Construction Challenges in Bowstring Steel Bridges

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ING-IABSE Workshop on "Design, Construction and Maintenance of Steel Bridges" , Dehradun, 19th & 20th October, 2024

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Sadasivam has received his bachelor's degree in Civil engineering from Bharathiyar University (1991) and post graduate degree in Structural Engineering from College of Engineering Guindy, Anna University (1993).

Overall he has 30 years of experience in various Infrastructure projects. He is mainly involved in Design and Construction engineering for High Speed Rail, Metros, Bridges and Road projects.

He is one of the Panel member of Plain, Reinforced and Prestressed concrete(CED#46), Bureau of Indian Standards.

He is a qualified Chartered Professional - **CEng-MICE (UK)** and LRQA certified Lead Auditor.

Bowstring Steel girder bridges are typically proposed at

- Bridges across Railway/Road Crossings where the span is significantly higher (say > 50m)
- Location warrants for Aesthetic appeal and hence enhances the beauty of neighboring area
- Transportation and Assembly of Steel Bowstring Girder modules is feasible at project location
- Limitations on availability of vertical clearance

Components of a Bowstring Steel Girder Bridge

Construction of Steel Bowstring Girder Bridges can be done using one of the following methods:

1. Push Launching of Bowstring Girder over Track Beams (Temporary Structure)
   - This method is adopted where adequate space is not available for crane movement within the span. Example : Railway crossing

2. Crane Erection Method
   - This method is adopted where adequate space is available for crane movement

3. Push Launching of Bowstring Girder over Track Beams
   - Case Study 1 – Construction of Tallah ROB (Railway Over Bridge)
   - Case Study 2 - KMDA ROBs and Flyover

Construction Challenges in Bowstring Steel Bridges

Case Study 1 - Construction of Tallah ROB (Railway Over Bridge)

Construction of Tallah ROB - Project Details

Total Length of ROB	: 213.470m (Total length of project within Railway Boundary)
Span arrangement	: 30.98m+52.08m (Bowstring)+52.08m (Bowstring)+26.25m+52.08m (Bowstring)
Overall Deck Width	: 2x12.20m
Clear carriageway width	: 2x9.5m
Min vertical clearance	: 6.25m (rail level to soffit)
Weight of Bowstring Girder	: 325 MT

Construction of Tallah ROB (Railway Over Bridge)

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Push Launching Method - Enabling Structures

Track beam at Assembly location

Side Shifting Beam

Track beam at Railway Span

Trestles

Railway Tracks

Push Launching Method - Assembly of Bowstring Girder over approach span

Push Launching Method - Installation of Spreader Beam and Pulling frame

Pulling Frame

Spreader Beam connected to Bowstring Girder

Push Launching Method - Launching of Assembled module into Railway span

Spreader Beam connected to Bowstring Girder

Pulling Frame

Push Launching Method - Assembly of next module in Approach Span

Push Launching Method - Launching of 1st Bowstring Girder into Railway Span

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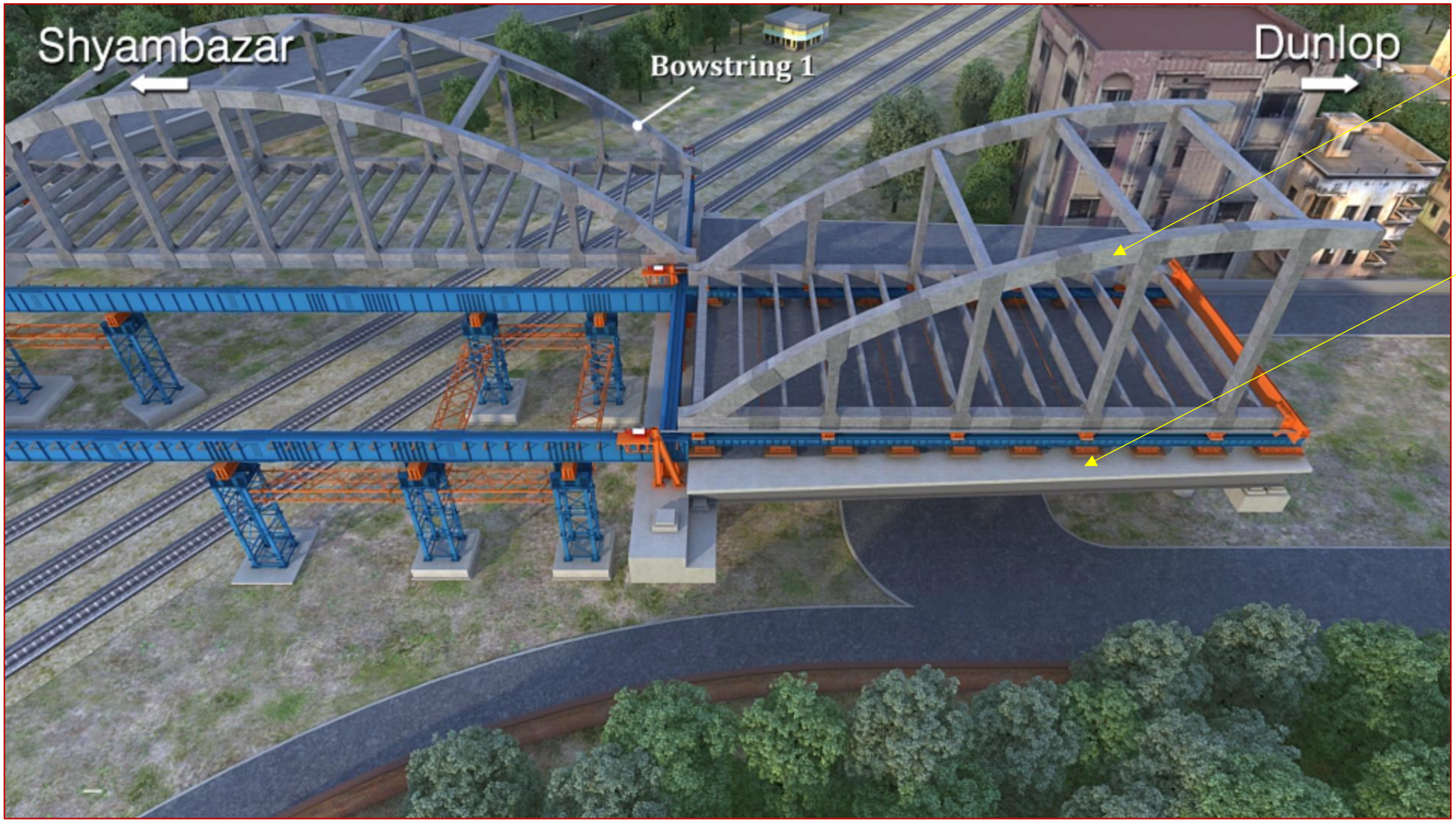
Spreader Beam connected to Bowstring Girder

Pulling Frame

Push Launching Method - Side Shifting of 1st Bowstring Girder over Piercap

Push Launching Method - Side Shifting of 1st Bowstring Girder over Piercap

Push Launching Method - Assembly of 2nd Bowstring Girder in Approach Span



Push Launching Method - Launching of 2nd Bowstring Girder into Railway Span

Push Launching Method - Installation of Side Shifting Beam

Bowstring Girder -1

Bowstring Girder - 2

Side Shifting Beam

Push Launching Method - Side Shifting of Bowstring Girder-2 to final position

Push Launching Method - Installation of Stools and Hydraulic Jacks

Bowstring Girder - 2

Hydraulic Jack

Lowering Stool

Push Launching Method - Lowering of Bowstring Girder-2 over Bearings

Push Launching Method - Side Shifting of Bowstring Girder-1 to final position

Bowstring Girder - 1

Side shifting Beam

Push Launching Method - Removal of Track Beam and Installation of Stools

Bowstring Girder – 1

Hydraulic Jacks

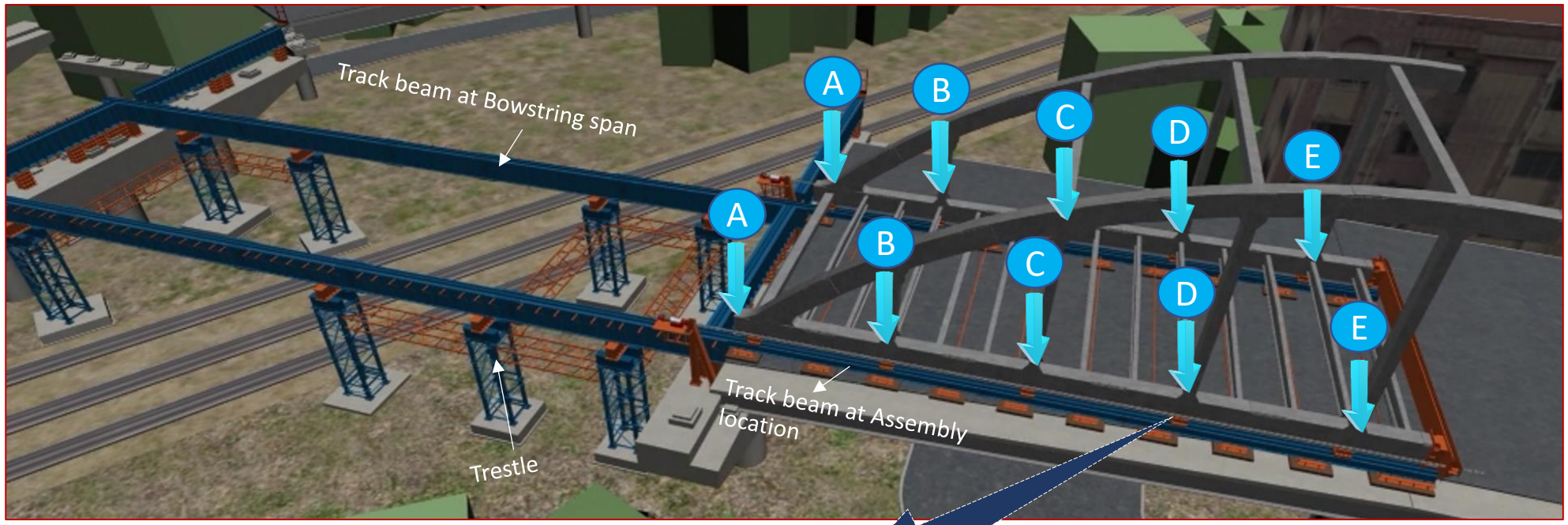
Stools

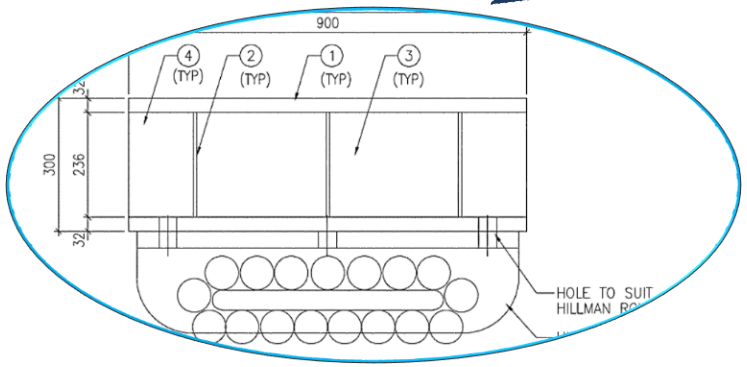
Push Launching Method - Lowering of Bowstring Girder-1 over Bearings

Bowstring Girder – 1

Bearing

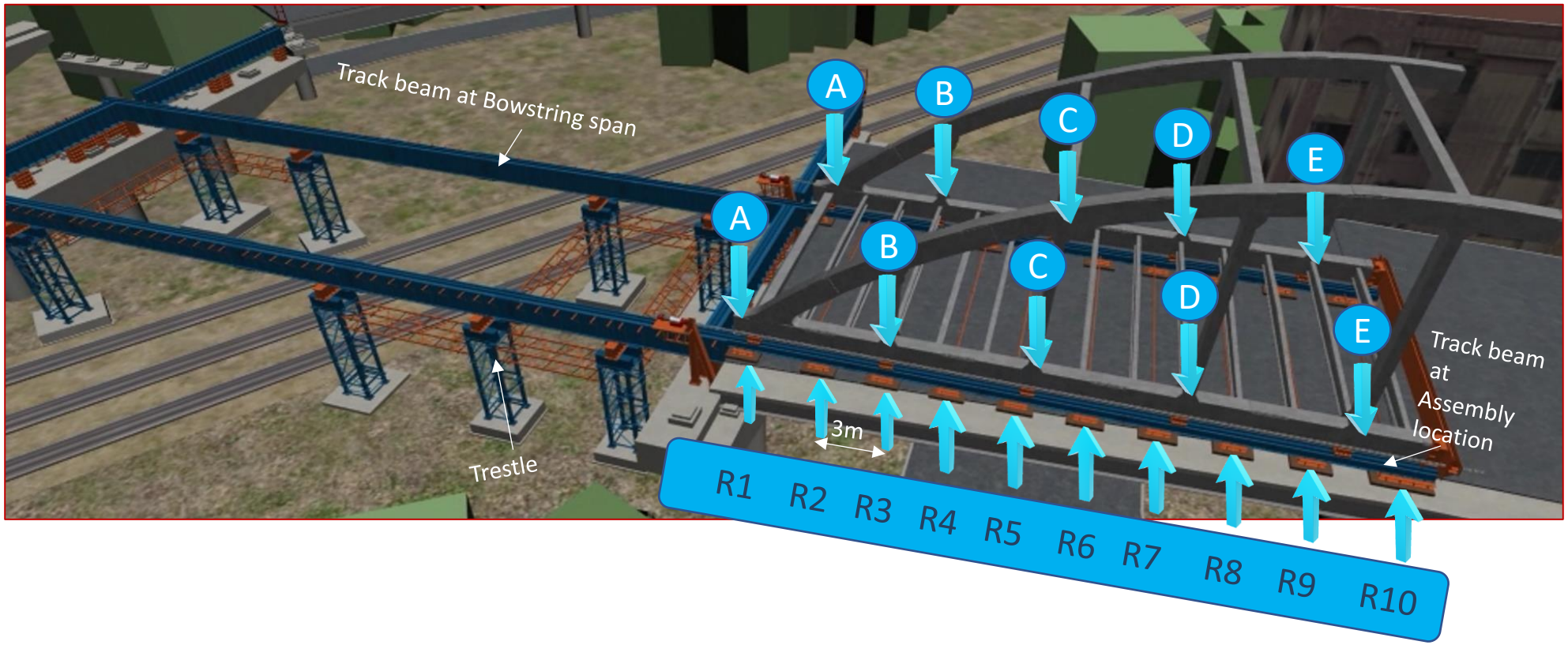
Push Launching Method - Reactions at Node points of Bowstring Girder



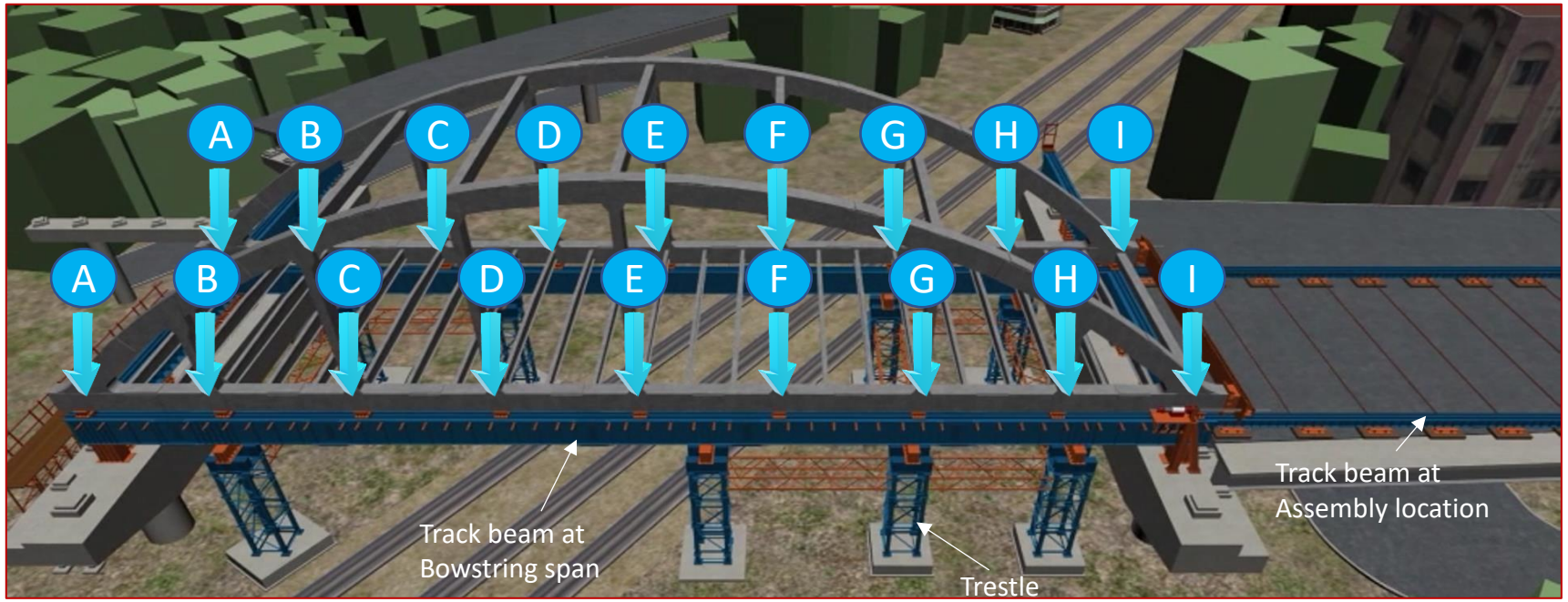


Hilman roller with Stool connected to Bowstring Girder bottom

Track Beam at CP2-P10 Span (Assembly location):

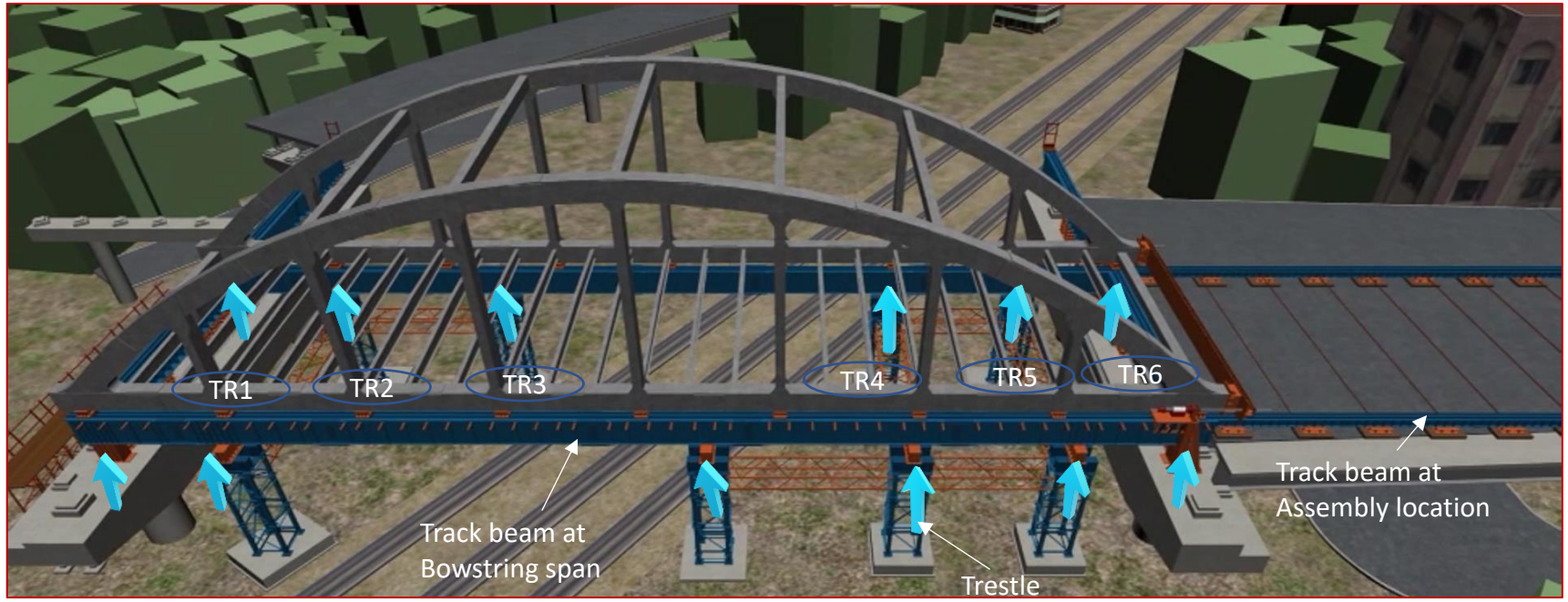


Push Launching Method - Reactions over Track Beam



Push Launching Method - Reactions over Trestles

Track Beam between Railway span:



Push Launching Method - 1st Bowstring Girder launched into Railway span (boundary)

Push Launching Method - Side shifting of 1st Bowstring Girder over Piercap

Push Launching Method - 2nd Bowstring Girder launched into Railway span (boundary)

Completed view - Three Bowstring Girder spans erected

Case Study 2 - Construction of KMDA ROBs and Flyover

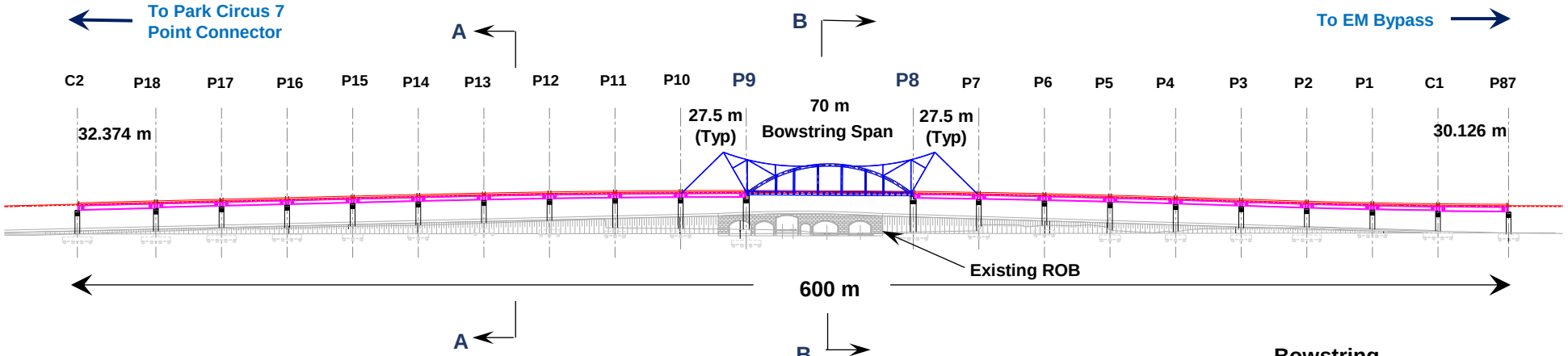
Construction of Park Circus ROB - Project Details

Project	- KMDA ROBs and Flyover
Client	- M/s Kolkata Metropolitan Development Authority (KMDA)
Contractor	- M/s L&T Construction
Consultant	- M/s L&T Ramboll Consulting Engineers Limited

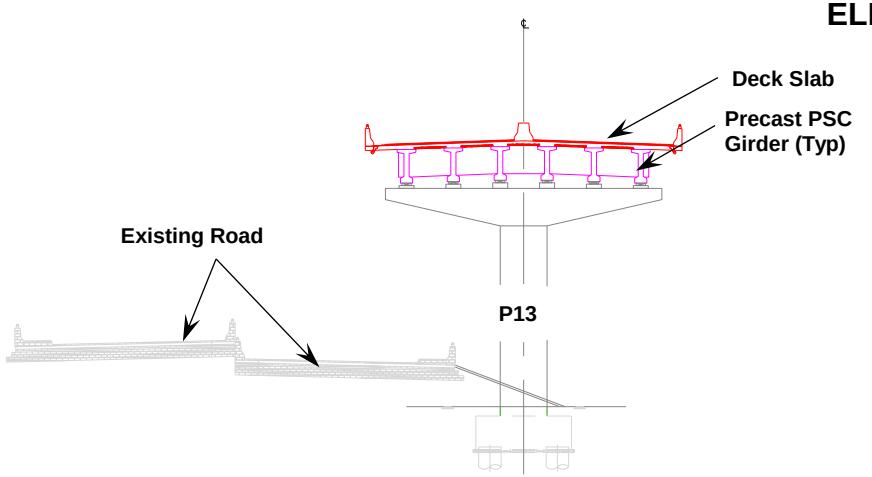
Park Circus ROB

ROB Span	- 70 m
Carriageway width	- 2 X 7.5 m
Approach Spans	- (1 x 32.374m + 9 x 27.5m) on Park circus 7-point side
	- (8 x 27.5m + 1 x 30.126m) on EM Bypass side

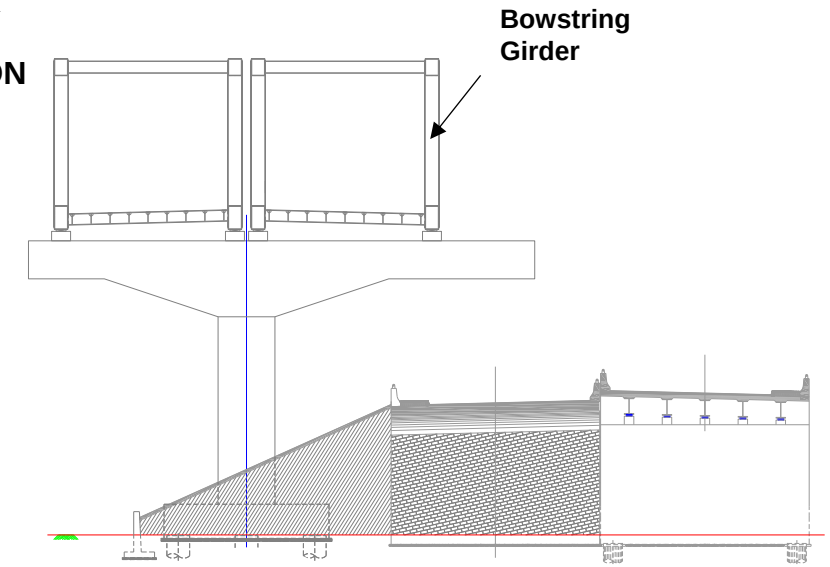
Park Circus ROB and Flyover



ELEVATION

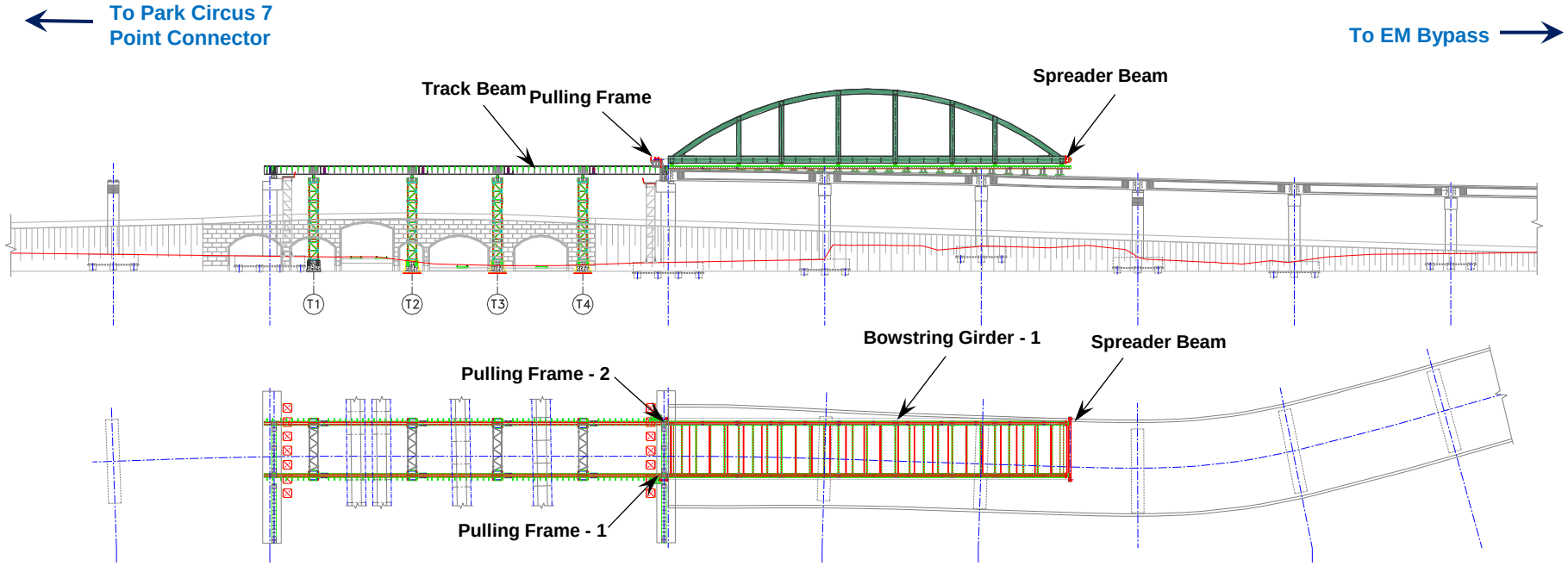


SECTION A - A



SECTION-B-B

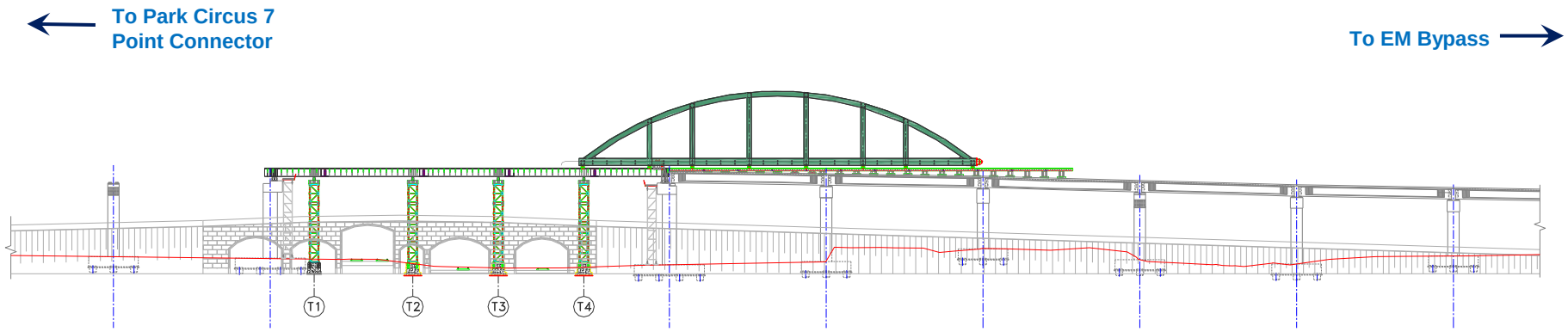
Bowstring Girder Assembly and Launching



PLAN
(Existing ROB not shown for clarity)

- ✓ Completion of Assembly of Bowstring Girder
- ✓ Completion of Erection of all Enabling works (Trestles and track beams etc.,)

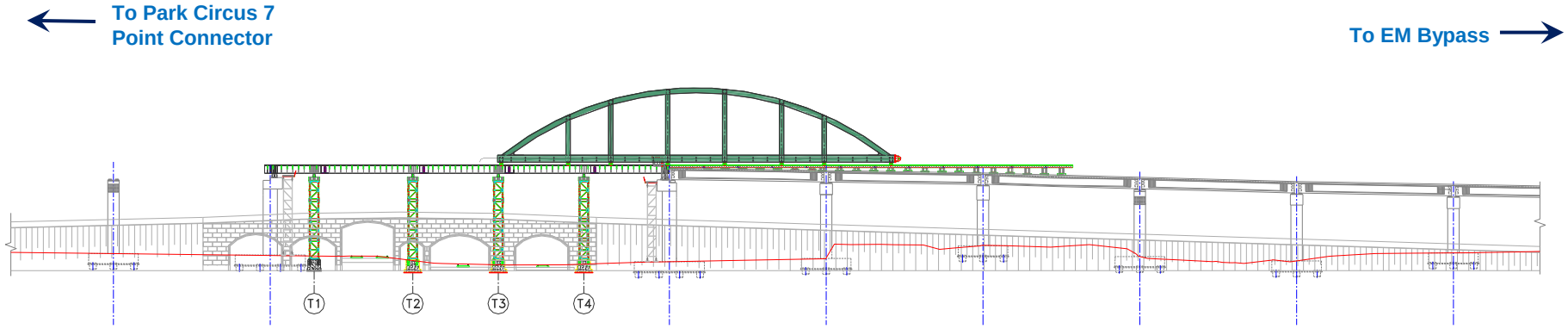
Bowstring Girder Assembly and Launching



ELEVATION

- ✓ **Launching of Bowstring Girder-1** using pulling arrangements

Bowstring Girder Assembly and Launching



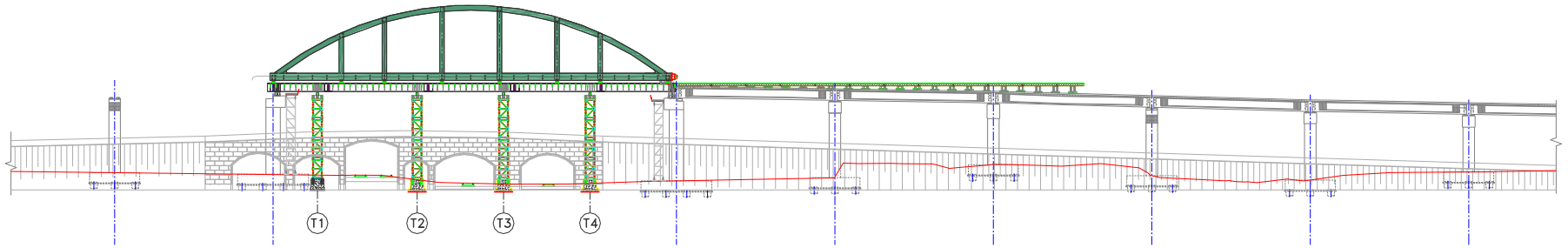
ELEVATION

- ✓ **Launching of Bowstring Girder-1** using pulling arrangements

Bowstring Girder Assembly and Launching

To Park Circus 7 Point Connector

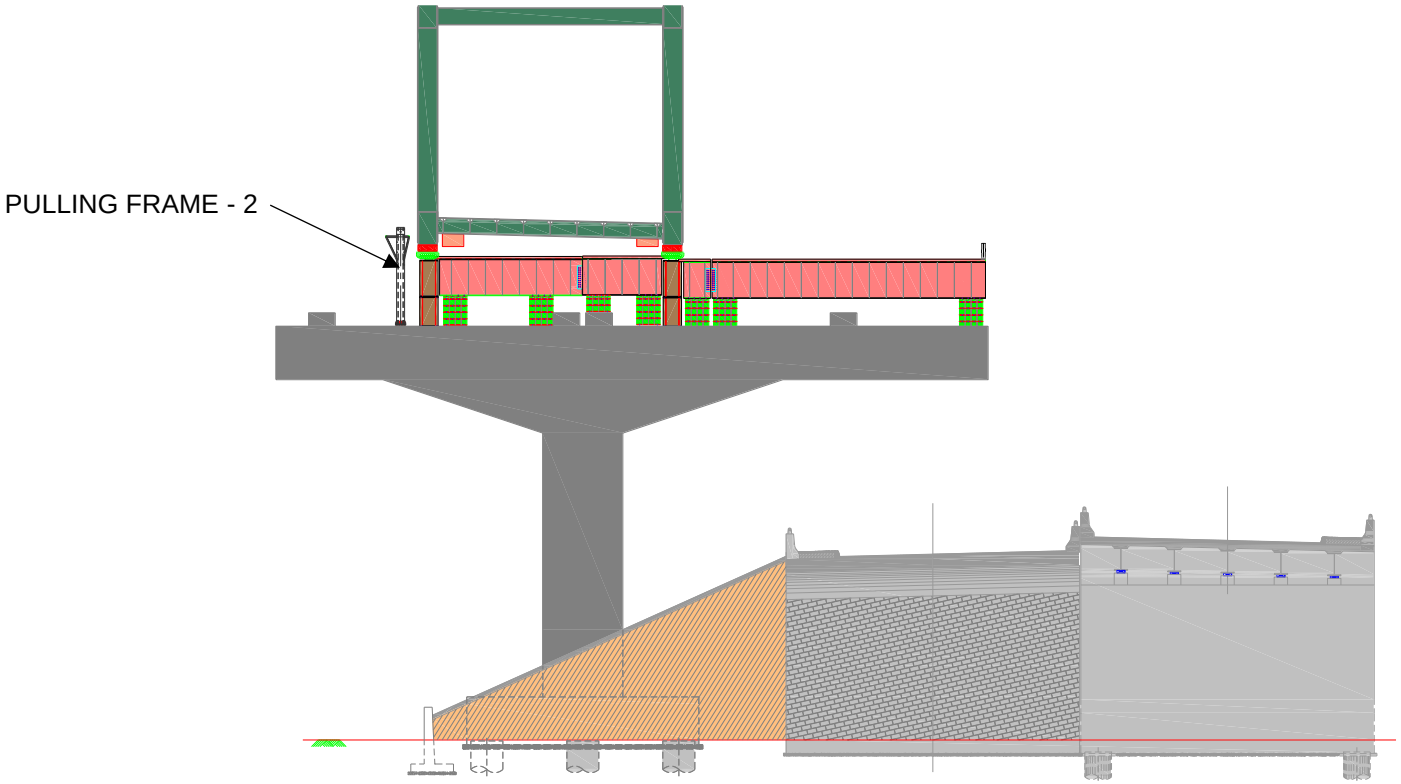
To EM Bypass



ELEVATION

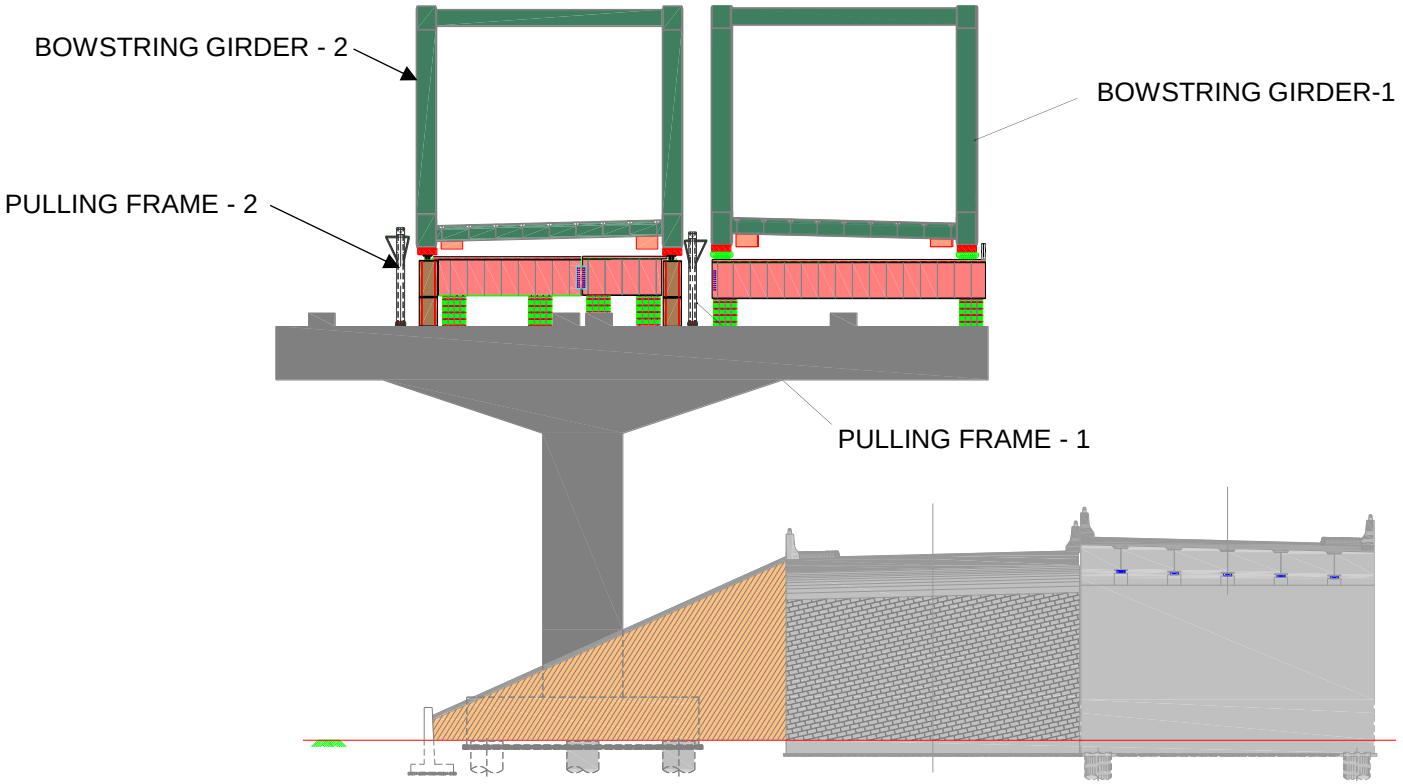
- ✓ **Launching of Bowstring Girder-1** using pulling arrangements

Bowstring Girder Assembly and Launching



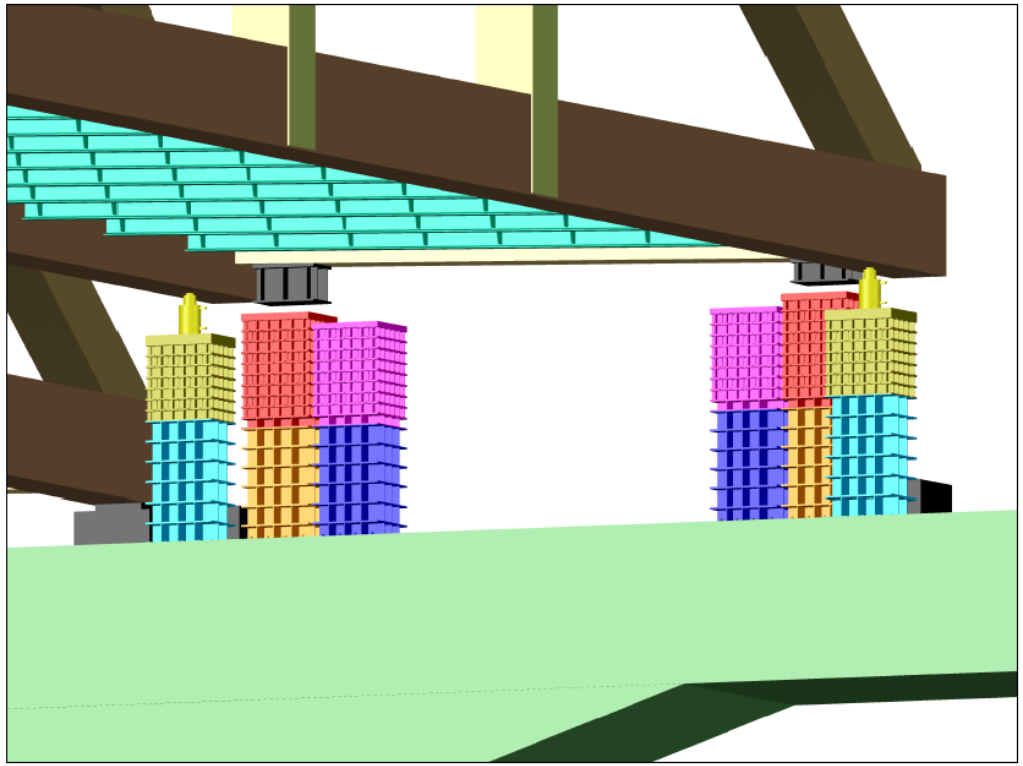
- ✓ The Bowstring girder-1 shall be side shifted using push-pull jack

Bowstring Girder Assembly and Launching



- ✓ Bowstring Girder-2 is launched.

Bowstring Girder Lowering



ISOMETRIC VIEW OF STOOL ARRANGEMENT ABOVE PIERCAP

Bowstring Girder - Enabling works

Trestle for supporting Track beam

Guide Frame

Pulling Frame

Bowstring Girder - Enabling works

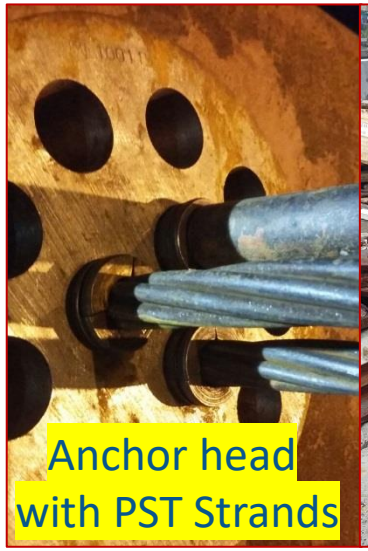
Footing of trestle supporting works

Spreader beam with pulling strands

Track beam with channel

Stool with Hillman rollers

Bowstring Girder - Enabling works

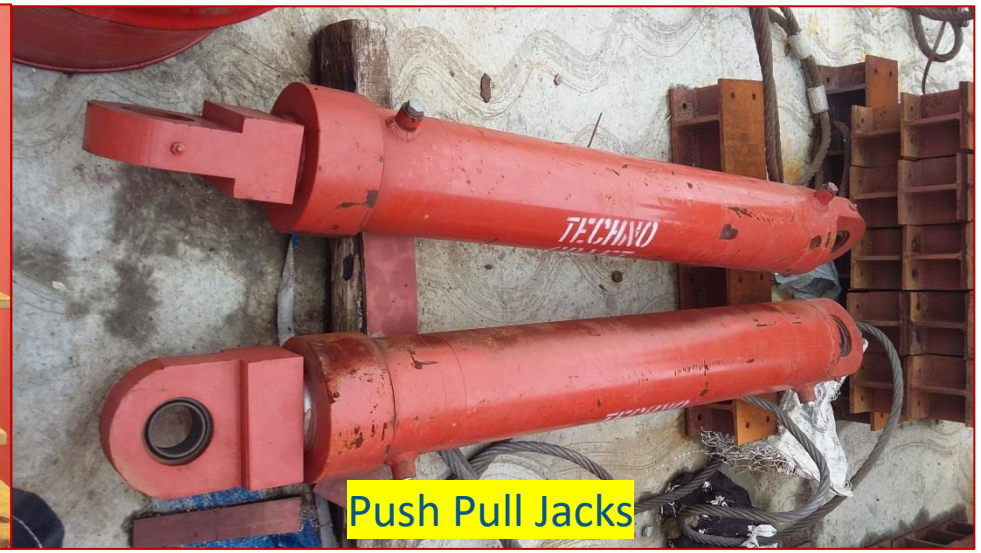

Anchor head with PST Strands


Stools


Hillman rollers

Jacks for Lifting and lowering of bowstring girder


Packing beams for lowering system



Push Pull Jacks

Park circus ROB Bowstring Girder - Assembly and Launching

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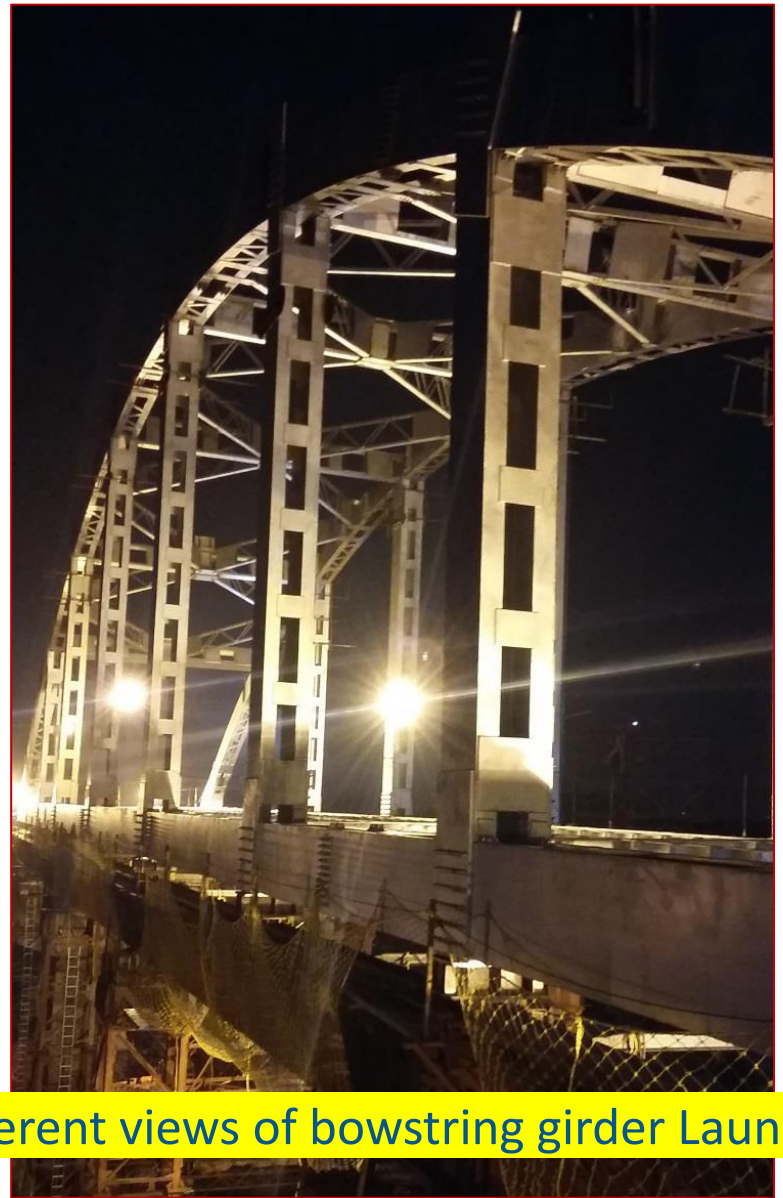


Different views of bowstring girder Launching

Park circus ROB Bowstring Girder - Assembly and Launching

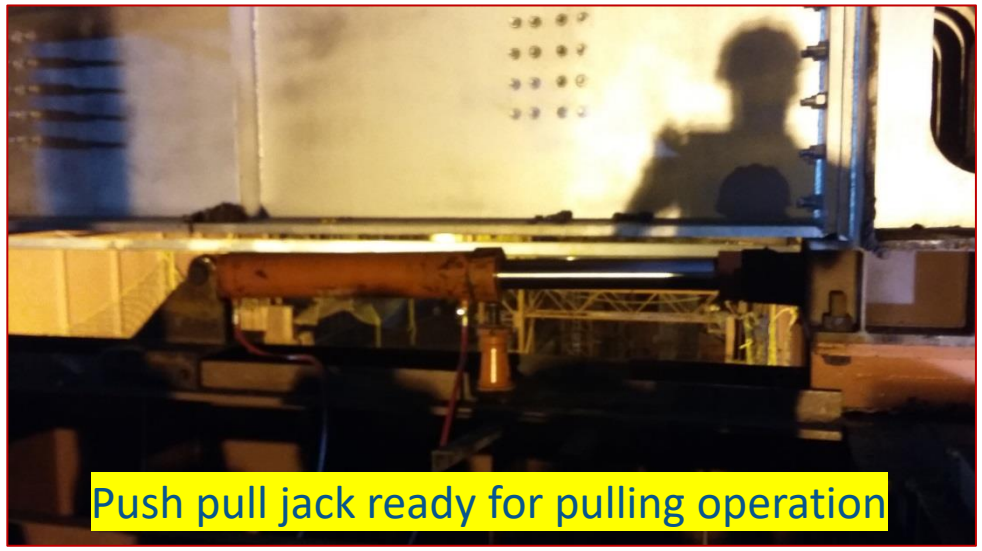
View of bowstring girder launching and existing live traffic below

Park circus ROB Bowstring Girder - Assembly and Launching

Completion of 1st bowstring girder launching

Removal of spreader beam

Changing Hillman roller direction

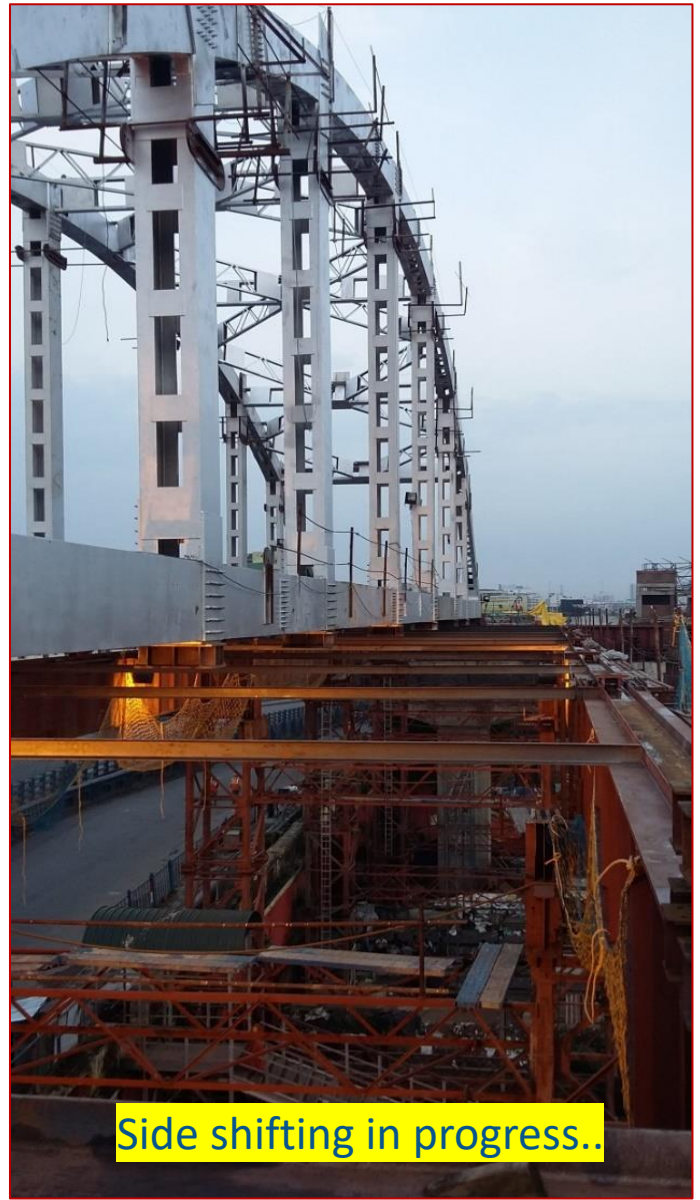


Push pull jack ready for pulling operation

Park circus ROB Bowstring Girder - Assembly and Launching

Start of side shifting

Side shifting in progress..



Side shifting in progress..

Park circus ROB Bowstring Girder - Assembly and Launching

View of Second bowstring girder assembly works

Park circus ROB Bowstring Girder - Assembly and Launching

View of Second bowstring girder assembly works

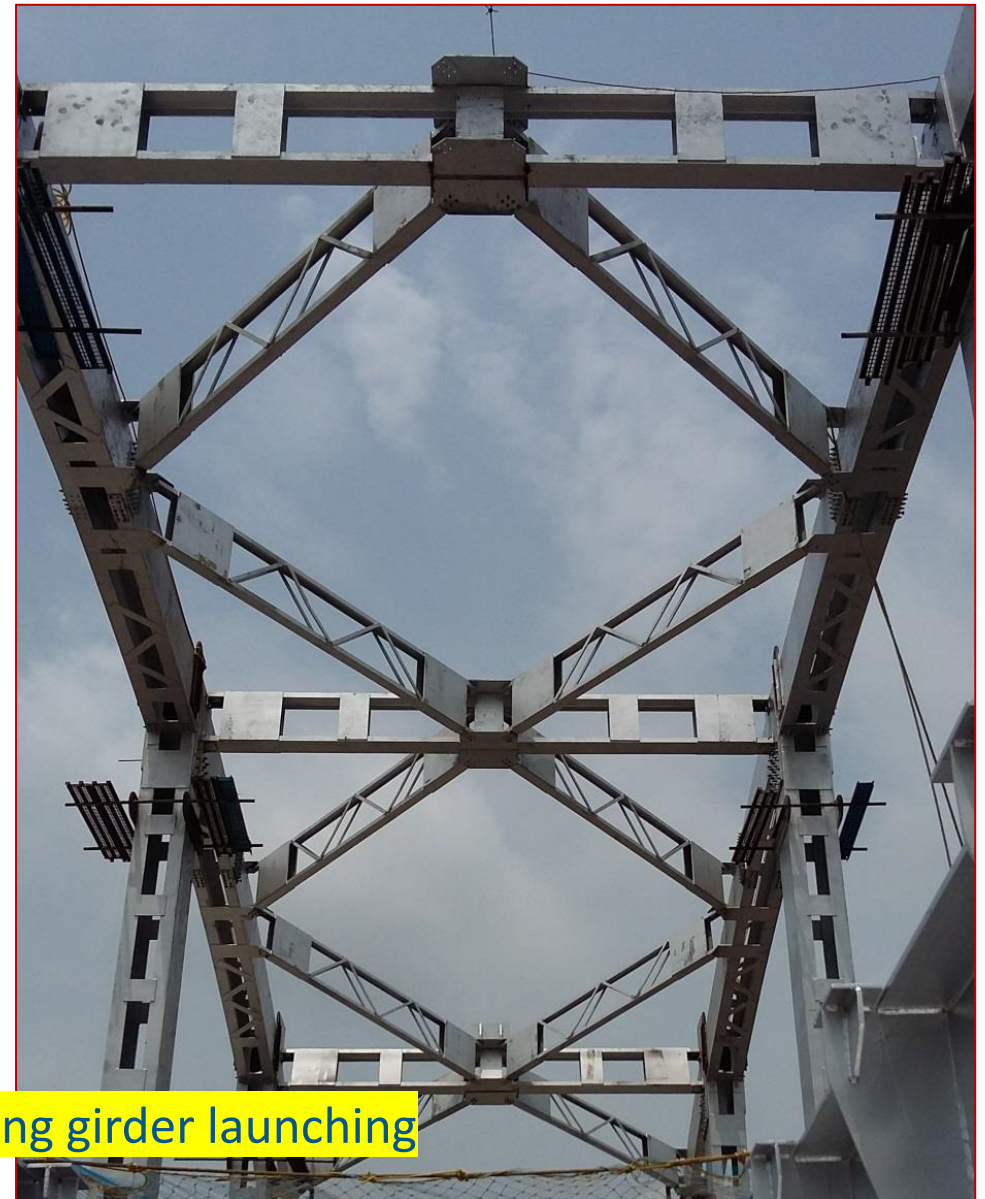
Park circus ROB Bowstring Girder - Assembly and Launching

Launching works of second bowstring girder in progress…

Park circus ROB Bowstring Girder - Assembly and Launching

Launching works of second bowstring girder in progress...

Park circus ROB Bowstring Girder - Assembly and Launching



View of bowstring girder launching

Park circus ROB Bowstring Girder - Assembly and Launching

Lowering of Bowstring girder

Park circus ROB Bowstring Girder - Assembly and Launching

Lowering of Bowstring girder

Park circus ROB Bowstring Girder - Assembly and Launching

Assembling /Erection of Architectural/Embellishment works

Park circus ROB Bowstring Girder - Assembly and Launching

Assembling /Erection of Architectural/Embellishment works

Park circus ROB - Bowstring Girder completed view

Completed View of Bowstring Girder with Architectural/Embellishment works

Bowstring Girder Bridge - Construction Challenges

Bowstring Steel Girder Bridge - Important aspects

1. Detailed Design and Fabrication Drawings - Bowstring Steel girder
2. Selection of Construction Methodology
3. Construction stage analysis of permanent works to suit the Construction Methodology
4. Design and detailing of enabling works
5. Selection of construction equipment and machinery to suit Construction Methodology
6. Construction tolerances to enable construction friendly launching or erection
7. Check list - Wind speed during launching, deflection, pulling force required, guiding rollers etc,.
8. Safety aspects - Power block, protection of IR works, existing bridges etc,.
9. Quality aspects - Fabrication works, bolts, welds, tightening works etc.,

- Fabrication of welded / bolted Bowstring Girder as per approved drawings.
- Sourcing of raw materials for fabrication shall be only from approved source.
- Physical, Mechanical and chemical testing of Raw materials shall be done from the Government approved NABL accredited laboratory.
- All the test reports shall be inspected and vetted by Railways. Selection of welding electrode, flux and wire shall be as per RDSO IRS M28, IRS M39 and IRS M46.
- All the bolts, nuts and studs shall be in accordance with Indian standards IS 1148, IS 1079, IS 1929, IS 10102.
- The paint shall be procured from RDSO approved manufacturer and as per IRS B1 2001.
- NDT of single and Double vee butt weld shall be done using USFD and radiography.
- NDT of 'T' fillet weld and lap weld shall be done using DPT in accordance with IS 3658 and RDSO approved DP kit to be used.

Bowstring Steel Girder Bridges - Safety

- Ensuring proper ingress and egress to workmen when working at height.
- Ensuring all the metal components in the vicinity of traction lines are properly earthed.
- Ensuring workmen are using PPE's that are stipulated to work near electrified lines.
- The erection activity is at Railway Station, public movement shall be restricted only to predefined safe zones.
- All movable components such crane booms, man lifts etc. shall operate at safe working zones from traction lines.
- Ensuring traffic wardens are available throughout the erection activity.
- Ensuring proper safety nets are provided below the Track Beams/Bowstring Girder to avoid fall of materials into the Railway boundary.





Thank You