A Report On

INTERNSHIP AT SGAWINGS CIVIL ENGINEERING CONSULTANT & ADVISOR (OPC.) PVT. LTD.

UNDER THE GUIDANCE OF

Mr. Vivek Abhyankar

SUBMITTED BY

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DEPARTMENT OF CIVIL ENGINEERING

UNIVERSITY OF MUMBAI

2021-2022

CONTENT

ACKNOWLEDGEMENT & INTRODUCTION

Apart from the efforts of me, the success of this Internship depends largely on the encouragement and guidance of Er. Vivek Abhyankar. I take this opportunity to express my gratitude towards him who has been helpful in the successful completion of this Internship. Also, a heartful gratitude to Mr. Vikas Kale for recommending me to get in touch with SGAWings Civil Engineering Consultant & Advisor (OPC.) Pvt. Ltd. for this Internship. I would like to thank Er. Vivek Abhyankar for providing me the opportunity to work as an intern and selecting me through the process which include a technical interaction and personal interview round held on December 09, 2021. The Internship was for a period of 2 months starting from 10th December 2021 to 10th February 2022. During this period, I was assigned to work on Pile Foundation which mainly included study of Pile Load Test, different codes of Indian Standard (IS), Indian Road Congress (IRC) along with the study of American Society for Testing and Materials (ASTM).

I would like to show my gratitude towards Er. Vivek Abhyankar for arranging a One-day visit to Mumbai Trans Harbour Link (MTHL) which helped me gain actual on-site knowledge of Bridge design. And, also thankful to Er. Jaywant Chandane from Stup Consultants Pvt. Ltd. for sharing his knowledge during the visit.

Without the encouragement and help this Internship would not have been materialized for which I'm thankful to Asst. Prof. Vikrant Kothari. It was great learning experience because of his tremendous support and help.

HRITK RAMESH BIRWADKAR

OBJECTIVES

- To study the process of conducting pile load test.
- To understand the various method of pile design.

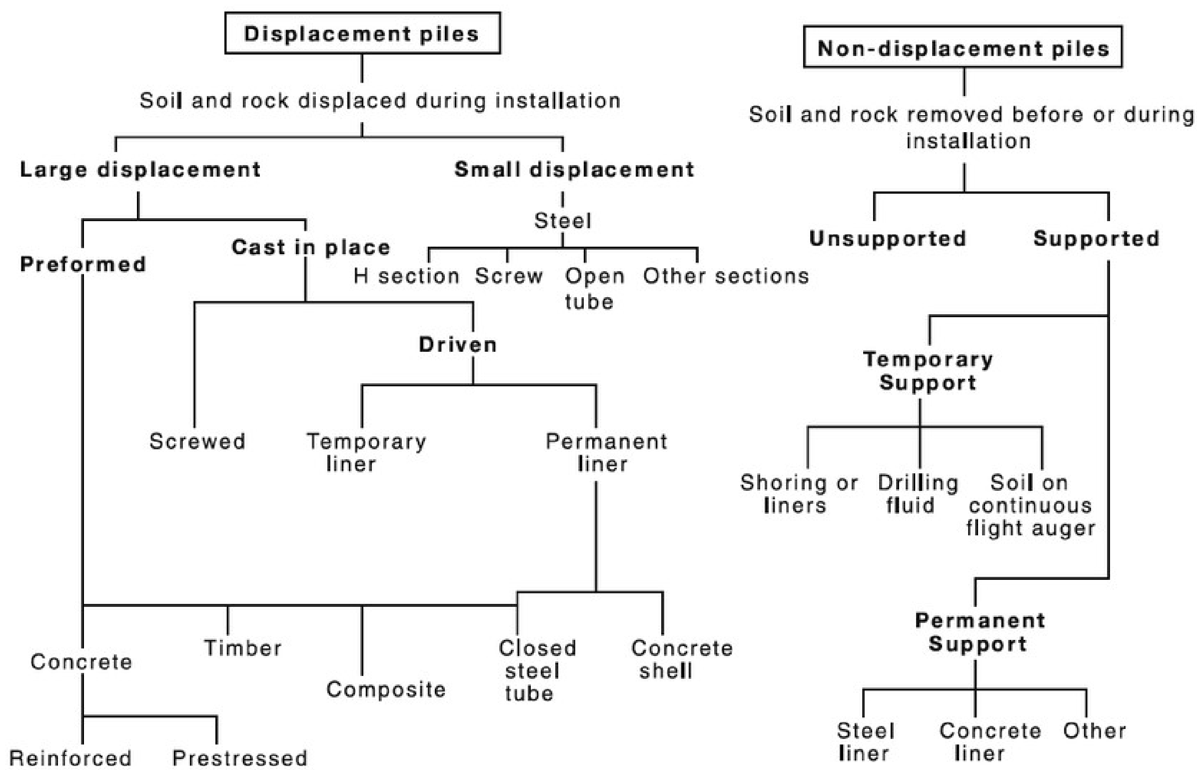
SUMMARY OF THE WORK DONE DURING INTERNSHIP

- **Week No. 01**

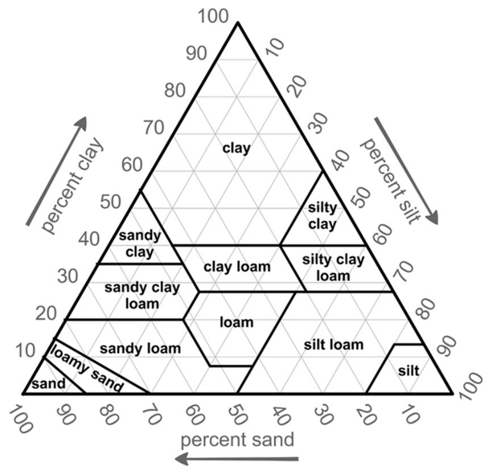
(10 December 2021- 16 December 2021)

Work carried out:

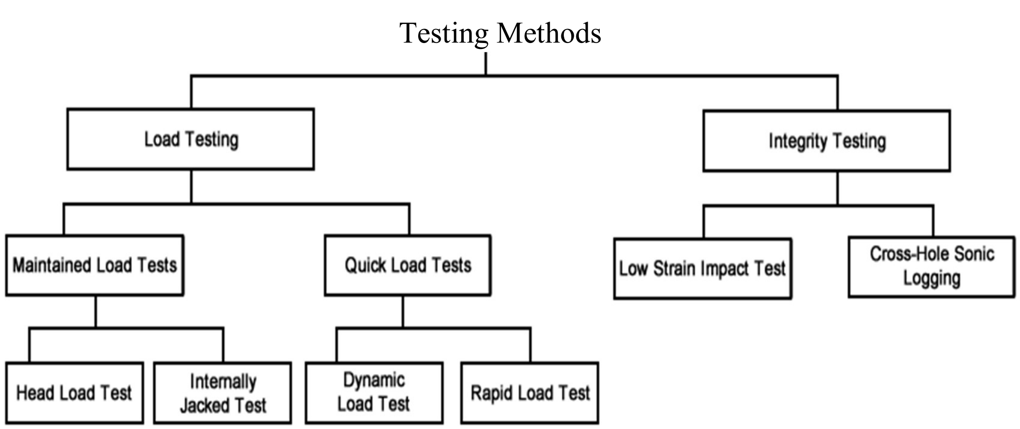
1. DETAILED STUDY OF CLASSIFICATION OF PILES:



2. STUDY OF TRIANGULAR CLASSIFICATION OF SOIL:
   In this the triangle consist of % sand on one side, % clay on the second side & % silt on the third axis. The soil can be classified into 12 different types by knowing the % composition of sand, clay and silt.



3. STUDY OF IS 2911 PART 4. 2010 LOAD TEST ON PILE:
   Pile load test is the most direct method for determining the safe loads on piles including its structural capacity with respect to soil in which it is installed. There are basically two test Routine test & Initial test. Initial test is carried out to determine ultimate load capacity and safe load capacity whereas Routine test is performed on the working pile to check whether the pile is capable of taking the working load assigned to it.
   The load can be applied on pile by two methods the first one is kentledge method in this load is applied by placing concrete blocks or sacks filled with sand on the platform provided above the testing pile. The second method is by providing ground anchors.
   Ground anchors are used to resist uplift of the basement or foundation and for testing of large diameter piles.



4. STUDY OF IS 2911 PART 1 SECTION 2 BORED CAST-IN-SITU PILES.

Bored cast-in-situ piles are formed within the ground by excavating or boring a pile within it, with or without the use of a temporary casing and subsequently filling it with plain or reinforced concrete.

Bored cast-in-situ Pile

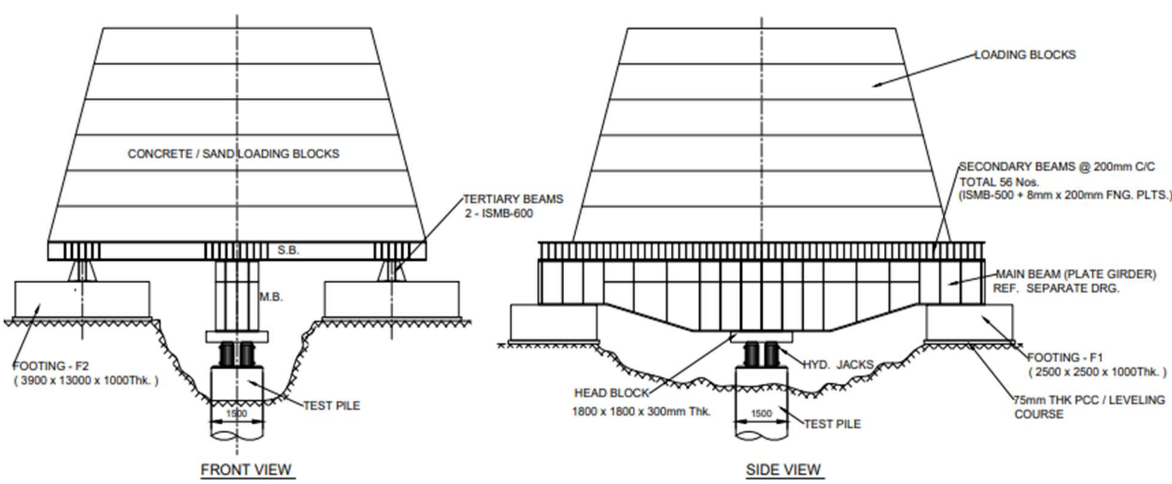
- **Week No. 02**

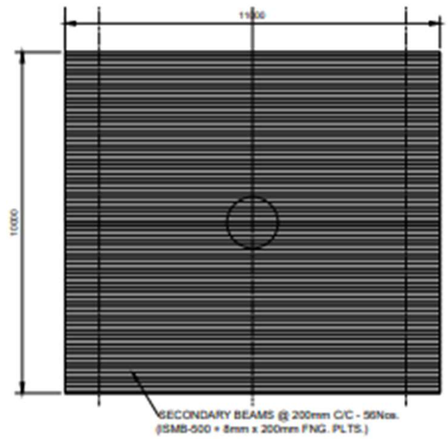
(17 December 2021- 23 December 2021)

<u>Work carried out:</u>

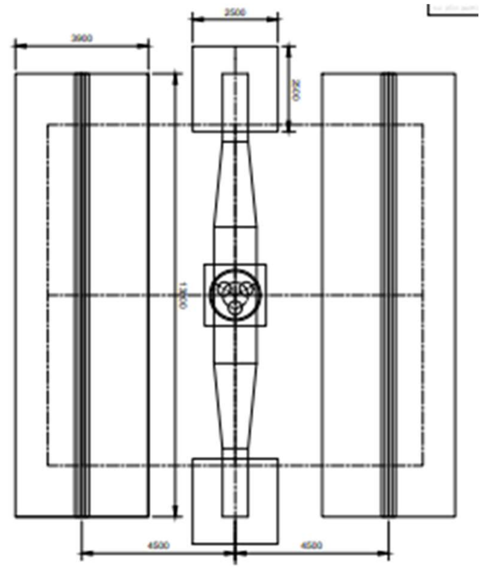
1. Study of Engineering drawings and Design calculations for initial pile load test for National Highway Authority of India (NHAI) LTD for Kerala Road Project.

2. Study of Static Initial Vertical Pile Load Test on 1500mm Diameter bore in-situ piles, using kentledge platform - Design calculations (400T x 2.5 = 1000T test load)





PLAN OF SECONDARY BEAMS



PLAN OF MAIN BEAM, TERTIARY BEAMS AND FOOTINGS

Design Basis / Data : Spacing between piles - 3 d
Safe bearing capacity of soil - 15 T/sqm

Reference Codes:

IS:800-2007 - Indian Standard code of practice for general construction in steel.
IS:808-2021 - Dimensions for Hot Rolled Steel Beam, Column, Channel and Angle Sections
IS:456-2000 - Plain and Reinforced Concrete - Code of Practice
IS:2911 (IV) 2013 - Code of practice for design and construction of pile foundations: Part 4 Load test on piles

Design Data / Assumptions:

Modulus of eleasticity of steel (Es) = 200000 N/mm^2
Density of Concrete = 2.4 T/m^3 . . . Ref IRC:87-1987

Load Calculations / Input Data:-

Diameter of the test pile	=	1.5	m
Minimum distance of footings from pile C/L	=	4.5	m
minimum width of pltf reqd	=	9	m
Length of kentledge platform	=	11	m (dimension parallel to central Plate Girder)
Actual Width of kentledge platform	=	10	m **Hence OK**
Plan area of the kentledge platform	=	110	sqm
Self wt of Kentledge	= @	624.3	kg/sqm ....assumed
	=	68.7	T
Width of the Support blocks at edge	=	0.50	m
Length of the Grillage above pile	=	1.8	m
Width of the Grillage above pile	=	1.8	m
Working load on Pile	=	400	T
Factor of Safety (Initial Load Test)	=	2.5	
Design load	=	1000	T
Factor Stability for kentledge	=	1.25	
Load to be placed on Kentledge	=	1250	T
Required weight of the blcoks / bags	=	1181	T

Design of Loading Platform

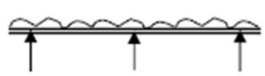
Design of Secondary Beams:-

Overhang	=	1	m
Simply suppported Length of Secondary beams, L	=	8	m
Spacing of beams	=	0.2	m C/C
Numbers of secondary beams	=	56	Nos
UDL on the Secondary Beams, w	=	2.11	T/m

Stage-1

Reaction in supprt in stage-1	=	11.16	T
BM in Secondary beams - stage-1	=	10.28	Tm (when the Jacks are not activated)
SF in Secondary beams - stage-1	=	9.05	T (at face of support)

Stage-2



Reaction at midspan in stage -2	=	17.9	T
Reaction in outter supprt in stage-2	=	2.23	T
BM in Secondary beams - stage-2	=	24.6	Tm (when full Jack load is applied)
SF in Secondary beams - stage-2	=	6.21	T (at mid span)

Design BM	=	24.55	Tm (Hogging / Sagging)
Design SF - at support	=	9.05	T
- at span -	=	17.9	T

Using ISMB 500 Sections as secondary beam at 0.2 m C/C (At site top / bottom 10mm plate is used)

With a top bottom p 8 mm Thk and 200 mm width

Ixx	=	45200	cm^4 of Single section without T/B plates
Ixx	=	6.58E+04	cm^4 of built-up section
D	=	500	mm basic section
D total	=	516	mm Depth of built-up section
Z	=	2552	cm^3
Web Thk	=	10.2	mm
Web area	=	5100	mm^2

Bending Stress	=	96.2	MPa	< 165MPa, Hence Safe	
Shear Stress	=	35.0	MPa	< 100MPa, Hence Safe	
Deflection of Beam in - stage - 1	=	7.61	mm	allowable = L/325	24.6 OK
Deflection in stage - 2	=	#######	mm	allowable = L/325	12.62 OK

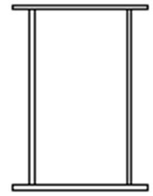
Design of Main Beams:-

Cantilever projection of MB	=	4.60	m
UDL on MB at stage - 2	=	90.91	T/m

	Forces at Mid Span			*Forces at Support*	
BM at face of Grillage	=	961.8	Tm	=	0 Tm
SF at face of Grillage	=	418.2	T	=	0 T

Using Plate Girder with Dimesnions as shown below

		Dimensions at Mid Sp		*Dimensions at Support*	
Total Depth of the MB	=	2000	mm	1250	mm
Width of both the flange	=	1250	mm	750	mm
Thickness of Flange	=	32	mm	32	mm
Numbers of Webs	=	2	mm	2	mm
Thickness of Webs	=	25	mm	25	mm



(Note :- The details design of Plate Girder is provided separately in 1680/DSN/TW-14)

Additional flange width =	0	mm	0	mm
Thickness of flange Thk =	0	mm	0	mm

			Properties at Mid Span		*Properties at Support*	
Moment of In	Ixx	=	1E+11	mm4	2E+10	mm4
Section Modu	Z	=	1E+08	mm3	4E+07	mm3
Shear Area	D	=	100000	mm	62500	mm

(Check for stresses at mid span)

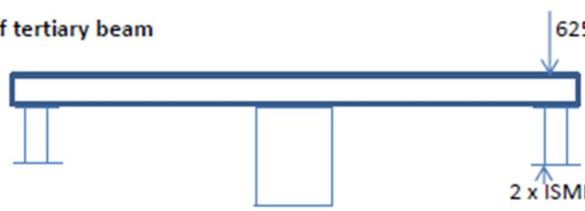
Bending Stress = 0.0 MPa < 165MPa, Hence Safe

Shear Stress = 0.0 MPa < 100MPa, Hence Safe

Deflection in stage - 2 = 0.00 mm allowable = L/325

(Average Ixx considered for deflection calculatio 0.00 Revise

Design of tertiary beam



v = 625 T

Using ISMB 600 Sections
Ixx = 91800 cm4
D = 600 mm
B = 210 mm 2 Nos
Z = 3060 cm3

Web Thk = 12 mm

Web area = 7200 sqmm

τ = 7.75 < <100 Mpa, Hence Safe

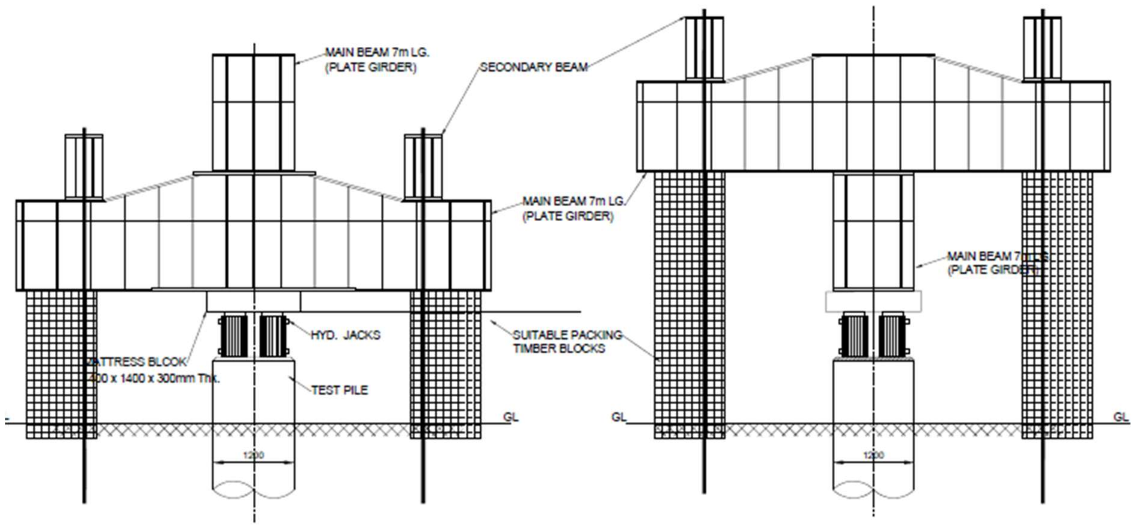
Bearing on concrete = 2.66 Mpa Allowable = 0.45 fck 6.75 Mpa OK

Summary of Design:-

Sr.	Item	Description	No	Length (m)	Wt	Total	
1	Secondary beams	ISMB 500 with TB plate	56	10	86.9	48.7	T
2	Main Beams	Plate Girder	1	11	--	11.9	Ref. Fabr. Drg.
3	Tertiary Beams	ISMB 600	4	13	156	8.11	T
						68.7	T
			Plan Area =			110	sqm
			Unit Weight =			624.3	kg/sqm

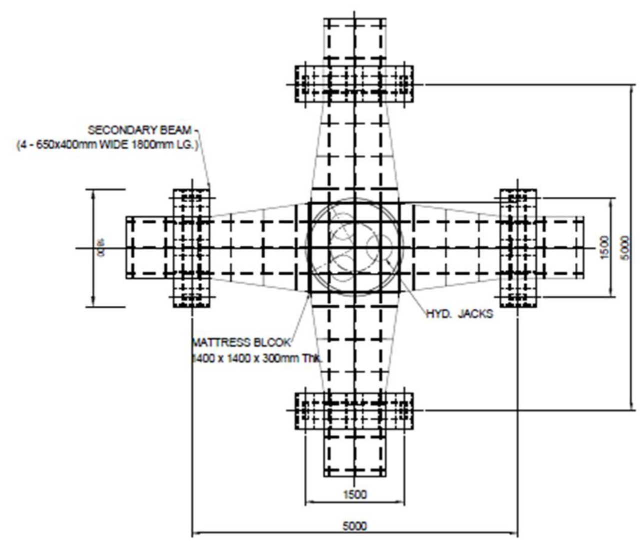
			Nos.	L	B	Thk		
4	Grillage	RCC Block	2	1.8	1.8	0.3	**1.94**	cum
5	Tertiary footing	RCC Block	2	13	3.9	1.00	**101**	cum
6	MB footing	RCC Block	2	3	3	1	**18**	cum
7	Ply wood	12mm	1	10	11		**110**	sqm
8	Safety Railing	NB-40	lump sum					rmt.

3. Study of Initial-Static vertical Pile Load Test on 1200mmf bore in-situ piles, using GR Anchors (2x480T x 2.5 = 2400T test load)



ELEVATION
SCALE (1:30)

SIDE VIEW
SCALE (1:30)



PLAN OF PILE WITH TEST ARRANGEMENT
SCALE (1:30)

Design Basis / Data :		
	Diameter of the Pile -	1200 mm
	Spacing between piles -	2.08 d
	Distance between Anchors -	5000 mm
	Length of the Main Girder -	6000 mm
	Length of the Secondary beams -	2000 mm
	Safe bearing capacity of soil -	15 T/sqm
	Safe Load on Pile -	960 T
	Test Load -	2400 T
	F.O.S for steel -	1.25 T
	Design Load for structural units -	3000 T
	Number of main Girders -	2 Nos.

Following parameteres are considered for the design of anchors

F.O.S for anchors -	2
Number of anchors -	8 Nos.
Load per anchor -	600 T
Safe capacity of strands -	16 T
Number of strands per Anchor -	38 Nos.
Average dia of strand -	15.2 mm
Area -	140 sqmm
Total Area -	5309 sqmm
Average new Dia -	82.2 mm
Gross dia on Anchor group -	133 mm
Diameter of the Concrete portion -	213 mm

Design Data / Assumptions:

Modulus of eleasticity of steel (Es) =		200000 N/mm^2	
Density of Structural steel	=	7.86 T/m^3	
Density of Concrete	=	2.4 T/m^3	. . . Ref IRC:87-1987

Load Calculations / Input Data:-

Length of the Grillage above pile	=	1400 mm
Width of the Grillage above pile	=	1400 mm
Thickness of Grillage	=	300 mm

Design of Structural Members :-

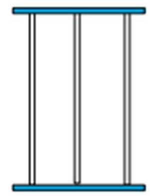
Grade of Steel Used for this members,	Fy	=	250 MPa
Allowable bending tension =	0.66 Fy	=	165 MPa
Allowable Shear stress =	0.40 Fy	=	100 MPa
Allowable combined stress =	0.90 Fy	=	225 MPa

Design of Main Beams:-

Span of Beam =		5000 mm
Factored design Point Load at mid =	on one girder	1500 T
Shear Force at Ends & Mid =		750 T
Bending Moment -	at face of grillage -	1350 Tm
	at mid -	1350 Tm

Using Plate Girder with Dimesnions as shown below

		Dimensions at Mid Span		*Dimensions at Support*	
Total Depth of the MB	=	1750	mm	1300	mm
Width of both the flange:	=	1200	mm	950	mm
Thickness of Flange	=	40	mm	32	mm
Numbers of Webs	=	3	mm	3	mm
Thickness of Webs	=	20	mm	20	mm
C/S area	=	196200	sqmm	134960	sqmm



			Properties at Mid Span		*Properties at Support*		
Moment of Ir	Ixx	=	9.35E+10	mm4	33885274347	mm4	0.36
Section Modu	Z	=	1.07E+08	mm3	52131191.3	mm3	0.49
Shear Area	D	=	105000	mm	78000	mm	0.74

(Check for stresses at mid span)

Bending Stress = 126.4 MPa < 165MPa, Hence Safe

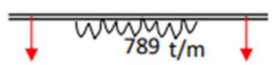
Shear Stress = 96.2 MPa < 100MPa, Hence Safe

Deflection at Mid = $PL^3 / 48.EI$ = 3.07 mm allowable = L/325 15.39 mm ...Hence OK

(Average Ixx considered for deflection calculation)

Design of Secondary Beams:-

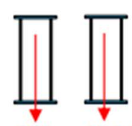
Span of Main beam -	=	2000	mm
Total Length of secondary beam -	=	3000	mm
Width of the main beam -	=	950	mm



Maximum BM -	=	286	Tm
Maximum SF -	=	375	Tm

Using Plate Girder with Dimesnions as shown below

		Dimensions at Mid Spa		*Dimensions at Support*	
Total Depth of the MB	=	950	mm	950	mm
Width of both the flange:	=	550	mm	550	mm
Thickness of Flange	=	32	mm	32	mm
Numbers of Webs	=	2	mm	2	mm
Thickness of Webs	=	20	mm	20	mm
C/S area	=	70640	sqmm	70640	sqmm



			Properties at Mid Span		*Properties at Support*		
Moment of Ir	Ixx	=	9.74E+09	mm4	9737329787	mm4	1.0
Section Modu	Z	=	2.05E+07	mm3	20499641.66	mm3	1.0
Shear Area	D	=	38000	mm	38000	mm	1.0

(Check for stresses at mid span)

Bending Stress = 139.5 MPa < 165MPa, Hence Safe

Shear Stress = 98.7 MPa < 100MPa, Hence Safe

Deflection at Mid = $PL^3 / 48.EI$ = 0.845 mm allowable = L/325 6.15 OK

Summary of Design:-

Sr.	Item	Description	No	Length (m)	Wt	Total	
1	Main Beams	Plate Girder	2	6.0	3.47	20.84	T
2	Secondary beams	Plate Girder	4	3	**0.56**	6.66	T
3	Tertiary Beams					27.5	T

Sr.	Item	Description	Nos.	L	B	Thk		
4	Grillage	RCC Block	**2**	1.4	1.4	0.3	**1.18**	cum
5	Safety Railing	NB-40	lump sum					rmt.

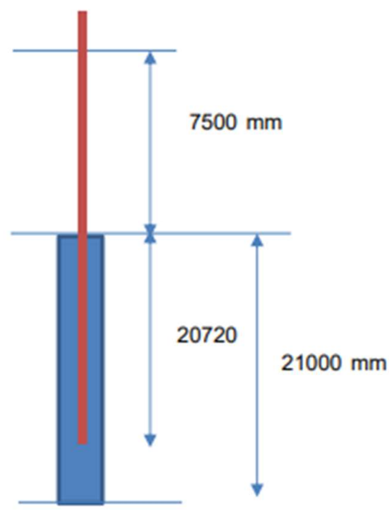
Anchor Design

Design Pull - 2400 T
Number of Anchors - 8 Nos.
F.O.S - 2

Load per anchor - 600 T

Number of strands per Anchor - 38 Nos.
Average dia of strand - **15.2** mm
Area - 140 sqmm
Total Area - 5309 sqmm
Average new Dia - 82 mm
Gross dia on Anchor - 133 mm

Provide anchor dia - **280** mm 61575 sqmm
Provide Fixed Length - **21000** mm



Strand Configuration - **7** - Ply **5.05** mm
Net Area of one strand - 140.2

0.2% proof load = 16 T

Elongation - 0.005706 mm per m

Bond stress betn. - Strand - Grout = 1 MPa **10** kg/sqcm
Grout - Rock = 0.5 MPa **5** kg/sqcm

Fix Length Required - 13642 mm Hence Safe
Embedment required - 6821 mm Hence Safe

Elongation of Fix length - 81.9 mm
Elongation of Fix length - 117.1 mm
Average elongation = 99.5 mm

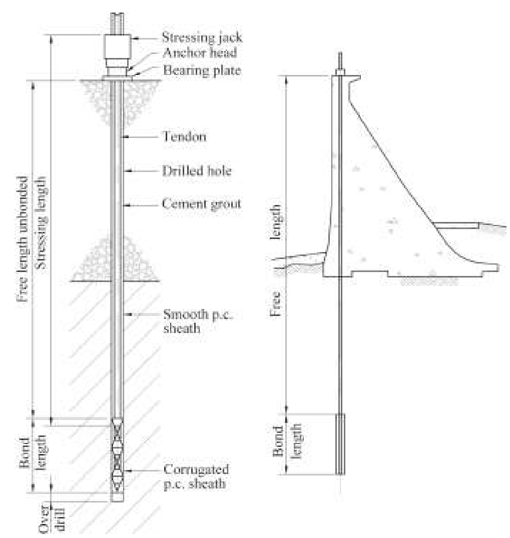
➢ Week No. 03

(24 December 2021- 30 December 2021)

<u>Work carried out:</u>

1. STUDY OF IS 10270.1982 GUIDELINES FOR DESIGN AND CONSTRUCTION OF PRESTRESSED ROCK ANCHORS.

   IS 10270.1982 deals with design and construction of permanent and temporary prestressed rock anchors constructed by using high strength prestressing steel they are also called as strands.
   Rock Anchors can be classified into two types, the first one is Permanent Anchors which are constructed for the service life of the structure. The second one is Temporary Anchors this are constructed for the duration of construction period only.



Rock Anchor

Drilling of Rock Anchor

2. PROCEDURE STUDY OF CYCLIC LOAD TEST ON HOW TO SEPARATE POINT RESISTANCE OR END BEARING & SKIN FRICTION.
   In cyclic load test a series of vertical downward incremental load each increment being of about 20% of safe load on the pile is applied. After application of load measurements or displacement in each stage of loading is maintained till rate of displacement of the pile top is either 0.1mm or 0.2mm in first one hour or till two hour whichever occurs first.
   The graph is plotted for Load on pile top vs Elastic settlement from the obtained readings. After that the Skin friction and End bearing are differentiated by using the following procedure.

i. Draw a tangent from the straighter portion of the curve obtained.
ii. Then draw a line parallel to the tangent such that it is passing through the origin.

iii. Draw vertical line from any % of load suppose load 1 the line will intersect the curve from that point draw a horizontal line

iv. The horizontal line will divide the line starting from the origin into two parts, the part lying on inner side is used to obtain End bearing and the outer portion is used to obtain skin friction value.

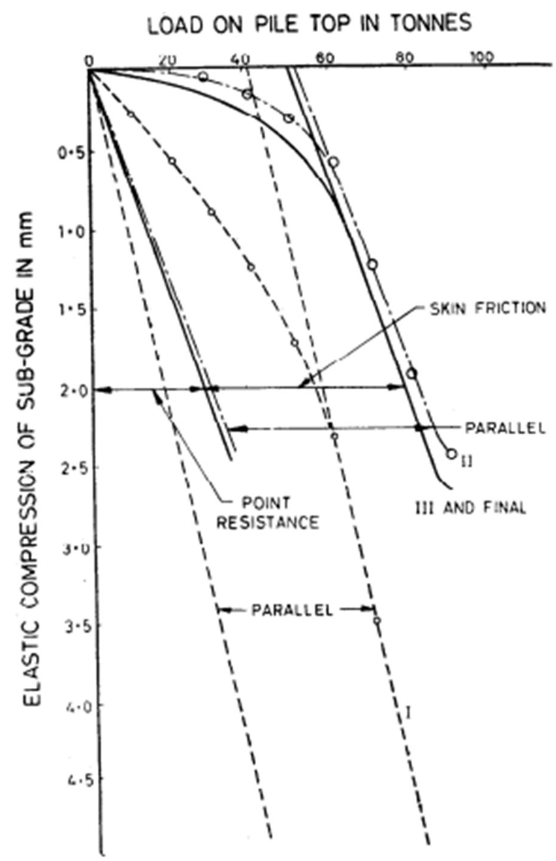


FIG. 2 ANALYSIS OF CYCLIC LOAD TEST DATA FOR SEPARATION OF SKIN FRICTION AND POINT RESISTANCE

- **Week No. 04**

(31 December 2021- 6 January 2022)

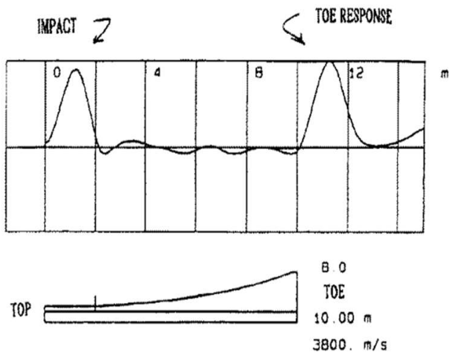
<u>Work carried out:</u>

1. STUDY OF LOW STRAIN INTEGRITY (NDT) TEST OF PILE.
   It is Non-Destructive type of testing in which the Integrity means the quality of the pile is tested. Low strain integrity testing provides velocity and force data. This data assist evaluation of pile integrity and pile physical dimensions (i.e. cross-sectional area, length), continuity and consistency of the pile material. This method will not give information regarding the pile bearing capacity.

This test should be performed 7 days after the casting of pile or after concrete strength achieves at-least 75% of its design strength, whichever occurs earlier.

Procedure-

Pile integrity is test by tapping a wooden or soft material hammer on the pile head and by measuring the pile head motion with the help of motion sensing device. The device is mainly placed in the centre of pile if the pile dia < 500mm, if pile dia> 500 the test should be carried out on three different locations on pile. The impact of the hammer should be within 300mm from the motion sensor.



Typical velocity traces generated by the apparatus for obtaining dynamic measurements

Low strain Integrity test of Pile

2. STUDY OF CROSS-HOLE SONIC TEST ON PILE:
   This test is also called as Ultrasonic cross-hole test or sonic cross hole test. The test measures the propagation time and relative energy of an ultrasonic pulse between parallel access ducts (cross-hole) or in a single tube installed during the time of construction. Access ducts typically have an internal diameter from 38mm to 50mm.

Ultrasonic Cross-Hole Testing on Pile

Procedure:

The cross-hole tubes are first filled with water after casting the in the pile. The tests shall be performed no sooner than 3 to 7 days after casting depending on concrete strength and shaft diameter (larger diameter shafts may take closer to 7 days). First the transmitter and receiver probe are released till the bottom of the pile, then they are pulled gently together. The ultrasonic waves are released from the transmitter end and received by the receiver and through this the graph is traced at different depth. The rate of pulse generation should be at-least one ultrasonic pulse for every 50mm or less depth.

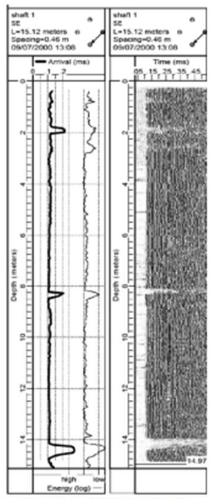


FIG. 2 Typical Ultrasonic Profile

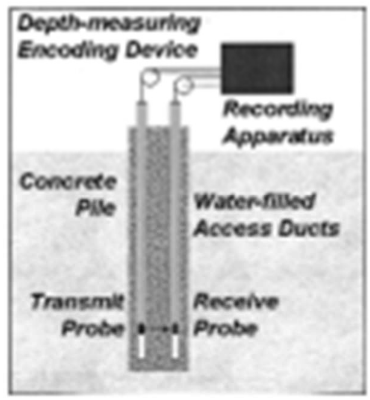


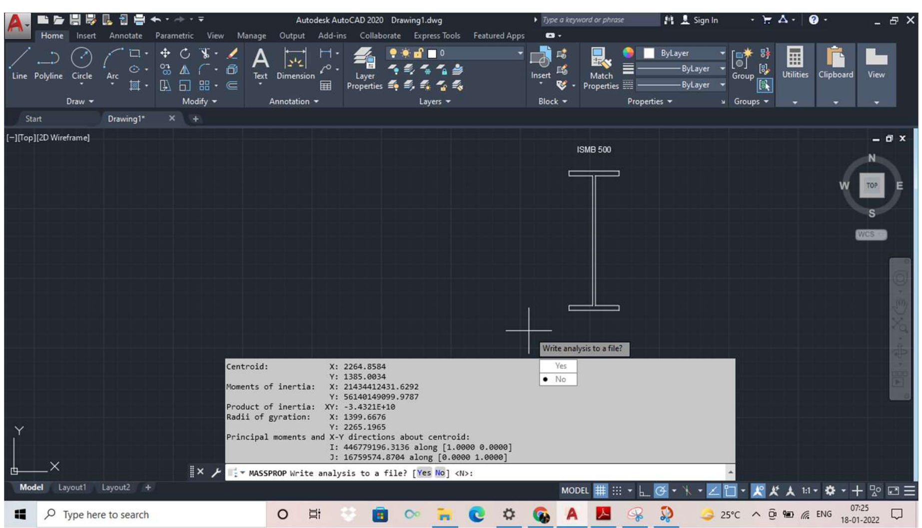
FIG. 3 Test Arrangement

- **Week No. 05**

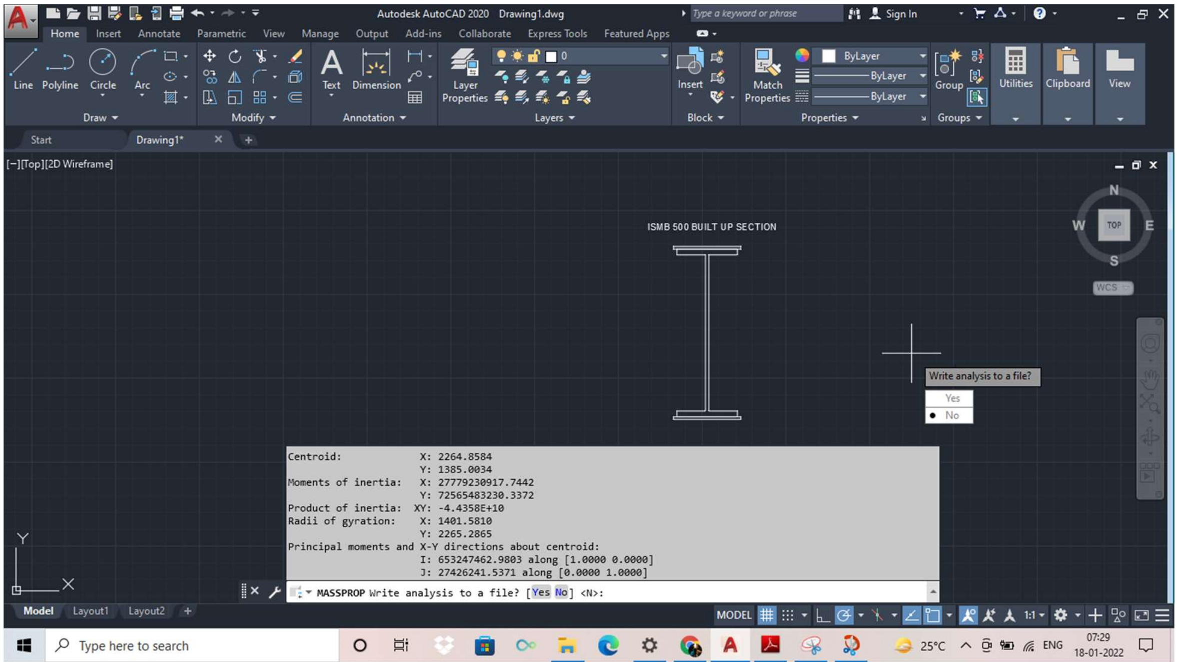
(7 January 2022- 13 January 2022)

<u>Work carried out:</u>

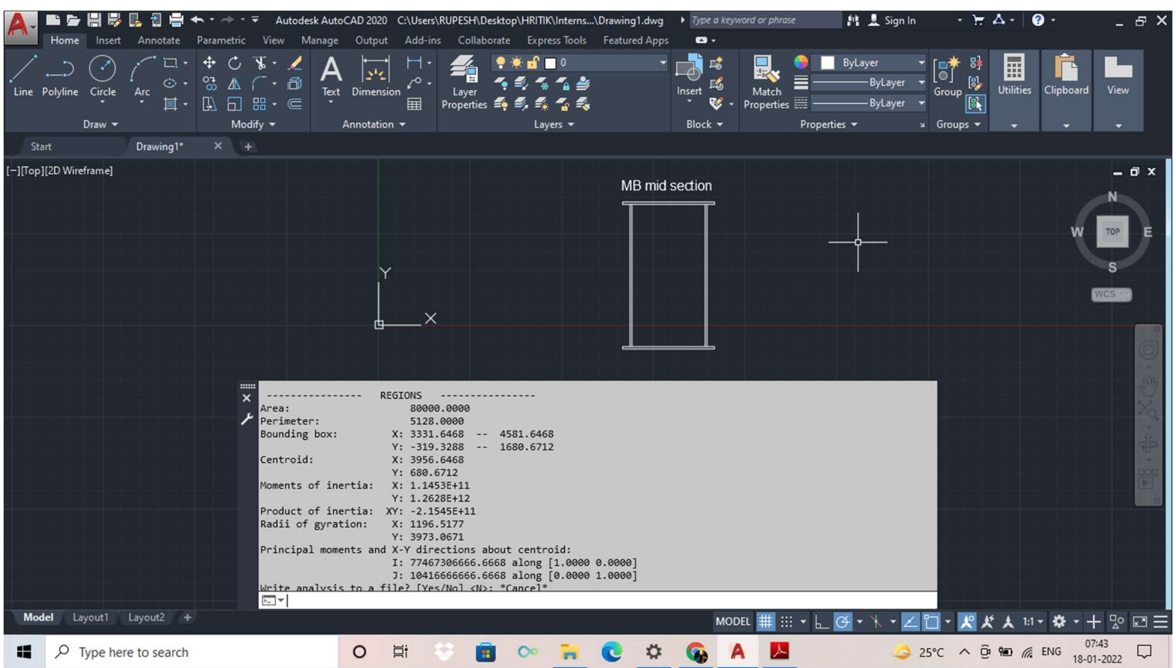
MOMENT OF INERTIA WAS CALCULATED FOR VARIOUS SECTIONS USING AUTOCAD.



<u>**For ISMB 500**</u>



For ISMB 500 Built-up-section



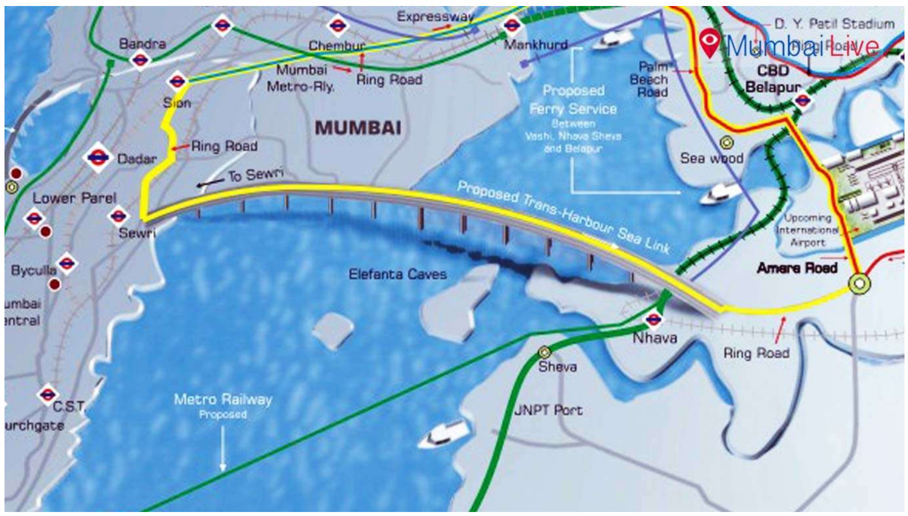
For Main Beam at Mid span having depth 2000 mm

➢ Week No. 06

(14 January 2022- 20 January 2022)

Visit at Mumbai Trans Harbour Link (MTHL)

PROJECT TYPE - Six-lane expressway sea bridge
LOCATION - Mumbai Metropolitan Region (MMR), Maharashtra, India
OWNER - Mumbai Metropolitan Region Development Authority (MMRDA)
TOTAL LENGTH – 21.79km (Package 1- 10.38km, package 2- 7.8km, package-3.61km)



The site location was package 3 having a total length of 3.613 km and the contractor involved was Larsen & Toubro. The estimated cost of package 3 is 1013.79 crore. During the visit following observation were made:

Casting yard of L&T

Casting of all the segments required during the construction of the bridge takes place here. Per day 3-4 segments are casted.

Reinforcement Cage of the segment in the casting yard

Segment after casting

Cantilever tendons Anchor Blister

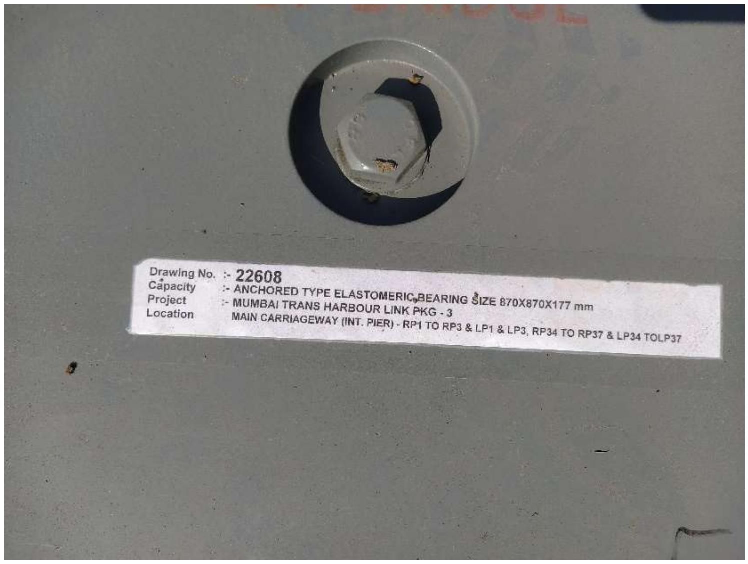
Sheathing Pipes

Sheathing Pipes creates the necessary void in the structure in which the pre-stressing steel (H.T. Strands) is free to move during stressing after the achieve concrete strength

Formwork of Segment

Reinforcement Steel Bars

Anchored Type Elastomeric Bearing



This is how the bearings are labelled with the size of the bearing(870x870x177mm) and the location where it has to be placed.

<u>Placing of segments for the alignment</u>

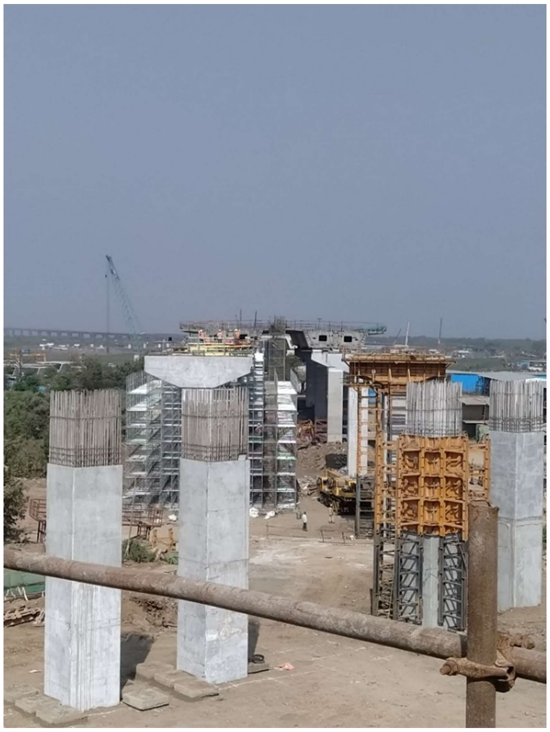
This is segmental bridge method, in this the bridge built in short sections (called segments), i.e., one piece at a time, as opposed to traditional methods that build a bridge in very large sections.

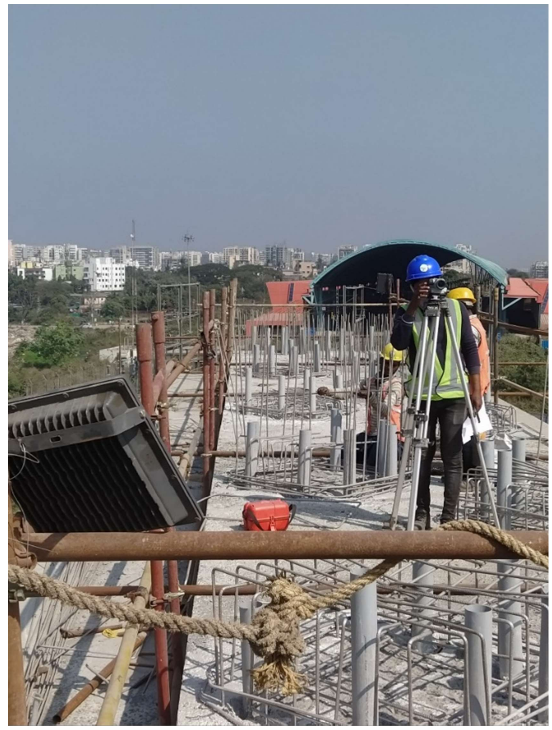
Cup-lock Scaffolding

Supports provided for cast-in-situ pier cap near railways tracks (span 60m)


Caging of the Pier cap


Pedestal provided on Pier cap





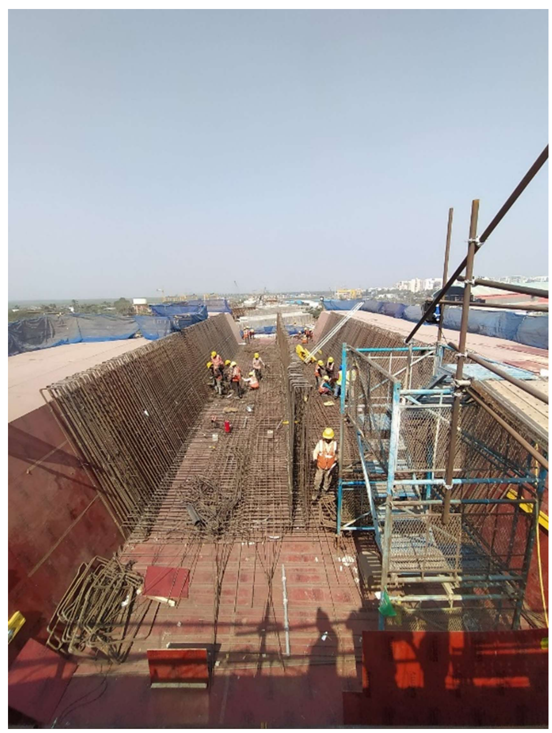
Here steel structure will be provided having the main span as 60m

Tag provided at the entrance of staircase

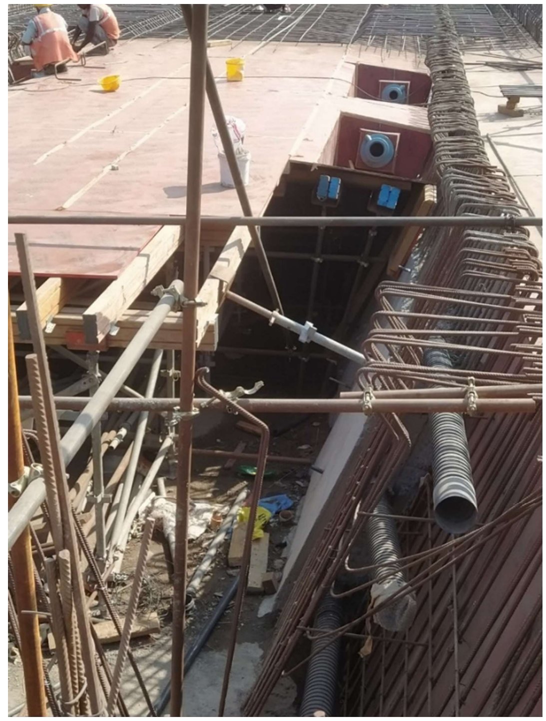
Always check the tag before entering, if its red then it may be dangerous to go up as some heavy work taking place. If its green then it is safe to go indication.


Blister provided in the cast-in-situ span

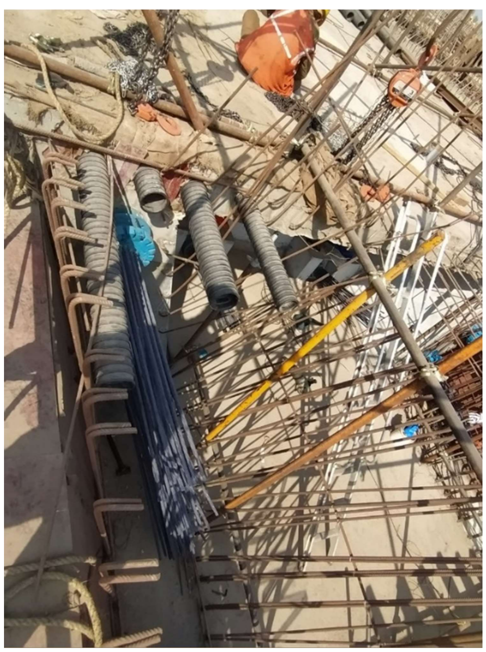
Blisters may form under both the waterproofing dense mastic asphalt layer or under the waterproofing membrane which is often applied as additional water protection under the mastic asphalt (MA).

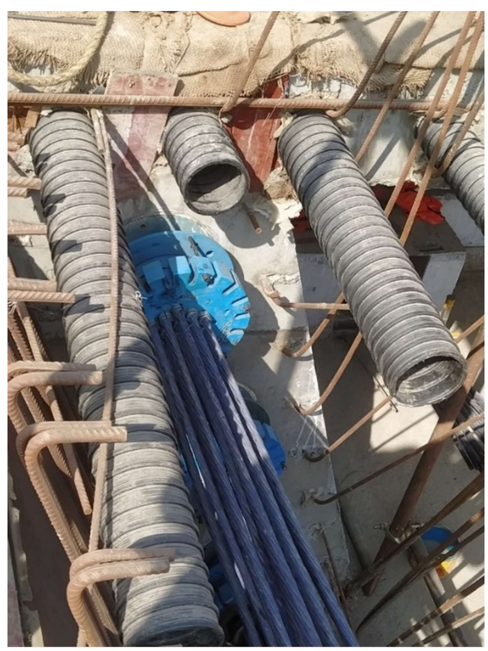



Cast-in-situ span Reinforcement work



Cast-in-situ span **Sheathing pipe placed in for prestressing**





The blue one are called as strand having a diameter of 15.2mm. They are also called as High tesnsile(HT) strand having Epoxy coating.

Epoxy-coated prestressing strand (ECS) is a relatively new product designed to reduce the effects of corrosion on steel strands in prestressed applications.

Set-up for Prestressing

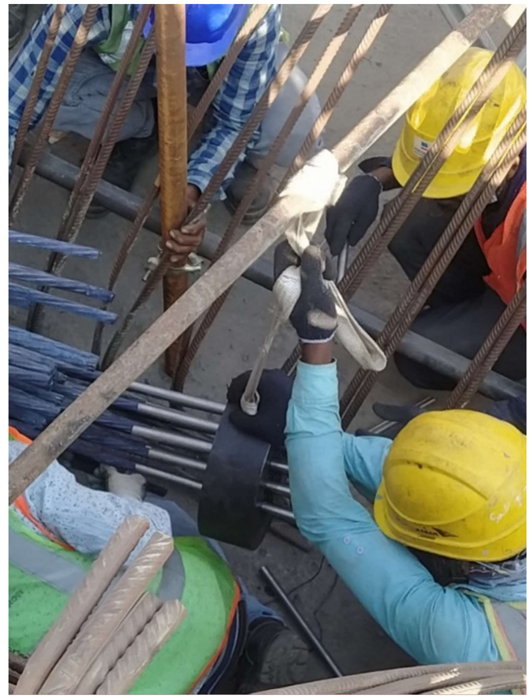
Pressure pump for applying pressure to tendons

Chain pully used for the adjustment of the jack

Tendons passed through jack for stressing process

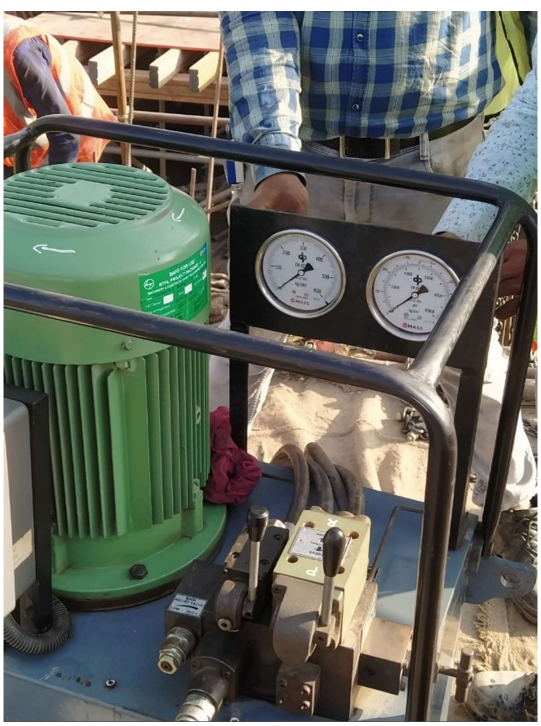
Wedge plate

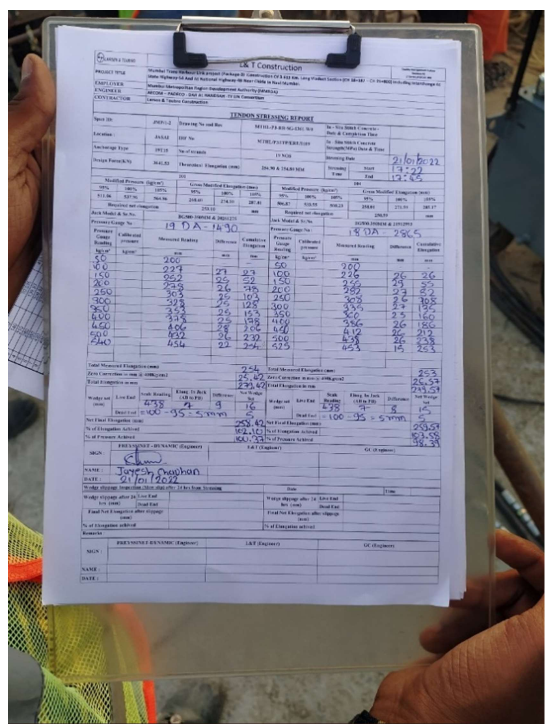
Anchor grip wedge



Wedges passed through the tendons

Guide pipe used to pass tendons through pulling plate





Dial Gauge (Units in kg/cm2)

Observation sheet used to note down the reading of Prestressing

- **Week No. 07**
  (21 January 2022- 27 January 2022)

  Work carried out:

1. STUDY OF IRC 78 (PILE FOUNDATION)
   Piles transmit the load of a structure to competent sub-surface strata by the resistance developed from bearing at the toe or skin friction along the surface or both. The piles may be required to carry uplift and lateral loads besides direct vertical load.
   The choice of piling system should be made depending upon the subsoil conditions and load characteristics of structures. The permissible limits of total and differential settlement, unsupported length of pile under scour and any other special requirements of project are also equally important criteria for adoption.

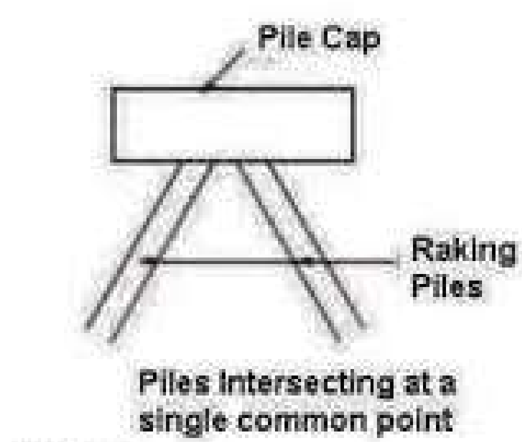
   <u>Spacing of piles</u>

- Spacing of piles should be considered in relation to the nature of the ground, their behaviour in groups and execution convenience
- Size of a cap carrying the load from the structure to the pile head or the size and effective length of a ground beam, may influence type, size and spacing of piles.
- The working rule which are generally suitable or followed for spacing of the piles are:-
  i. For Friction pile, the spacing centre should not be less than the perimeter of the pile or 3d where d is the diameter of the pile.
  ii. For End bearing pile the minimum spacing of the pile should be 2.5d and the maximum spacing should be 3.5d where d is the diameter of the pile.

Permissible tolerances for piles shall he as under:

i. For vertical piles 75 mm at piling platform level and tilt not exceeding 1 in 150
ii. For raker piles tolerance of 1 in 25.

Raker piles are piles driven inclined to vertical surface in order to provide resistance to the horizontal force. The purpose of raked pile is to sustain the majority of the horizontal load.



The maximum Rake to be permitted in pile shall not exceed the following:

i. 1 in 6 for all bored piles.
ii. 1 in 6 for driven cast-in-situ piles.
iii. 1 in 4 for Precast driven piles.

Criteria for Diameter of the pile:

- For marine structure the minimum diameter of pile shall be 1 m.
- For bridges beyond water zone and for bridges on load the minimum diameter should be 750 mm.

Differential settlement of Pile:

Non uniform or Un-even settlement of the soil beneath the foundation of a structure that may lead to “sinking” of different parts of the structure which causes cracks and other structural problems. The differential settlement between two neighbouring piers should not be greater than 1 in 400 of the span.

Factor of safety:

- Minimum factor of safety (FOS) should be 2.5
- For piles on rock, FOS shall be 3 on End bearing component.

For both Precast and cast-in-situ piles, the values regarding grade of concrete, water cement ratio, slump shall be as follows:

	Concrete Cast-in-situ by Tremie	Precast Concrete
Grade of concrete	M 35	M35
Min. cement contents	400 kg/m3	400 kg/m3
Max. W.C. ratio	0.4	0.4
Slump (mm)	150-200	50-75

Routine load test:

The minimum number of tests to be conducted is as given below for confirming pile capacity.

Total number of Piles for the Bridge	Minimum No. of Test Piles
Up to 50	2
Up to 150	3
Beyond 150	2 percent of total piles (fractional number rounded to next higher integer number).

Structural Design of Pile

A pile as a structural member shall have sufficient strength to transmit the load from structure to soil. The pile shall also be designed to withstand temporary stresses, if any, to which it may be subjected to, such as, handling and driving stresses. The test pile shall be separately designed to carry test load safely to the foundation.

Reinforcements for Cast-in-situ Piles

- The area of longitudinal reinforcement shall not be less than 0.4 percent nor greater than 2.5 percent of the actual area of cross-section in all cast-in-situ concrete piles.
- Clear spacing between vertical bars shall not be less than 100 mm.
- Grouping of not more than two bars together can be made for achieving the same.
- Lateral reinforcement shall be provided in the form of spirals with minimum 8 mm diameter steel, spacing not more than 150 mm.

Reinforcements for Pre-cast driven Piles

Area of longitudinal reinforcement shall not be less than the following percentages of the cross-sectional area of the piles:

- For piles with a length less than 30 times the least width - 1 .25 percent
- For piles with a length 30 to 40 times the least width - 1 .5 percent
- For piles with a length greater than 40 times the least width -2 percent.

Design of Pile Cap

- The minimum thickness of pile cap should be 1.5 times the diameter of pile.
- A minimum offset of 150 mm shall be provided beyond the outer faces of the outer-most piles in the group.
- If the pile cap is in contact with earth at the bottom, a levelling course of minimum 80 mm thick plain cement concrete shall be provided.
- The top of the pile shall project 50 mm into the pile cap and reinforcements of pile shall be fully anchored in pile cap.

Levelling course:

A course of variable thickness used to eliminate irregularities in contour.

Levelling course

The pile cap may be designed using beam theory or, by using 'strut & tie' method. All reinforcement in pile cap shall have full anchorage capacity beyond the point at which it is no longer required.

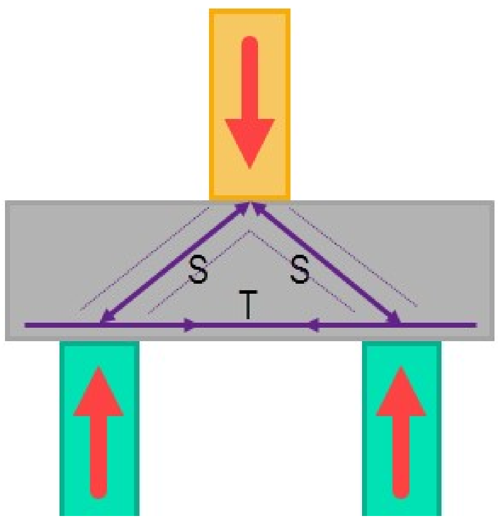
By using Beam theory

In this the pile cap is handled as an inverted beam and designed like a beam for bending and shear. But if the circumstances require a higher pile cap and thus the span-to-depth ratio is less than 2 which is the limit of the beam theory. Then the pile cap is designed using strut & tie method.

By using Strut & Tie Method

In the strut and tie method, the truss components are the followings:

- Struts (S): concrete
- Ties (T): reinforcement
- Nodes: intersections of struts and ties



2. STUDY OF CONSTRUCTION OF BRIDGE IN MARINE CONDITIONS

   Three main methods of Construction of bridges in water are:

   i. Battered Piles:
   Battered piles are piles hammed into the water at an inclined angle to give the ability to carry lateral loads.

Battered Piles installation process:

- Use of a Barge for easy transportation of piles

  A barge is a flat-bottomed boat, built mainly for river and canal transport of heavy goods/materials.

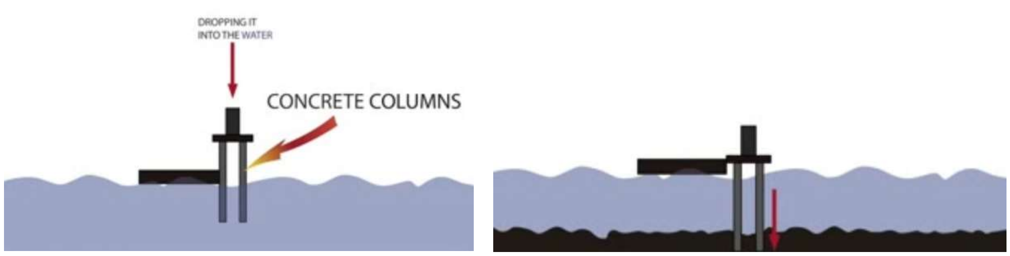
- Moving the pile driver with the help of a barge to the required location

  A pile driver is a mechanical device used to drive piles (poles) into soil to provide foundation support for buildings or other structures.

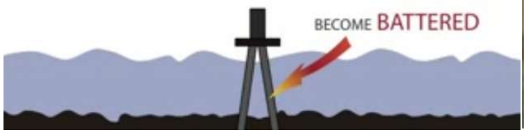
Barge and Pile Driver

- Drop the pile driver and hammer the piles into the water

Pile driving is a process of forcing a pile into the ground. The pile drivers are made of different materials (concrete piles or steel piles). The pile drivers are dropped into the water and hammered to the bottom depending on the depth of the water and the type of soil underneath.



The pile is hammered into water to the bottom until it becomes battered. A battered pile means the piles are driven down until it turns outward or inward at an angle, this makes the pile firm and increase their ability to carry lateral loads.



Once the piles are firm and above the water level, the pile caps are constructed and the construction of the bridge can continue.

ii. Cofferdam:

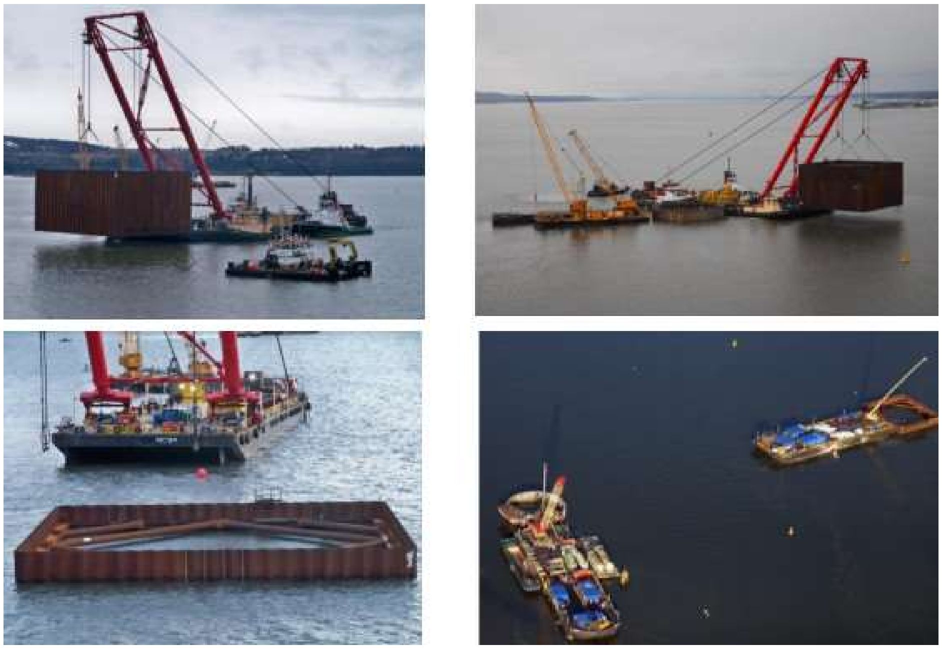
A cofferdam is a temporary structure (in boxes or circular shapes) which is built to remove water from an area and make it possible to carry on the construction work under reasonable dry condition. They are required for projects such as dams, construction of bridge piers and abutments.

<u>Construction of cofferdams</u>

The cofferdam can be built by placing the sheet piles in water. Sheet piles are interlocked or welded together; they must be airtight.

<u>Sheet piles</u>

The cofferdam can be built by placing the sheet piles in water or built on land and placed in the water with the help of a barge.



Placing of cofferdam using Crane or Barge

Creating Dry work space by pumping the water out

The water in the enclosed cofferdam is pumped out until the depth of water is reached. This gives a dry environment for the workers to carry out the construction process.

iii. Caisson:

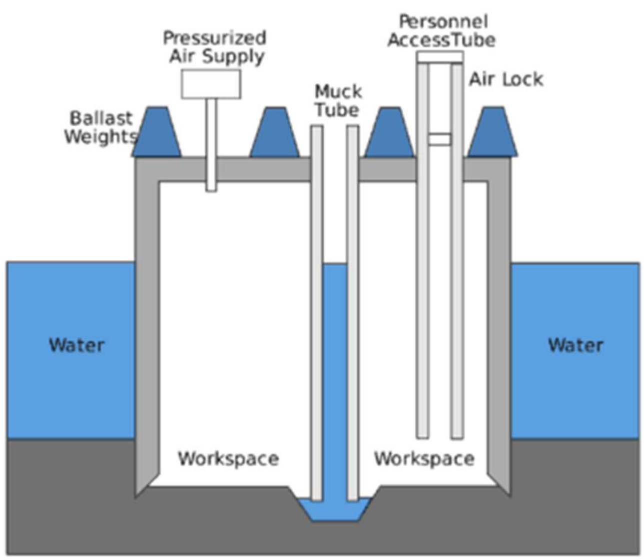
A Caisson is a watertight structure used for retaining water in order to work on the foundations for bridges, piers, and other structures. The water is pumped out to create a completely dry work environment. Some caissons can be open-air caissons, whereas others may use compressed air to keep the mud and water out. Installation involves pushing it into the mud, until it reaches clay or another solid foundation. Due to the pressures inside of caissons, there are many risks to the workers.

Different types of caissons

Box caissons are put into place and filled with concrete, and may make up the foundation for other structures. These caissons must be anchored to allow them to remain in the proper position until they have been filled with concrete.

Bos Caisson

Compressed air caissons this type uses the power of compressed air to create a dry environment which is more adequate for the laying of concrete.



Compressed air caisson

CONCLUSION

Piles and Pile foundations have been in use since prehistoric times. Pile is commonly described as a columnar element of a building foundation. Its function is to transfer the load from a superstructure to the hard layer in the soil, or on to the rocks. The safe bearing capacity of the pile is mainly tested by performing a Pile Load Test on it. Use of load test databases for comparison between calculated and interpreted capacities has provided insights on the suitability of use of design methods under varying pile and soil conditions. During this period, I was able to identify the different classification of the piles, the materials used & various technique used for testing them. Study of various IS Codes, IRC and ASTM help me gain more knowledge about different Pile Load Test and also their integrity testing. Also, the Study of Engineering drawings and Design calculations for initial pile load test using Kentledge platform & Ground Anchors for National Highway Authority of India (NHAI) LTD for Kerala Road Project helped me to understand the actual design calculations done for the testing of Piles. Visiting to Mumbai Trans Harbour Link (MTHL) added some more knowledge and experience about the on-site construction work and the difficulties faced during the construction period. I was able to see Pre-stressing process in-situ and also learned new concepts like Segmental method of Bridge construction, provisions of the Blisters in segments while casting and many more techniques used in Infrastructure Projects. Overall, I would describe my internship as a positive and instructive experience which is surely going to enhance my technical skills and Knowledge in Infrastructure.