Design and Construction aspects of Arch bridge over Chenab River

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He has overall experience of 25 years in Infrastructure Projects. He is mainly involved in Design of Bridges, project planning, making construction schemes and development of related enabling structures. Areas of expertise are in Long span bridges, expressways and Industrial Structures.

He is a Chartered Member & Fellow – Institution of Engineers (India).

He is Individual Member – Deep Foundation Institute (DFI)

Design and Construction aspects of Arch bridge over Chenab River

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MAKE
Global, Asia Pacific, India Winner
2016, 2017

MIKE
Global, Asia Pacific, India Winner
2018, 2019, 2020,2021, 2022

CII MOST INNOVATIVE ENTERPRISE 2021
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CII INDUSTRIAL INNOVATION AWARDS 2021

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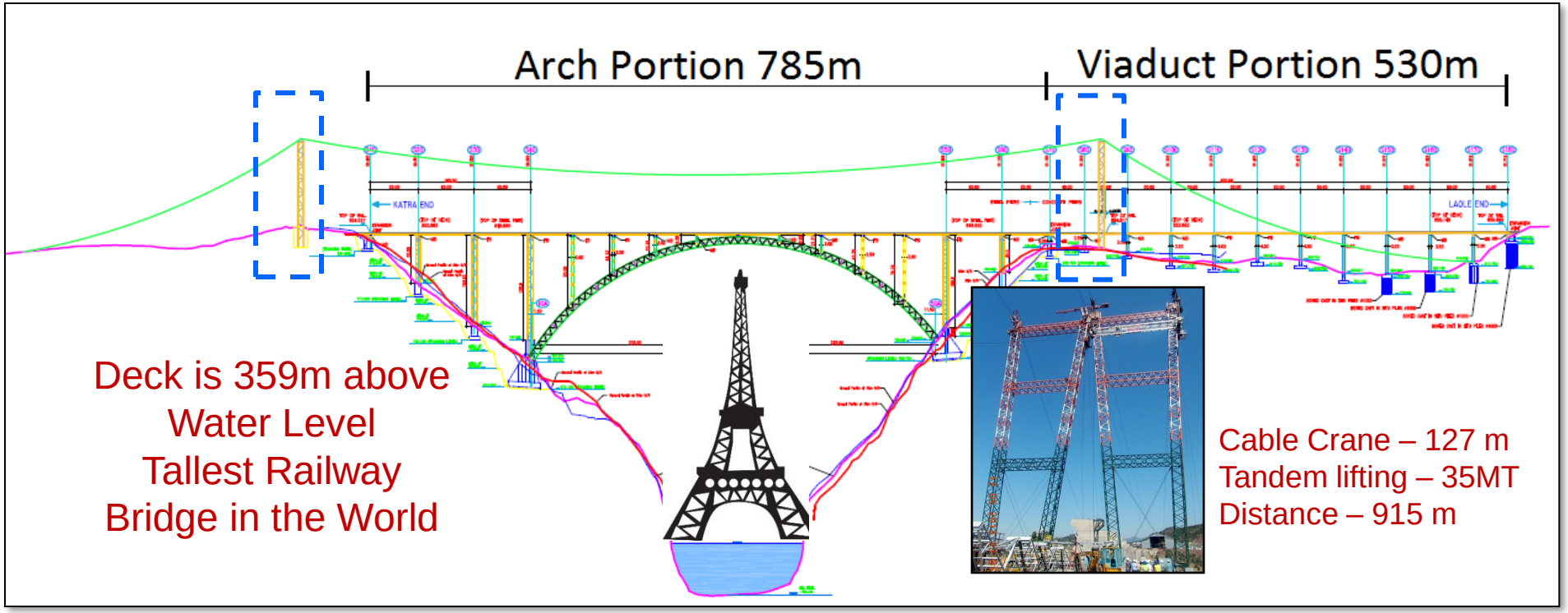
CHENAB BRIDGE- Udhampur – Srinagar – Baramulla Rail Link Project

Key Stake Holders	
Clients	Konkan Railways Corporation Limited Northern Railways
Contractor	Chenab Bridge project Undertaking U/o Afcons Infrastructure Limited
Clients Consultant	Scott Wilson Kirkpatrick & Co. Ltd (England) Scott Wilson Kirkpatrick India Pvt. Ltd. Flint & Neill Partnership (London)-JV (COWI)
Designers	WSP Finland Ltd - Leonhardt Andre' & Partners Germany
Slope Stabilization	IISC, Bangalore IIT, Delhi ITASCA (USA)
Construction Engineering & Enabling Structures	Afcons Infrastructure Limited

GENERAL ARRANGEMENT



Total Length of Bridge	: 1315 m
Bridge Height at Arch Portion	: 359 m
Main Arch Span	: 467 m

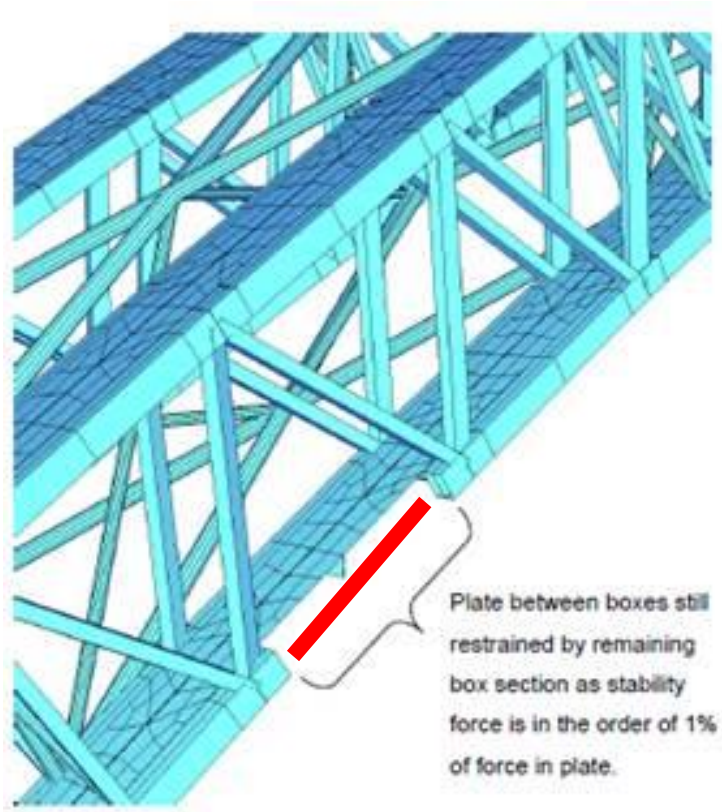
Civil Works:

- Excavation Quantity : 10,00,000 Cum
- Concreting Quantity : 65,000 Cum
- Rock Bolting : 1,40,000 Rmt
- Fabrication and Erection Works : 31,000 MT

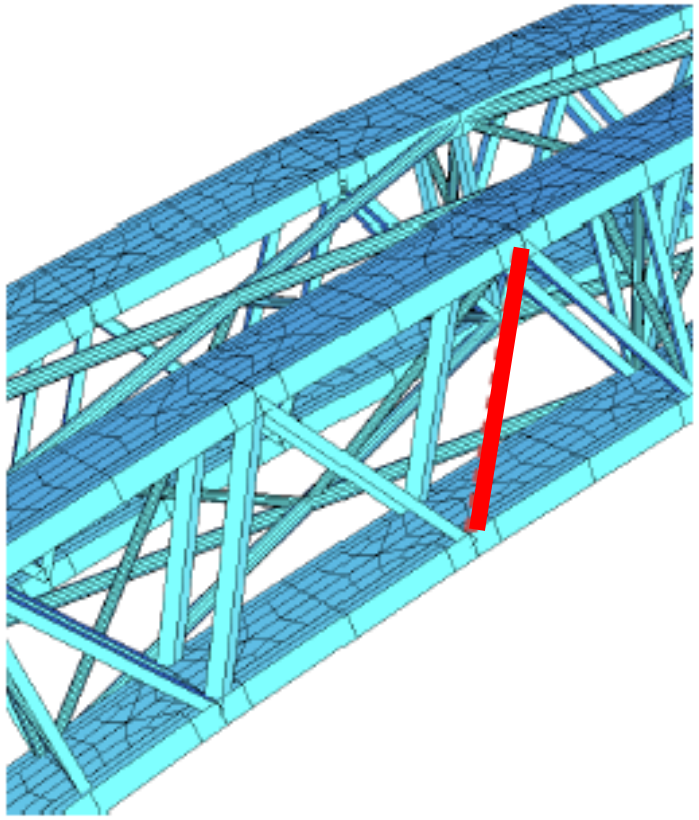
- Geographical Location
  - High Altitude in the vicinity of snow-clad Himalayan Mountains Close to Zero-degree temperatures
  - Seismically highly active area - Zone V
- Geological Condition
  - Unstable slopes
  - Unpredictable Erratic Geology

Special Considerations in Design - Blast Loads

- Load for Foundations – Pressure generated by explosion of 100kg (TNT equivalent) occurring at ground level at 20m from face of piers/abutments.
- For Superstructure – Pressure generated by an explosion of 40 Kg (TNT equivalent) on the deck of bridge.



One chord member

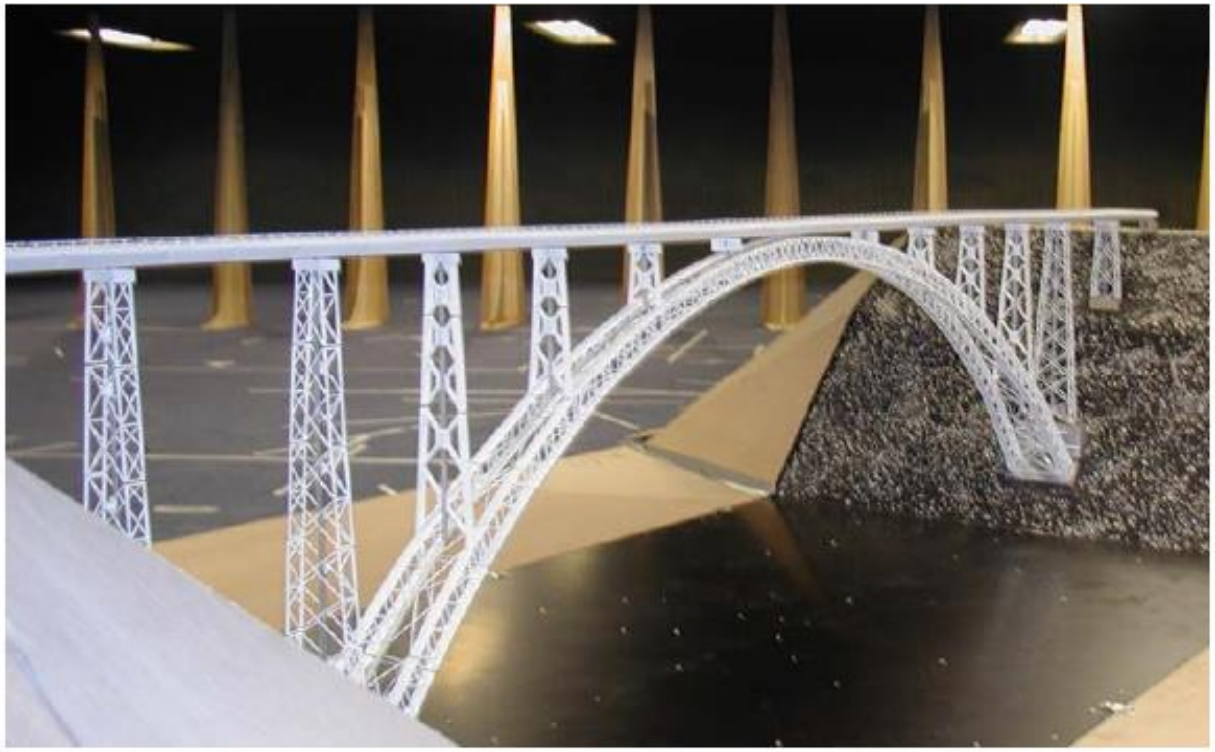


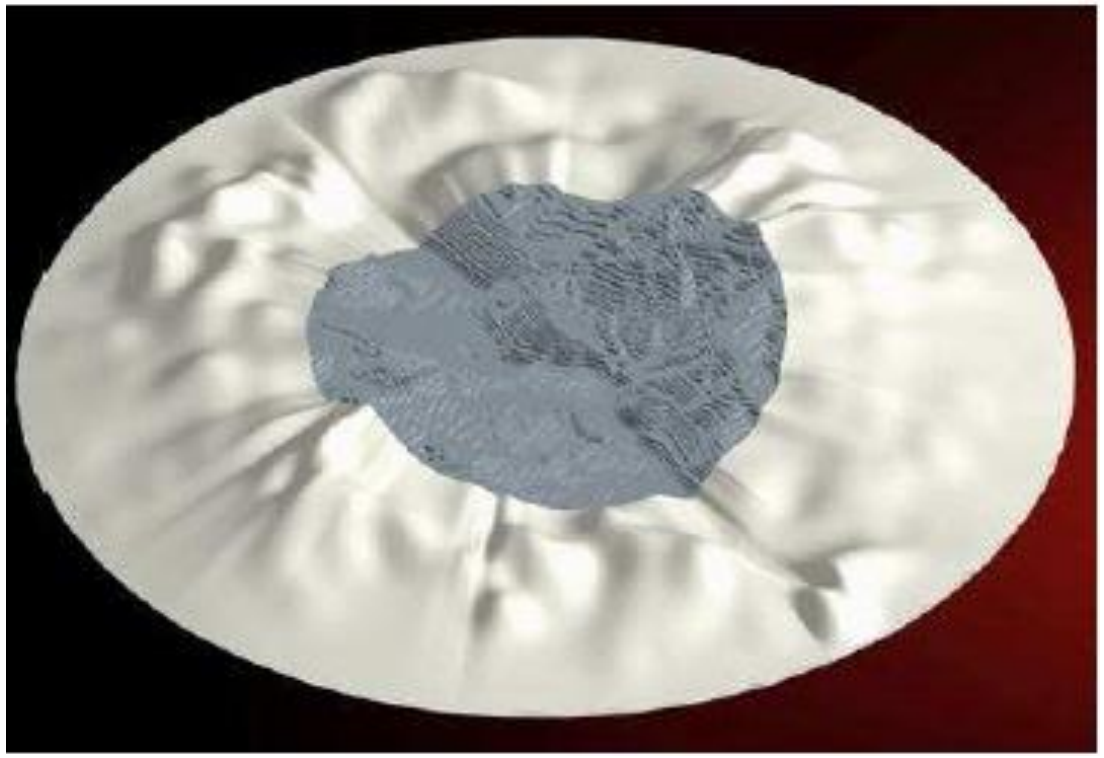
One diagonal member of the arch truss

- **Redundancy**

One Arch chords buckles, or one diagonal member of the arch truss fails due to blast loading. The Railway on the bridge incidentally can safely travel without the bridge collapse failure on the mentioned redundant location.

WIND TUNNEL TESTING





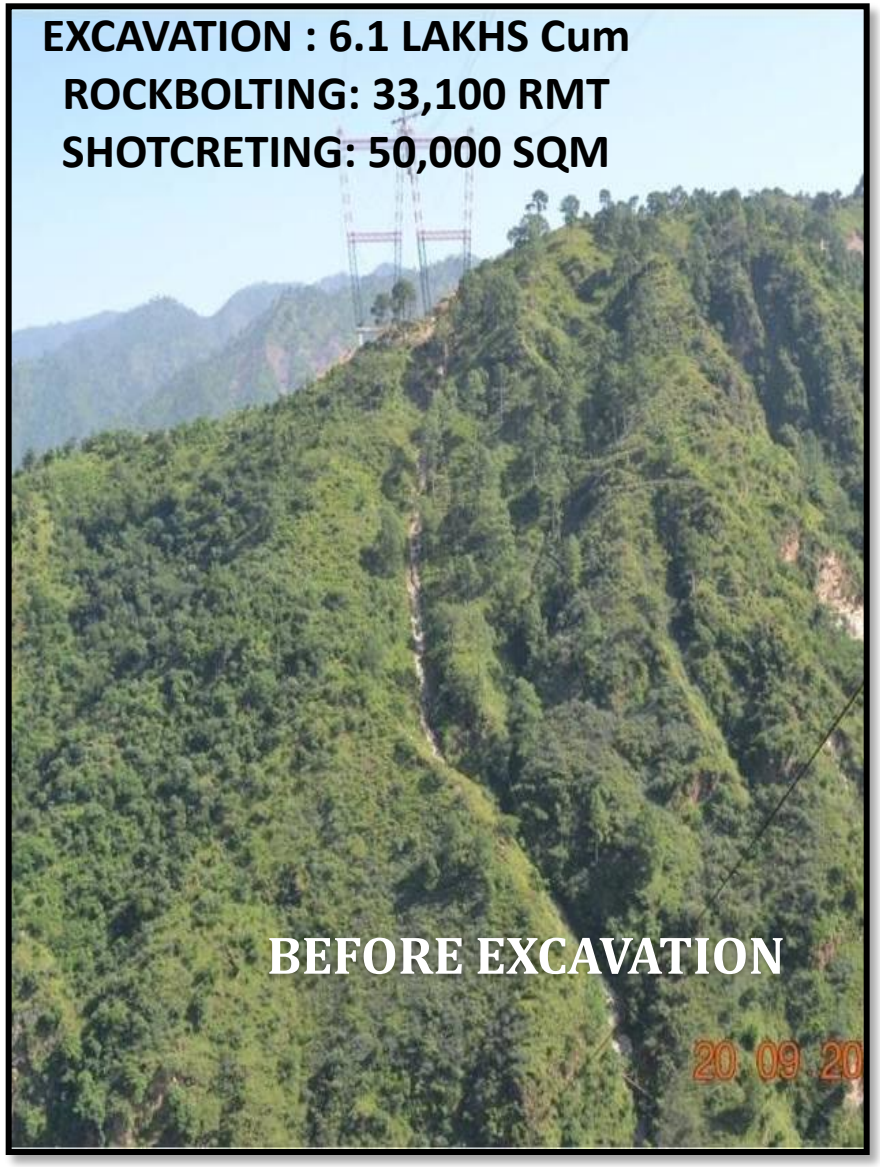
Wind Tunnel Tests carried out in Force Technology Lab in Denmark.

BROAD METHODOLOGIES OF DESIGN AND EXECUTION

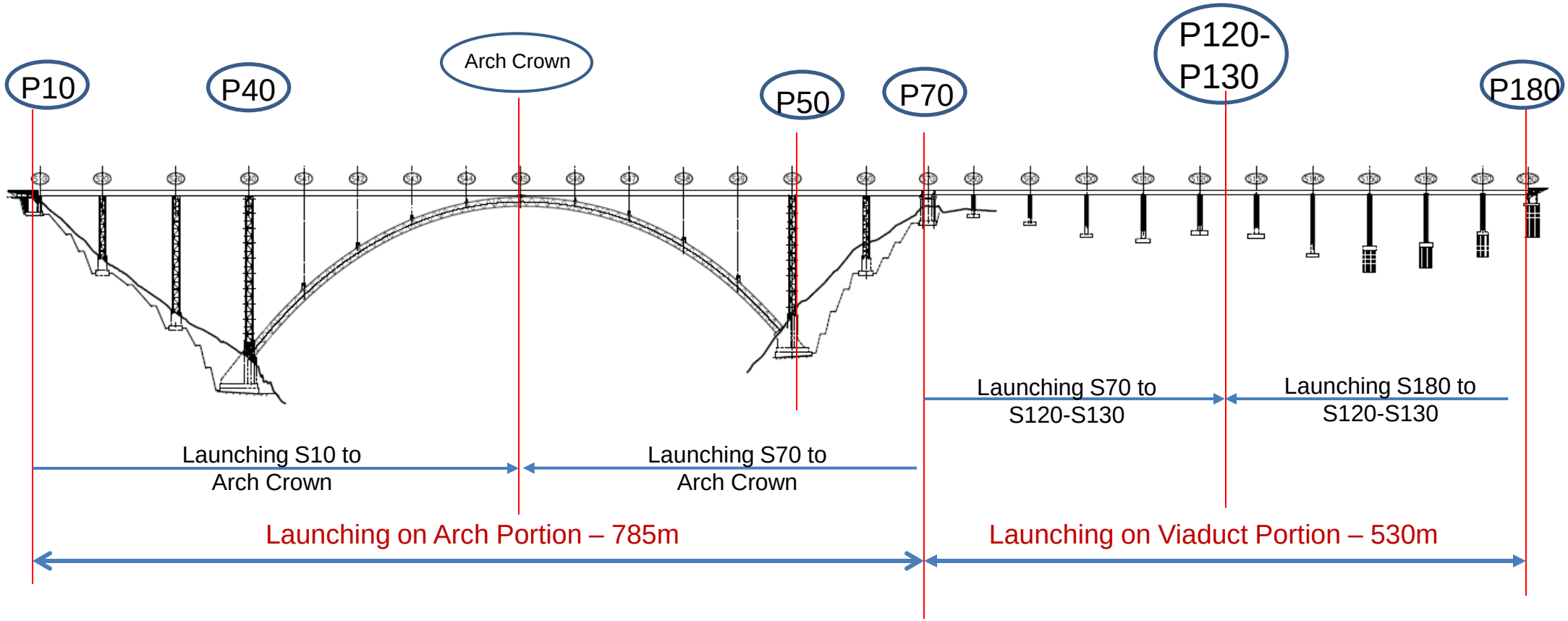
PLANNING & EXECUTION – APPROACH ROADS

Approach Roads totaling 15 km were constructed

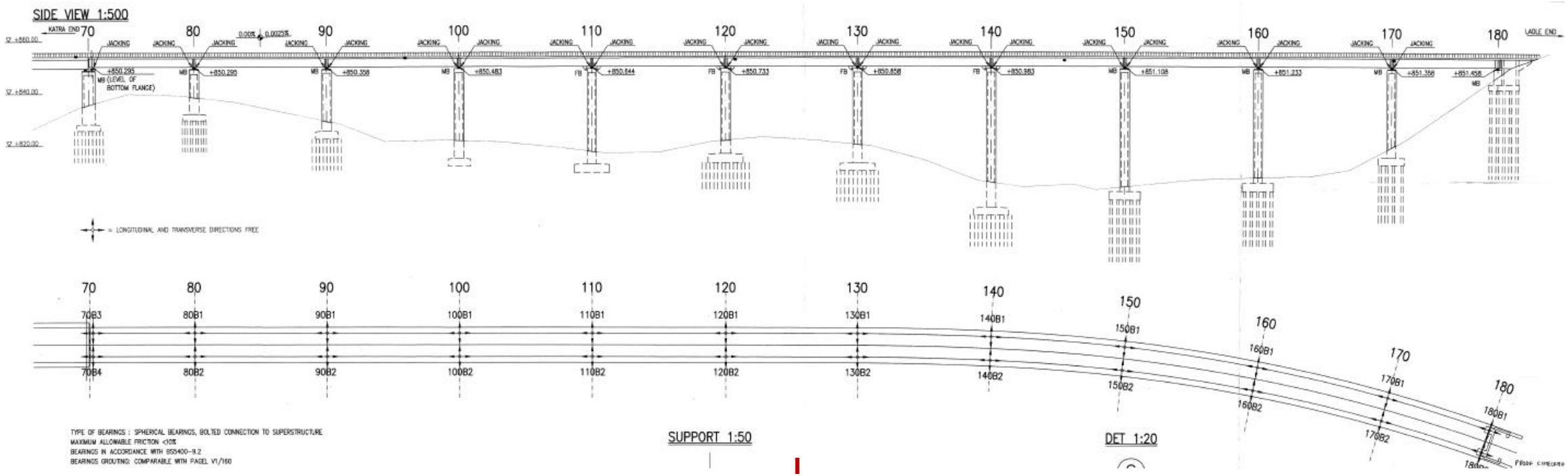
PLANNING & EXECUTION - SLOPE STABILIZATION AND SUBSTRUCTURE



Bridge Deck Erection by Incremental Launching Method



Bridge Deck Erection by Incremental Launching Method



Part 2 - Straight Viaduct Spans
S70 to S120-S130

Part 1 - Viaduct spans with curve of varying Radius S180 to S120-S130

Incremental launching of Viaduct Spans

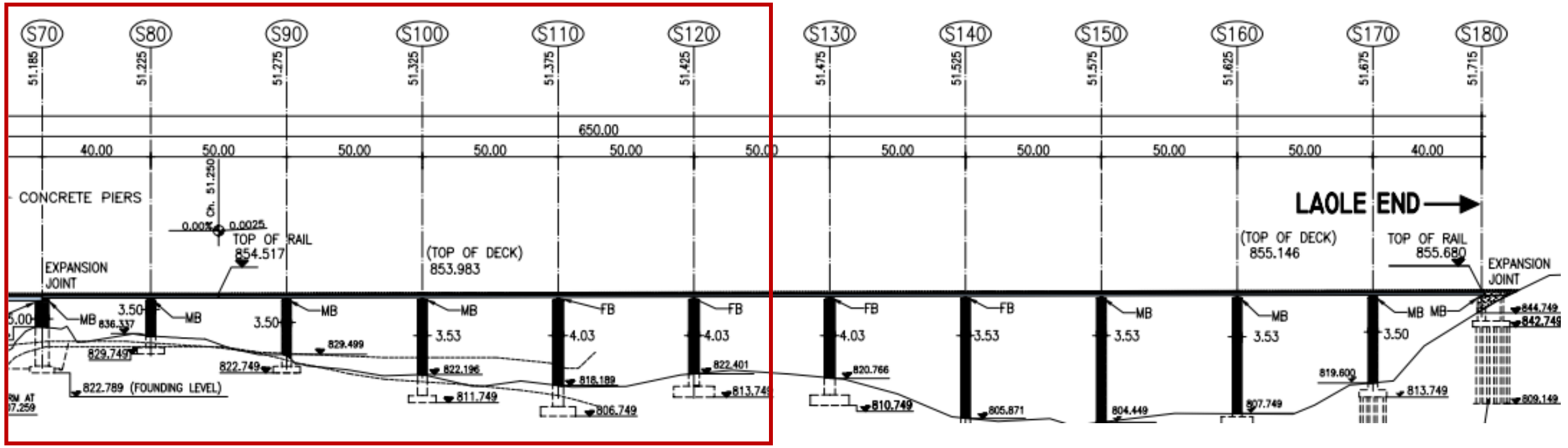
PART 1 – Bridge Deck Erection on Curves of Varying Radius S180 to S120

Pushing of Segment Arrangement @ S180 Abutment

PART 1 – Bridge Deck Erection on Curves of Varying Radius S180 to S120

Incremental Launching completed view on Combined Transition and Circular Curve

PART 2 – Bridge Deck Erection on Straight Spans S70 to S120



Actions taken for Straight Viaduct Launching

- Segment Joining Platform at Deck Level
- Lifting arrangement for Segments on Platform
- Welding & Sliding arrangement of Segments on platform for Incremental Launching

PART 2 – Bridge Deck Erection on Straight Spans S70 to S120

Segment Platform @ S70-S80

Segment Transportation to Platform

Lifting of Segment on Platform

PART 2 – Bridge Deck Erection on Straight Spans S70 to S120

Puling Arrangement @S90
Supporting frame & Strand Jacks added on Pier S90

Incremental Launching of Viaduct Span in Progress

BRIDGE DECK ERECTION ON VIADUCT PORTION (COMPLETED VIEW)

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Incremental Launching completed view on Combined Transition - Circular Curve & Straight Alignment

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PARAMETERS AND PERMANENT STRUCTURES USED IN ARCH ERECTION

- Cable crane
- Permanent steel pier P40 and P50
- Temporary towers over piers P40 and P50
- Stay cables
- Foundations at S10, S20, S70 and S80

INSTALLATION OF PYLONS AND CABLE CRANE FOR ERECTION OF ARCH

Pylons at each end

Cable crane with tandem

3D VIEW OF S40 & S50 FOUNDATION

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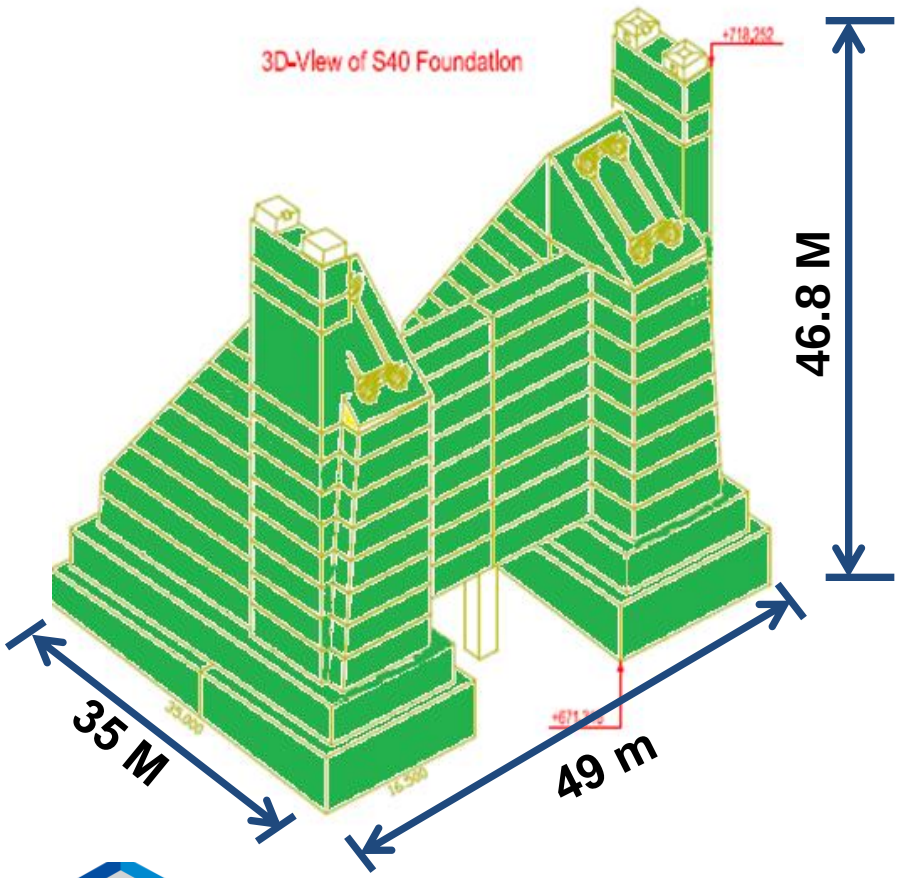
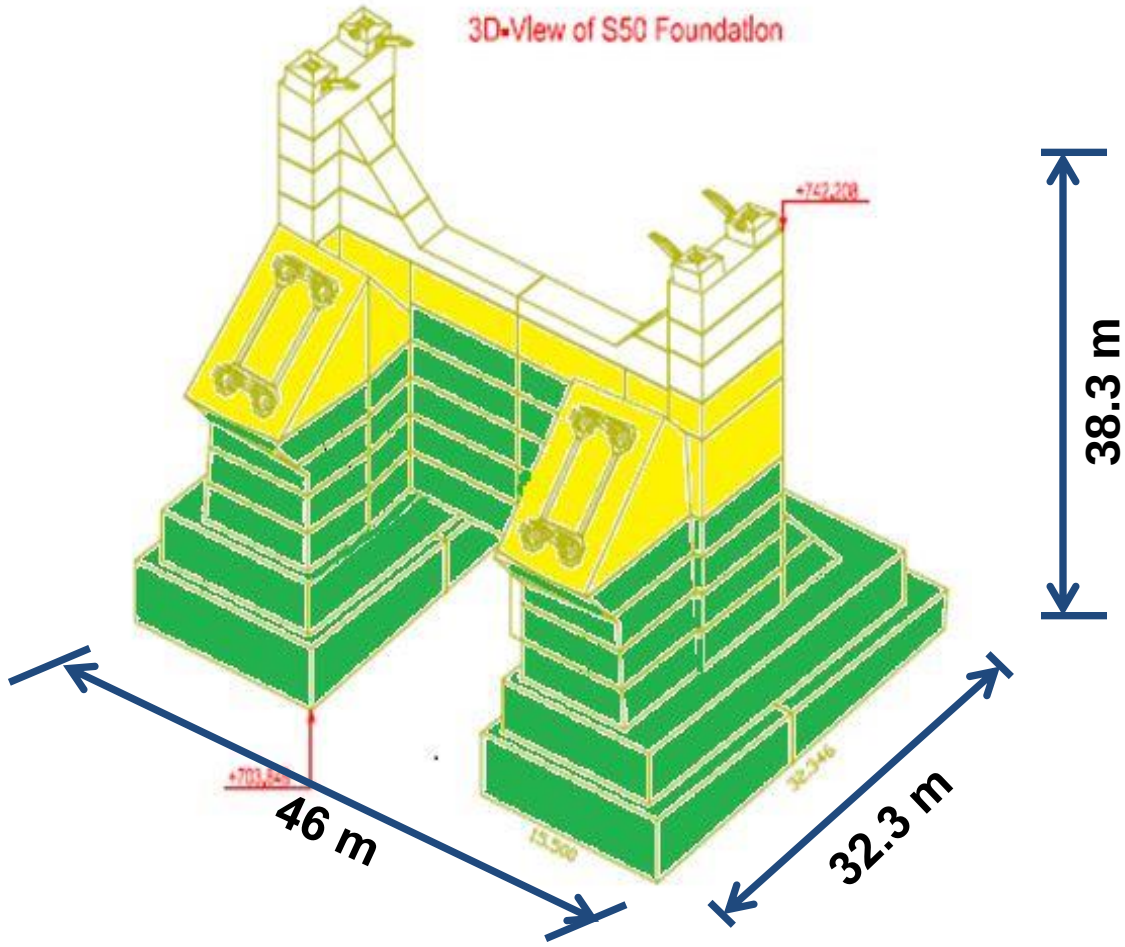
Total Concrete Qty .19325 Cum
No. of Pours : 28 Nos.
Biggest Pour : 1570 Cum



Total Concrete Qty .17505 Cum
No. of Pours : 24 Nos.
Biggest Pour : 1482 Cum



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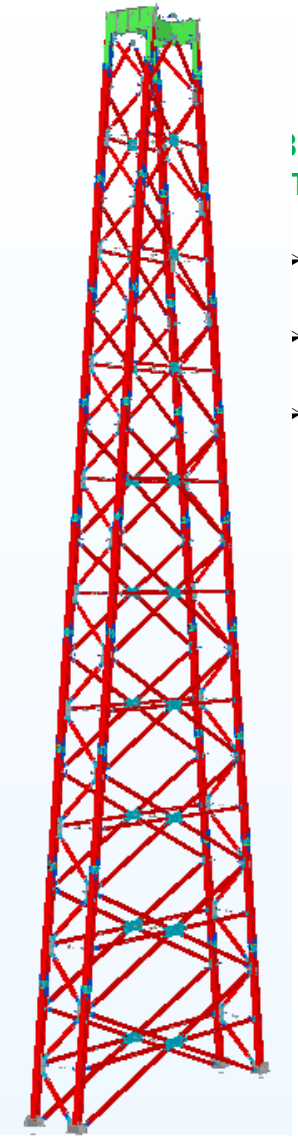
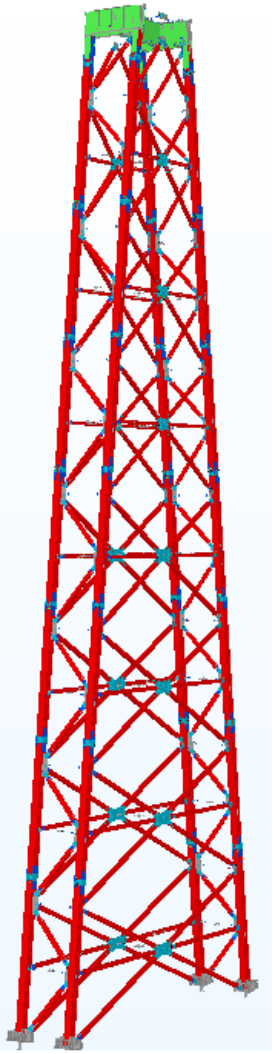
INSTALLATION OF PIERS FOR ERECTION OF ARCH & BRIDGE DECK SUPPORT



3 D view of Steel pier P40 (TEKLA BIMSIGHT)

- Height of pier = 130.9 m
- Base in transverse direction = 40.0 m
- Base in Longitudinal direction = 6.0 m



3 D view of Steel pier P50 (TEKLA BIMSIGHT)

- Height of pier = 106.9 m
- Base in transverse direction = 34.3 m
- Base in Longitudinal direction = 6.0 m

INSTALLATION OF PIERS FOR ERECTION OF ARCH & BRIDGE DECK SUPPORT

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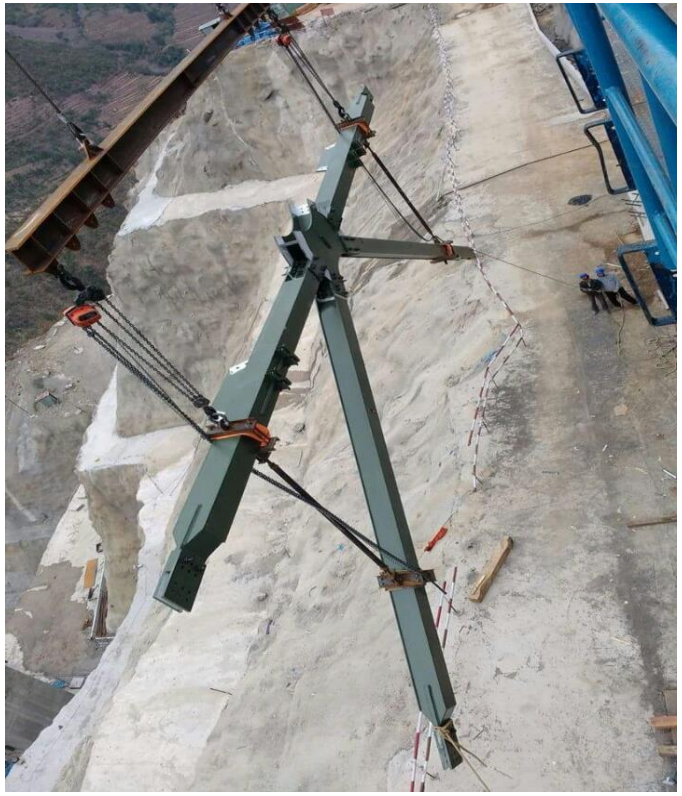
Erection of Pier in Progress

Erection of Pier Base Segment



Erection of Bracing Assembly

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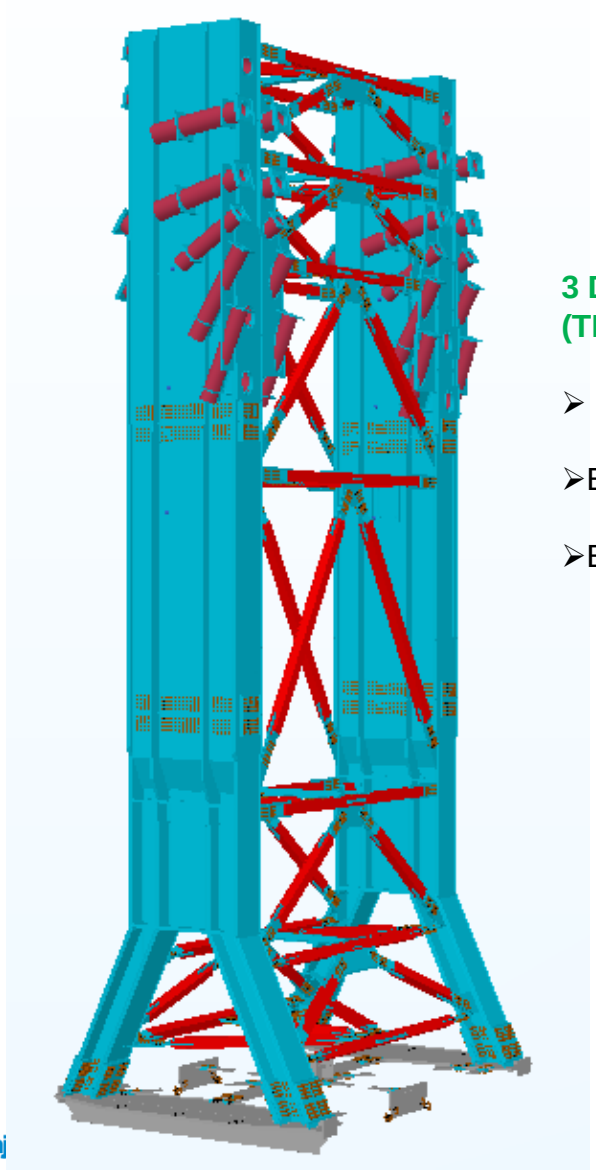
INSTALLATION OF TEMPORARY TOWER FOR ERECTION OF ARCH USING STAY CABLES



3 D view of Temporary tower S40 (TEKLA BIMSIGHT)

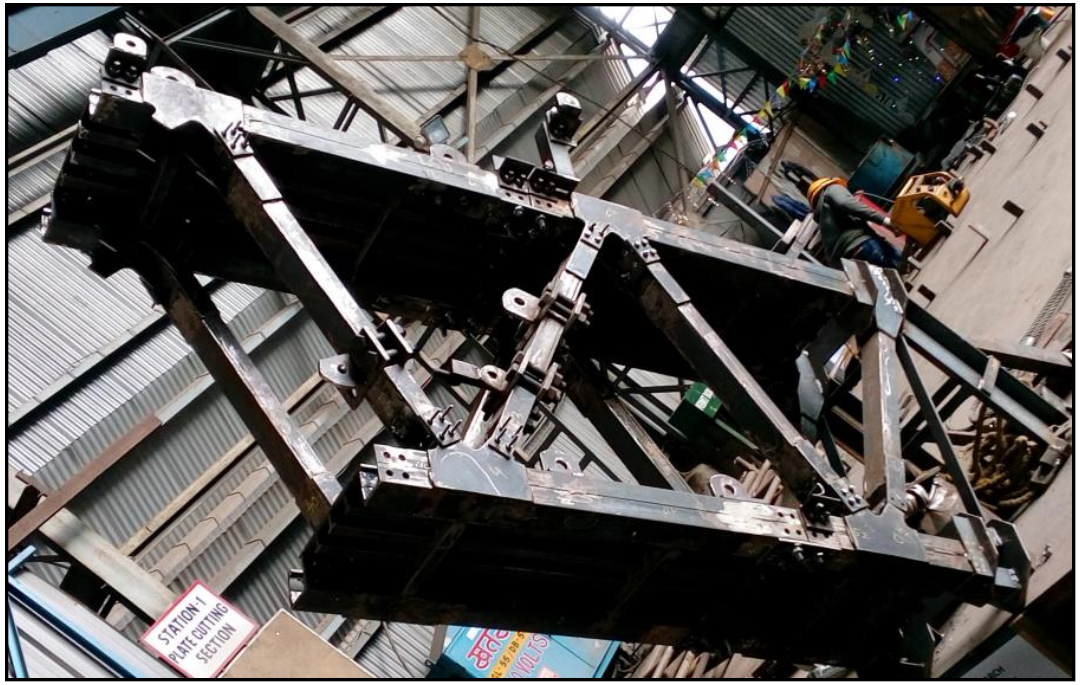
- Height of pier = 24.0 m
- Base transverse direction C/C = 9.0 m
- Base in Longitudinal Direction= 3.0 m

Erection of Temporary tower on Pier in progress

ARCH ERECTION PROCESS CONSISTS OF

- TRIAL ASSEMBLY
- GLOBAL ERECTION CYCLE
- ARCH CLOSURE

LOCAL ARCH ERECTION CYCLE

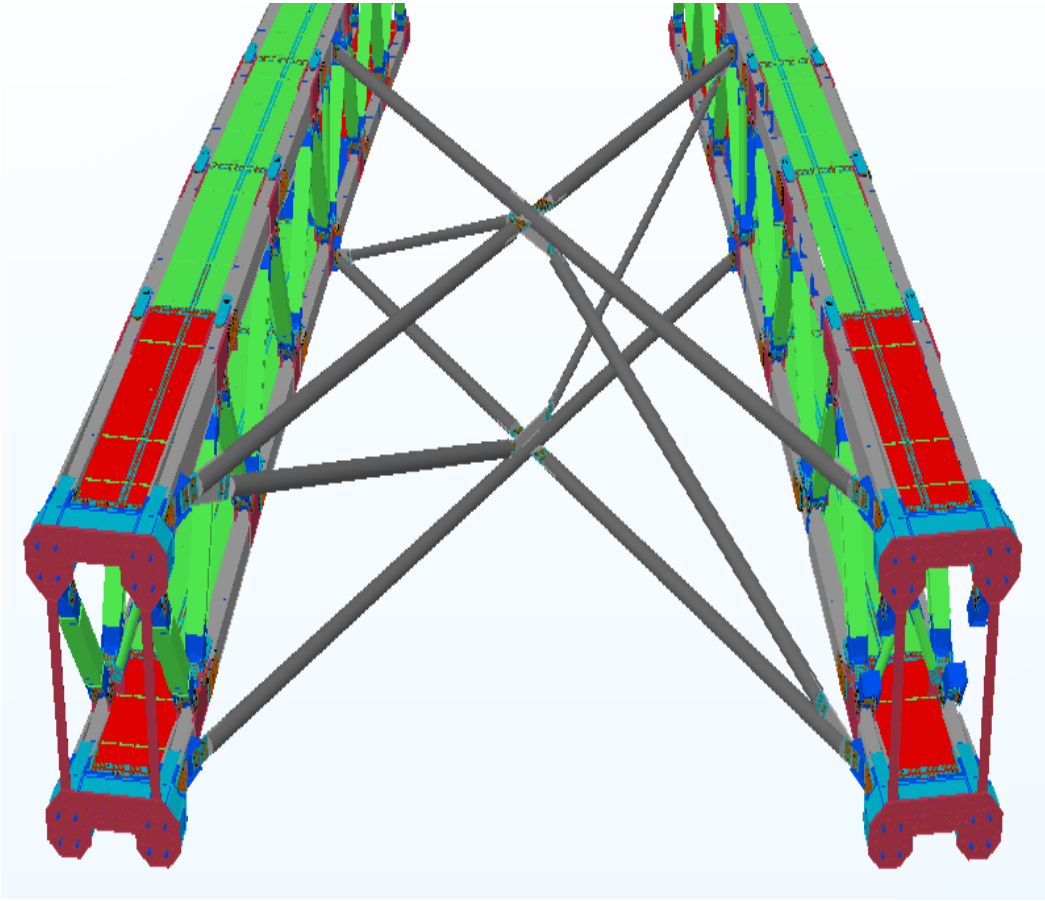


Mockup of arch
Scale = 1 : 10

Full scale trial assembly of Arch

MOCK-UP AND FULL-SCALE TRIAL ASSEMBLY OF ARCH

TEKLA snapshot of wind bracings



- Wind bracings – Control wind induced vibrations during cantilever construction of the arch

- Arch has a width of around 35 m at the abutment and reduces to almost 9.5 m at the arch crown

- Maximum length of wind bracing is 40 m, consists of pipe sections and has a gusset connection inclined in all three directions

WIND BRACING ERECTION

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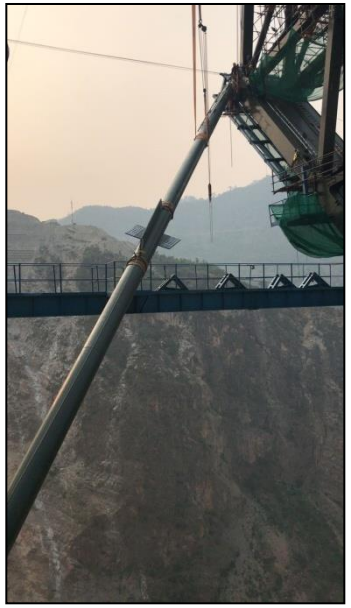

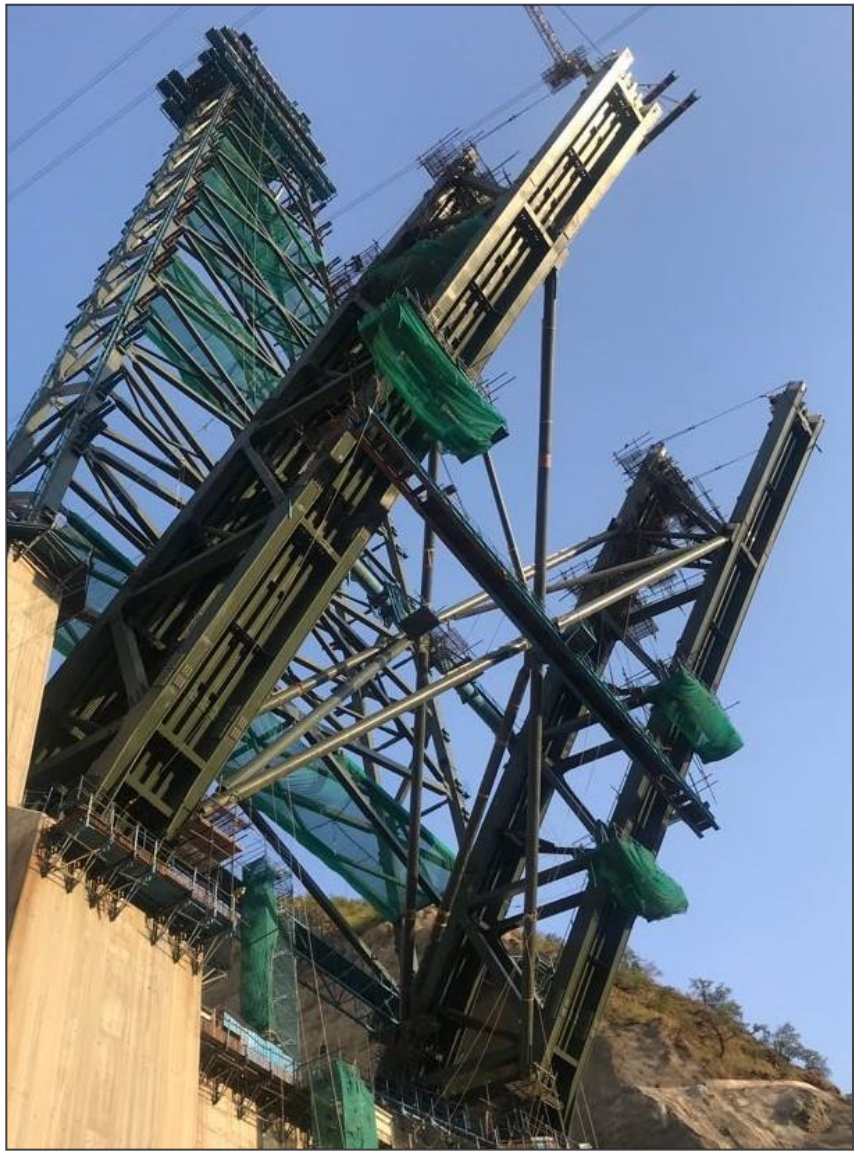

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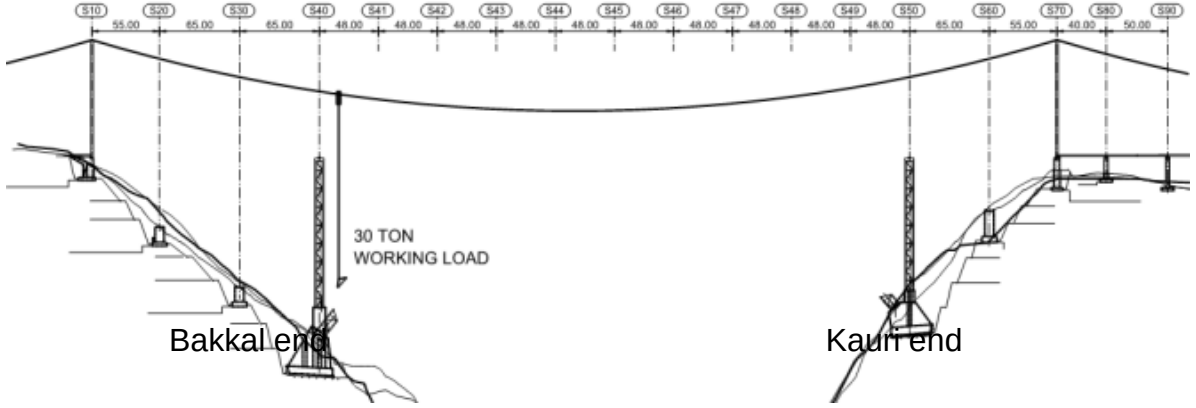
GLOBAL ARCH ERECTION CYCLE

GLOBAL ARCH ERECTION CYCLE



Arch erection proceeds with Base Plate Erection

GLOBAL ARCH ERECTION CYCLE

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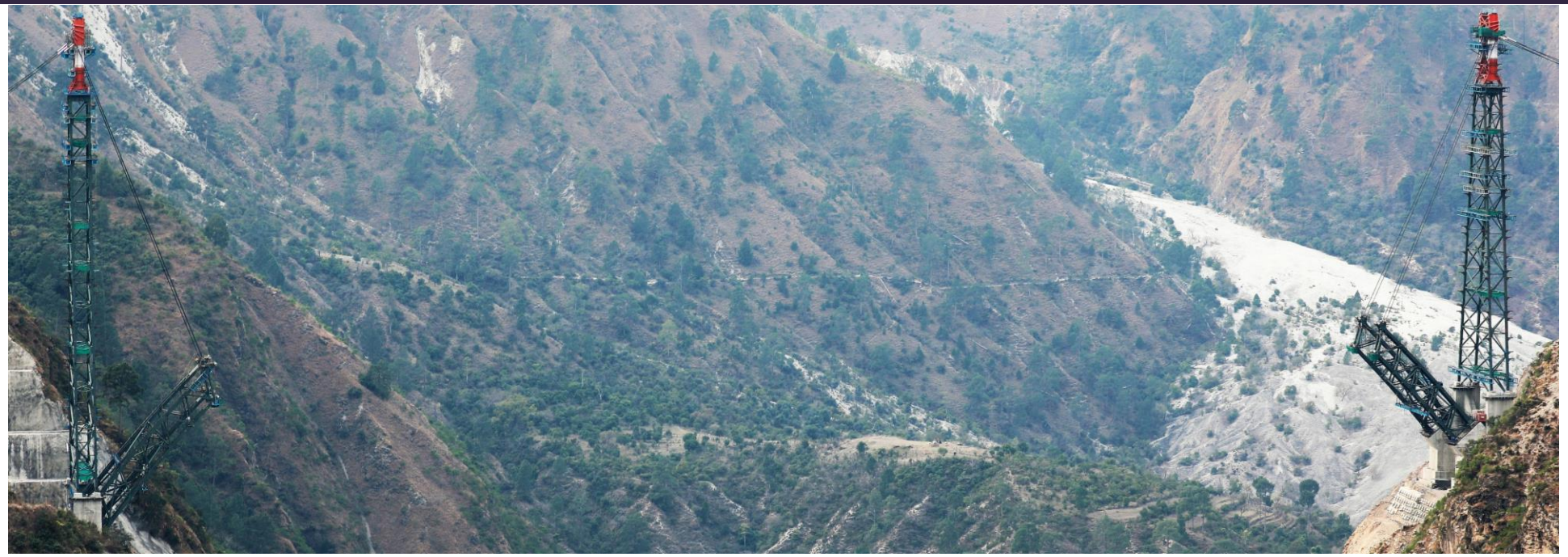
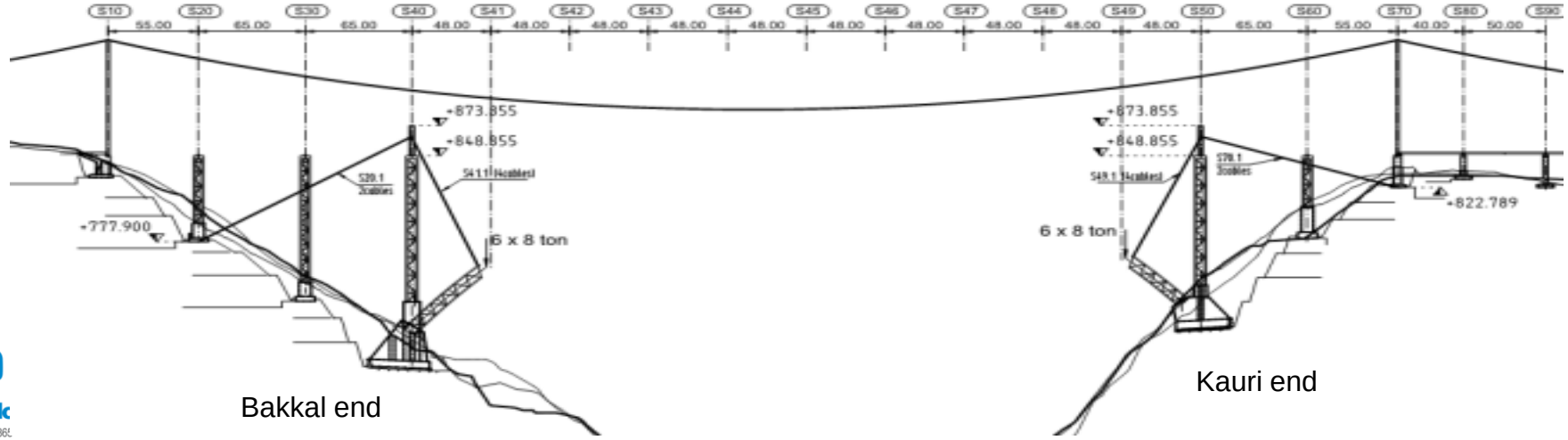


Erect Arch upto S41 on Katra end
Erect Arch upto S49 on Leole End

Install forestay cables S41.1 and backstay cables S70.1

Install forestay cables S49.1 and backstay cables S20.1



Bakkal end

Kauri end

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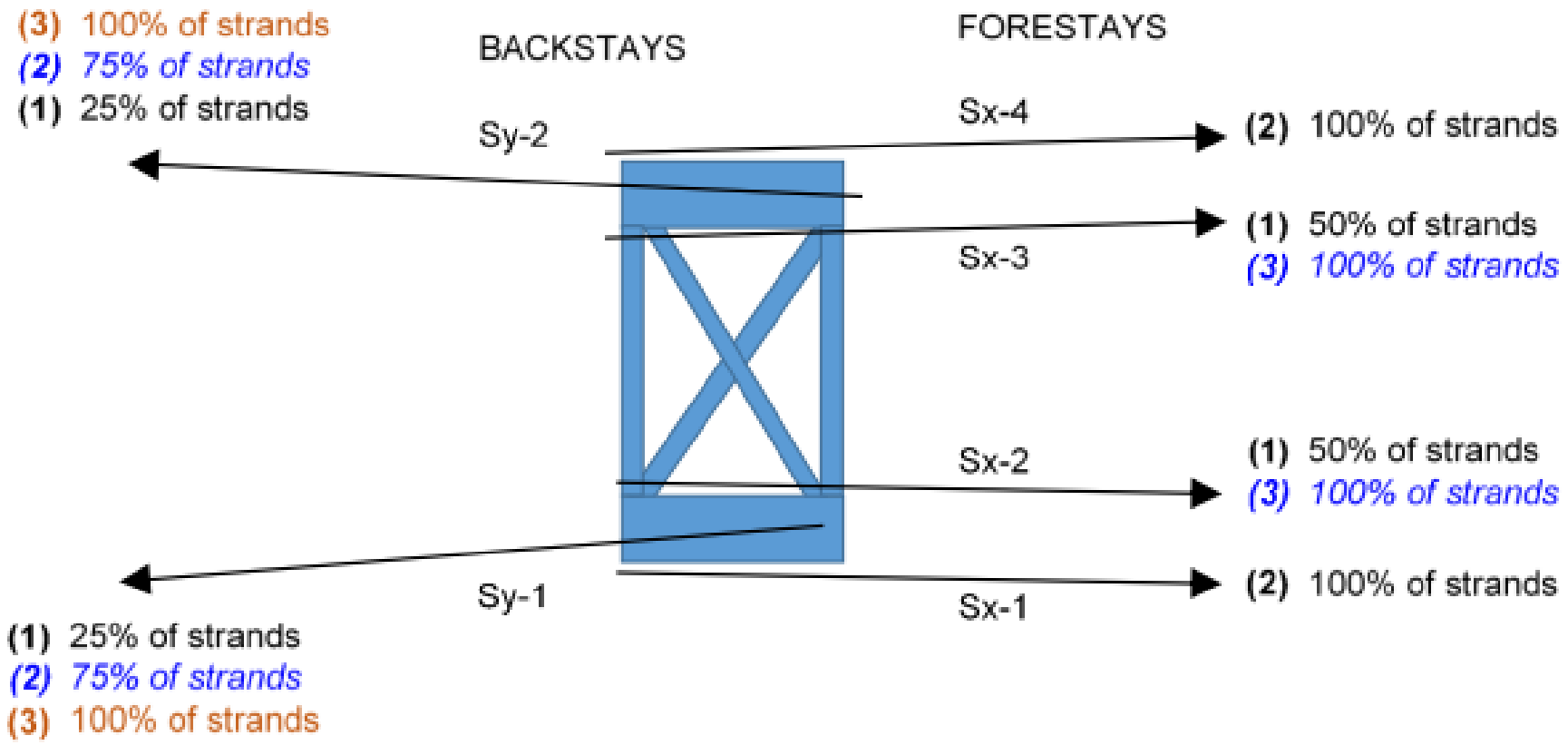


(x) 2nd Stressing of cable as Italic Blue

(x) 3rd Stressing of cable as Orange

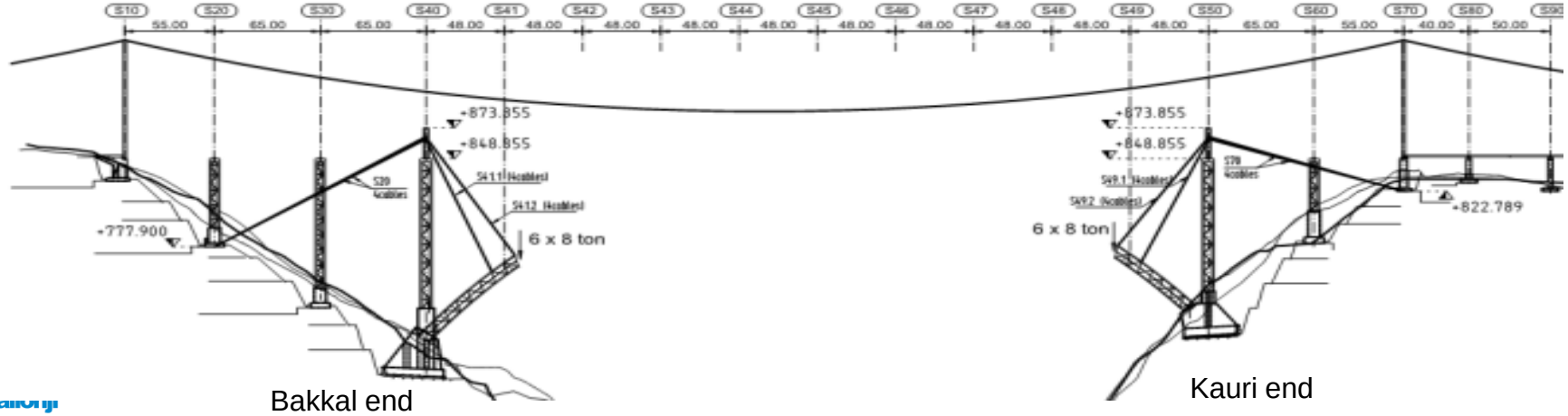
STAY STRESSING SEQUENCE

GLOBAL ARCH ERECTION CYCLE

Proceed with Arch Erection

Install forestay cables S41.2 and backstay cables S20.2

Install forestay cables S49.2 and backstay cables S70.2



Bakkal end

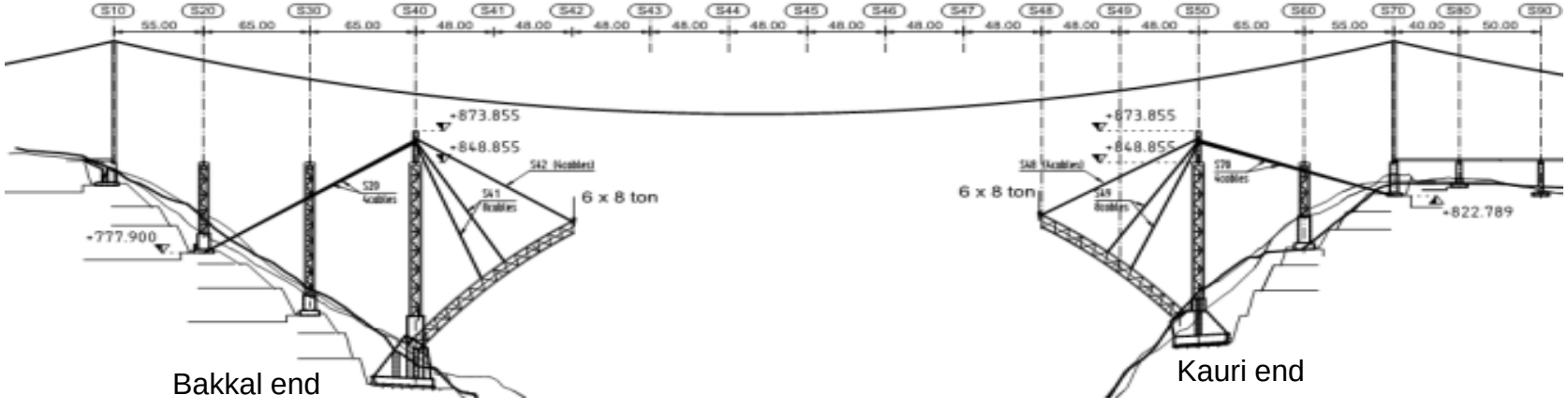
Kauri end

GLOBAL ARCH ERECTION CYCLE

Erect Arch upto S42 on Katra end
Erect Arch upto S48 on Leole End

Install forestay cables S42 and restress backstay cables S20

Install forestay cables S48 and restress backstay cables S70

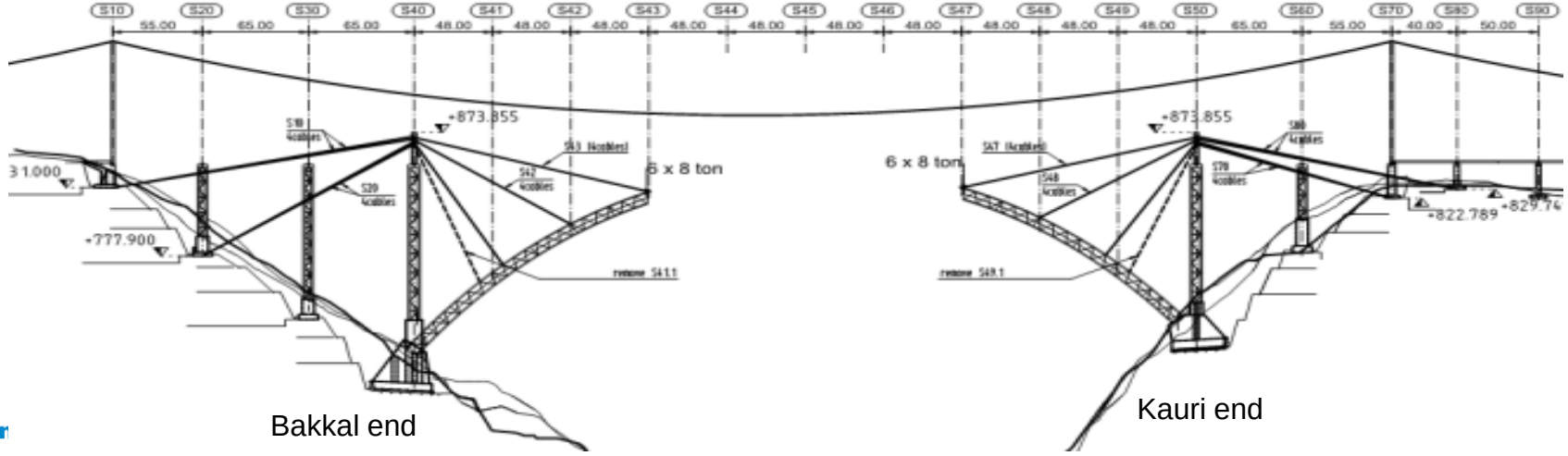


GLOBAL ARCH ERECTION CYCLE

Erect Arch upto S43on Katra end
Erect Arch upto S47 on Leole End

Install forestay cables S43 and backstay cables S10

Install forestay cables S47 and backstay cables S80



Bakkal end

Kauri end

GLOBAL ARCH ERECTION CYCLE

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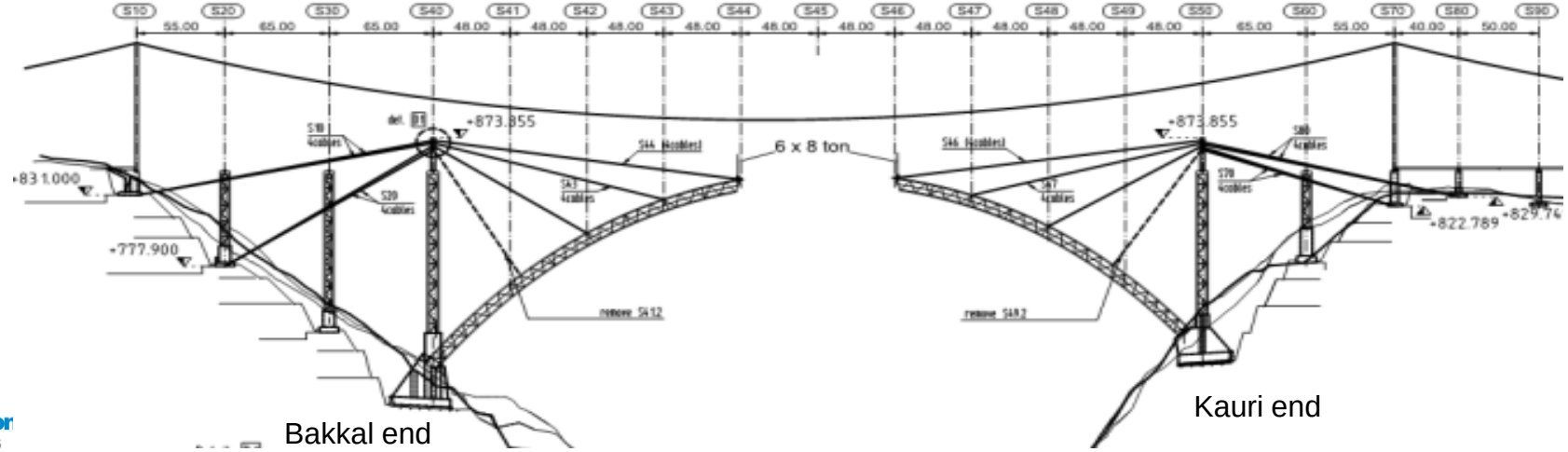
Erect Arch upto S44on Katra end
Erect Arch upto S46 on Leole End

Install forestay cables S44 and restress backstay cables S10

Install forestay cables S46 and restress backstay cables S80



Bakkal end

Kauri end

GLOBAL ARCH ERECTION CYCLE

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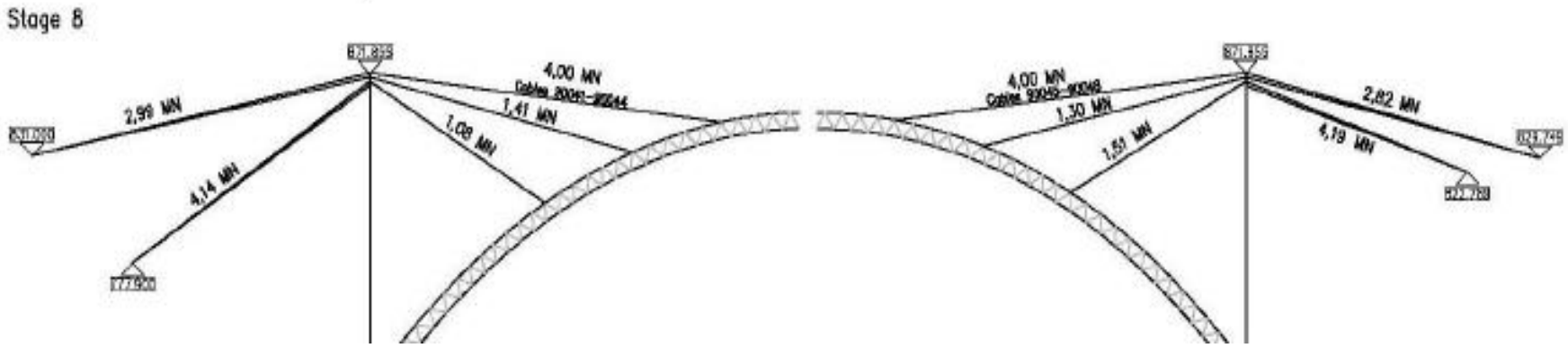
Remove Forestay Cables S41.1/S41.2 on the S40 Side

Remove Forestay Cables S49.1/S49.2 on the S50 Side

Proceed with arch erection towards the closure



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GLOBAL ARCH ERECTION CYCLE

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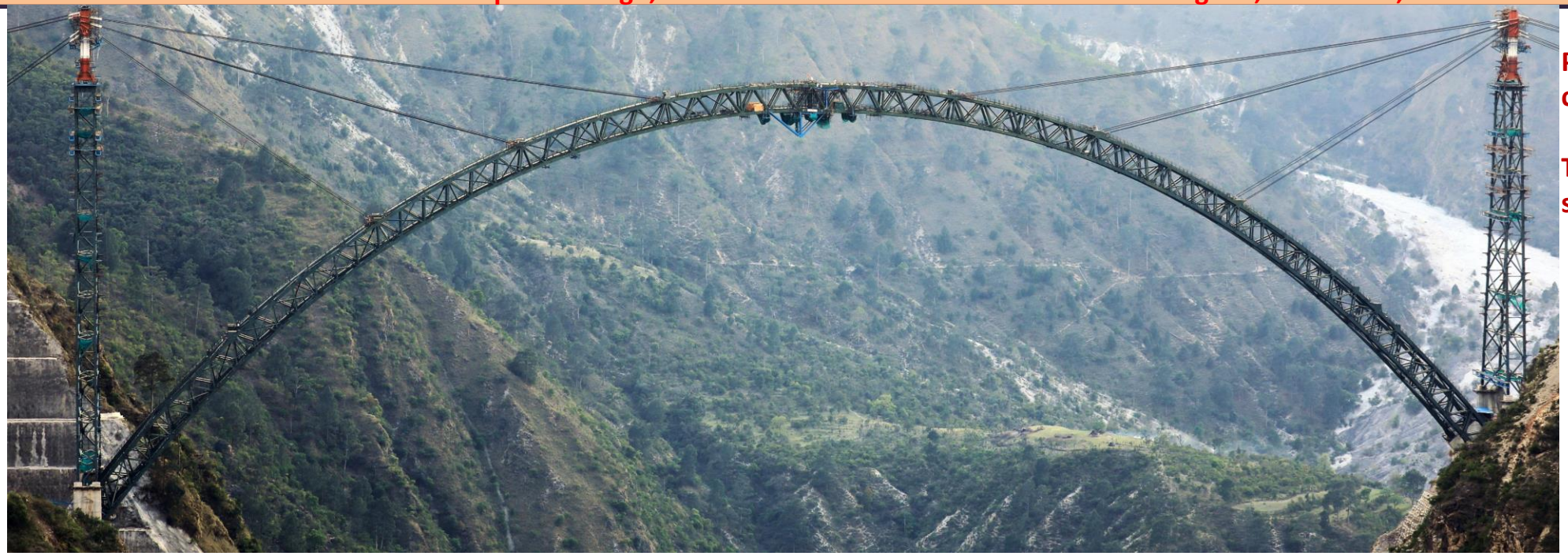
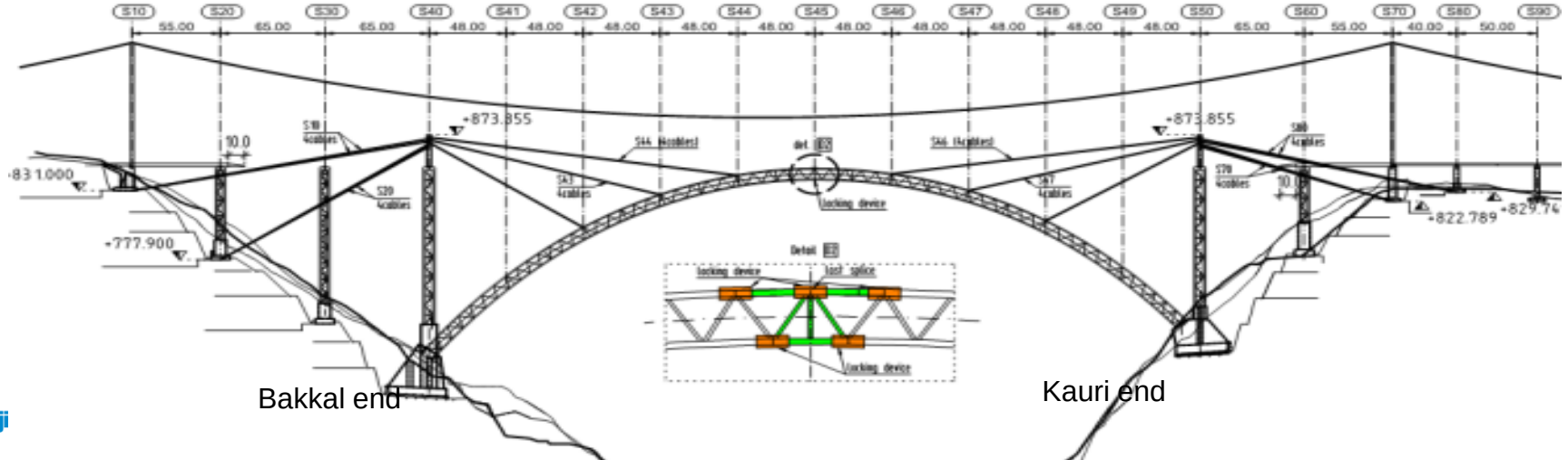


Proceed with arch erection till closure is reached

Temporary Cables being de-stressed and removed at site.



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ARCH CLOSURE (Complete)

Method for Bridge Deck Erection on Arch by Incremental Launching Method

DECK LAUNCHING IN-PROGRESS

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DECK LAUNCHING IN-PROGRESS

DECK LAUNCHING COMPLETED

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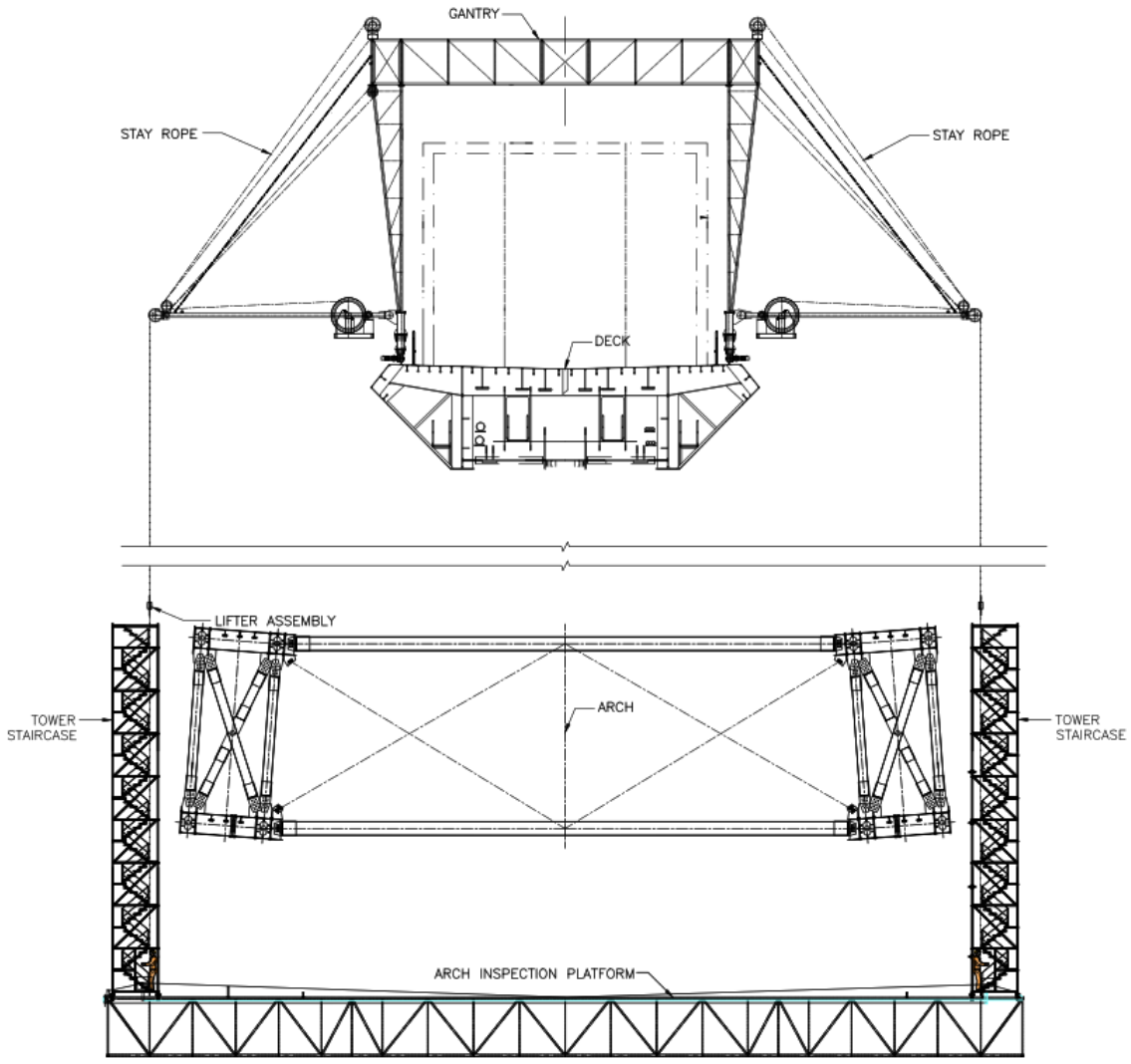
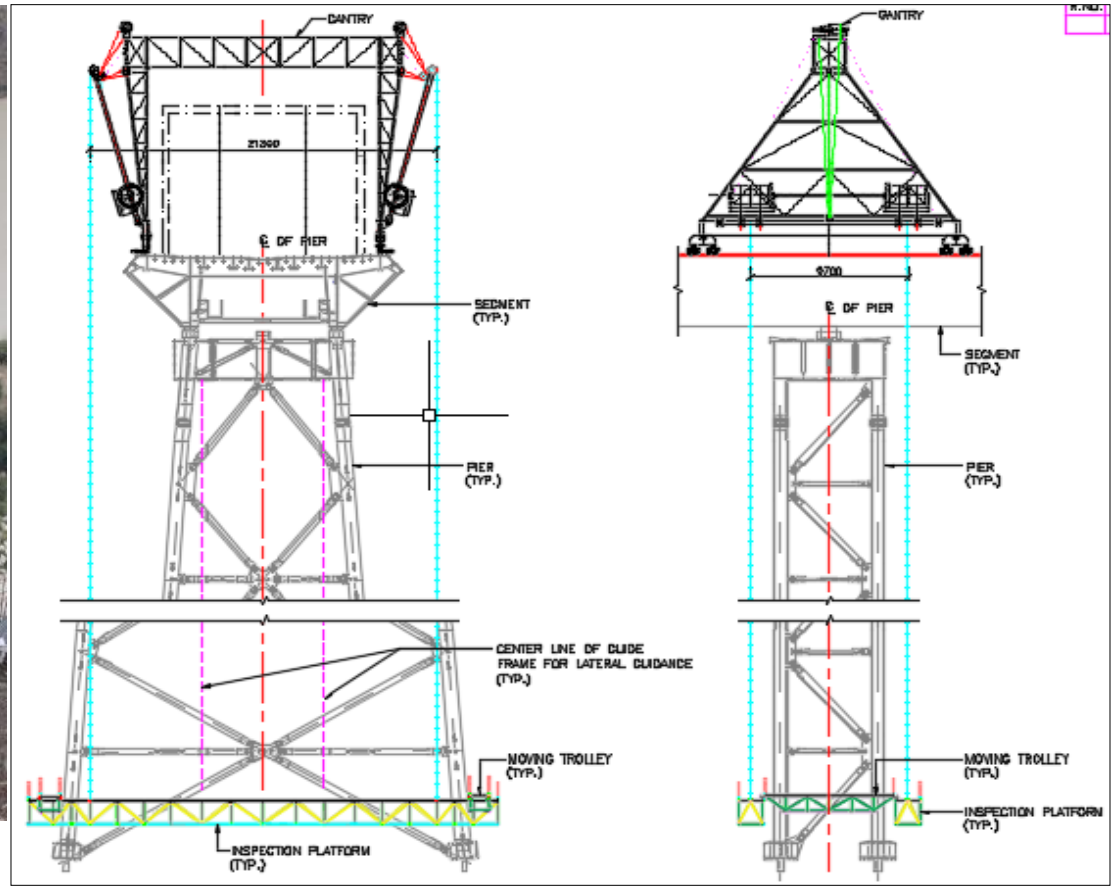
Inspection and Maintenance
Arch Inspection



Inspection and Maintenance
Arch Inspection

Gantry crane moves on the rails fixed on top of the Chenab Bridge deck. The Gantry on the bridge moves from S10 to S70), Boom Luffing to adjust the varying width of the Arch

Inspection and Maintenance
Pier Inspection



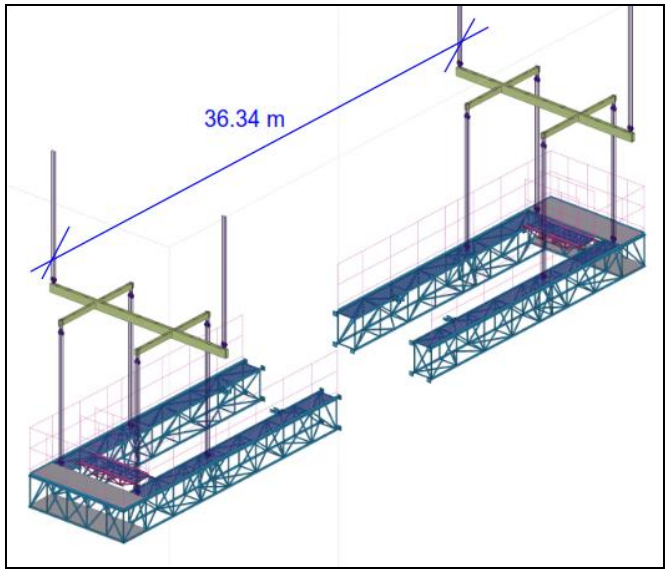
The pier inspection platform is used to inspect piers P20, P30, P40, P50 and P60 and dimensions varies as per respective pier geometry.

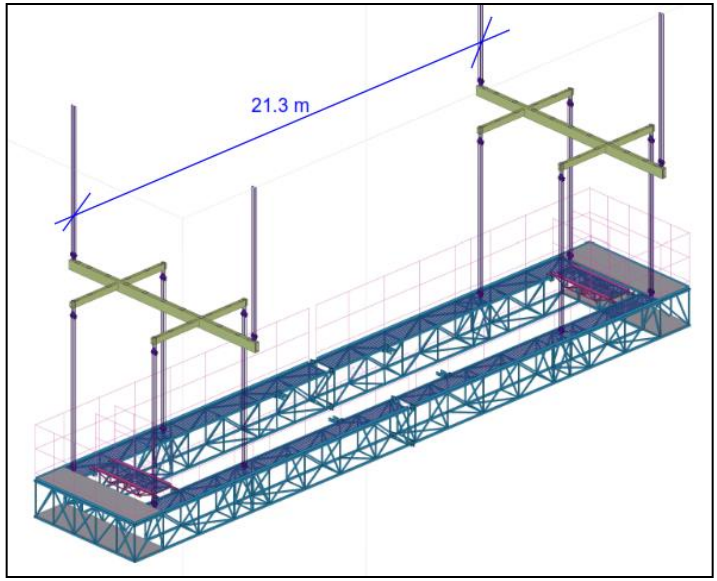
.

The gantry travels along the bridge with the two 'C' Shaped Platforms till it reaches the centre line of the trestles to be inspected.

The C-Shaped Platforms are joined together for inspection of Trestles.

The Trestle inspection platform is used to inspect Trestles T41, T42, T43, T47, T48 & T49 .





Thank you

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