CONSTRUCTION METHOD FOR FAST TRACK ERECTION OF SKEW STEEL TRUSS BRIDGE IN ALEP PACKAGE-2

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ABSTRACT

Fast track construction requirements have pushed engineers to the new limits. The erection and launching of the superstructure of bridges have become the most critical part of the projects requiring skilled labour and specialized equipment. Every bridge or viaduct has its own individuality in terms of its function, structure or construction method. The construction method, though not very noticeable after the construction, has its own significance with respect to the cost of the bridge as it determines the time for completion of project and the design of the bridge. Some methods emphasize on construction time while the others provide a high degree of convenience to work independent of the surroundings like heavy traffic, live rail lines, deep valleys, rivers, etc.

The methodology adopted for erection of the steel ROBs at chainage 67+600 in the Agra Lucknow Expressway (ALEP), Package 2, was dependent on time as well as the surroundings, in this case, the Delhi-Kolkata busy railway lines. Construction of bridges over railway lines is always a difficult task considering their importance and strict norms of the railway authority in India. In such scenario, constructing a steel bridge over one of the busiest railway lines, running the most important express-trains of the country, was a challenging task. The timely completion of this steel bridge was crucial to meet the deadlines of one of the most ambitious projects -The Agra-Lucknow expressway, recently completed in the country. This paper describes the detail methodology adopted for erection of the skew steel bridge over railway lines.

1. INTRODUCTION

The Agra-Lucknow expressway is considered one of the most ambitious infrastructure projects in India. After its completion, the travel time between Agra and Lucknow has been cut down from six hours to three-and-a-half hours. But the construction of this six lane expressway in the time schedule of two years was not an easy task. Afcons Infrastructure Limited was awarded the task of completion of 126 km out of the 302 km stretch of the expressway. This involved construction of 6 major bridges including a 750m long bridge over the river Ganga, 8 flyovers, 23 underpasses, 29 minor bridges and 4 ROBs.

Construction of bridges over railway lines is always a difficult task considering their importance and strict norms of the railway authority in India. In such scenario, construction of two steel ROBs over one of the busiest railway lines, running the most important express-trains of the country, was a challenging task. The timely completion of these steel ROBs was crucial to meet the deadlines of the project

The proposed steel ROBs consisted of four steel trusses, out of which two trusses were over busy railway lines. Each steel truss weighed 1500 tonnes and was 87.6m long, 20.65m wide, with 44 degree skew angle in plan (Refer figure 1).

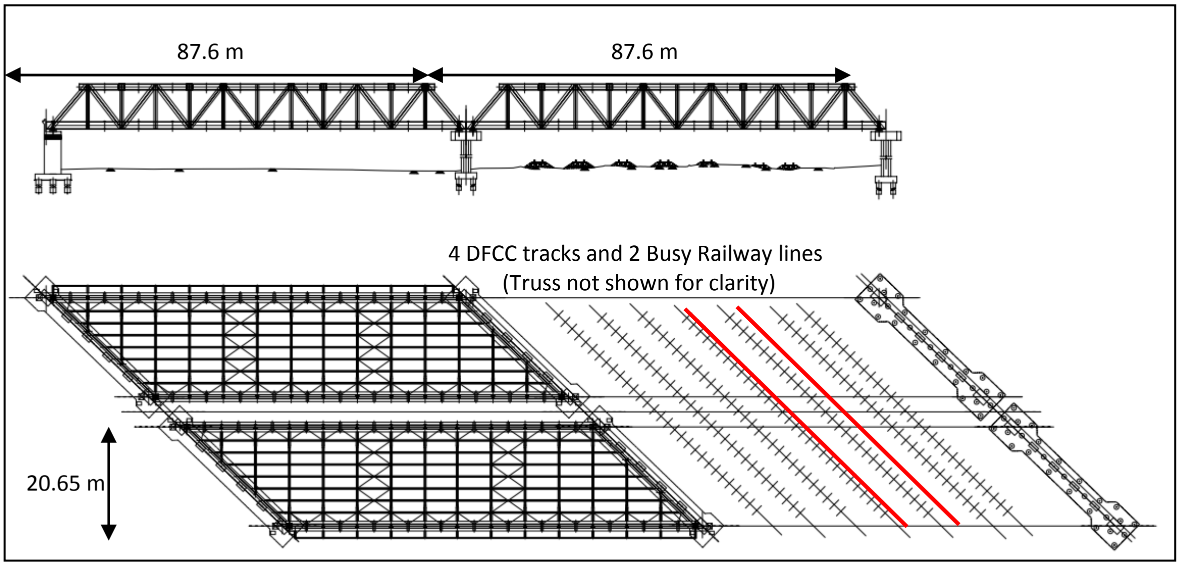

FIGURE 1 Elevation and plan of the proposed ROB (Active railway lines marked in red)

FIGURE 2 Actual site photograph

The simplest method of erection would be by directly assembling the truss over railway lines by using a crane. But this was impossible in the 75 minutes block time given by the railway authority. So it was decided to erect these steel trusses on adjacent spans and roll them (launch) on elevated supports over the railway lines to their final position. The methodologies considered for erection of the trusses are given below.

2. METHODOLOGIES FOR LAUNCHING

i) Methodology 1: The earlier methodology was to fix rollers on temporary supports and roll the truss over it. But this methodology was later discarded since there were high reactions on the bottom chord member of the truss. The bottom chord member would require to be heavily stiffened for these high concentrated loads.

ii) Methodology 2: In this methodology, rollers were mounted at each bottom node point of the truss. This evaded the problem of high concentrated reactions on the bottom chord member, in the earlier methodology. The top surfaces of the temporary supports were fabricated such as to offer smooth entry and exit of rollers over them. This scheme was finalized and got approved by the railway authorities for final erection.

3. COMPONENTS FOR LAUNCHING

The launching operation requires many structural and electro-mechanical components. The major components for push launching are described below:

i) Push Launching supports:

To ensure the stability of the truss during the different stages of launching, temporary supports are required to be erected at intervals. These supports provide surface for the movement of rollers and so were called Rolling track supports (RTS, Refer Figure 3).

In the launching of the steel ROBs, two sets of six RTS were provided, one on each side of the truss, for launching operation of a single truss. These supports were also used for erection of the truss. A strip of high grade steel was welded on the top of RTS due to requirement of high bearing stresses from rollers. The top surface of RTS was profiled to allow smooth entry and exit of rollers over it (Refer Figure 4).

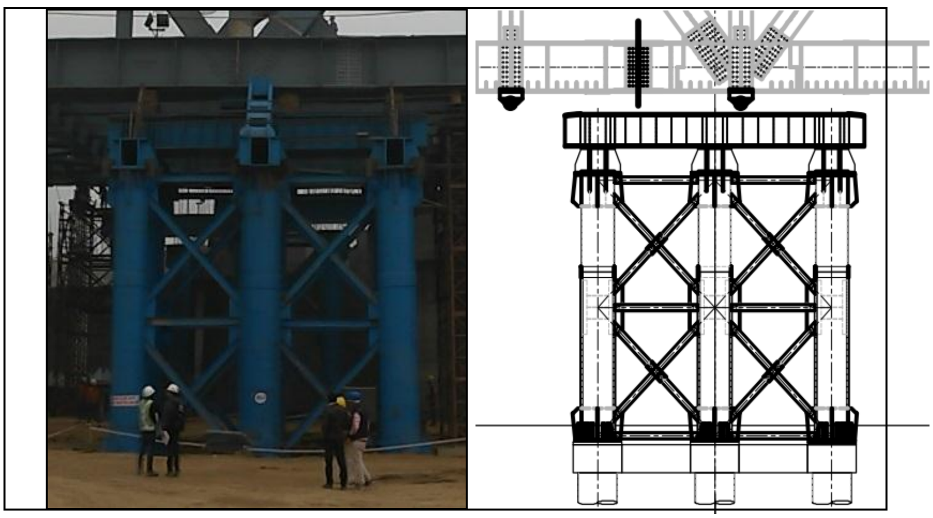

FIGURE 3 Typical RTS

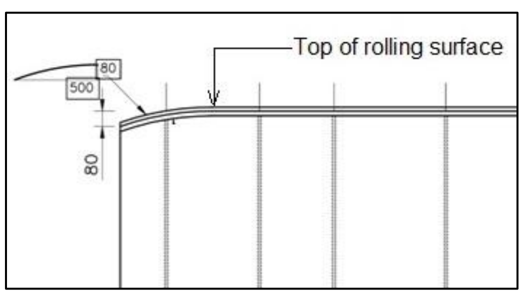

FIGURE 4 Typical rolling surface profile of top of RTS

ii) Nosing truss:

The nosing truss is a truss connected at the forward/rear side of the truss to increase stability during launching. The nosing truss has lesser self weight as compared to the main truss. The nosing truss also helps in reducing the forces in the main members of the truss and also the loads on the rollers.

In this launching, a nosing truss of 15m length was connected at the forward launching end of the truss (Refer Figure 5).

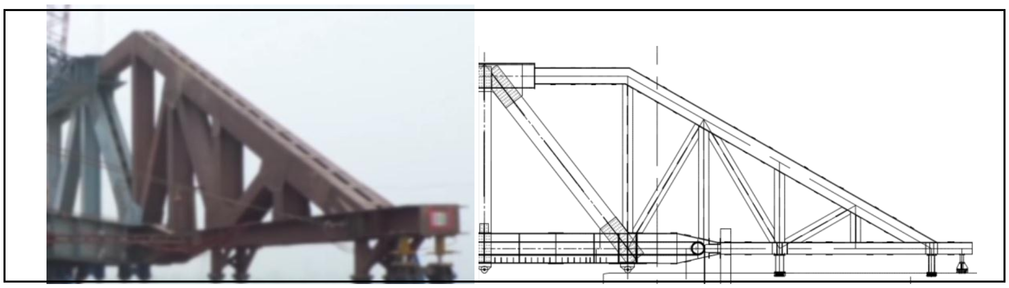

FIGURE 5 Nosing truss

iii) Rollers:

Since, rolling friction is less than sliding friction, we have preferred to use rollers for moving the truss. The coefficient of friction of the rollers was an important parameter for selection of the rollers. For this reason, Hilman rollers were used for their low coefficient of friction of less than 5 percent. Also, Hilman rollers are very compact in size and weight.

The maximum load at each node point was found out during various stages of launching and accordingly, Hilman rollers of appropriate capacity were attached at each node point (Refer Figure 6).

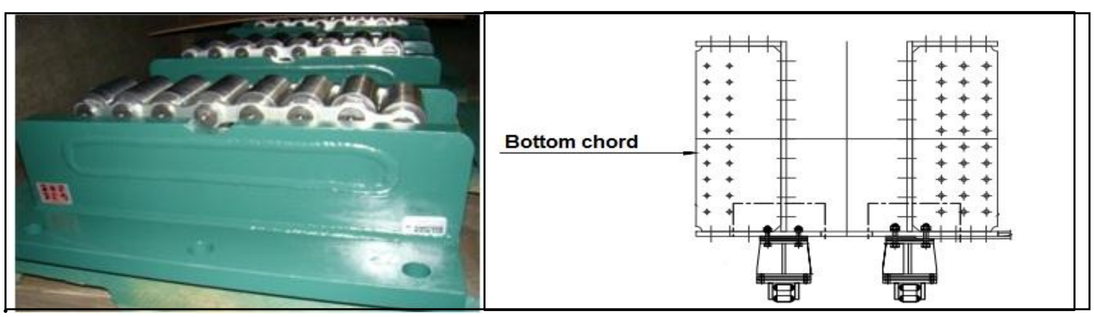

FIGURE 6 Hilman rollers and their fixing to Bottom chord of truss

iv) Wire rope:

Wire Rope of diameter 32 mm and grade 1570 conforming to IS 2266:2002 was used for the pulling operation.

v) Winches:

Winches were used to provide the pulling force for launching. Since the speed of launching required was more due to only 75 minutes block time, two electric winches (Refer Figure 7), with line pulling speed of 3.5m/min and capacity 10 tonnes, were used.

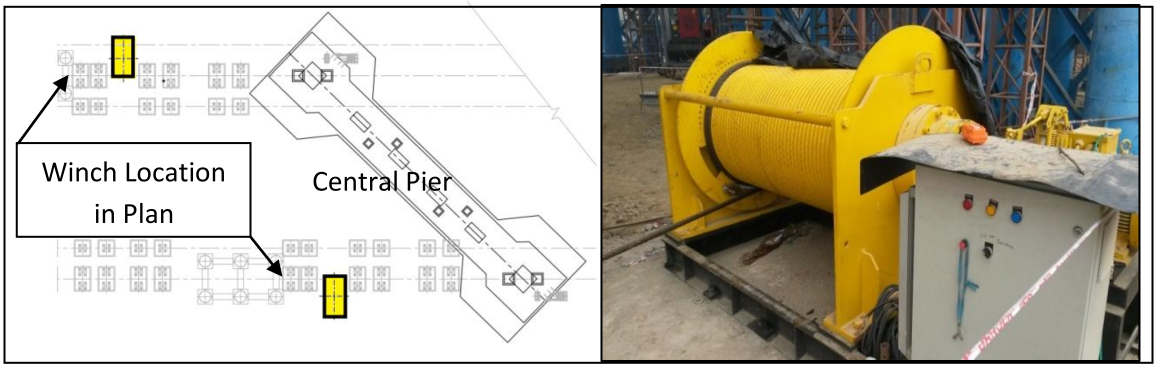

FIGURE 7 Electric winch

vi) Sheave Pulleys:

To reduce the capacity of the winch, sheave pulley blocks were used. Total four numbers of 3-sheave pulleys (Refer Figure 8), two at the back of the truss and two in the front, were used for the launching operation.

The total weight of the truss was 1500 tonnes.

Due to 5% friction offered by the rollers, total pulling force required at one end was equal to, 1/2 x 0.05 x 1500 = 37.5 tonnes, say 60 tonnes.

Due to six falls of rope on three sheave pulleys, pulling load was reduced to 60/6 = 10 tonnes. So, two electric winches of capacity 10 ton each were used on either side of the truss.

FIGURE 8 3-Sheave pulley blocks

vii) Anchor beam:

Two anchor beams are connected on either side of the truss at the rear end, for attaching the two 3-sheave pulley blocks (Refer Figure 9).

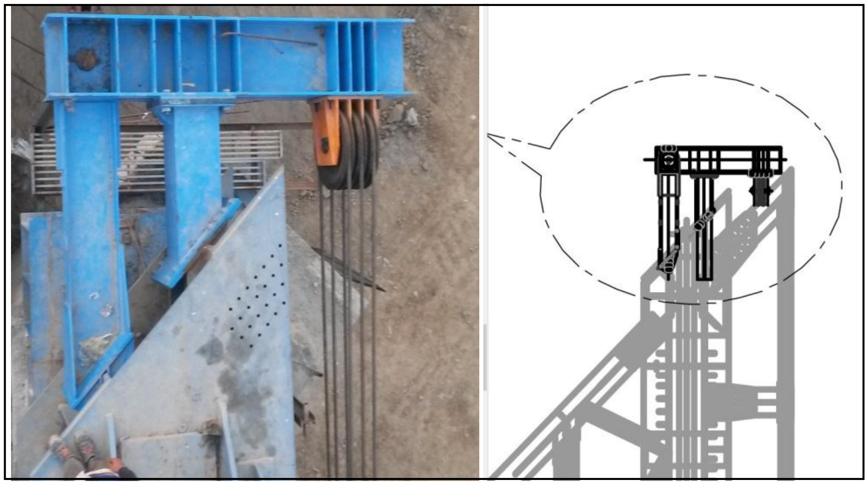

FIGURE 9 Anchor Beam

viii) Pier Brackets:

Two brackets were connected to the central pier, on either side of the truss, for transferring the horizontal pulling force to the pier support. The two front 3-sheave pulley blocks were connected to the pier bracket (Refer Figure 10).

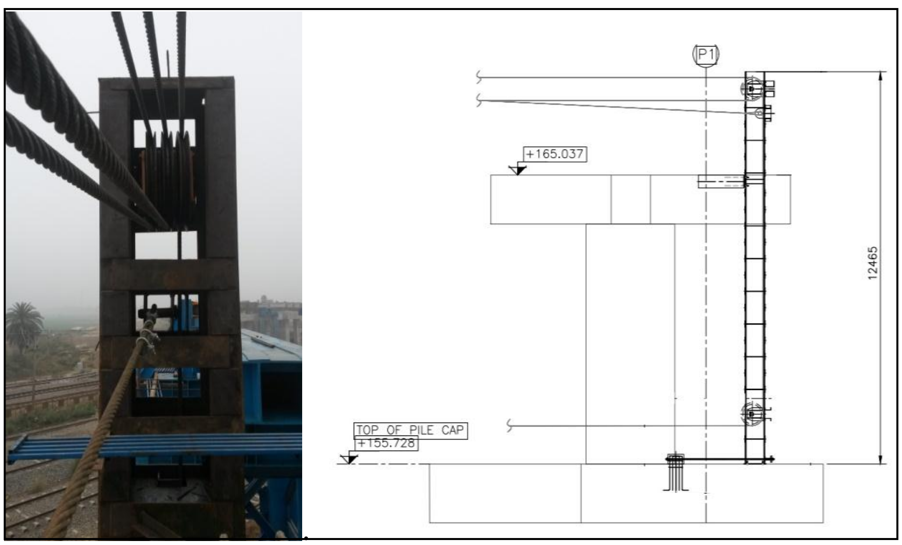

FIGURE 10 Pier Bracket

ix) Guide Rollers:

There is a possibility of the truss to move in the lateral direction during push launching due to reasons such as skewness of the truss, unequal pulling force at both ends of the truss, more friction on one side, etc. To avoid excessive lateral shifting, guide rollers mounted on brackets (Refer Figure 11), were provided on RTS. The guide brackets were designed for 10 percent of the maximum vertical load.

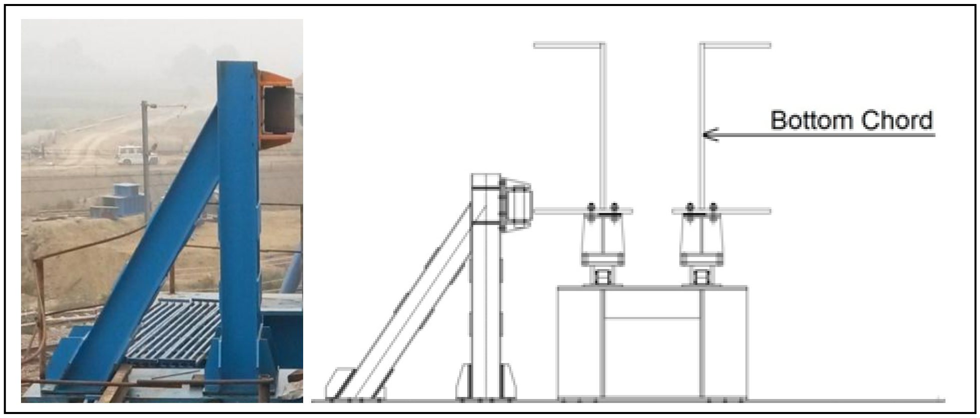

FIGURE 11 Guide Bracket

4. DETAIL METHODOLOGY

Stage 1 (Refer Figure 12)

i) All the RTS were first erected on pile foundations, followed by erection of assembly trestles.

ii) Speed restrictions were applied to trains during the erection of RTS5 support which was close to railway track.

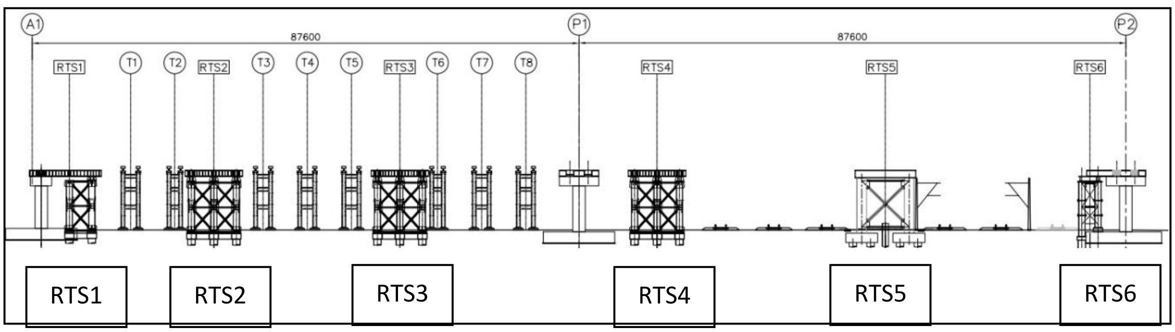

FIGURE 12 Stage 1

Stage 2 (Refer Figure 13)

i) The main truss members alongwith nosing truss members were erected over timber packing placed on assembly trestles and RTS.

ii) After complete erection of main truss, rollers were connected at each bottom node point of the truss.

iii) Anchor beams were connected to the main truss and pier brackets were erected.

iv) The entire assembly was jacked up and all timber packings were removed. The truss was then lowered such that the truss would be resting on only RTS supports through rollers connected at nodes.

v) Wire rope was reeved on the pulleys and finally connected to the winch, as shown in figure 14.

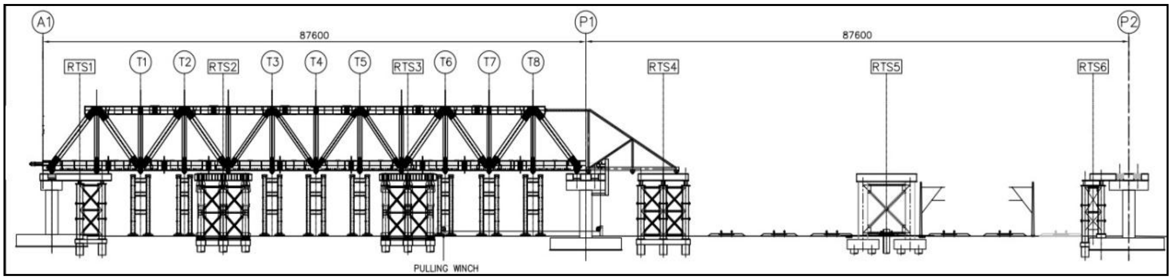

FIGURE 13 Stage 2

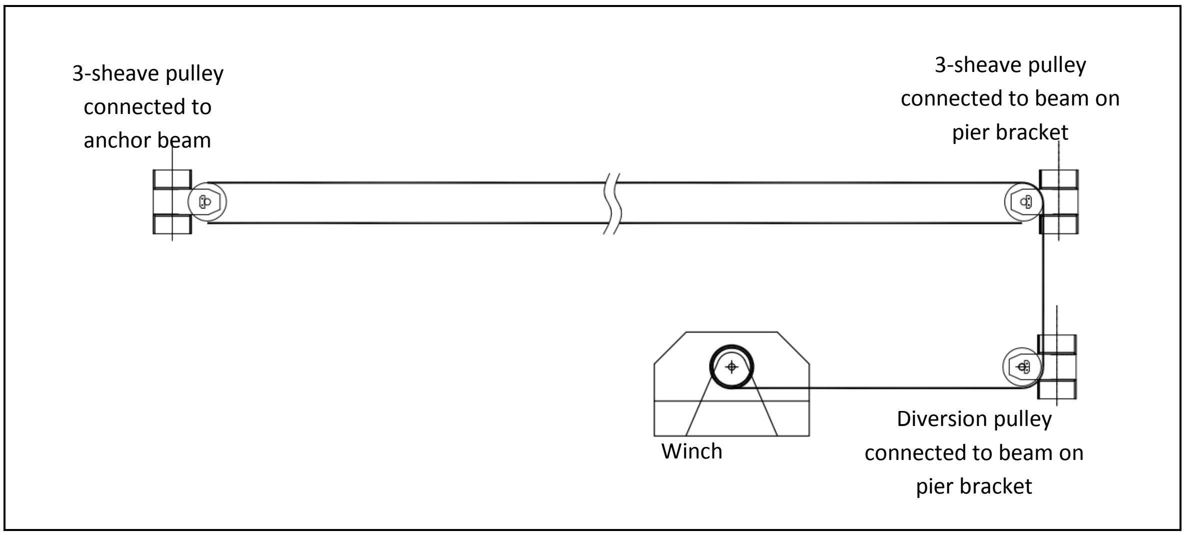

FIGURE 14 Reeving arrangement

Stage 3 (Refer Figure 15)

i) The truss was supposed to be launched in two phases. In first phase, truss was launched by 37.5m.

ii) During this launching no railway block was required since truss was crossing over DFCC tracks.

iii) The erection of the truss, behind the truss being launched, could be started after the completion of first phase of launching.

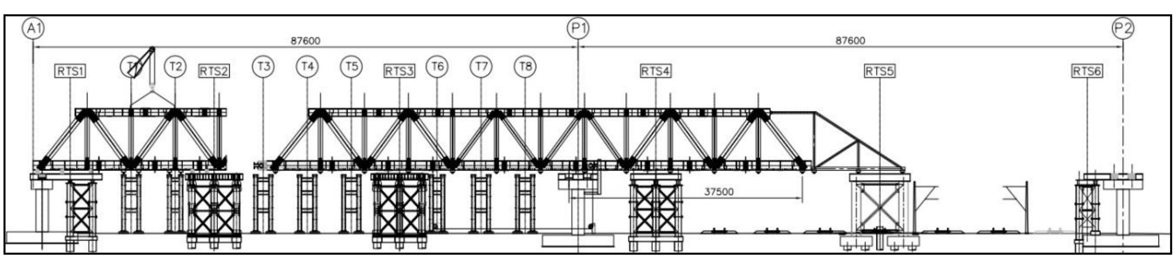

FIGURE 15 Stage 3

Stage 4 (Refer Figure 16)

i) In the second phase of launching, truss was launched by 50.1 m.

ii) Block had to be taken from railway during this phase of launching.

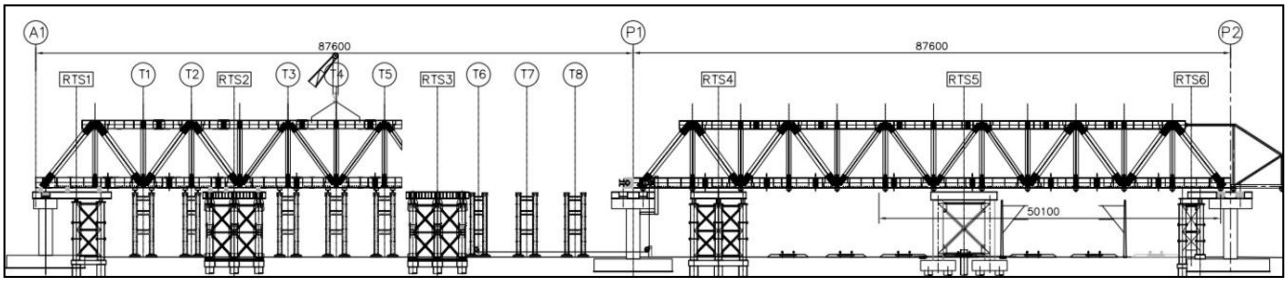

FIGURE 16 Stage 4

Stage 5 (Refer Figure 17)

i) After the truss reached its final position, nosing truss was dismantled.

ii) The rollers were removed from node points and misalignment if any due to lateral shift was corrected.

iii) The truss was then lowered on bearings.

iv) The erection of the back truss was also simultaneously completed.

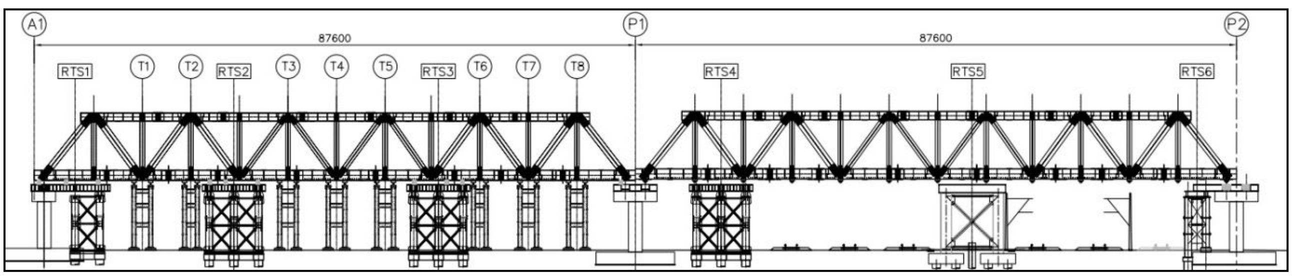

FIGURE 17 Stage 5

Stage 6 (Refer Figure 18)

i) All the assembly trestles and RTS were dismantled, followed by casting of deck slab on deck sheet.

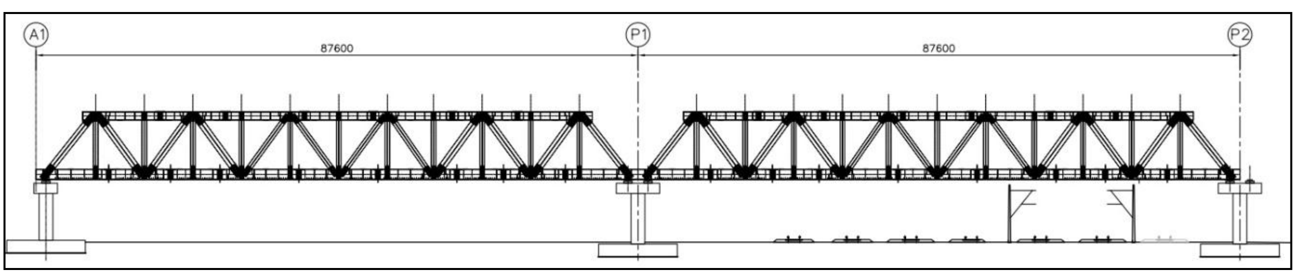

FIGURE 18 Stage 6

Deflection mitigation

i) The lateral deflection of the truss was restricted by the guide rollers on RTS.

ii) The vertical deflection of the truss was catered by attaching jacks mounted on rollers, at the tip of the nosing truss. In case the front rollers of the nosing truss went below the rolling track surface, the jacks on the nosing truss were operated till the front rollers come above the rolling track surface. The truss was then moved forward and the jack was again closed so that the entire load was transferred to the front rollers of the nosing truss (Refer Figure 19).

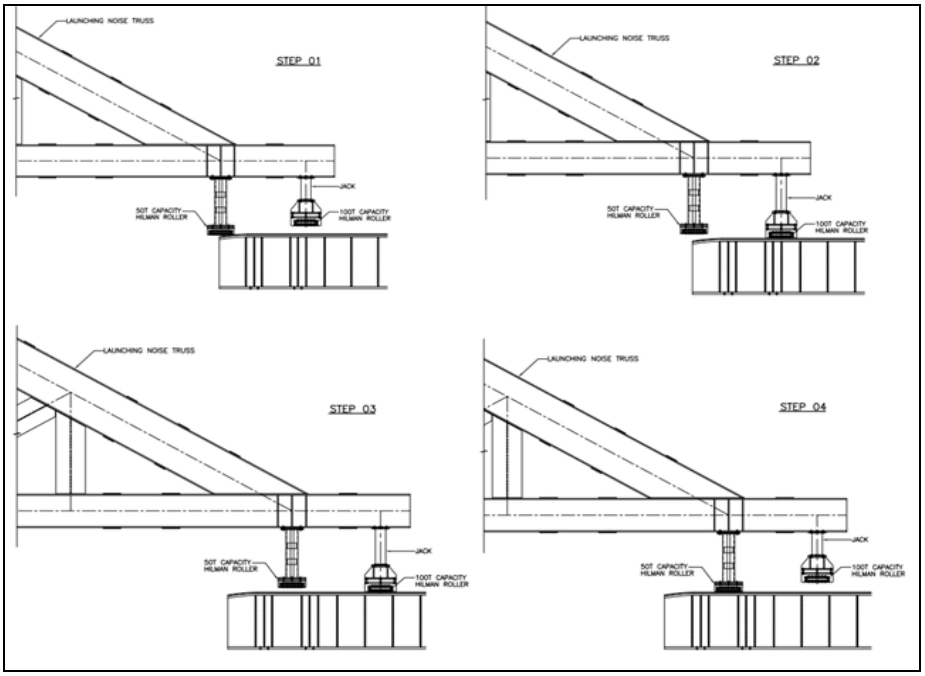

FIGURE 19 Vertical deflection mitigation

5. MAJOR CHALLENGES

i) Precise survey was required throughout the project. Initially survey was required to locate position of all RTS. Also, after erection the top surface of all RTS were required to be at same level with tolerance of +-5mm. Changes in the location and levels of RTS would have considerable effect on the loads of each roller. Also continuous monitoring of the deflections of the truss was required during the launching operation.

ii) Strict tolerances had to be followed for fabrication of all RTS, as they were the major load taking members during launching and their final level after erection had to be same.

iii) Assembly of the truss was another challenge due to the geometric complexity of the truss. Also after complete assembly of the truss, a camber of 100mm was required at the center of the truss.

iv) For erection of RTS support, site had to work with caution due to its close proximity to the railway lines with high voltage overhead wires.

FIGURE 20 Photograph of completed truss

6. OBSERVATIONS/CONCLUSIONS

i) The launching was successfully completed in the block time of 75 minutes given by the railway authority.

ii) The speed of launching observed was 0.5 to 0.6m/min.

iii) The average pulling force required during launching was 1.8 to 2.2 tonnes (coefficient of friction equal to 1.4% to 1.8%). The maximum pulling force was 6 tonnes, which was observed when the rollers were climbing the top girder of RTS during entry.

iv) The guide rollers proved very important during the launching operation as the truss was being guided by the guide rollers on lateral shifting.

v) This steel ROB was the one of the heaviest, widest and longest bridge with largest skew angle ever launched over busy railway tracks, in India, till date.

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