofs, natural and induced draft cooling towers, long span bridges, maritime structures and large diameter pile foundations. He has made extensive use of precasting techniques in most of his projects.

Mr K. Senthilnathan is senior manager (engineering) with L&T, ECC Division. An expert in construction methods and erection scheme for bridges and marine structures, he is instrumental in devising methodology for incremental launching/segmental construction and precast prestressed hollow piles for marine structures.



Mr S. Balaji is a senior design engineer in L&T, ECC Division. He has designed moulds and launching girders for erection of bridge superstructure. He has considerable experience in design of enabling works for bridges and flyovers.

(Source: ICJ November 2002, Vol. 76, No. 11, pp. 721-724)