

## **“Construction of Y-Shaped ROB with one leg on Curved alignment in a busy, electrified yard having extensive built-up area in approaches”**

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### **SYNOPSIS**

Ludhiana is a major industrial city of Punjab having thickly inhabited area on both sides of track leading to Amritsar. Ludhiana junction is a major electrified yard of Indian/Northern Railway having 21 no. lines handling about 144 No. of Up & Down passenger trains and average 22 No. of Goods Trains daily. On the right side of track, the old Ludhiana city exists whereas on the left side, the newly developed posh area of Civil Lines etc exists. The access to common public on both sides was provided by means of FOB popularly known as Lakkar Pul, which had now outlived its life (Being more than 100 year old). Owing to increase in traffic and for the convenience of public on both sides of the track, ROB was constructed on deposit work basis for Ludhiana Municipal Corporation.

Due to complexity of site, the alignment was finalized as Y shaped ROB consisting of two legs - Straight leg (Two spans) at skew angle of  $20^{\circ}15'$  degree and Curved leg (Two spans) having radius of 71 m. The superstructure was designed as Composite Girder. The steel girders were designed as straight and curvature effect was given in Deck slab. The required super-elevation was provided by varying heights of girders.

Since the ROB was spanning over busy electrified yard, having thickly inhabited area on both sides of track, with no clear space available for placement of assembled girders, the launching of Girders was a very challenging task and the same was accomplished successfully by using some innovative ideas. Road cranes of different capacities ranging from 140 T to 500 T capacity were utilized for launching of girders in traffic cum OHE blocks.

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## **1.0 Introduction:**

The work of construction of new ROB consisting of 2 legs i.e. straight and curved leg with two spans each in the Ludhiana yard was a deposit work of Municipal Corporation, Ludhiana.

The site of work was located in busy, electrified Railway yard having 21 no. of running lines with OHE and was surrounded by inhabited, congested area on both sides of tracks.



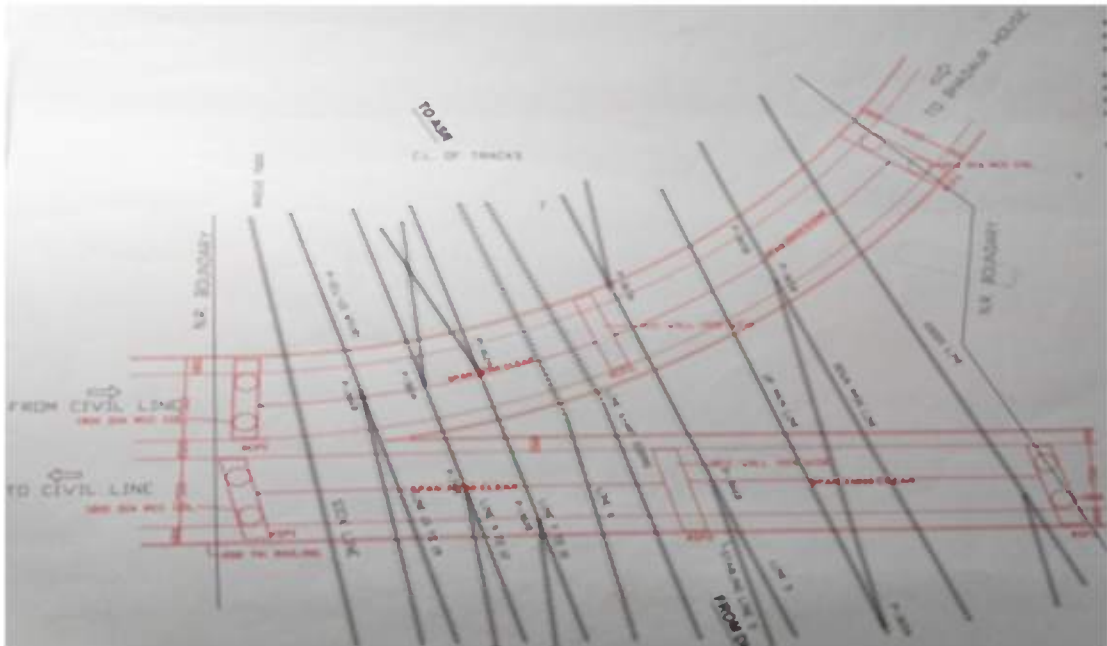
Ludhiana Yard

The work was sanctioned in lieu of the abandoned 100 years old FOB commonly known as "Lakkarpul" which was connecting the old city (Society Cinema) with new city (Civil Lines) for pedestrian traffic.



## 2.0 Scope of work:

The scope of work in the Railway portion was consisting of two legged ROB (for One way traffic on each leg) - each leg having two spans with the following configurations.



Layout of Y-Shaped ROB

- a) **Straight leg:** This is the straight portion and crosses the Railway tracks at a skew angle of  $20^{\circ}15'$ . This leg connects the civil lines area of new city with Raikhy cinema end of old city.
- 1<sup>st</sup> span i.e. RSP1 - RSP2 = 33.840 M (Clear span)/35.190 M(c/c bearing)
  - 2<sup>nd</sup> span i.e. RSP2 - RSP3 = 32.920 M (Clear span)/34.270 M(c/c of bearing).
  - **Sub-structure** was consisting of 2 nos. of RCC columns of 1800mm dia at ends outside the track over a pile cap of 08 nos. of RCC piles 1M dia 21 M deep in RSP1 and 06 nos. of RCC piles 1M dia 21 M deep in RSP3 along with 1 no. of RCC wall of 1 M thick over a pile cap of 08 nos. of RCC piles 1M dia 18 M deep in RSP2.

- **Super-structure** was consisting of 6 nos. of composite steel girders in each span with the length of 36.090 M (RSP1 – RSP2) and 35.190 M (RSP2 – RSP3).
- **Carriage way** - 7.50 M wide with anti-crash barrier on both sides and 1.5 M foot-path on one side.
- **Bearings** – POT/PTFE bearings have been provided.

b) **Curved leg:**

**General:** This leg is in curvature and joins the civil lines area of new city with the Bhadaur house area of old city. The leg consists of 02 nos. of spans having curvature of radius 71 m (  $24^{\circ}38'$  ) in carriage way. All fabricated steel girders used in superstructure were straight and the curvature has only been given in deck slab.

- 1<sup>st</sup> span i.e. RCP1 – RCP2 = 29.194 M (Clear span)/30.394 M(c/c bearing of girder G3 – G4)
- 2<sup>nd</sup> span i.e. RCP2 – RCP3 = 34.362 M (Clear span)/35.556 M(c/c of bearing of girder G3 – G4)).
- **Sub-structure** was consisting of 2 nos. of RCC columns of 1800mm dia at ends outside the track over a pile cap of 08 nos. of RCC piles 1M dia 21 M deep in RCP1 and 06 nos. of RCC piles 1M dia 21 M deep in RCP3 along with 1 no. of RCC wall of 1 M thick over a pile cap of 08 nos. of RCC piles 1M dia 18 M deep in RCP2.
- **Super-structure** was consisting of 6 nos. of straight composite steel girders in each span with the length varying from 30.070 to 32.753 M (RCP1 – RCP2) and 33.216 to 40.119M (RCP2 – RCP3). The super elevation of 2.5% and the curvature having 71 M radius has been provided in the deck slab.
- **Carriage way** – 8.4 M wide with anti-crash barrier on both sides and 1.5 M foot-path on one side.
- **Bearings** - POT/PTFE bearings have been used.

c) **Approaches:**

The work on the approaches has been executed by PWD/Punjab. The approaches on both the ends of the Railway spans consist of the following configurations:

**Civil lines end:** The approach at this end, which is common for both legs of the ROB, is 284.70 M long including 2 nos. of obligatory spans of 20 M RCC continuous beam and is straight without any curvature. The carriage way consists of 2 x 8.85 M wide having a grade of 1 in 28.

**Raikhya Cinema end:** The approach at this end is 262.190 M long including 1 no. of 20 M long obligatory RCC span and is in curvature consisting of 3 nos. of curves having a radius of 55, 80 & 55 M respectively with the speed restriction of 35 KMPH. The carriage way consists of 1 x 8.4 M wide having a grade of 1 in 23.

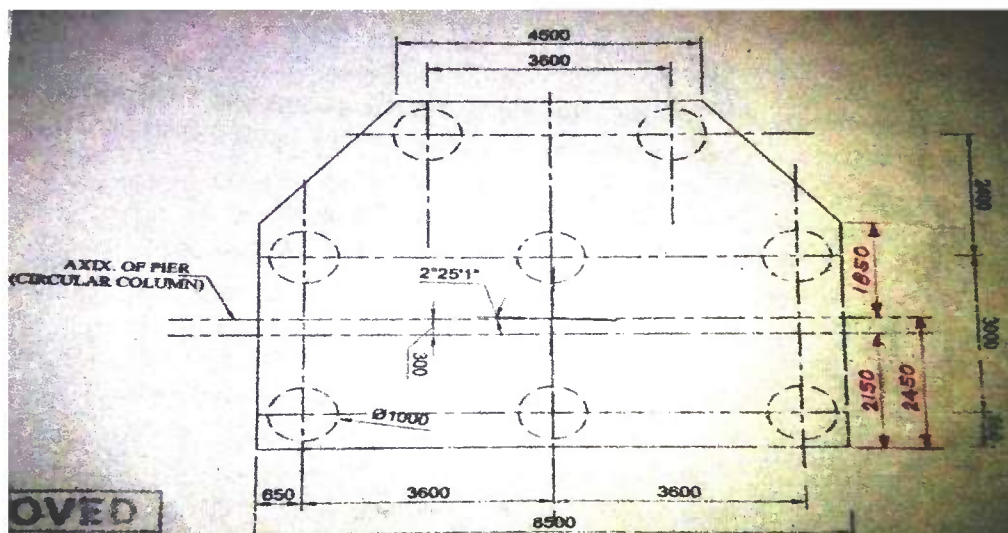
**Badhaur House end:** The approach at this end is 272.28 M long including 1 no. of 20 M long obligatory RCC span and is in curvature consisting of 1 no. of curve having a radius of 27 M with the speed restriction of 25 KMPH. The carriage way consists of 1 x 8.4 M wide having a grade of 1 in 24.

### **3.0 Design & Drawings:**

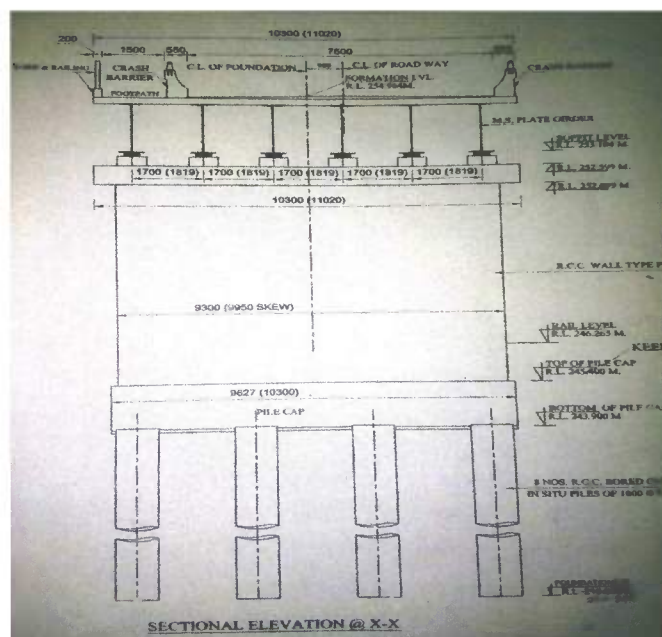
Since the subject work was in complicated layout, involving curved spans and skew piers, the work of consultancy to design and supply the drawings of sub-structure and super structure was outsourced & executed by M/s. P.K.S Infra Engineers Pvt Ltd, Vasundhra, Gaziabad.

The salient features of the design are as follows-

- Due to space constraint on one side of the track, the foundation of pier was designed as eccentric.

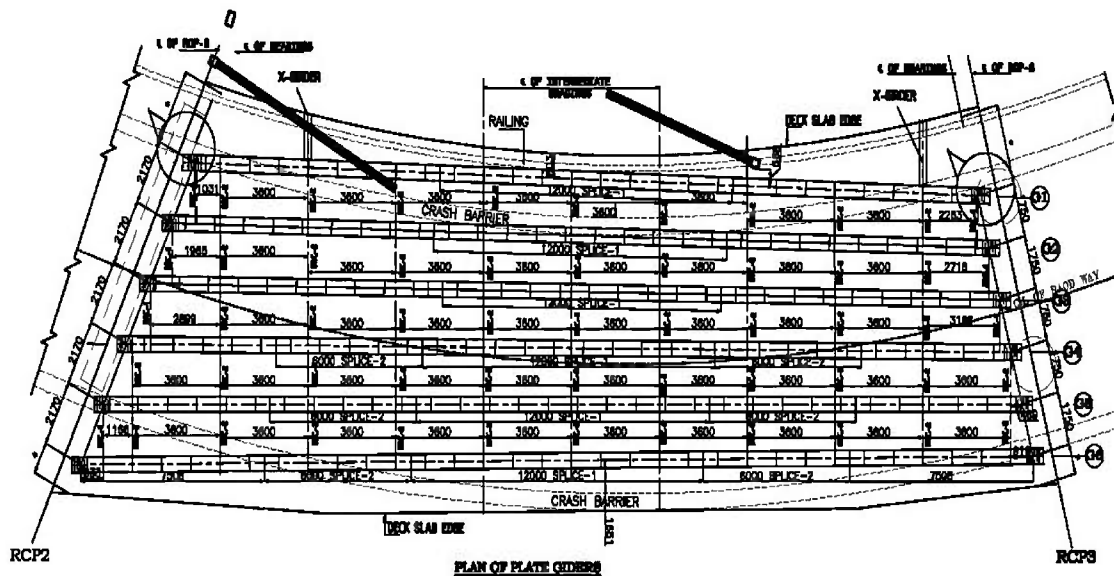


- The space between tracks was limited. Therefore, instead of 1800 mm dia circular columns as provided for end piers, 1.0 m thick wall was provided for central pier.



- Normally the length of span girders is kept uniform. In the present case, however, due to curved alignment, the length of span girders has been varied.

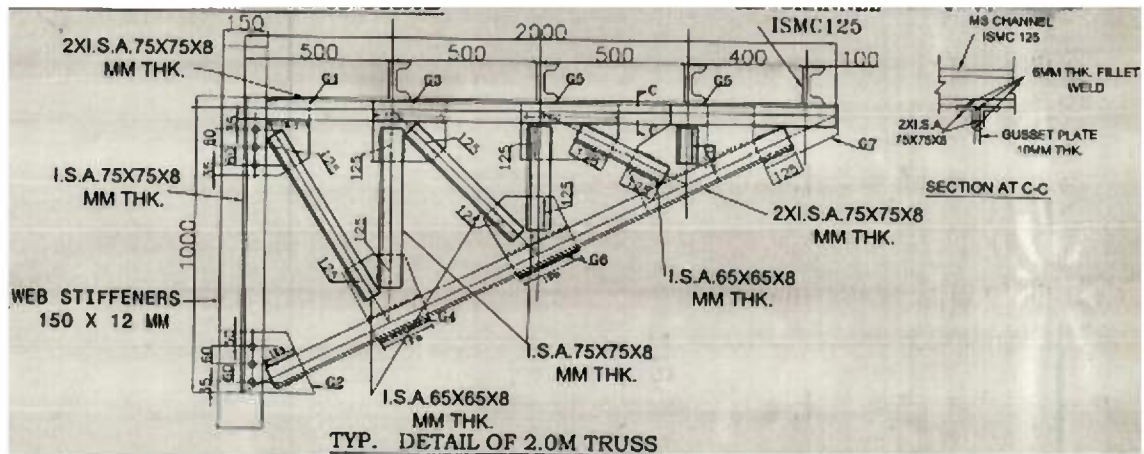
- Ordinarily, the spacing between span girders is kept uniform. But due to infringement of existing OHE portals/masts, spacing of girders has been varied from one end of the span to the other end. It varies from 1900 mm to 2300 mm in the first curved span and from 1750 mm to 2170 mm in the second curved span.



Variable Length and Variable Spacing of Girders

- To cater for the cross slope/super elevation in the carriageway, normally height of pedestals on the pier cap is varied and depth of girders is kept same. However, in the present case, height of pedestals has been kept the same and advantage of this has been taken to correspondingly increase the depth of girders with the increase in length of span girders.
- Overhang of deck slab beyond outer girder generally varies from 1.0m to 1.50m. In the present case, due to the constraints related to positioning of span girders, as stated above, this overhang is approximately 2.70m. So, side brackets of varying length were provided to support the deck slab.





Brackets upto 2.7 m for Deck Slab

**4.0 Execution of work :** The work of construction of ROB in lieu of existing FOB (Lakkarpul) in Ludhiana Railway Station yard was executed through works contract, which was awarded to M/s. SEC & Khazana JV, Mohali after deposit of funds by the Municipal Corporation, Ludhiana.

#### **4.1 Dismantling of existing FOB:**

The existing FOB at the site of the proposed ROB in Railway portion was required to be dismantled first to facilitate the construction of new ROB which was dismantled in 3 traffic-cum-OHE blocks i.e. two blocks of 4 ½ hours each & one block of 3.00 hours in Ludhiana Yard after meticulous planning & co-ordination with various departments of the Railways i.e. Engg., Operating, Signal & Communications, Electrical (TRD), Mechanical etc & after obtaining the approval of the Commissioner of Railway Safety.



## Dismantling of FOB



#### **4.2 Execution of Sub Structure work-**

The work of casting of piles, pile caps, piers and pier caps was executed in stages as per availability of clear site and OHE cum traffic blocks. RMC was used in the execution of all types of structures. The work of dismantling of underground concrete/RCC foundations of dismantled FOB and casting of 04 nos. of piles each at the pier location of RSP2 (central pier of straight leg) and RCP2 (central pier of curved leg) was executed in a 35 days traffic-cum-OHE block of line no.5. The work of casting of 03 nos. of piles at RCP2 was executed in a traffic-cum-OHE block of 12 days of line no 6. Traffic-cum-OHE block of line no.5 & 6 was obtained for 26 days to cast the pile caps at RSP2 and RCP2.



Casting of Central Piers

Pier caps of pier RSP2 and RCP2 were also cast after obtaining the traffic & OHE block of 16 days each of ART siding, line no.5 and stabling siding.

#### **4.3 Fabrication of steel Girders -**

The superstructure of the bridge was consisting of fabricated steel girders and RCC deck slab. The steel girders were fabricated in the Fabrication workshop at Morinda as per approved QAP, WPSS & WPQR. In total, 796 MT structural steel was consumed in the fabrication of steel girders of all the four spans of both legs i.e. straight and curved leg of

the ROB. The steel plates used in the fabrication of the girders were procured from M/s. SAIL and were got tested from approved NABL labs before use at site.



Heat No & Other Details on Plates

All the consumables i.e. flux, electrodes, primers, paint etc. were also got tested before use.



Flux and Electrodes

All the operations and testing was well documented. After fabrication, the trial assembly was conducted at site to ascertain the camber required as per approved plans.



Trial Assembly of Girders in the Workshop

Strict quality control was ensured at all the stages of fabrication i.e. marking, cutting, fit-up, SAW welding, MIG welding etc. Regular tests for welding i.e. DPT, Macro itching, Ultrasonic testing etc. were ensured as per relevant IS codes and RDSO guidelines.



DPT of Welded Girders





Metalizing of Girders

The girders were painted with aluminum paint after sand blasting, metalizing and provision of primers (etch primer and zinc chromate).

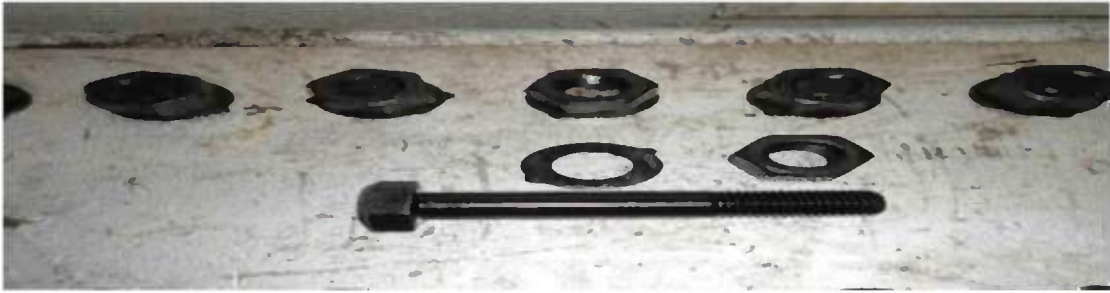


Painting of Girders

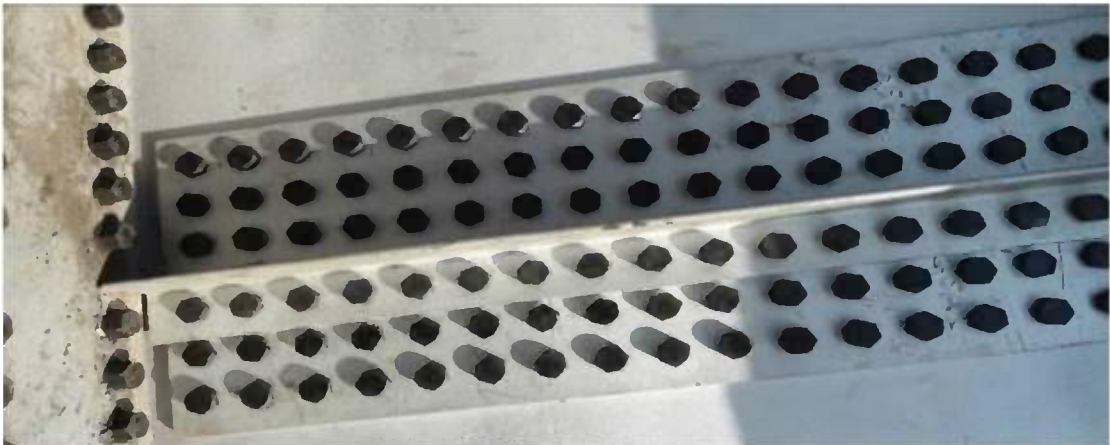


Aluminium Painting of Girders

HSFG bolts of class 8.8 were used for bolting of girders after necessary testing.



HSFG Bolts



Splice Joint with HSFG Bolts

#### **4.4 Launching of Girders :**

Launching of girders was the most challenging aspect of this work in view of the space constraint for assembling of girders after leading from the Fabrication workshop, entering in & positioning of cranes for launching of girders over electrified tracks with minimum disruption of Railway traffic. Accordingly, after the site inspections and studying the various constraints along with the requirements of cranes of various capacities, the launching of the girders were planned in consultation with all other concerned departments and executed under various traffic-cum-OHE blocks after obtaining the mandatory CRS sanction.

##### **a) Launching of Span RSP2 – RSP3**

First of all, the girders of this span (6 nos. of 35.19 M long) were launched. After the leading of 18 steel fabricated girders by road trailers, the same were assembled using HSFG bolts outside the track near Parcel siding on Society

Cinema end, where space was generated after dismantling of unauthorized shops.



Assembling of Girders of Span RSP2-RSP3

The girders were launched using crane of capacity 165 MT in a traffic & OHE block of 3.30 hours (2.00 hours + 1.30 hours).



Launching of Girders of Span RSP2-RSP3

In addition to crane of capacity 165 MT another two cranes of capacity 140 MT & 100 MT which were also used for shifting of assembled girders simultaneously during the launching of girders.

**b) Launching of Span RSP1 – RSP2**

The launching of this span was very challenging. There were total 6 nos. of girders of length 36.09 M in this span. Since there is an inhabited, congested



area near the tracks, there was a major constraint of space for assembling of girders after leading the same from the Fabrication workshop. After considering all the factors, the girders were assembled on the civil lines end approach at the top, which had already been completed by PWD/Punjab. After assembling the girders, they were shifted towards the track and placed in such a way that  $1/3^{\text{rd}}$  length of the girders was in hanging position as shown below.



Girders in Overhanging Position before launching

The girders were launched using a crane of capacity 300 MT (brought from Delhi) in a traffic and OHE block for  $3\frac{1}{2}$  hours after lowering the OHE of Sick line siding. For entering the crane into the yard, one of the end piers of Curved span had to be dismantled as there was no other space for positioning the crane.



### Launching of Girders of Span RSP1-RSP2

In addition to crane of capacity 165 MT another crane of capacity 140 MT was also used for shifting of assembled girders simultaneously during the launching of girders.

#### c) **Launching of Span RCP1 – RCP2.**

The launching of girders of this span was the most difficult and a challenging task due to the space constraint & numerous OHE Masts/lines in the yard. The lowering/restoration of all the OHE lines for launching of girders was not feasible in a short traffic & OHE block. There was no space for assembling the girders near in the yard. Therefore, the assembling of the girders of this span having length varying from 30.07 M to 32.753 M was carried out on the deck slab of Straight Leg of ROB on the span RSP1 – RSP2, which had already been completed by that time.



Lifting of Girder of Span RCP1-RCP2 from Deck slab of Straight leg

The launching of the girders was carried out in a traffic and OHE block of 3½ hours using crane of capacity 165 MT. The crane was brought into the yard from the Society Cinema end after taking 30 min Block of the two Main lines. For crane operation, lowering of the OHE of line no.13 to 19 in the Yard was done. The crane was positioned between the central piers of the two legs of the ROB.



Placement of girders of Span RCP1-RCP2

After the launching of 1<sup>st</sup> three girders, the crane was shifted towards straight leg to launch the balance three girders. Launching of the last girder, in particular, was very critical as the angle of the boom was very sharp due to space constraint between the two legs of the ROB. In addition to the crane of capacity 165 MT, another crane of capacity 140 MT was also used for shifting of assembled girders simultaneously during the launching of girders. After launching, the crane was taken out under OHE & traffic block from the same route towards Society Cinema end.

d) **Launching of Span RCP2 – RCP3.**

The girders of this span were varying in length from 33.21 M to 40.119 M due to curved alignment. It was decided that no track would be blocked for positioning of cranes for launching, so that there is minimum requirement of OHE and Traffic block. This meant that the crane would have to work at a greater radius and for this, a crane with longer boom length and higher capacity was required. Accordingly, crane of higher capacity (500 MT) was specially arranged and the girders were launched in a traffic & OHE block of 3.00 hours only.





The girders were assembled outside the Railway tracks and were launched without lowering of any OHE. Leading of the 500 MT crane with counter weight of 80 MT in a big trailer to the site of work through the crowded lanes of old city, having numerous electric cables and telephone overhead crossings was a tough job, which was carried out successfully with the help of civil and traffic police.

#### **4.5 Construction of Deck slabs:**



200 mm thick RCC deck slabs were provided both in straight and curved leg. Since the site of work was located in the electrified, busy yard in which no traffic and OHE block for long duration was feasible, it was difficult to use conventional shuttering for deck slabs. As such, suitable alternates to

conventional shuttering were used in both legs of ROB. The Deck slab in straight portion has been cast using precast RCC slabs 50 mm thick. POP was used to fill up the joints so that there was no leakage of slurry during concreting.



Precast RCC Slabs used as Shuttering for Deck slab of Straight leg

The cantilever portion has been cast using fabricated Steel brackets in both legs. To reduce further time, the deck slab in both spans of curved leg has been cast using sacrificial shuttering (turf sheet) 1.6 mm thick.



Sacrificial Shuttering for Deck Slab on Curved leg

Foot path 1500 mm wide on one side (inner side of curve in curved spans) and anti-crash barrier on both sides of carriage way have been provided with protective screens on outer anti- crash barrier and foot path railing.



OHE Protective screen on Anti- crash barrier

## **5.0 CONCLUSION**

The elimination of level crossings is a priority area for the Indian Railways. Even though a large number of LHS/RUBs are being constructed, the provision of ROB becomes inevitable in areas with high traffic density. However, construction of ROB is not always very simple, particularly in lieu of the level crossings existing in big Railway yards having extensive built-up area in the approaches. The experience of Lakkarpul ROB at Ludhiana shows that this challenging task can be accomplished by innovative design solutions and execution techniques.





Photos of Completed Straight Leg of ROB



Photos of Completed Curved Leg of ROB



Photos of Completed ROB

