WELCOME

07-April-2023

Session 6

Construction of Bridge Including Approaches Across River Zuari on NH 17/Nh-66, Panjim

By

SCON Infrastructure

SCON INFRASTRUCTURE

सड़क परिवहन
एवं राजमार्ग मंत्रालय
MINISTRY OF
ROAD TRANSPORT
AND HIGHWAYS
सत्यमेव जयते

OVM

PROJECT : CONSTRUCTION OF BRIDGE INCLUDING APPROACHES ACROSS RIVER ZUARI ON NH 17/NH-66, PANJIM MANGALORE SECTION PACKAGE-II

CONTRACTOR : DILIP BUILDCON LTD.

CLIENT : MINISTRY OF ROAD TRANSPORT & HIGHWAY (MORTH)

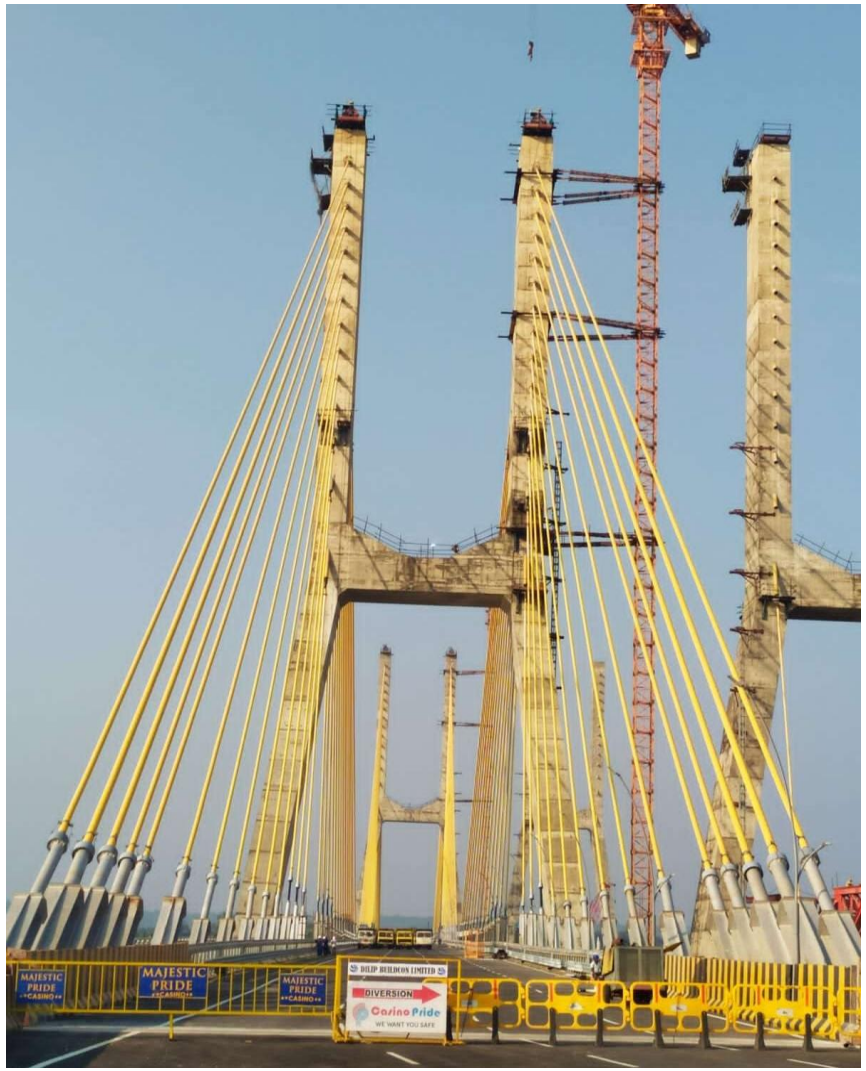
info@sconinfra.com

www.sconinfra.com

SCON-OVM SCOPE OF WORK

1. Supply of STAY CABLE ANCHORAGE SYSTEM including:
- HT PE Coated Galvanised 15.7mm Dia. Strand (1400 MT)
- OVM 250 Anchorage (37, 55, 61 Strand Capacity)
- Double layer HDPE Pipe
- High Performance Dampers
- Waterproof Covers
- HEALTH MONITORING SYSTEM

2. Installation of Stay Cable Anchorage System
3. Providing Technical Assistance and Stressing & Monitoring of HT Strands.
4. Installation of HEALTH MONITORING SYSTEM
5. Supply of Pre-stressing Anchorage System for concrete girders
6. Supply of Lead Rubber Bridge Bearings for Cable Stayed Portion.



New Zuari River Bridge

SALIENT FEATURE OF ZUARI BRIDGE

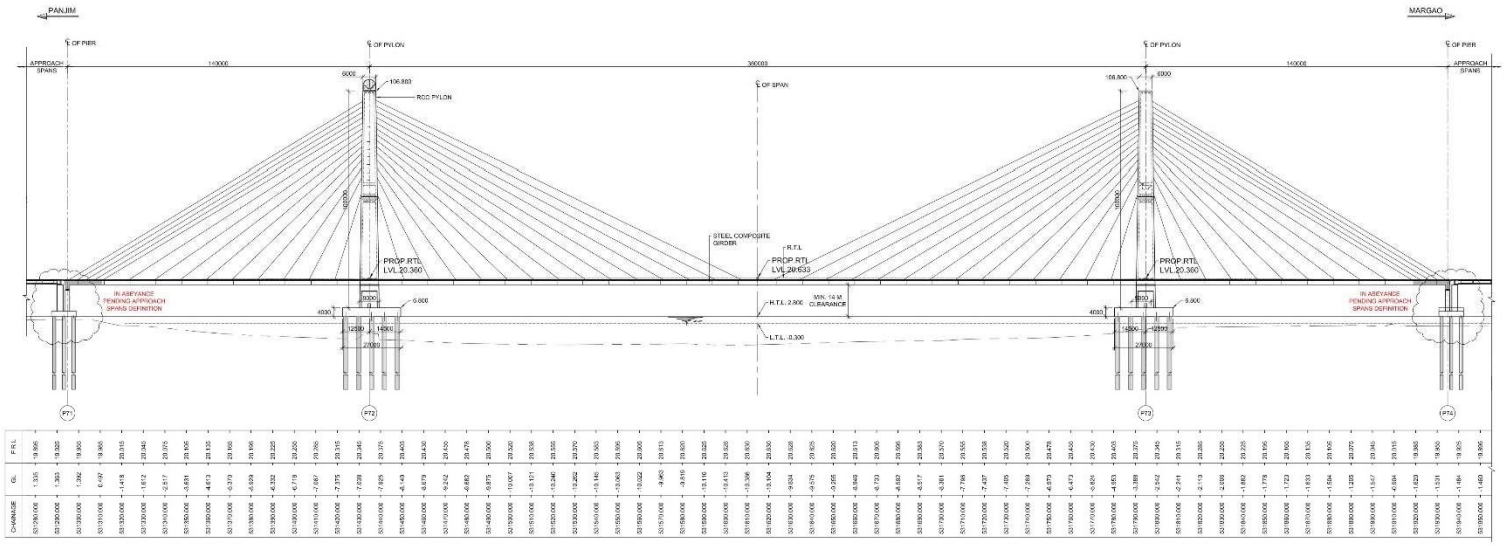
Name of Project: Construction of Bridge including approaches across river Zuari on NH-17/NH 66 on Panjim - Mangalore Section in the State of Goa (Package II) through EPC Contract

– Total Length of the Project	:1.084 km
– Elevated 8 Lane approach	: 325m
– Elevated 4+4 Lane approach of Split CW	: 119m
– 4+4 lane Cable Stayed Bridge with Split CW	: 640m
– **Total Project Cost**	**: Rs. 545.40 Crores**
– **Appointed Date**	**: 11th April 2016**
– Authority's Engineer	: TPF Engineering Pvt. Ltd., Mumbai
– Design Consultant	: Mr. Erwan Vicat, INGEROP, French
– Proof Consultant	: Dr. Dewei Chen, Tongji University, Shanghai

SALIENT FEATURE OF ZUARI BRIDGE

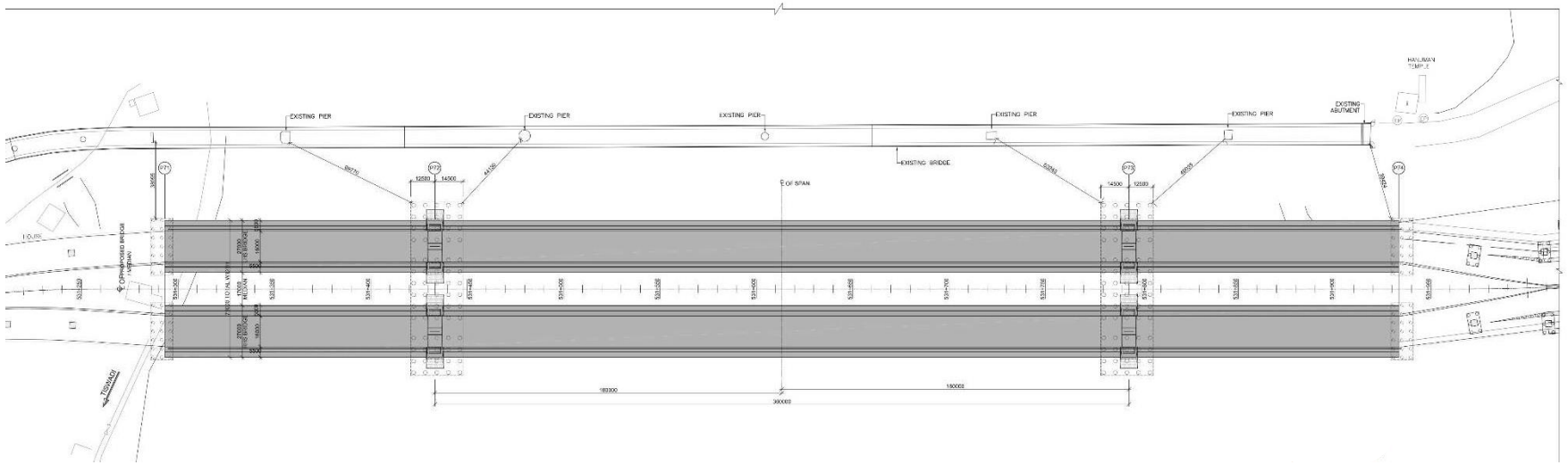
Length of main cable stay section	640 Meters -140M + 360 M + 140M 2 parallel bridge
Steel deck segments	110 Numbers
Segment dimension	27 x 12 x 2 Meter
Precast slab	1648 Number
Stay Cables	224 Numbers
Approach Bridge Length	444 Meters
Precast segments	112 Numbers
I - Girders	54 Numbers

PLAN OF THE BRIDGE



LONGITUDINAL SECTION OF BRIDGE

(SCALE - 1 : 1000)



Details of the Bridge

- **Span Configuration** : 360m central span with 140m back spans (2 Parallel Bridges on Combined Foundation.)
- **Main Foundations** : 78 x 2.0m diameter Piles (Friction & End bearing) of average length 40m - 45m.
- **Back Span Foundations** : 21 x 1.5m diameter Piles of average length 35m.
- **Piling Methods** : Conventional Piling Gantries at start & maximum numbers with Rotary Rigs on Floating Pontoons.
- **Pile Caps for Pylons** : 89.8m x 27m x 4m (9698 Cum.) above HFL to cater for 2 Parallel Bridges and Central Observatory Tower.
- **Pile Caps for Back Span Piers** : 29.5m x 11.5m x 2.5m (848 Cum.) partly on land and partly on water.
- **Pylons** : 100m high Pylons of varying rectangular sections with Link Beam at 50m level.
- **Stay Anchorage Brackets** : Welded with Steel frame boxes embedded in concrete.
- **Deck** : Composite with Steel Deck of 27m wide and Precast slab (M-65). Steel Grade is IS2062-E350C equivalent to S355J2 (60mm to 16mm thick plates).
- **Anchorages** : OVM 250 – 37, 55, 61 (PE Sheathed Galvanized 15.7mm Strands).
- **Dampers** : High Performance Dampers, OVM.
- **Bearings** : Lead Bearings at Pylon Locations and Spherical Bearings at Back-Span Piers.

PYLON

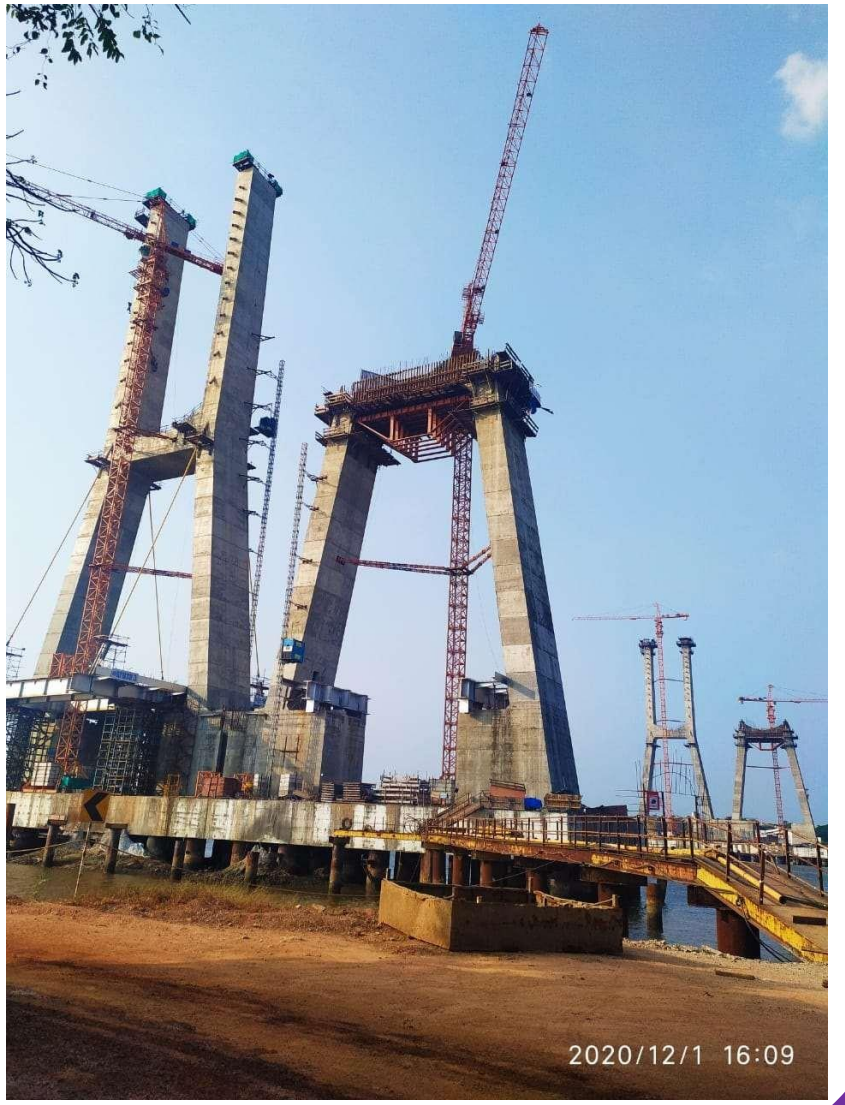
- The bridge consists of 4 nos. of identical twin H-type pylons, over the two pile caps.
- The height of pylon legs 100m above pile cap with a Link beam at 50m Level
- 14 nos. of steel frame with 28 Stay anchorage pipes are embedded in each pylon legs.
- Grade of steel for steel frame is E350c.
- Doka climbing formwork system with BS7 anchor cone (Jumping formwork) of 3m lift is used with different inclination of 81^{0} & 1^{0} up to tie beam level. Further lifts are vertical. Climbing Cone, Sealing Sleeves and Lock anchorage of 160mm is used.

Concrete: As Pylon height is 100m, high performance **Self Compacting Concrete** (IS:10262-2019) of M65 Grade is being used along with PCE (Polycarboxylate Ester) Admixture for better fluidity. The following are the various ingredients per Cum. of Concrete:

Cement	= 270kg		
GGBS	= 240kg,	UGGBS	= 30kg
Coarse Aggregate (20mm)	= 560kg,	(10mm)	= 560kg
Fine Aggregate	= 720kg		
W/C Ratio	= 0.29		
Corrosion Inhibitor	= 3kg		
Polycarboxylate Ester Admixture	= 0.6% of Cementitious Material		

Reinforcement Steel : Fe 600 grade of steel for 40mm dia. has been used in addition to Fe 500 D CRS steel as per IS-1786.

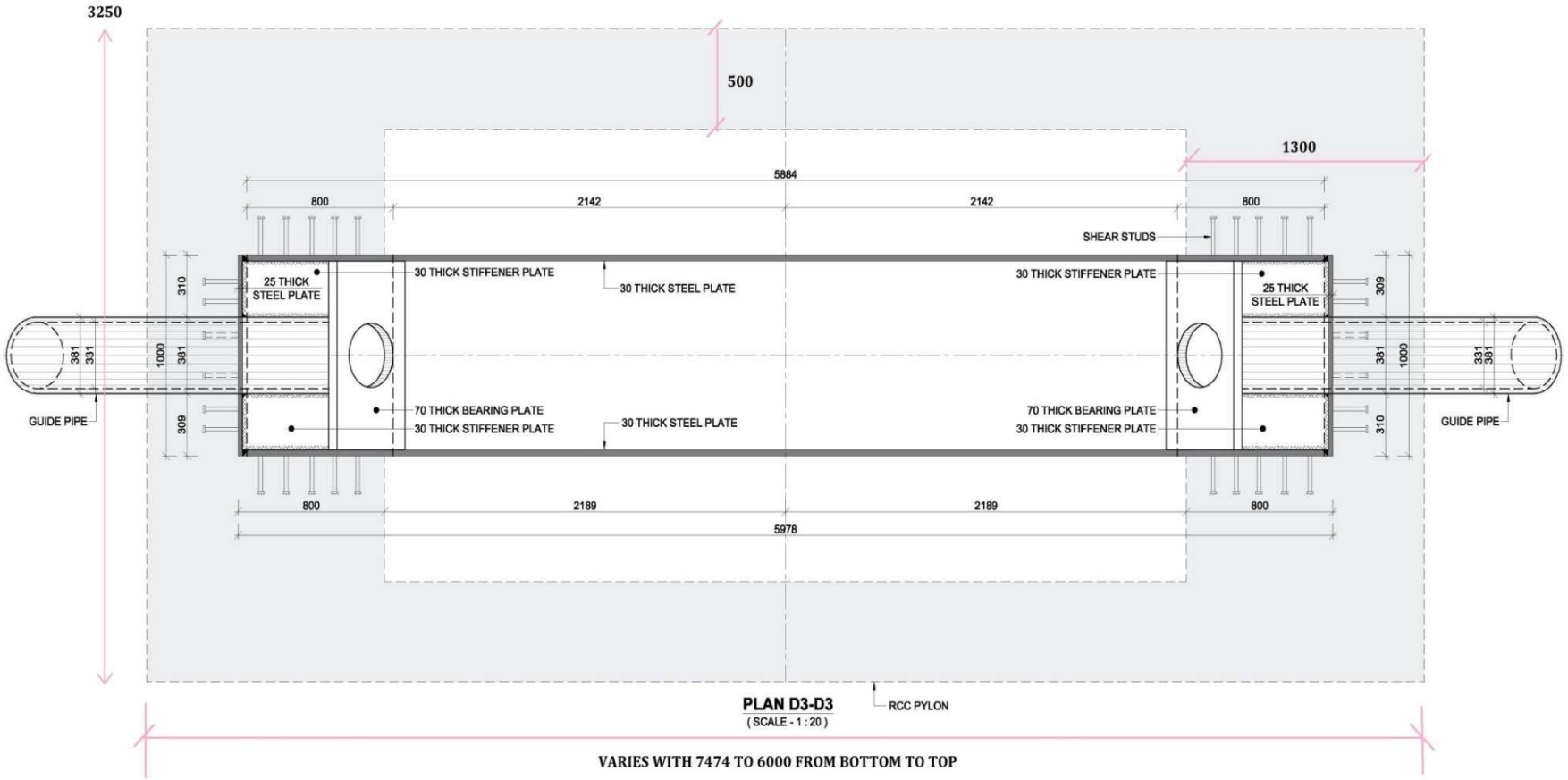
PYLON



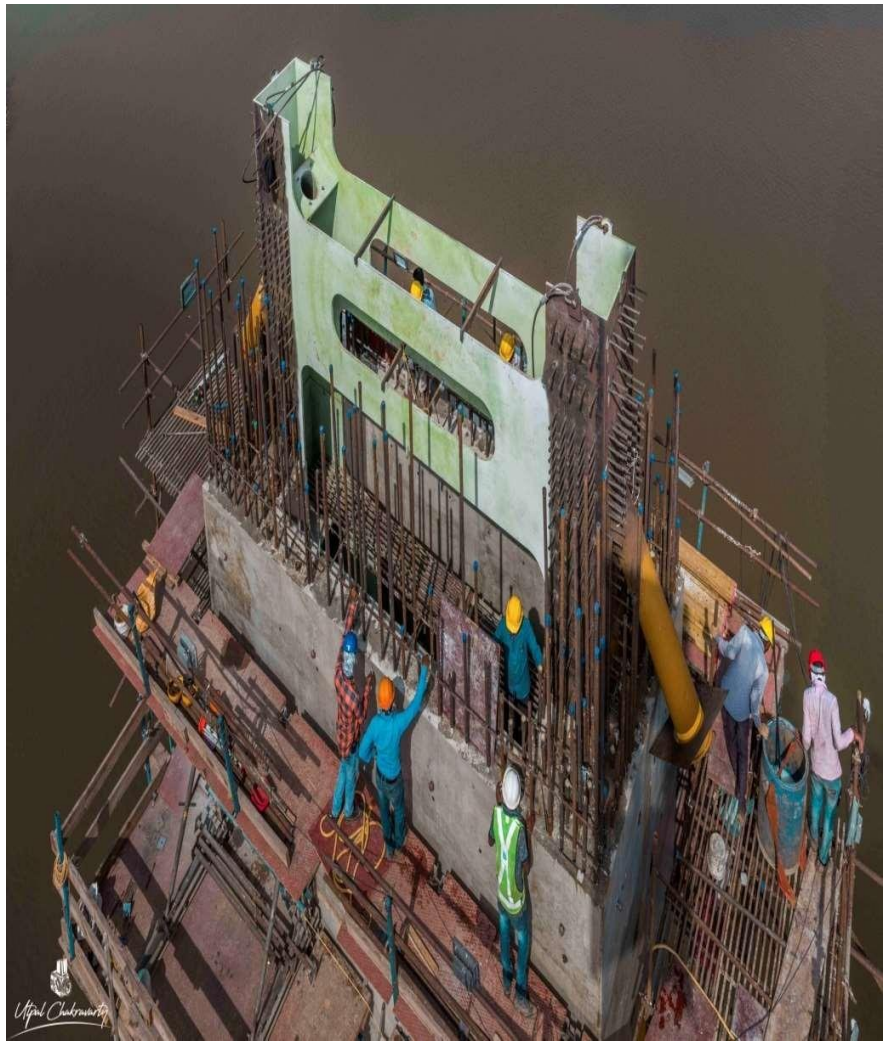
PYLON

STEEL FRAME FOR STAY-CABLE ANCHORAGE

Steel Anchorage Frame: Fabricated frame with Inclined Guide tube of Seamless Pipe of diameter 319mm to 440mm of EN 355J Grade were lifted and placed inside the pylons for fixing of Cable Anchorages.



STEEL FRAME FOR STAY-CABLE ANCHORAGE



SUPERSTRUCTURE DATA: STAY-CABLE

4+4 lane Cable Stayed Bridge is with Split Carriage Way for a length of **640m using Steel Super Structure of 10,500MT with** Concrete precast slabs (6 Types) 4m x 4.5m of 250mm thickness with longitudinal & transverse stitch with shear studs forms the top part of the composite deck.

- 27m x 2m x 12m : 92 (Regular)
- 27m x 2m x 13.44m : 4 (Pier Table)
- 27m x 2m x 7.60m : 8 (End of Back Span)
- 27m x 2m x 10.85m : 4 (End of Back Span)
- 27m x 2m x 10.58m : 2 (Closure)

Total : 110 Segments

- A total of 1648 nos. of precast slabs with an Avg. Weigh of 12 T is used.

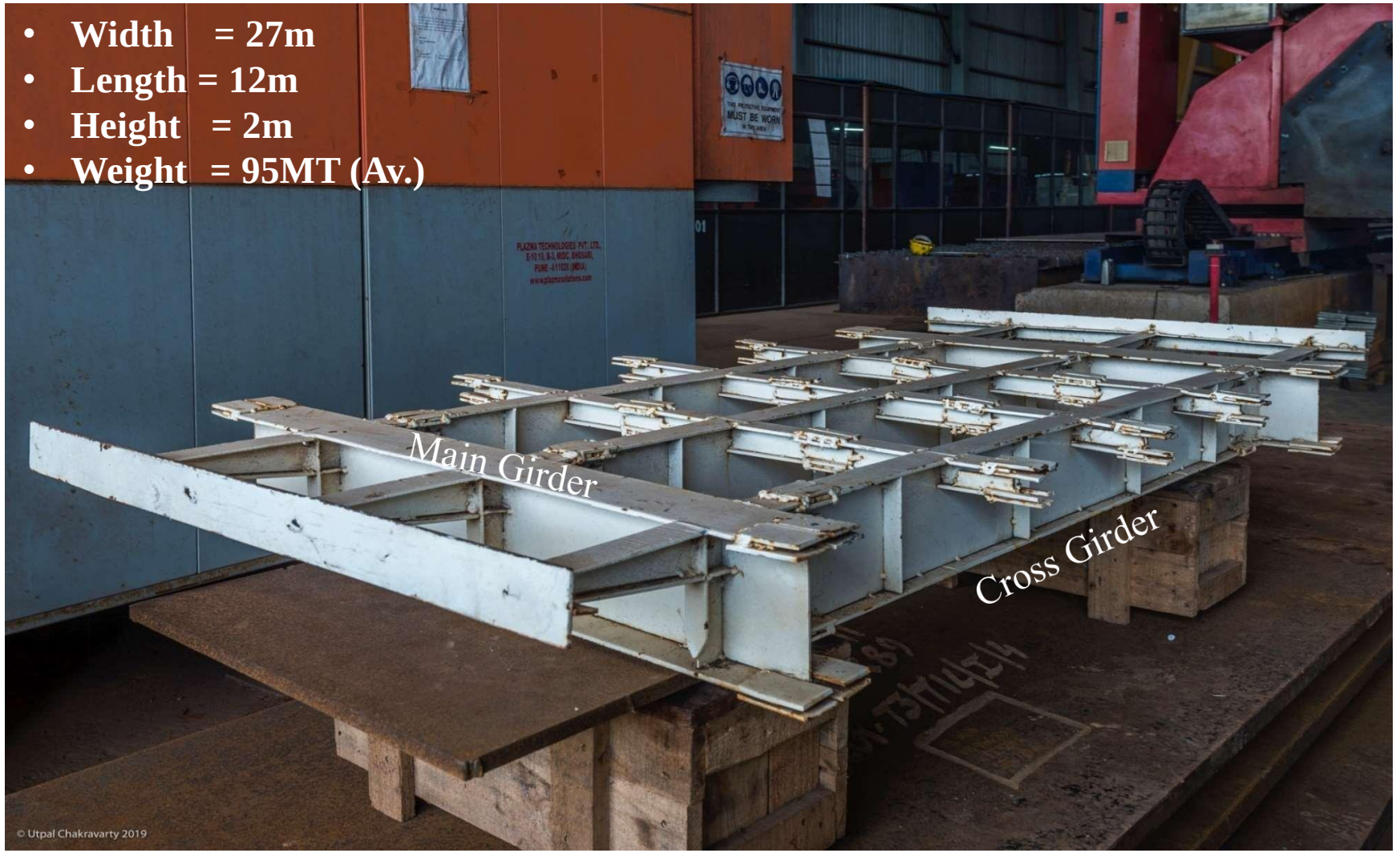
THICKNESS OF PLATES

- Main Girder : 60mm, 50mm & 30mm
- Cross Girder : 25mm & 14mm
- Joinery Beam : 25mm & 14mm
- Stringers : 20mm & 16mm
- Footpath : 20mm & 12mm
- Stiffener Plate : 35mm & 12mm

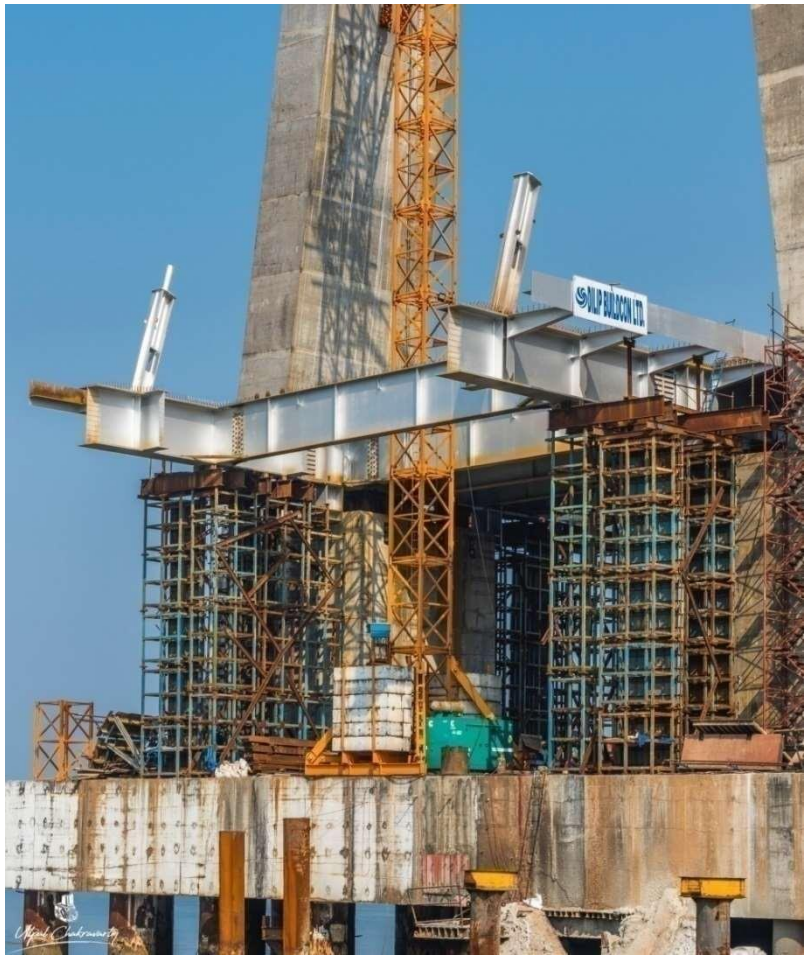
- Special orders were placed for large size plates (12mx2.5m & 16.5mx1.95m) to minimize welding.
- Procured from M/s Welspun Corp. Ltd., Gujarat

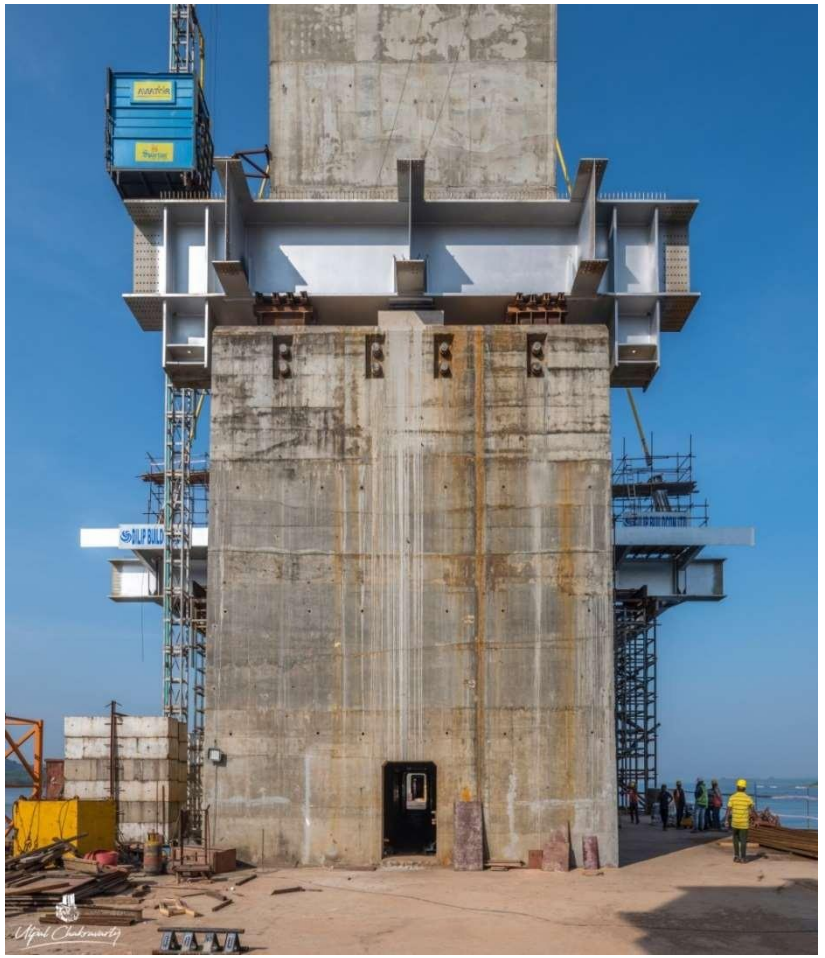
SUPERSTRUCTURE DATA: STAY-CABLE

- **Width = 27m**
- **Length = 12m**
- **Height = 2m**
- **Weight = 95MT (Av.)**



STEEL SEGMENT (PIER SEG.) ERECTION PHOTOS

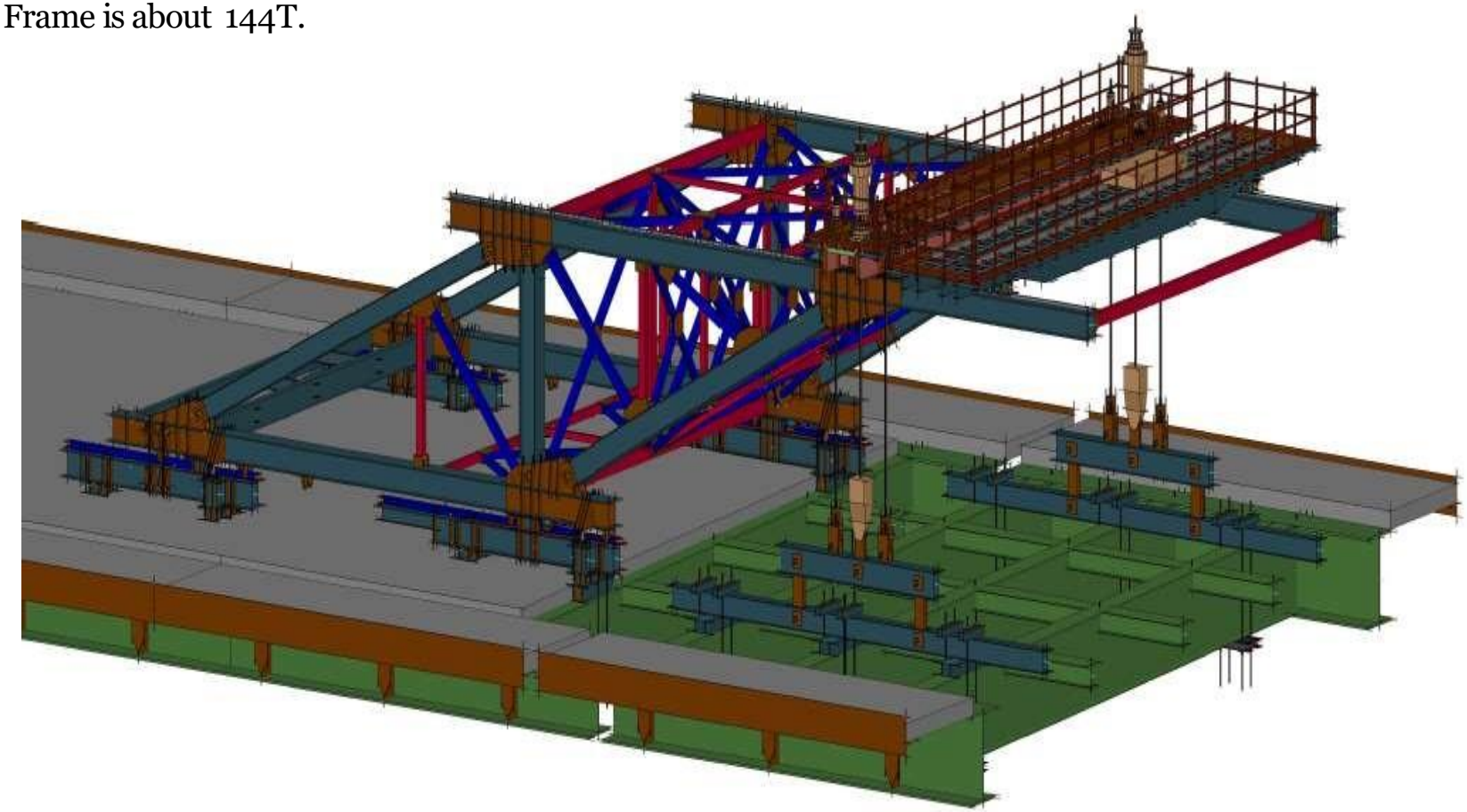




PIER SEGMENT WAS MOUNTED ON THE TEMPORARY SUPPORTS IN THE PILE CAP USING CRANES.

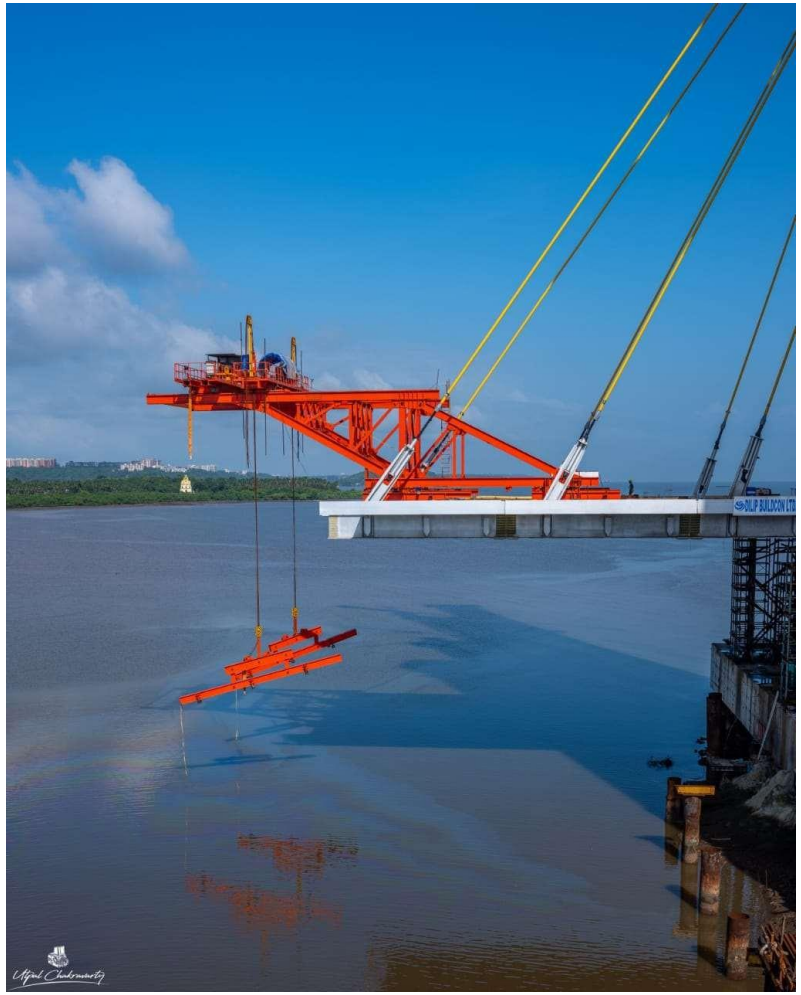
STEEL SEGMENTS ERECTION USING LIFTING FRAME

Once Pier table steel segment is erected, Bottom Chord assembly is placed using crane on **Hilman Rollers** laid on concrete slab. Connect cross beam to fix bracing beams. Segments will be lifted using Strand jack and 50mm dia. Macalloy bar. Pre-cast slabs will be lifted with hoist. The total weight on single Lifting Frame is about 144T.



SEGMENT LIFTING FRAME

STEEL SEGMENTS ERECTION USING LIFTING FRAME



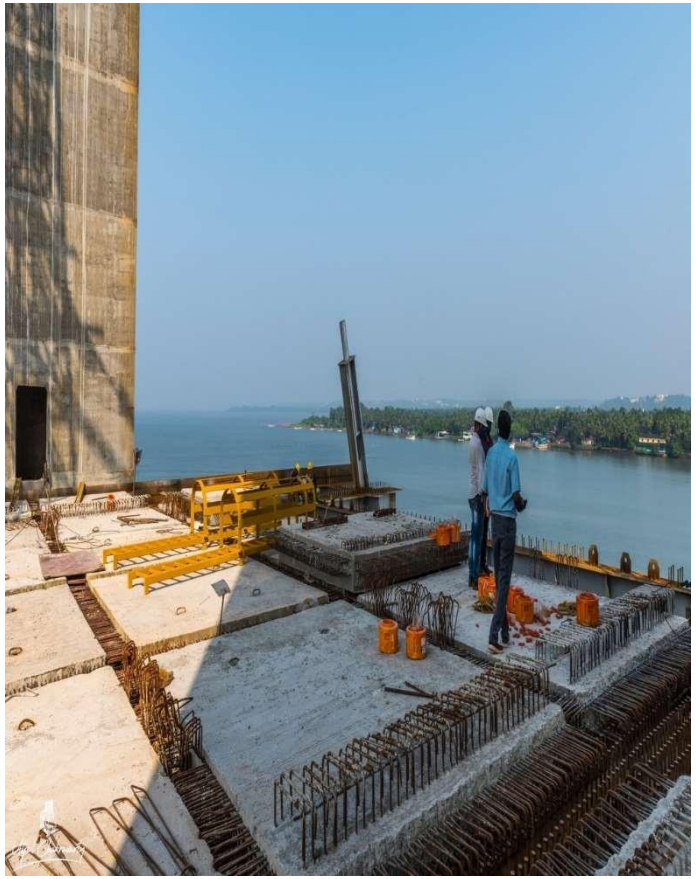
STEEL SEGMENTS ERECTION USING LIFTING FRAME

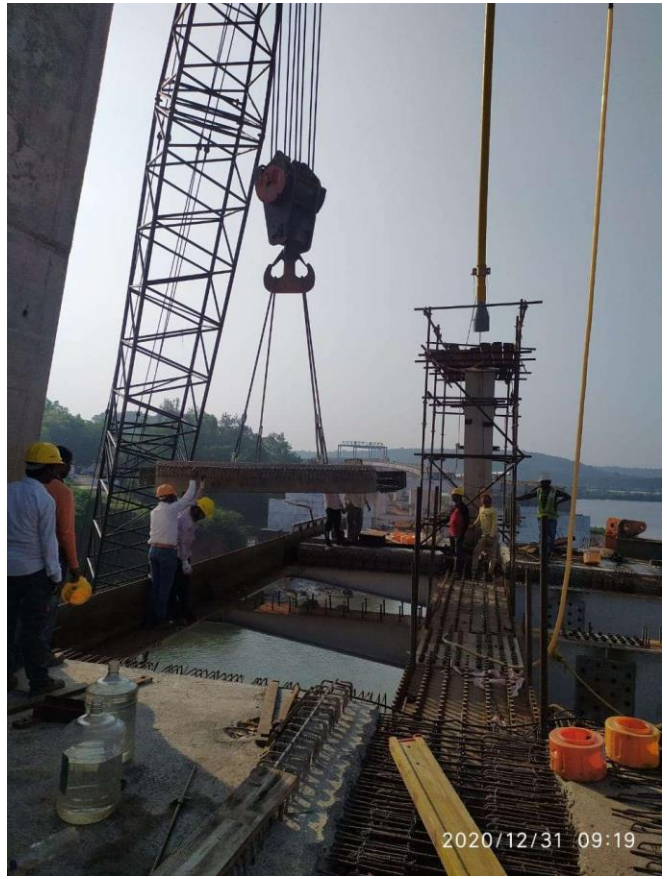
Sequence of activities for launching of steel segment & Precast slabs:

1. Erection of steel segment and splicing with previously erected steel segment.
2. Partial stressing of stay cable for application of precast slabs.
3. Load transfer on to the steel segment.
4. Erection of precast slabs followed by longitudinal & transverse stitch.
5. Final stressing of stay cable.
6. Auto launching of Lifting frame.

PRECAST SLAB ERECTION

1. Pre-cast slabs are installed after segment is launched and installed.
2. Initially Precast slabs near the edges are installed before partial stressing of cables.
3. Remaining all precast slabs are installed after partial stressing followed by transverse and longitudinal stitching of concrete.



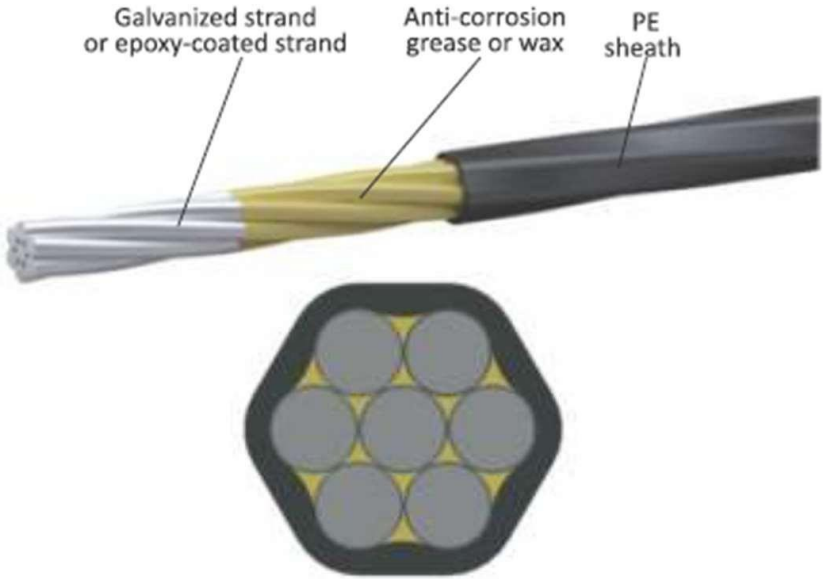


SCON STAY-CABLE ANCHORAGE SYSTEM

P.E. Coated HT Galvanised Strand

- **P.E. Coated, Low Relaxation, HT Galvanized Strands of 15.7mm Dia.** used for Zuari River Bridge along with OVM 250- 37, 55, 61 Anchorages
- Max. Breaking Load of Strand : 279 kN
  Tensile Strength : 1860 MPa
- There are (2 x 14) 28 Stay Cables in both side of Pylon Legs, totaling (8 x 28) **224 Cables** are with 37, 55 & 61 Strands and length varies from 45m to 185m.
- Total Quantity of strands required for both bridges= **1400 MT**

P E Coating of Strands for Stay Cable



P.E. Coated Galvanised Strand

CABLE STAY SYSTEMS

OVM250 STAY CABLE SYSTEM

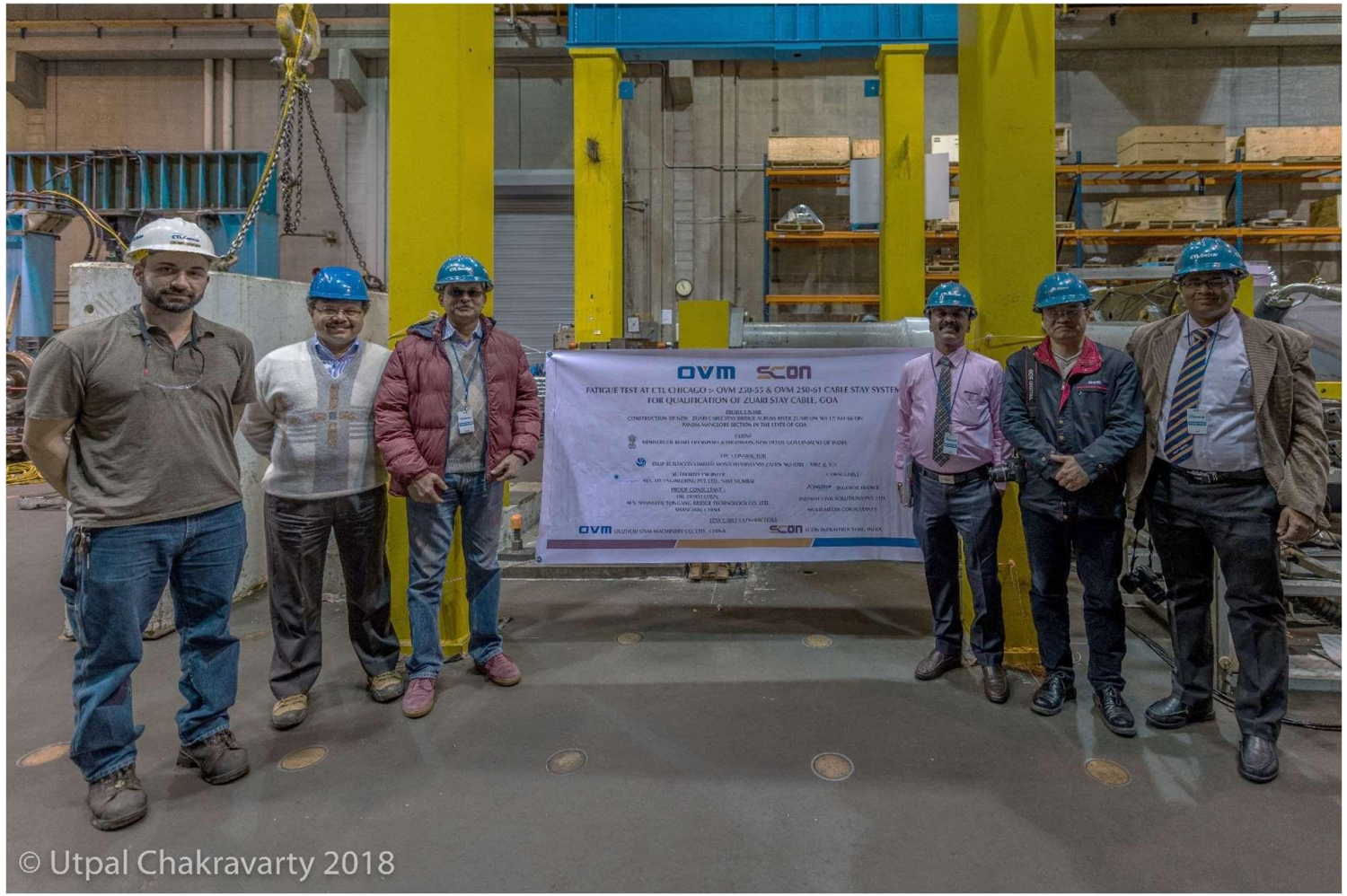
CABLE STAY SYSTEMS

OVM250 STAY CABLE SYSTEM

Designation	Strand No.	15.7mm Strand	
		Breaking Load of Cable (kN)	Max Admissible Load kN (0.45 F_{GUTS})
OVM250-37	37	10323	4645
OVM250-55	55	15345	6905
OVM250-61	61	17019	7659

TESTING OF OVM ANCHORAGE SYSTEM

FATIGUE & TENSILE TEST ON ANCHORAGE



QUALIFICATION TESTING OF ANCHORAGE SYSTEM

The Cable Stay Systems qualifications test:

	F_{pk} [1]	Characteristic		Main use Stay cable		Extended optional use Extradosed cable	
		Test	Section	N[0]	Test specimen	N[0]	Test specimen
Anchorage system	≤ 25MN	Axial fatigue,	6.2.1	3	Small, medium and large[2]	1	5 MN cable[3]
		Bending fatigue	6.2.2	1	5 MN cable[3]	0	-
		Leak tightness	6.2.3	1	7 MN cable[4]	0	-
	> 25MN	Axial fatigue	6.2.1	1	Largest[6]	0	-
Saddle system	Any	Axial fatigue, friction	6.3.1	1	15 MN cable[5]	1	5 MN[3]
		Bending fatigue	6.3.2	1	5 MN cable[3]	0	-
		Effective friction	6.3.3	1[7]	single MTE	0	-
		Leak tightness	6.3.4	1	7 MN cable[4]	0	-

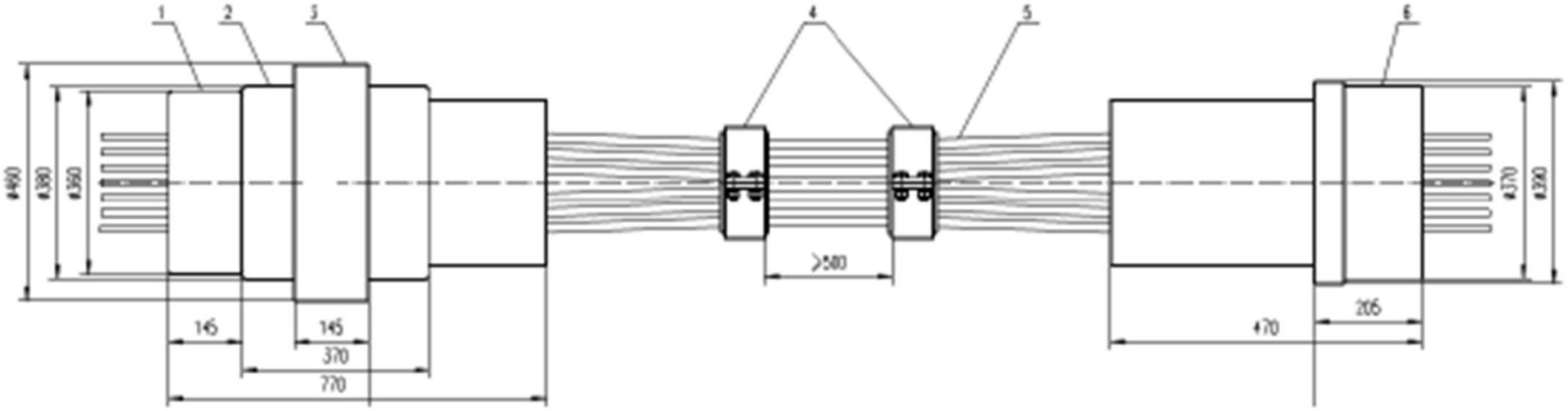
[0] Number of tests
[1] Maximum load capacity of the system
[2] Small: One unit of the lower third; Medium: One unit larger than middle size of middle third; Large: The largest unit of the range
[3] cable capacity corresponding to 19 strands 15.7mm
[4] cable capacity corresponding to 27 strands 15.7mm
[5] cable capacity corresponding to 55 strands 15.7mm
[6] unit size or largest acc. to lab capabilities
[7] one series of 72 tests

QUALIFICATION TESTING OF ANCHORAGE SYSTEM

FATIGUE & TENSILE TEST ON ANCHORAGE

Two tests conducted:

1. **Laboratory for Naval Ship Hydrodynamics and Structure Performance at Wuxi in Jiangsu province of China (OVM 250- 37)**
2. **CTL Group's Laboratory located in Skokie, Illinois, USA (OVM 250- 55, OVM 250- 61)**



Test Setup For Fatigue Test Of OVM 250-61 Anchorage

QUALIFICATION TESTING OF ANCHORAGE SYSTEM

The Fatigue Test and Tensile Test was carried out in accordance with-

CIP Cable Stays Recommendations of French Interministerial Comission on Prestressing (June 2002)

Criteria for qualification of anchorage system-

Article 11.2.2.2 of CIP Recommendations, “The fatigue test is positive if: the specimen goes through two million cycles of axial loading without detected breakage of more than 2% of the wires of which the cable stay is made; And the mean length of the specimen stabilizes after 100,000 cycles and does not vary more than 5 millimeters throughout the two million cycles”

QUALIFICATION TESTING OF ANCHORAGE SYSTEM

OVM 250-37 Stay Cable Tested in China		
Parameters	**Standards**	**Actual**
Load Cycles	☐ 2000000	2000000 +
Breakage of wires	< 5 Wires	Nil
Tensile(95% UTS)	> 9881 KN	9892 KN
Elongation	> 1.5%	2.8%

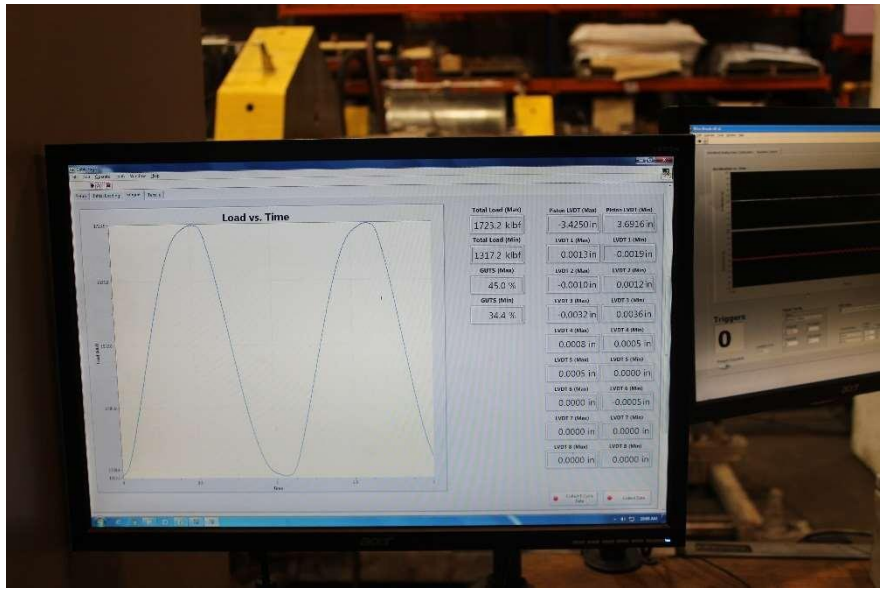
OVM 250-55 Cable Tested in CTL USA		
Parameters	**Standards**	**Actual**
Load Cycles	> 2000000	2000000 +
Breakage of wires	< 8 Wires	Nil
Tensile(95% UTS)	> 14577 KN	14638 KN
Elongation	> 1.5%	1.7%

OVM 250-61 Cable Tested in CTL USA		
Load Cycles	> 2000000	2000000 +
Breakage of wires	< 9 Wires	Nil
Tensile(95% UTS)	> 16168 KN	16280 KN
Elongation	> 1.5%	1.6%

- **OVM 250- 37, 55, 61 Anchorages <u>Passed</u> the Fatigue and Tensile Tests in the International Laboratories**

QUALIFICATION TESTING OF ANCHORAGE SYSTEM

QUALIFICATION TESTING OF ANCHORAGE SYSTEM



GEOMETRY CONTROL POINTS

- If a construction method such as the balanced cantilever is used, it is important that the cables are stressed asthe construction stages progress.
- It may be necessary to alter the stresses in a number of cables after any one stage so that the overall geometry of the bridge is kept within acceptable limits, predefined at the design stage.
- Points to be surveyed/ measured during construction stage:

  i. **CABLE FORCE**

  Cable force after stressing of each cable should be checked maintained within the allowable limits. It is recommended that the stay cables take stresses only up to 45 % of their breaking load. The tolerance limit is set as **+/- 5%**

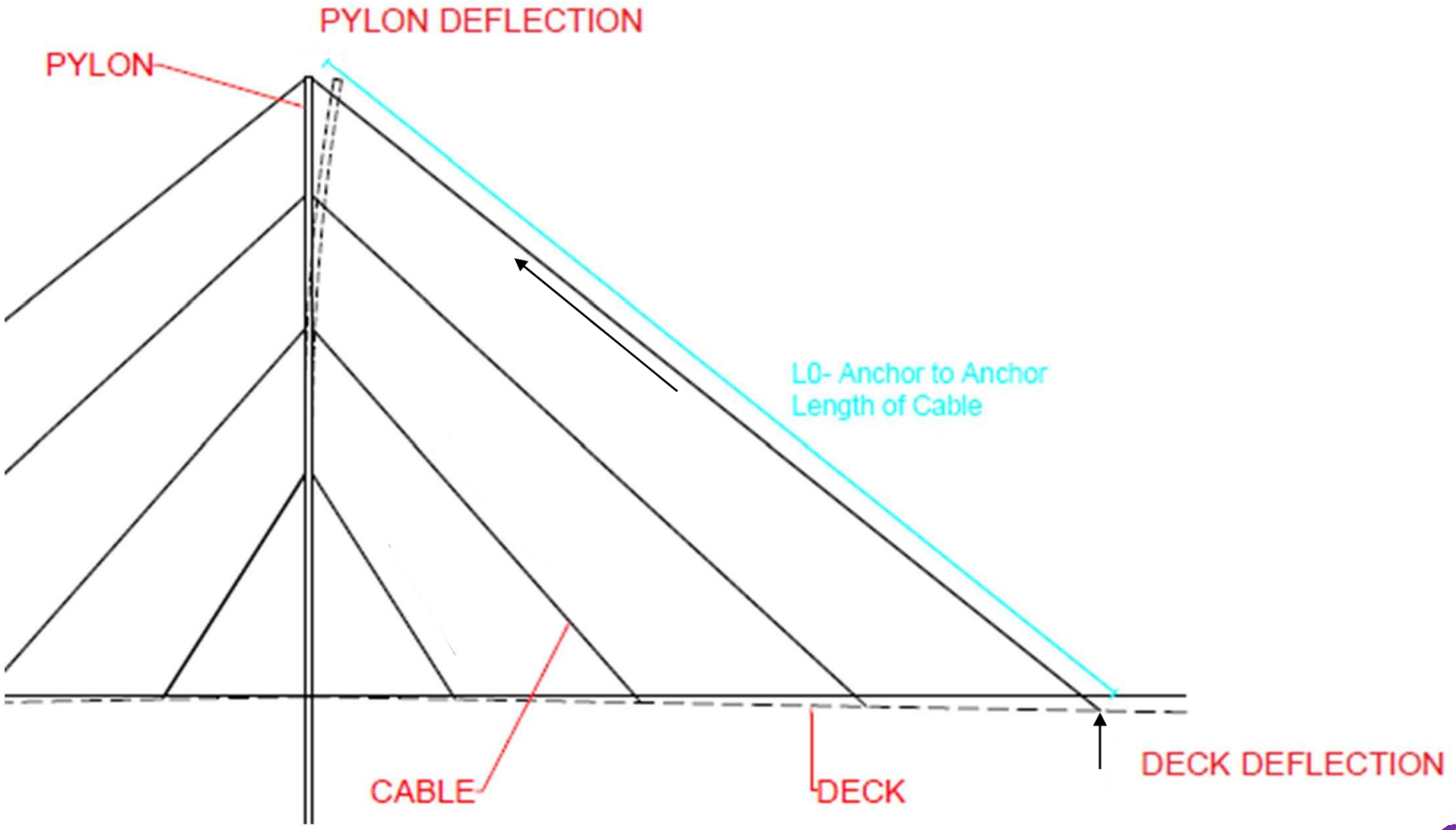
  ii. **BRIDGE DECK PROFILE**

  Deck Profile should be surveyed after every stressing to maintain the required level of the deck. Pre-defined tolerance limits should be set, by the designer, to keep deck profile in check at every construction stage.

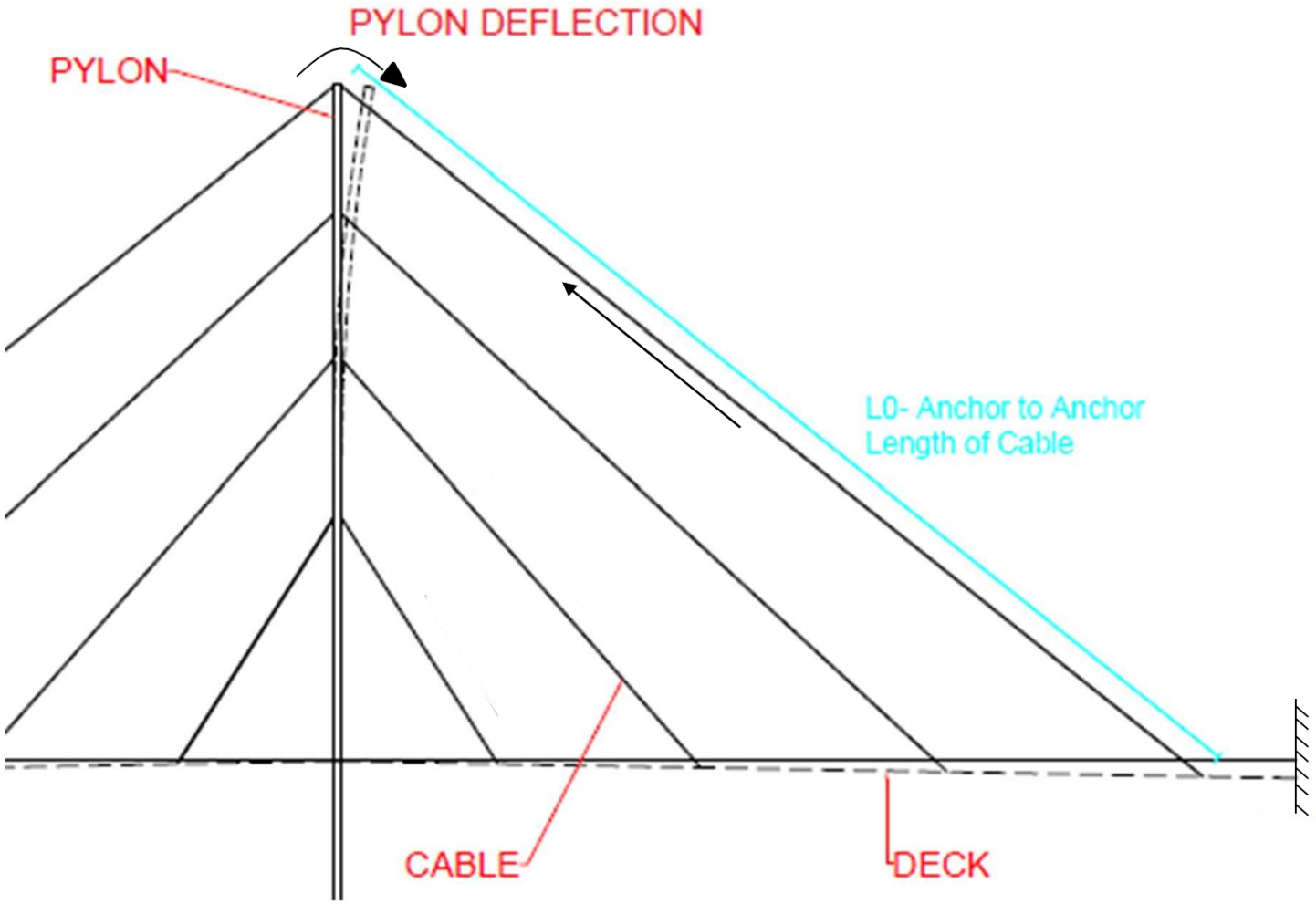
  iii. **DEFLECTION/MOVEMENT IN PYLON**

  Pylon deflection should also be measure at every construction stage, to keep the deflection within limits. Pylon deflection limit should be set by the designer. Pylon tends to deflect more depending on the deck conditions. When the final segment is fixed with the abutment, Pylon deflection is comparatively more.

Geometric Data required for Cable Stressing



Geometric Data required for Cable Stressing



OVER-STRESSING FORCE

- **OVER-STRESSING FORCE:**

Deflection in Deck and Pylon occurs gradually with stressing of strands. Therefore, the force on already stressed strand will reduce too as a result. The change of distance between anchor points of master strand is the greatest.

Required Data Points for calculating OVER-STRESSING FORCE:

- **CABLE FORCE (F)**
- **DEFLECTION OF DECK AT ANCHOR LOCATION. (Δd)**
- **DEFLECTION/MOVEMENT IN PYLON. (Δp)**
- **ANCHOR TO ANCHOR LENGTH OF CABLE (L_0) BEFORE & AFTER STRESSING.**

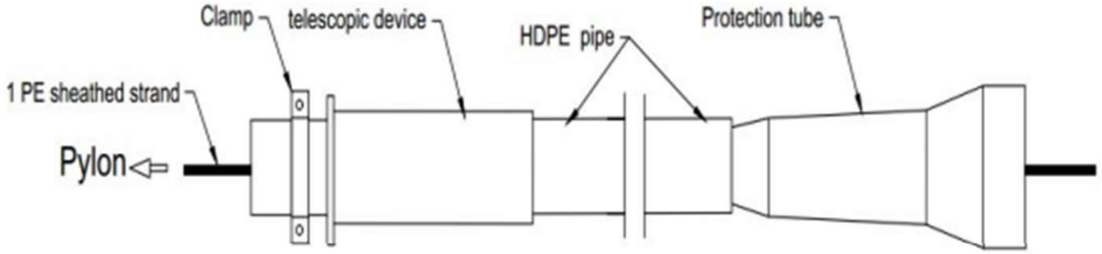
METHODOLOGY FOREX

Following process is followed for execution of the cables:

1. HDPE Pipe Installation
2. Installation of Strands
3. Initial Stressing of Strands
4. Final Stressing of Strands
5. Fine Tuning of Cables using Multi-pull Jacks

METHODOLOGY FOR EX

- **HDPE PIPE INSTALLATION:**



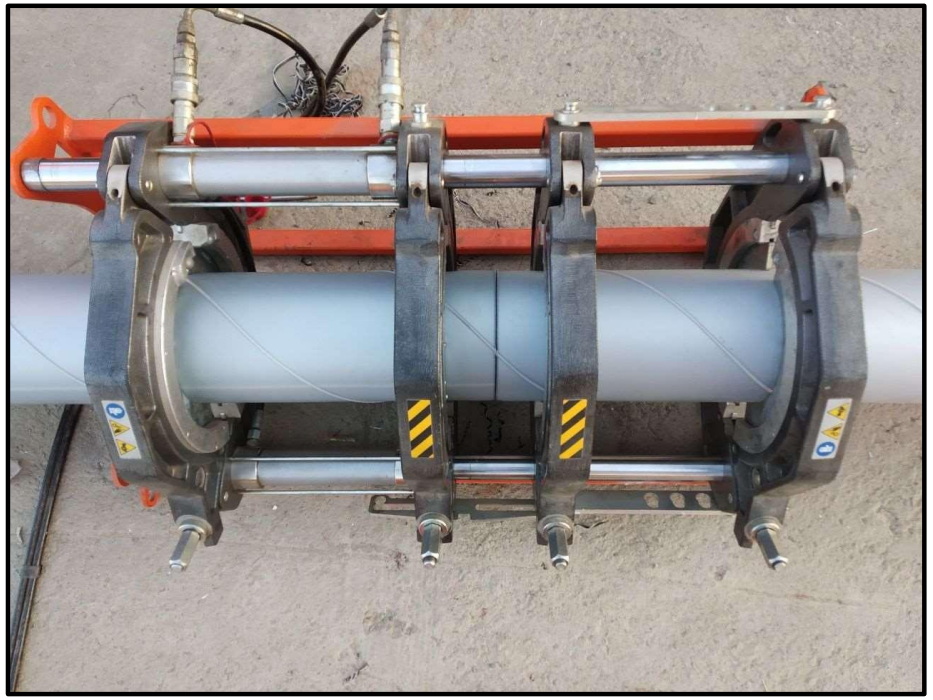
Assembly before lifting

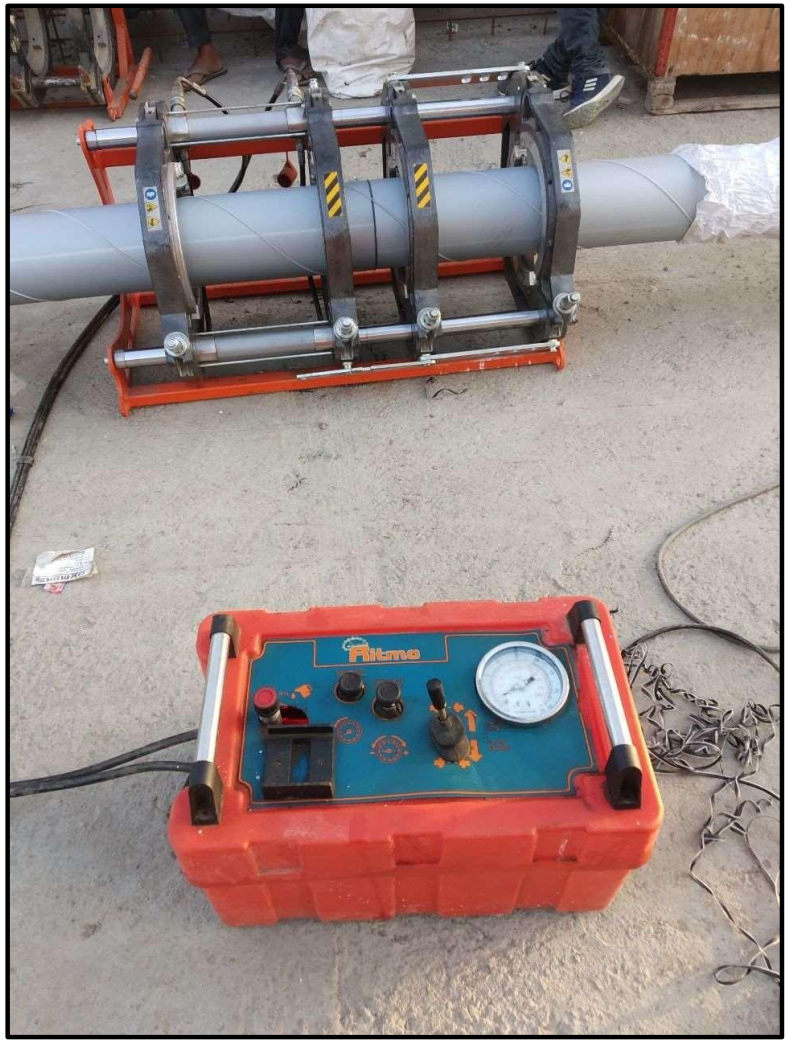
METHODOLOGY FOREX

HDPE PIPE INSTALLATION:

3. HDPE Pipe is then arranged on stool rollers for ease in installation of HDPE Pipe. 1 single Strand is passed through the pipe to be installed along with the HDPE Pipe
4. Pylon end of the pipe is hooked to the Tower crane using Lifting belt and slowly lifted to it position and fixed at the Pylon Guide Pipe. Th strand is passed through the Anchorage using winch machine inside the Pylon and locked on the Anchorage using wedges.
5. Deck end of the HDPE Pipe is pulled near the guide pipe on deck and fixed. The strand is passed through the anchorage and fixed.

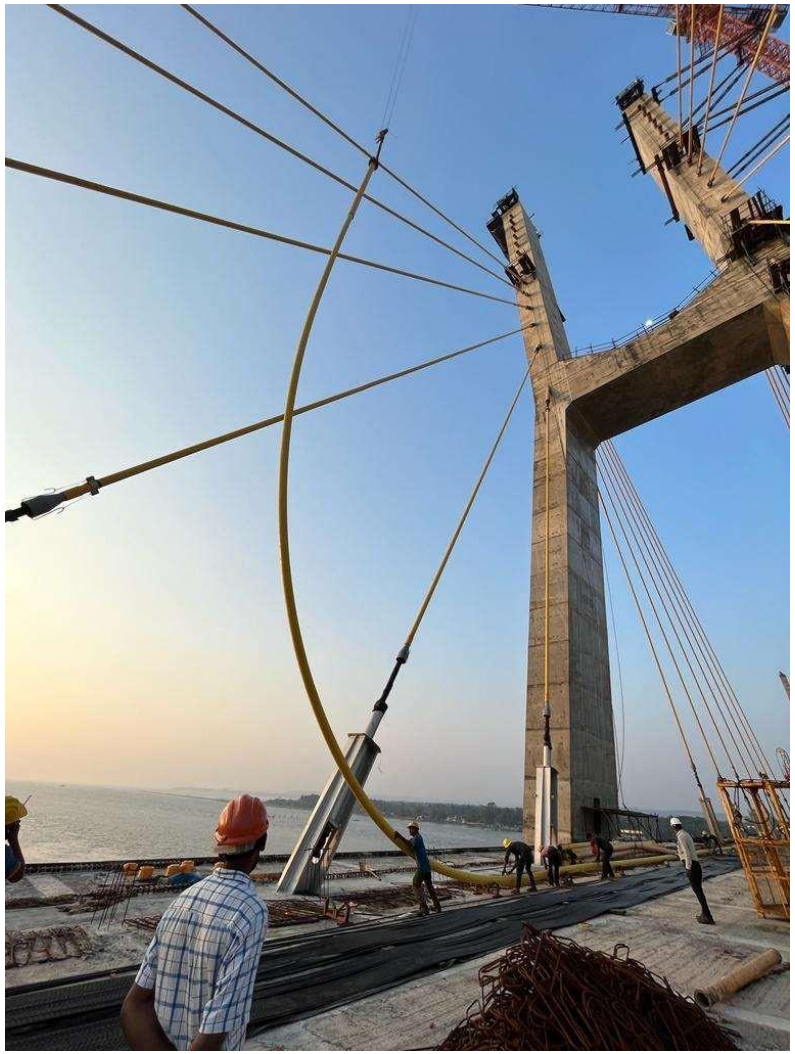
METHODOLOGY FOREX



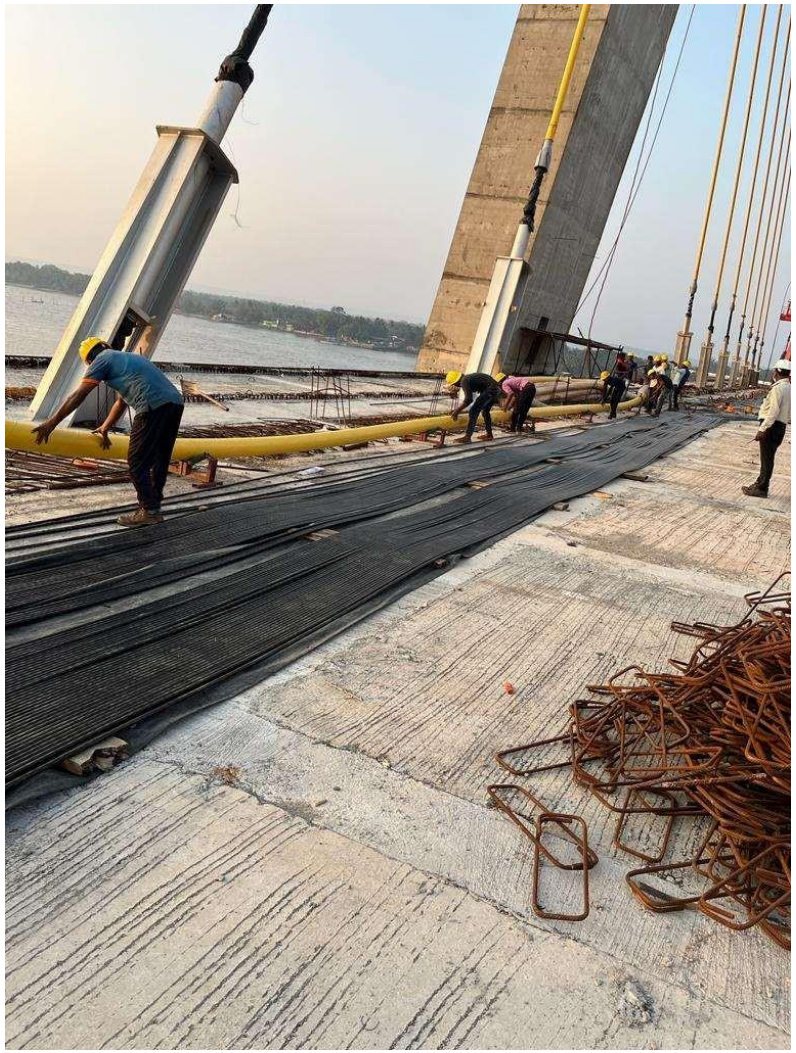


HDPE PIPE WELDING

METHODOLOGY FOR EX

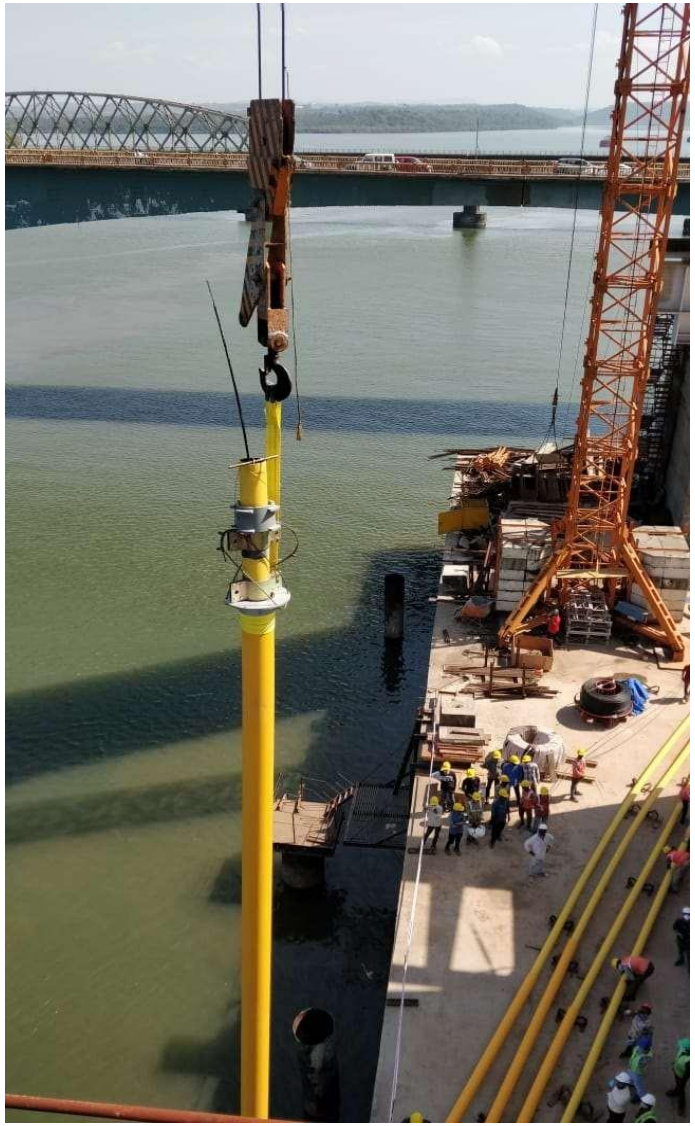


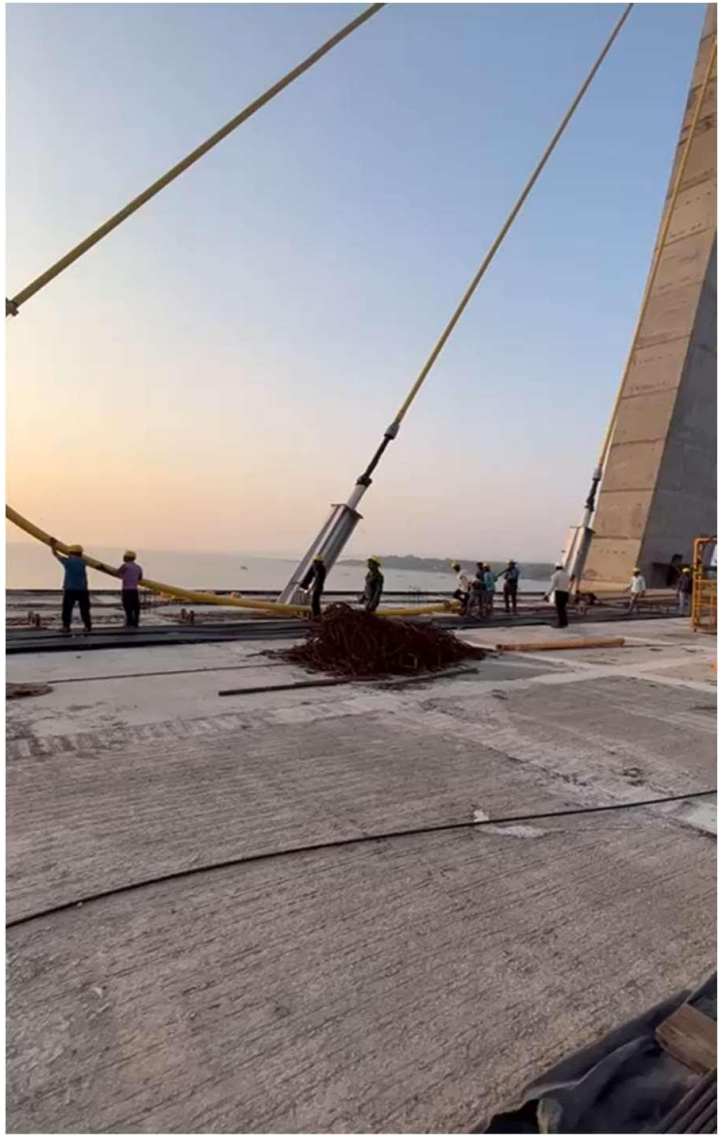
INSTALLATION OF HDPE PIPE



HDPE PIPE PUSHED USING STOOL ROLLERS

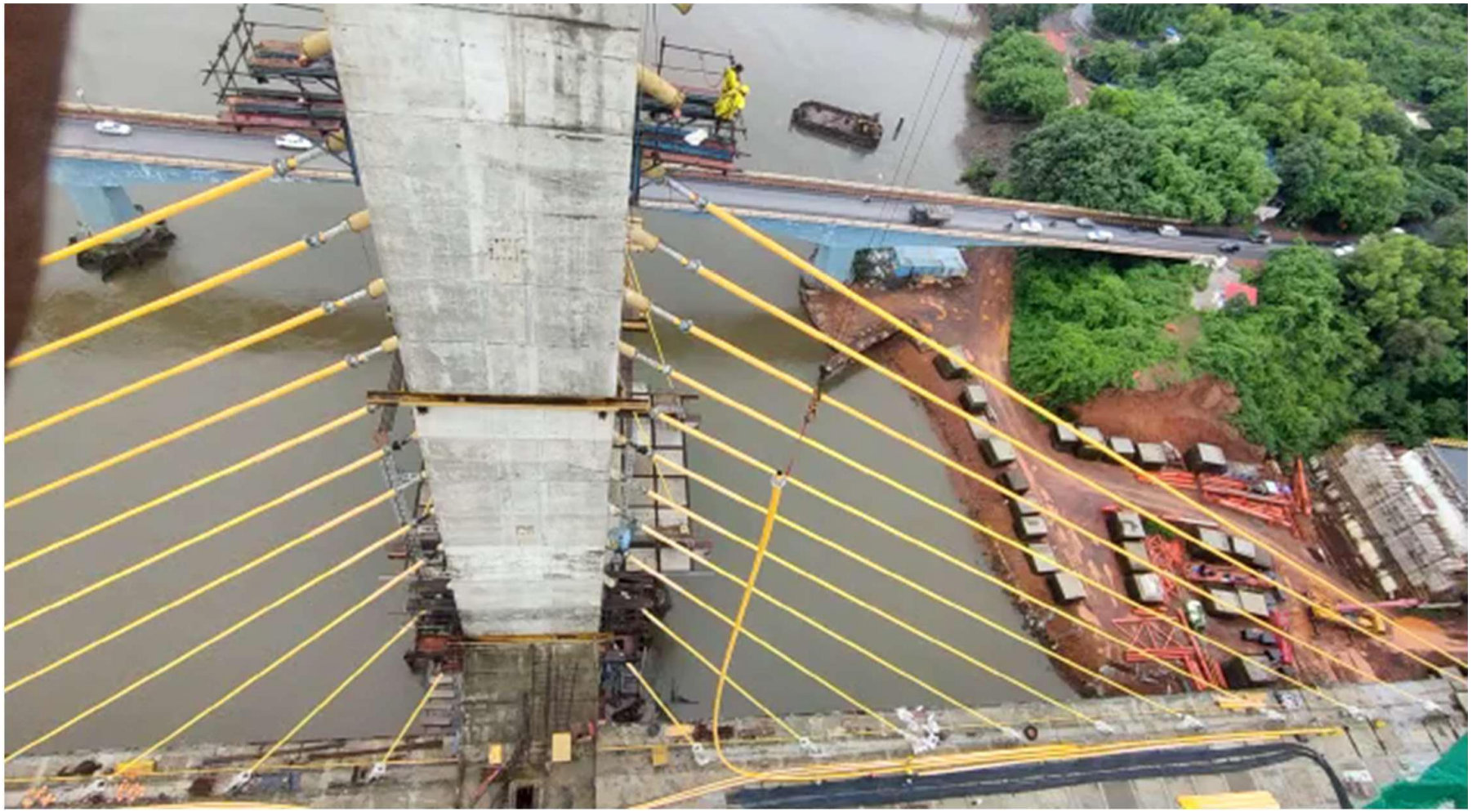
METHODOLOGY FOR EX





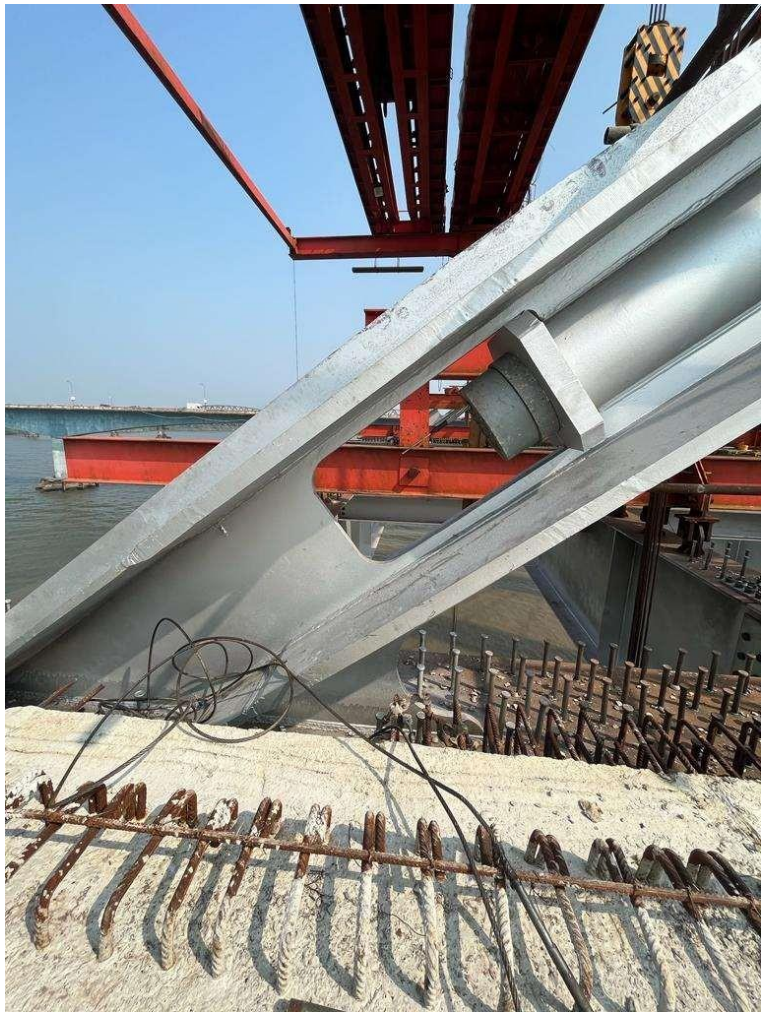
INSTALLATION OF HDPE PIPE

METHODOLOGY FOR EX

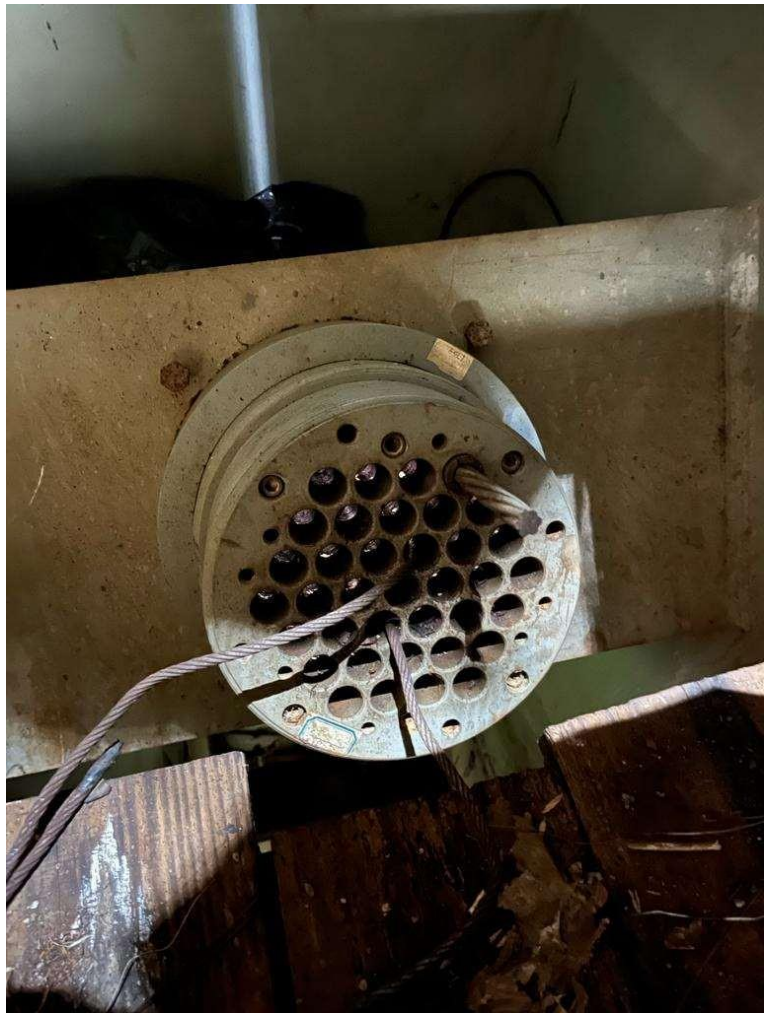


INSTALLATION OF HDPE PIPE

METHODOLOGY FOR EX



STRAND FIXED ON DECK END



STRAND FIXED ON PYLON END

METHODOLOGY FOREX

STRAND INSTALLATION:

1. Strands are cut into specific given lengths from the strand coil bundles and laid on the deck slab for installation.
2. Connect the 1st strand to the Strand Threading Machine cable installed on top of the Pylons.

METHODOLOGY FOREX

3. Cable is then installed by passing it from top end of HDPE Pipe to the bottom/deck anchorage and locked at deck anchorage.
4. Other end of cable is passed inside the pylon and locked on the Pylon anchorage.

STRAND LOCKED ON PYLON END

METHODOLOGY FOR EX

INITIAL STRESSING OF STRANDS:

1. After installation of strand, stressing is carried out.
2. Stressing is carried out in 2 stages: Initial & Final
3. Initial stressing is carried out according to the load given by the Designers.
4. Mono-Strand jacks are used for stressing.

METHODOLOGY FOR EX

FINAL STAGE STRESSING OF STRANDS:

1. After placement of all the pre-cast concrete slabs on the deck, final stressing is carried out.
2. Final Stressing Load along with theoretical deck deflection, anchor to anchor length before & after stressing is provided by the Designers.
3. Final Stressing is also carried out with mono-stressing jack.

METHODOLOGY FOR EX

FINE TUNING OF CABLES USING MULTI-PULL JACK:

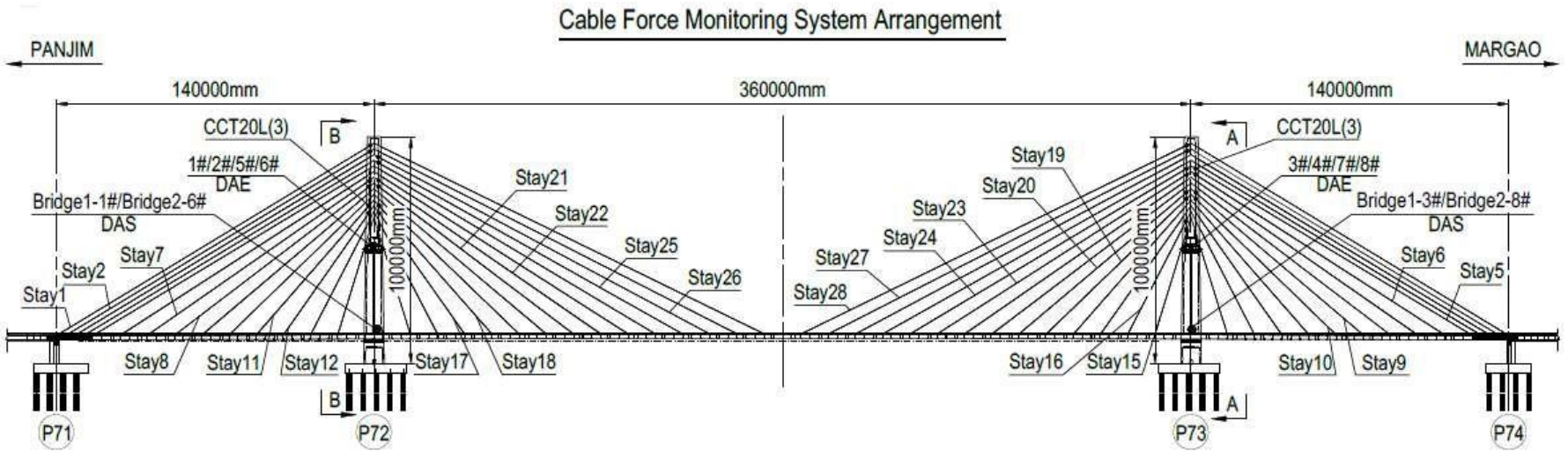
1. After completion of installation and stressing of all the cables, deck level and alignment is surveyed.
2. Crash barriers are installed and remaining concreting work is completed.
3. Load in strands are monitored.
4. Designers then provide additional load to be applied on the cable depending on the alignment of the bridge, load in cable, etc factors.
5. Multi-pull Jack is used for this stage of stressing.

FACTORS AFFECTING CABLE STRESSING

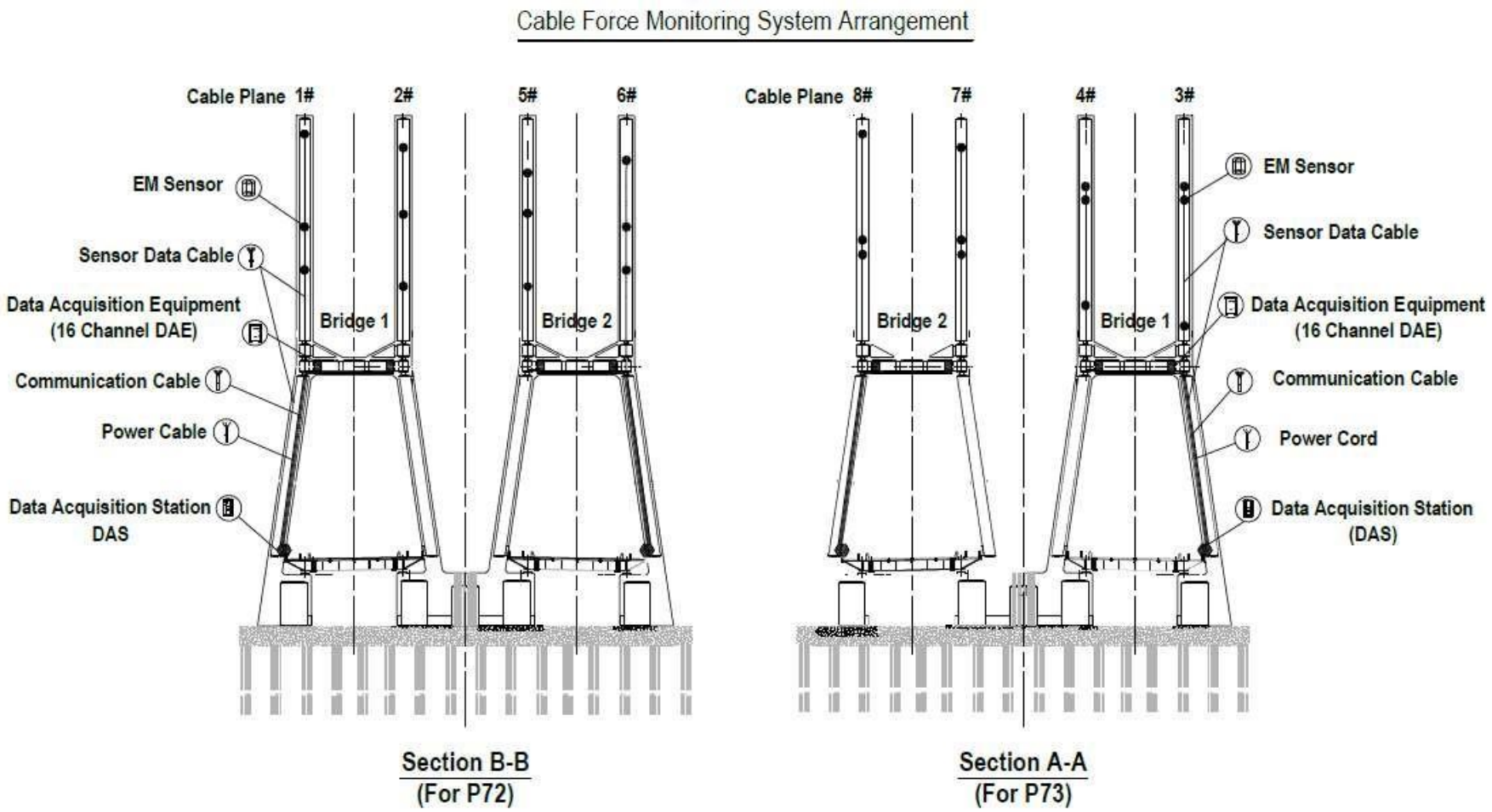
- Cable force is the primary and important factor considered in Pre-stressing of Cable Stayed Bridges.
- Elongation of the cable is also measured during the stressing process.
- Actual elongation of the cable may vary from theoretical elongation with respect to various factors.
- Factors like:
  - Temperature variations during stressing
  - Wind Force
  - Actual Deflection value at anchor point, etc.
- All these factors contribute in variation in Actual Cable Force and Elongation.
- According to **FIB Bulletin 89 "Acceptance of cable system using prestressing steel"**, the tolerance limit is **+/- 5 %of the target value (Force or Elongation)**

CABLE FORCE MONITORING SYSTEM

- OVM250 stay cable system is adopted on ZUARI bridge and there are totally 224 cables.
- Magnetic flux sensors are installed on 24 cables, about 10% of all cables are selected to be monitored.
- The whole bridge is equipped with 8 sets of 16 channel data acquisition boxes and 4 sets of data acquisition stations.
- The data acquisition box is installed in the upper crossbeam, and the data acquisition station is installed near the door opening of the outer pylon leg.
- Through GPRS communication with the host computer in the monitoring room, the cable force online acquisition system is realized.
- The four bridge tower systems are independent subsystems with the same configuration.

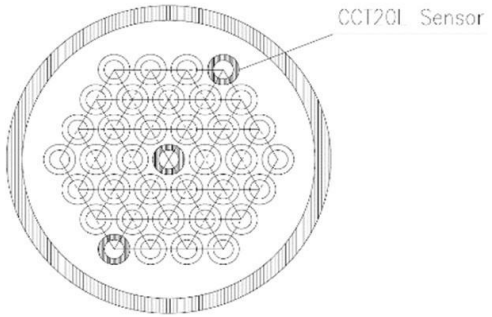


CABLE FORCE MONITORING SYSTEM

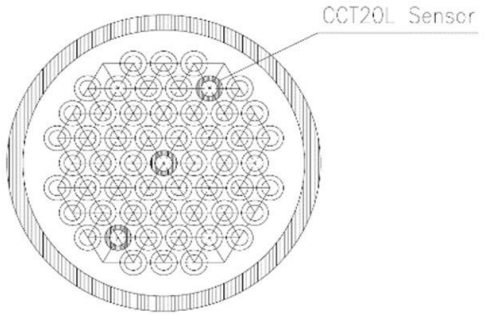


CABLE FORCE MONITORING SYSTEM

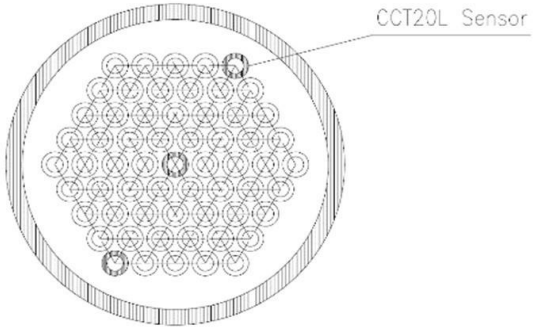
During the strand installation at site, the strand goes through the sensor. There are 3 types of anchorage as 37 holes, 55 holes and 61 holes. The installation position of the sensor on the anchorage is shown in the following figure.



OVM 250-37



OVM 250-55



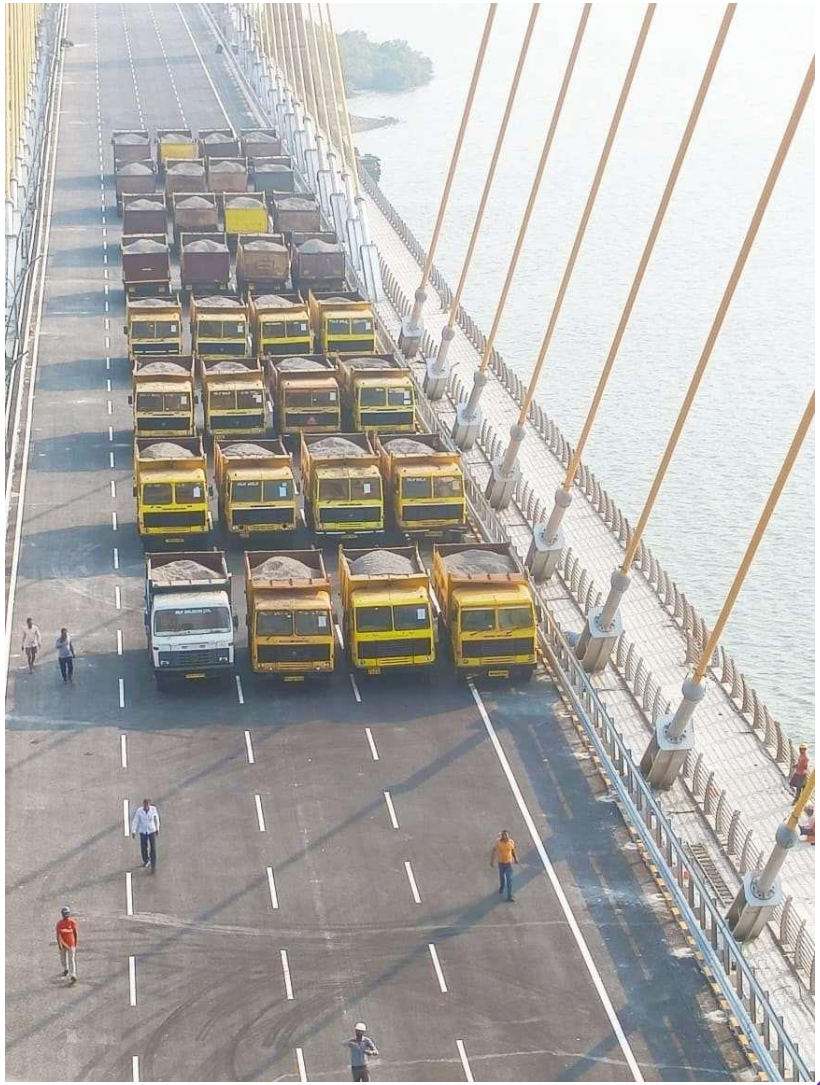
OVM 250-61

Example of sensor installation

LOAD TESTING OF THE BRIDGE

LOAD TESTING OF THE BRIDGE

- Load Test carried out by PWD, Goa after completion of bridge.
- 32 Vehicle carrying 32 Tonnes each i.e. 1024 Tonnes.
- Vehicles were placed on the most critical point of the bridge for over 24 hours.
- Deflection recorded at the location was within the permissible limits of the bridge.



LOAD TESTING OF THE BRIDGE

END