PROJECT REPORT

(May-June 2023)

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Project Introduction

This report covers my works as an intern with RIE Structural Pvt. Ltd, an Engineering Consultancy in Mumbai between 5th May 2023 and 30th June 2023.

Initially, I studied the drawings for various types of bridges, IRC codes and MIDAS Software. I was given training on MIDAS Software, functioning of the various components of the bridges, various loads and its effects carried on by the components.

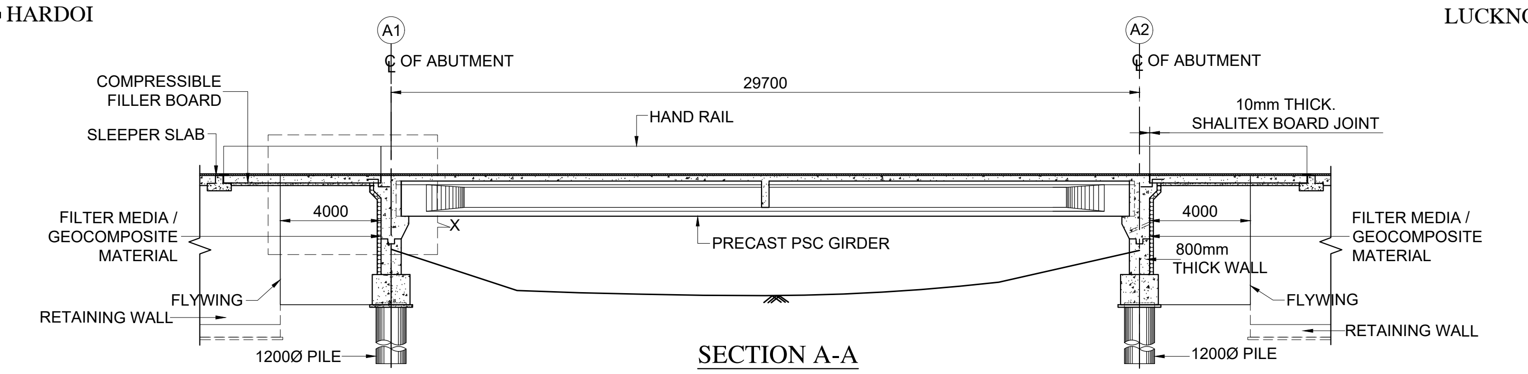
I was assigned a single-span integral bridge. It is a part of Hardoi bypass on NH 731 in the state of Uttar Pradesh. Following are the features of this bridge:-

- Foundation – Single row of 3 piles of 1.2 m dia.
- Substructure – Wall Type Abutment supported over Piles
- Superstructure – Precast PSC I-Girders at 2.7m center to center and Deck Slab

Approach for the Analysis and Design

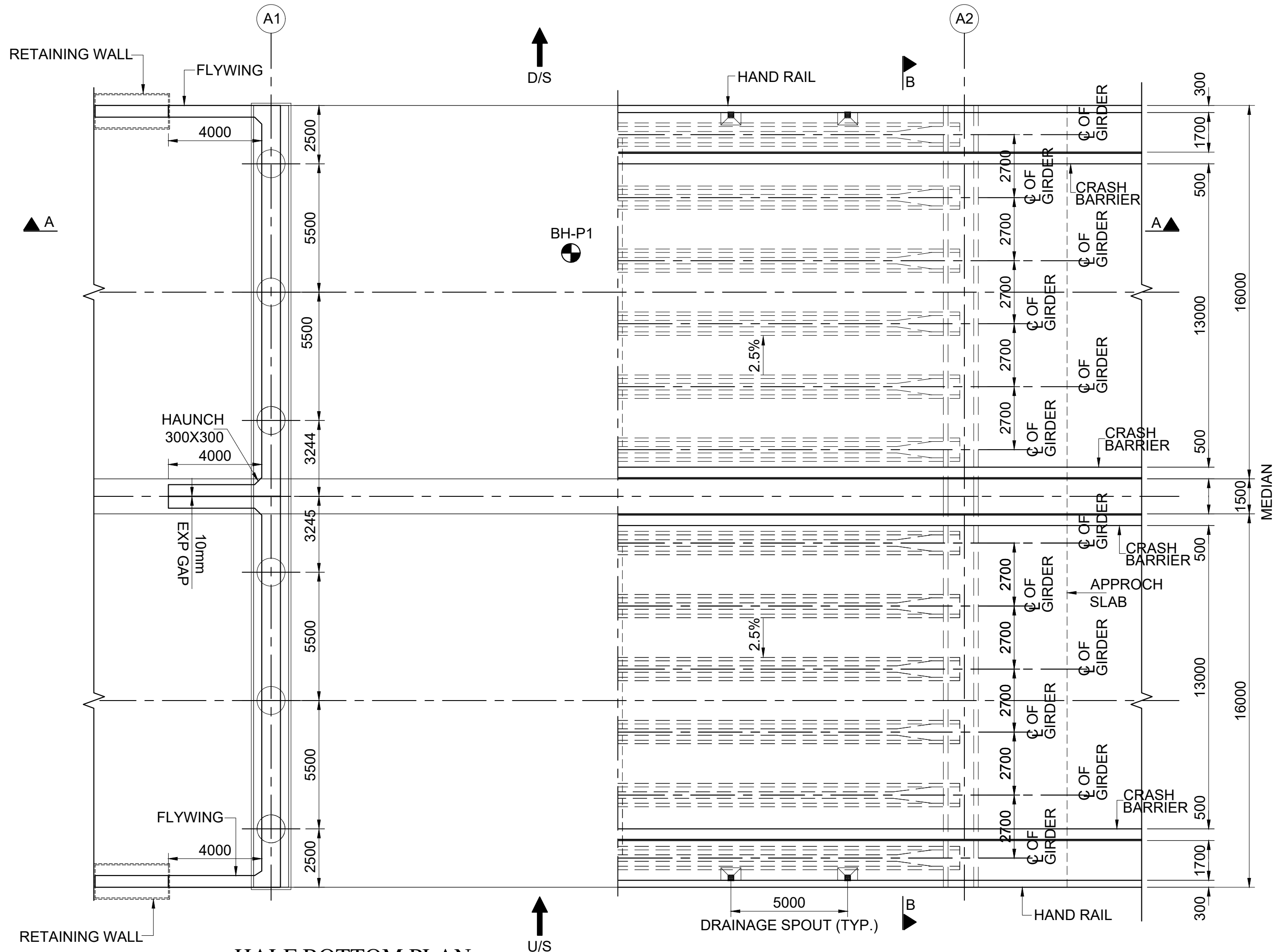
- Modeling of the structure has been done considering the construction sequence as this is an Integral bridge. Some of the forces have been carried as simply supported during construction which get locked even if the structure becomes integral. For this various construction stages have been modelled.
- As girders are precast and launched and deck slab is casted over it, these loads are carried over by the girders as simply supported. Stresses due this get locked in the structure and are not acted upon like integral bridge.
- Loading was applied over the model and analysis has been carried out.

GAD of the Bridge is attached below for an understanding of the Bridge Type.



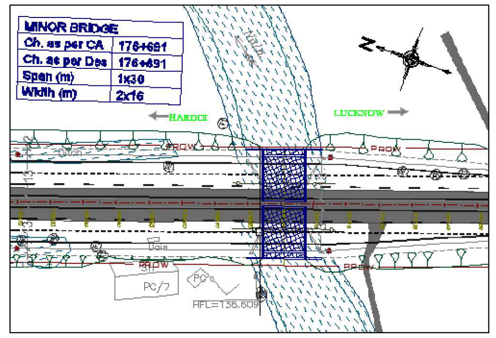
SECTION A-A

FRL	138.496		138.466
OGL.	135.500	133.659	135.500
TIE BEAM TOP LVL.	134.500		134.500
TIE BEAM BOTTOM LVL.	133.300		133.300
PILE BOTTOM LVL.	109.300		109.300
CHAINAGE	176+676.15	176+691	176+705.85



HALF BOTTOM PLAN

HALF TOP PLAN



KEYPLAN

Structural dimensions may change during detailed design.

HYDRAULIC DETAILS.

H.F.L	135.521m
SCOUR ABUTMENT	133.301m
DISCAHRGE, Q	1335 cusec =37.80cumes

CONSTRUCTION SEQUENCE:-

1. Ground should be well compacted at abutment location before pile work.
2. Piles will be bored & concreted at the abutment location.
3. Tie beam, Wall & Abutment cap will be casted.
4. The superstructure consist of pre-cast PSC girders that will be casted in the casting yard and prestressed as per the age and min.concrete strength as mentioned in Girder Drawing.
5. Girders will be launched supported over the abutment cap.
6. During construction all girder shall be laterally tied together to avoid dislocation.
7. Shuttering and Reinforcement for deck slab, abutment diaphragm and intermediate diaphragm will be erected.
8. The deck slab and diaphragms will be casted together.
9. The shuttering will be removed after concrete attains the desired strength.
10. The backfill behind wall should be fill simultaneously at abutment A1 and A2 after construction. The difference in fill should not be more than 600mm each side.

NOTES:-

1 . All dimension are in mm and levels are in meter,unless otherwise noted. Only written dimension shall be followed.
2 . The structure is designed for one lane of IRC-70R loading and one lane of class A or three lane of IRC class A loading which ever governs.It is also cheked for SV loading.
3 . Grade of concrete in various components shall be as under.

Deck Slab	- M40
PSC (Girder)	- M50
Abutment	-M35
Wall	-M35
Pile & Tie beam	-M35
Intermediate Diaphragm	-M40
End Diaphragm	-M40
Hand Railing	-M40
Levelling Course	-M10
Crash Barrier	-M40
Approach - Slab	-M30

4. The Reinforcement steel is HYSD bars grade Fe-500D conforming to IS:1786-2008
5. Clear cover to outer most reinforcements shall be as follow :
   - i) Superstructure - 45mm
   - ii) Substructure - 50mm
   - iii) Pile,Tie beam - 75mm
   - iv) Wall
     - Earth face - 75mm
     - Water face - 75mm
   - v) Flywing
     - Earth face - 75mm
     - Water face - 75mm
6. Type -1 wearing coat consisting of bituminous concrete 50mm thick laid in single layer as per MORTH 5th revision CL. 2702.1 shall be provide. 3mm thick asphalto seal or equivalent waterproofing layer to be layed below wearing coat.
7. This drawing shall be read in conjunction with relevant highway drawing. FRL Camber and section shown in the drawing shall be verified with corresponding approved drawing of highway before

DESIGN DIRECTOR	NATURE OF REVISION & DESCRIPTION	REV.	DATE
	FIRST ISSUE	00	05.04.2023

AUTHORITY: NATIONAL HIGHWAYS AUTHORITY OF INDIA (MINISTRY OF ROAD TRANSPORT & HIGHWAYS)

INDEPENDENT ENGINEER: G-ENG ADVISORY JV VOYANTS SOLUTION ASS. CIVIL MANTRA

CONCESSIONAIRE: HARDOI HIGHWAYS PVT. LTD.

DESIGN CONSULTANT: RAJ INFRA ENGINEERS. 802, RUBY CRESCENT, ASHOK CHAKRAVATI ROAD, ASHOK NAGAR, KANDIVALI (E) MUMBAI 400 101.

PROJECT NAME: IMPROVEMENT AND UP-GRADATION OF EXISTING ROAD TO 4-LANE WITH PAVED SHOULDER FROM KM 175.080 TO 229.070, END OF HARDOI BYPASS TO END OF HARDOI DISTRICT OF NH 731 ON HAM BASIS IN THE STATE OF UTTAR PRADESH.

DRAWING TITLE: GENERAL ARRANGEMENT DRAWING FOR MNB AT CH.176+691 (1X30)

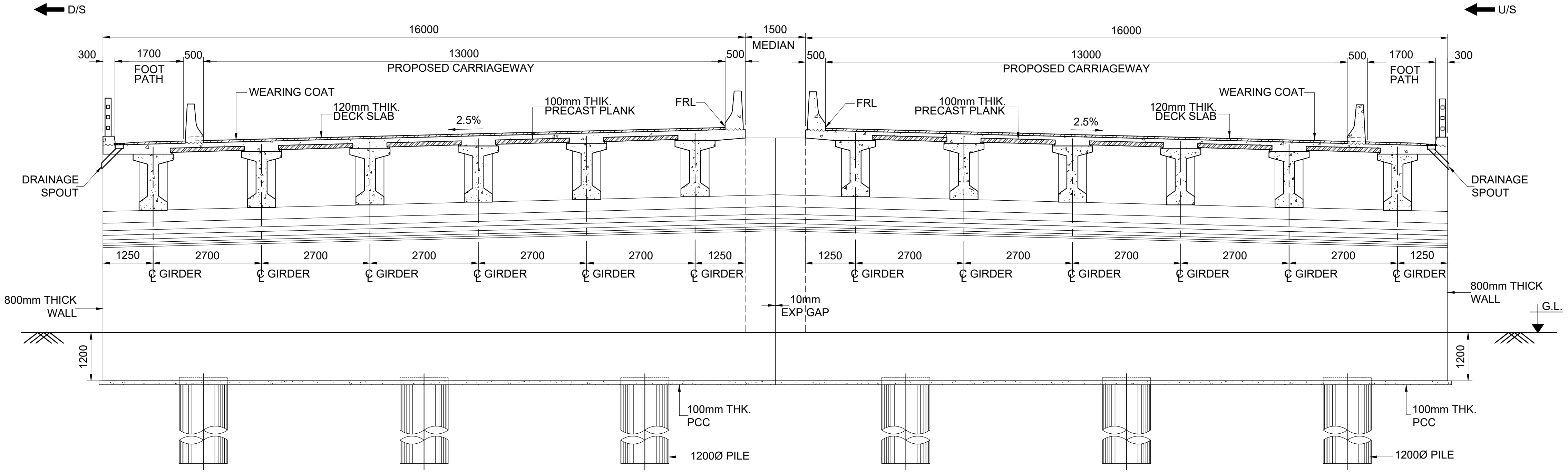
DRAWN :	V.D.	CHECKED :	S.J	SCALE :	NTS
APPROVED :	V.A.	REVIEWED :	V.G.	DATE :	05.04.2023

METHOD OF PROJECTION

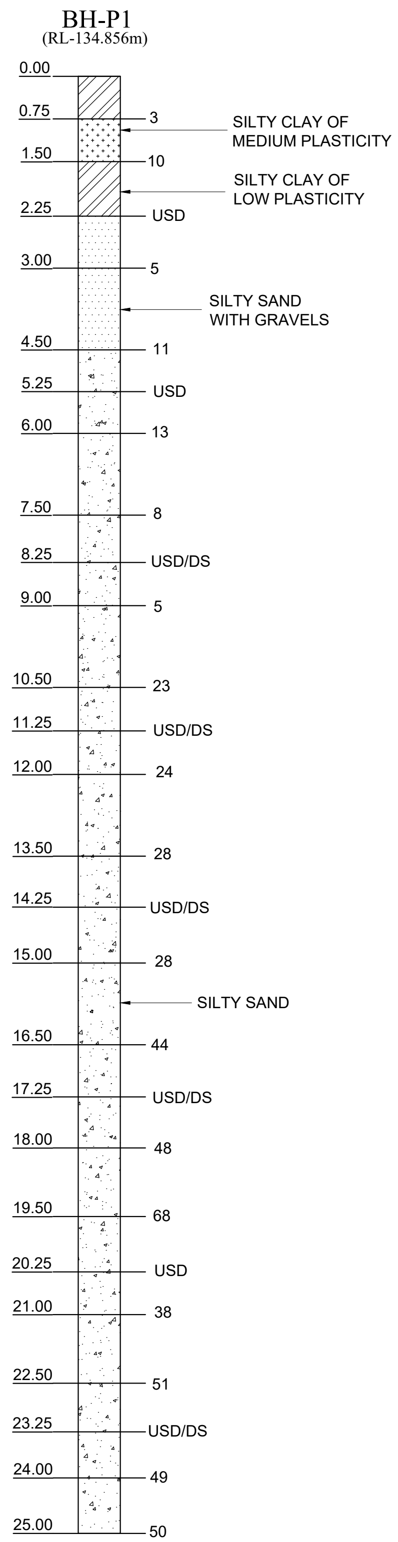
DRAWING NO. PNC-HH-176+691-MNB-101

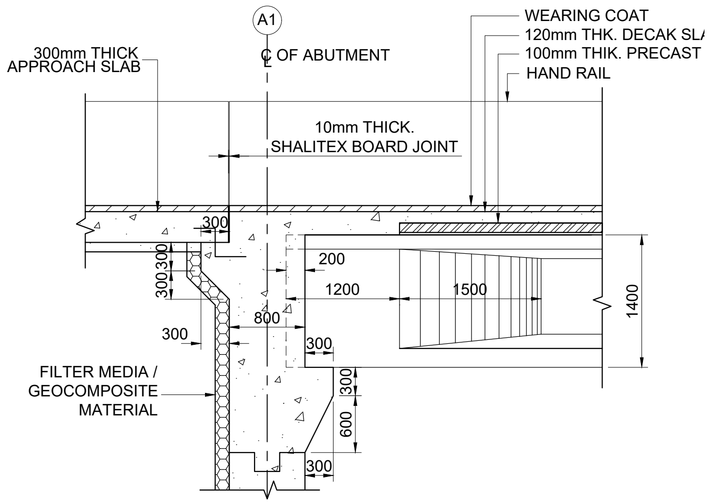
SHEET 01 OF 02 REV. 00

A3

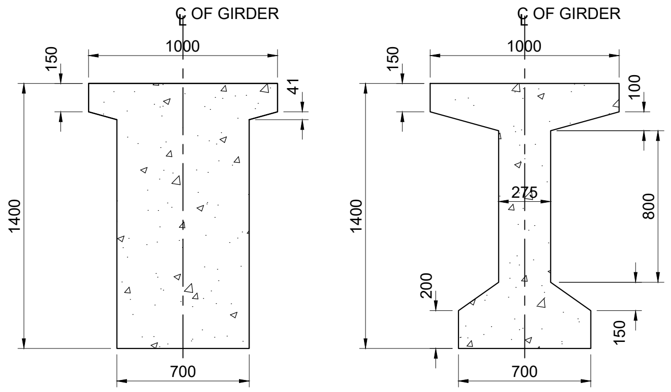


SECTION B-B





DETAIL - X



DETAIL OF PRECAST PSC GIRDER

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DRAWING NO. PNC-HH-176+691-MNB-101

SHEET 02 OF 02 — REV. 00

A3

Construction Sequence: -

1. Piles will be bored & concreted at the abutment location.
2. Tie beam connecting all the 3 piles at abutment, abutment wall & cap will be casted.
3. The superstructure consists of pre-cast PSC girders that will be casted in the casting yard and prestressed as per the age and minimum concrete strength as mentioned in Girder Drawing.
4. At this stage girders are checked for stresses developed due to prestressing force applied as this is a critical stage for the girder due to huge prestressing force applied.
5. These girders will be launched and supported over the abutment cap.
6. During construction all girder shall be laterally tied together to avoid dislocation.
7. Shuttering and Reinforcement for deck slab, abutment diaphragm and intermediate diaphragm will be erected.
8. The deck slab and diaphragms will be casted together.
9. The shuttering will be removed after concrete attains the desired strength.
10. The backfill behind wall should be fill simultaneously at abutment A1 and A2 after construction. The difference in fill should not be more than 600mm each side.

Construction Stage Analysis and Modelling :-

1. Substructure and Foundation modelling- Piles are laterally supported by soil which apply earth pressure. Soil springs are applied all over the pile to model the interaction between soil and pile.

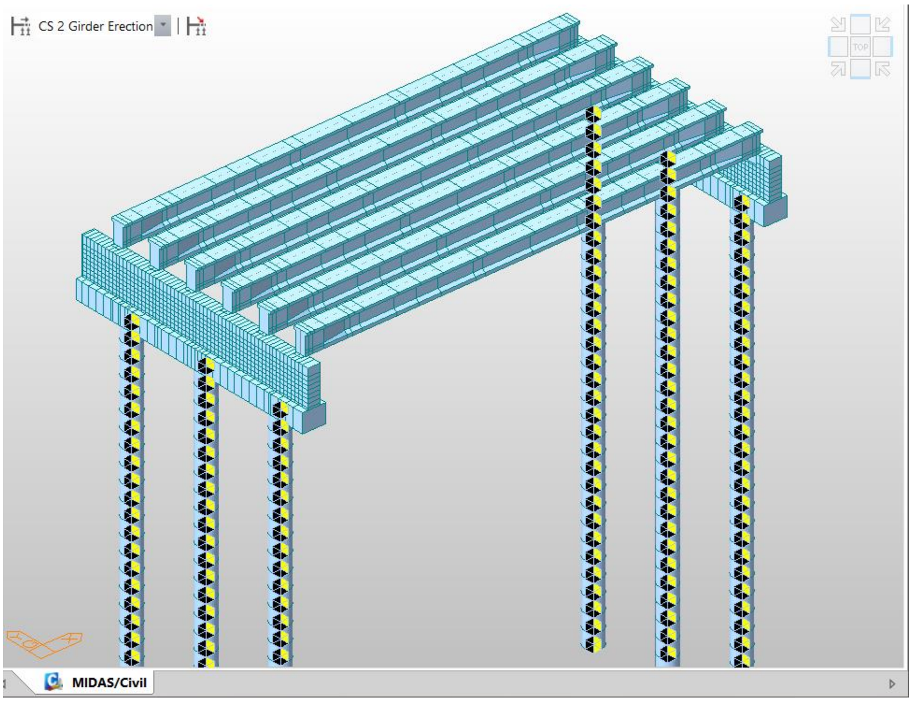


Figure – Showing girders launched over pier cap

2. Girder modelling and analysis-
    - Girders are initially simply supported over pier cap.
    - These are I- girders which are tapered at the ends to become T-girders. This is done in order to accommodate the anchorage blocks at ends.

- Pre-stressing force is applied on the girders to counter the deflection and bending moments caused by the dead load and other loads. As a result of this overpowering pre-stressing force, the girder hogs upwards and so it needs to be checked for stresses developed at this critical stage.

PRESTRESSING TENDONS

- Tendons can be Post-Tensioned or Pre-Tensioned. In pre-tensioning, the tendons are stretched prior to placing concrete while in post-tensioning the tendons are stressed after the concrete has been casted. **Cables are post-tensioned in our case.**
- The tendons are stressed by the use of hydraulic jacks.
- The cables are labelled as 12k13 or 12t13 where 12 represents the maximum number of strands in a prestressing cable while 13 represents the nominal diameter.

- Consecutive cables are anchored from opposite ends due to the huge size of hydraulic jacks. Anchorage slip of 6 mm is provided for transfer of prestress to concrete.

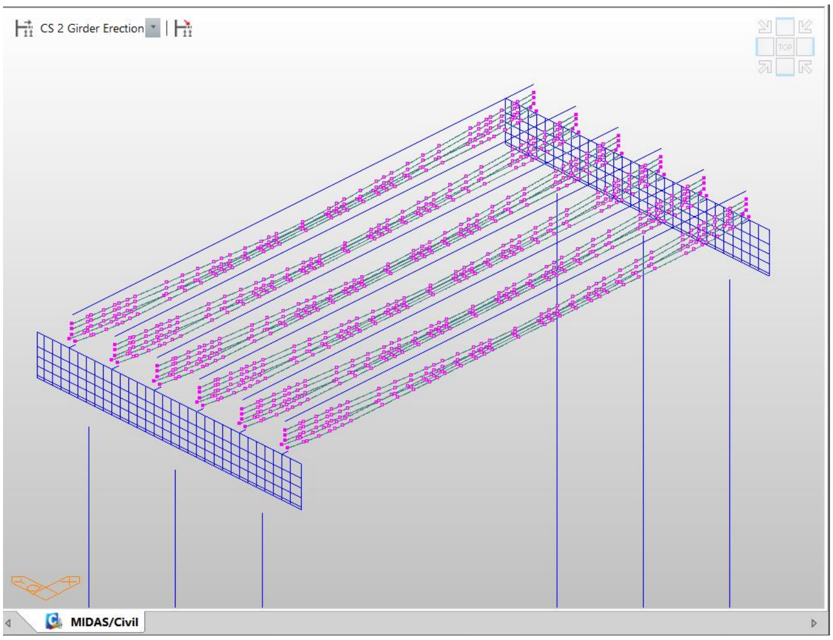


Figure-Showing Pre-stressing tendons

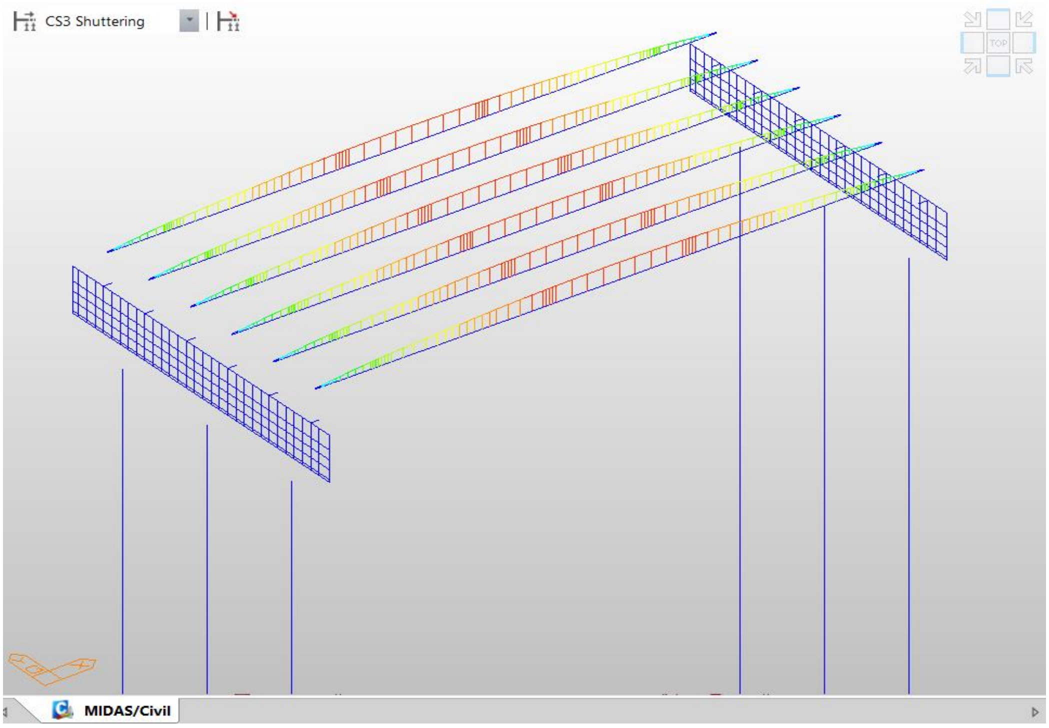


Figure – Showing BMD due to Pre-stressing tendons

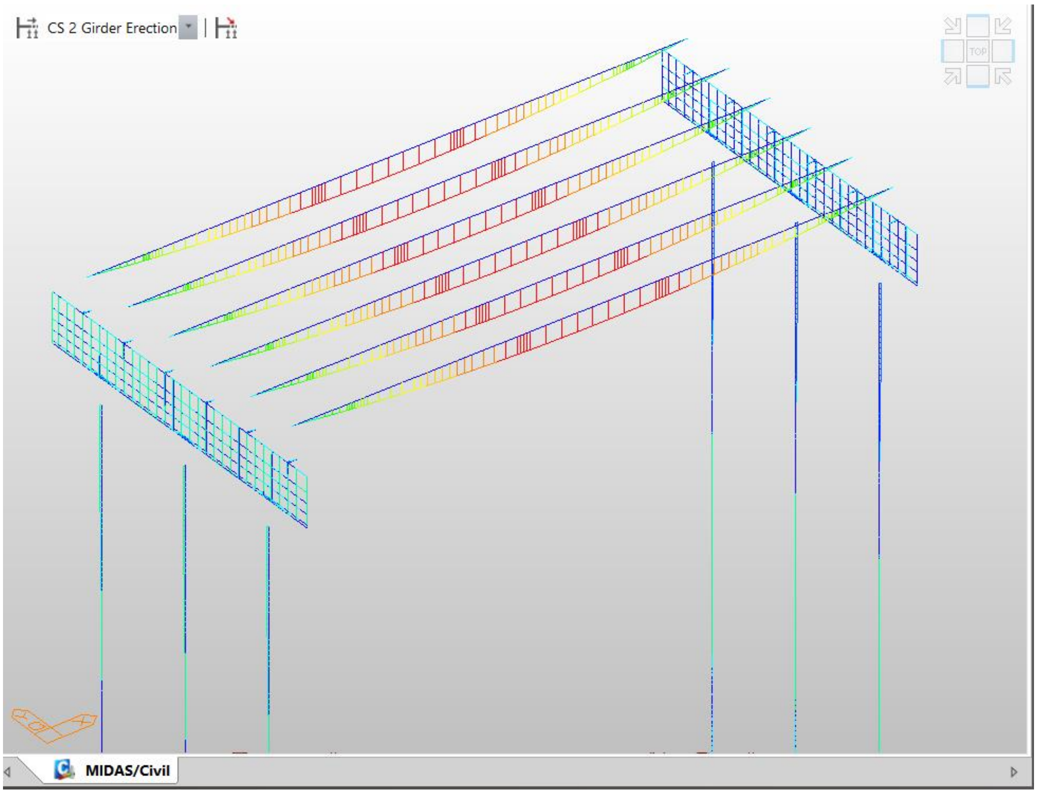


Figure – Showing BMD due to Girder Weight

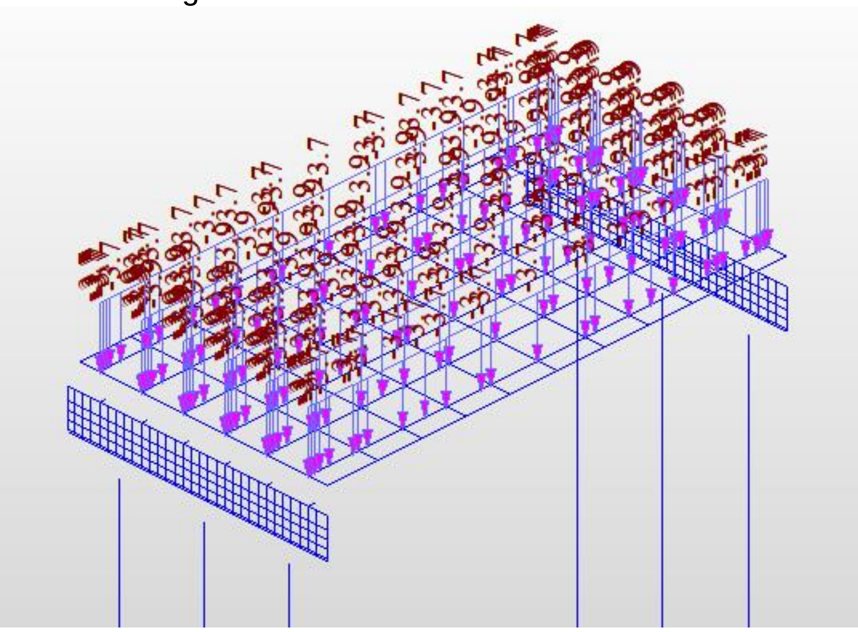
- Deck slab with a weight almost equivalent to that of the girder is also applied over the girder which will act as simply supported load over the girders.
- Along with deck, diaphragm at abutment location is also casted. When the concrete hardens, it makes the superstructure integral with substructure.
- Further, loads like SIDL (Super-imposed Dead Load) which consist of Wearing coat, Crash Barrier and traffic live loads are applied and then analyzed.
- Structure is also analyzed for other environmental forces like wind, earthquake and temperature.

LOADINGS AND LOAD COMBINATIONS

The loads applied are with reference to the provisions of IRC 6

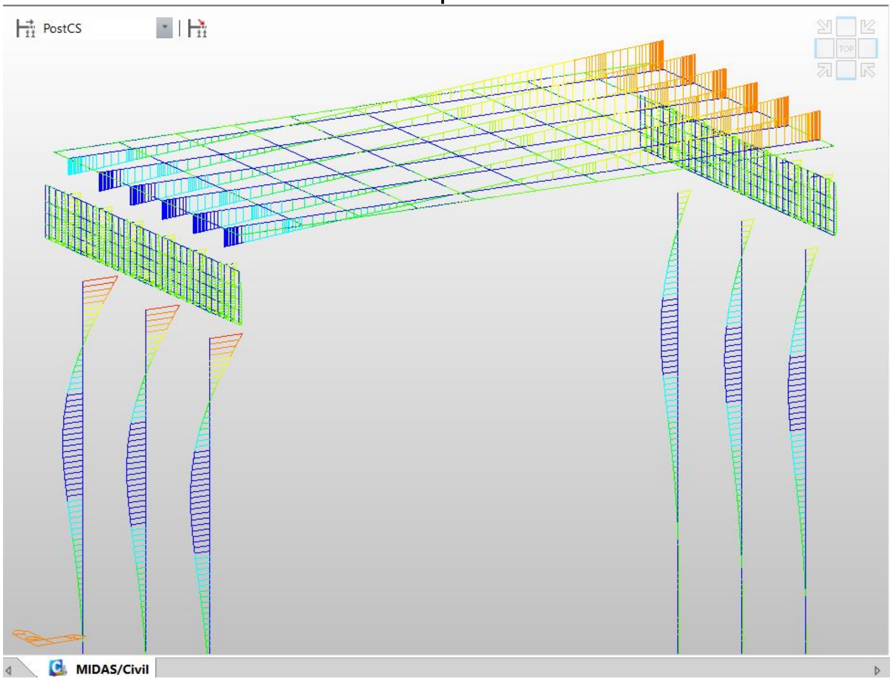
1. Dead Load (DL) :- This comprises of the loads corresponding to the Self-Weight of various bridge components like Abutment wall, girders and deck slab etc.
2. Construction Stage Live Load :- This refers to the load due to the machinery which is used for construction and the labour that works on it.

3. SIDL Wearing Coat and Crash Barrier.



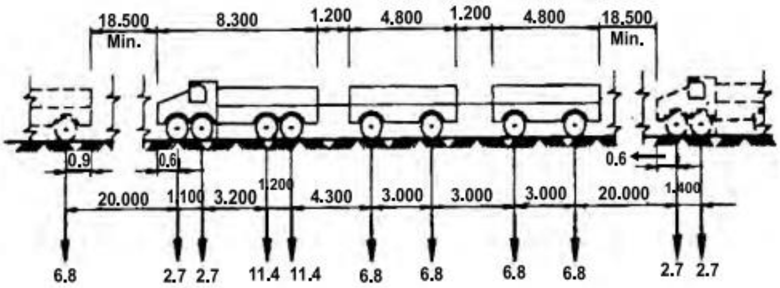
4. Earth Pressure Loads:-
    - Active Earth Pressure – This occurs when the abutment wall moves away from the soil. In this case, minimum earth pressure exerts over the wall. This is called Ka.
    - Passive Earth Pressure – This occurs when the abutment wall moves significantly towards the soil. In this case, maximum earth pressure exerts over the wall. In our case, movement of the wall towards the soil is limited. This movement is mainly due to temperature rise which is summer condition. Earth Pressure corresponding to this movement is called K*. Procedure for calculation of K* is as per IRC:SP-115 which is the code for Integral Bridges.
    - Earth Pressure at Rest – This occurs when wall remains stationary. This is called Ko and its value is in between Ka and K*.
    - Live Load Surcharge – They are applied on the soil behind the wall. These are due

to vehicles standing over the embankment behind abutment that increase the vertical stress which consequently increase the lateral stress.
BMD for Earth Pressure in the positive X direction is as follows:s



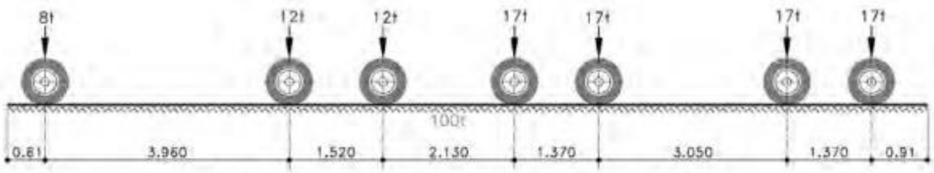
5. Moving Loads :- There are various classes of vehicles-

- Class A refers to the normal vehicles that ply on road.



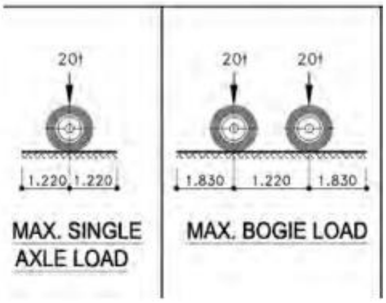
Class A Train of Vehicles

- Class 70R Wheeled – This refers to industrial multi-axle truck loading. A total of 100 tonnes is distributed over various axles as shown.

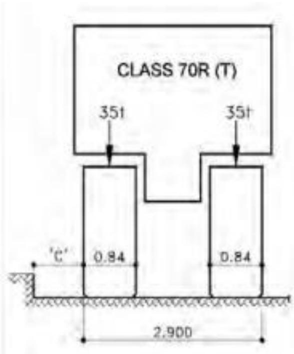


CLASS 70R (WHEELED) - LONGITUDINAL POSITION

Max. single axle and Bogie load is as shown below:-



Class 70R Tracked – This refers to army tank loading wherein a load of 70 tonnes is applied as a uniformly distributed load.



For multi-lane bridges meaning having carriageway width of 5.3m and above, each class 70R loading is considered to occupy 2 lanes and no other vehicle shall be allowed in these two lanes.

Live load combination corresponding to the carriageway widths have been given in IRC:6 as follows:-

Table 6: Live Load Combination

S. No.	Carriageway Width (CW)	Number of Lanes for Design Purposes	Load Combination (Refer Table 6A for diagrammatic representation)
1)	Less than 5.3 m	1	One lane of Class A considered to occupy 2.3 m. The remaining width of carriageway shall be loaded with 500 kg/m^2
2)	5.3 m and above but less than 9.6 m	2	One lane of Class 70R OR two lanes for Class A
3)	9.6 m and above but less than 13.1 m	3	One lane of Class 70R for every two lanes with one lanes of Class A on the remaining lane OR 3 lanes of Class A
4)	13.1 m and above but less than 20.1 m	4	One lane of Class 70R for every two lanes with one lane of Class A for the remaining lanes, if any, OR one lane of Class A for each lane.
5)	16.6 m and above but less than 20.1 m	5	
6)	20.1 m and above but less than 23.6 m	6	

- Special Vehicle (SV) loading – This loading is considered to ply close to the center of carriageway and no other live load is to be considered when this loading is applied. This loading is applied in a very controlled manner.

  It is assumed that this loading will not ply when weather conditions are extreme. Hence, effect of wind, seismic and temperature will not be considered for load combinations with SV loading.

  Since Special Vehicle is considered to move at a speed not more than 5 kmph, effect of tractive force, braking force and dynamic impact on live load will not be considered.

  The longitudinal axle arrangement of SV loading is as shown:

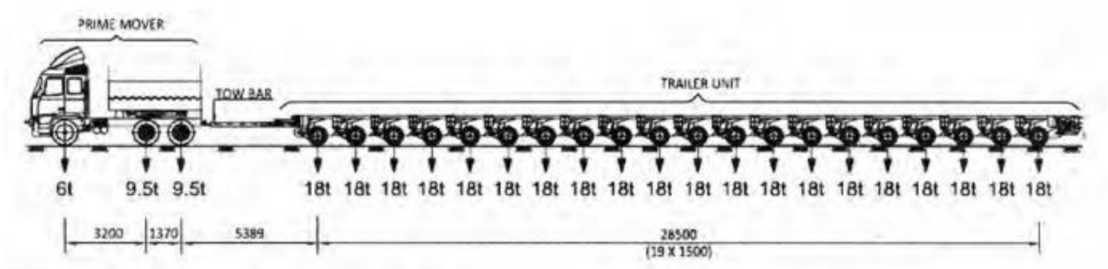


Fig. 6: Typical Axle Arrangement for Special Vehicle

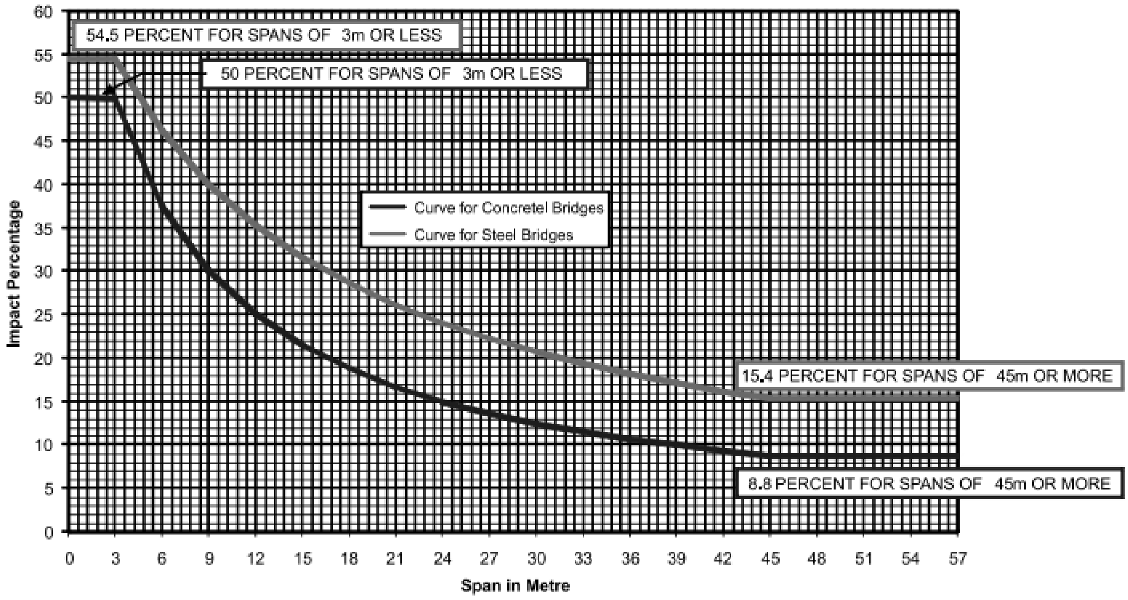
Congestion factor

This is applied on areas which are more prone to congestion. This is not applicable for SV loading.

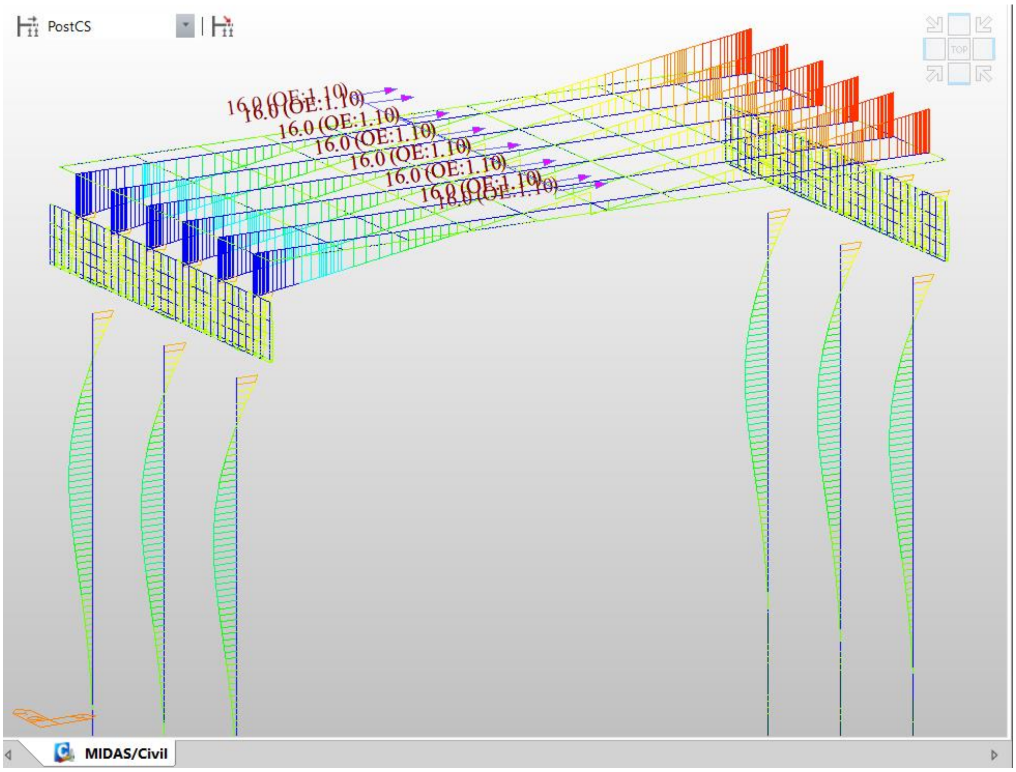
Impact factor

The Impact load on bridge is due to sudden loads which are caused when the vehicle is moving on the bridge.

This is inversely proportional to the length of the span. The graph is as shown below.



6. Braking force:- This refers to longitudinal forces exerted due to the brakes applied by the vehicles. There is a low possibility that all vehicles on the carriageway can apply brakes simultaneously.



7. Wind Load :-
    - Wind pressure depends on the geographical conditions, terrain of the surrounding and the height of bridge above the ground. The Basic wind speed for various locations of India have been given as a map in IRC:6.
    - The intensity of wind force is based on hourly wind speed corresponding to different heights for bridges situated in plain terrain and terrain with obstructions. The table below from IRC:6 shows hourly wind speed and wind pressure.

Table 12: Hourly Mean Wind Speed and Wind Pressure

(For a Basic Wind Speed of 33 m/s as shown in Fig. 10)

H (m)	Bridge Situated in			
	Plain Terrain		Terrain with Obstructions	
	V_z (m/s)	P_z (N/m²)	V_z (m/s)	P_z (N/m²)
Up to 10 m	27.80	463.70	17.80	190.50
15	29.20	512.50	19.60	230.50
20	30.30	550.60	21.00	265.30
30	31.40	590.20	22.80	312.20
50	33.10	659.20	24.90	373.40
60	33.60	676.30	25.60	392.90
70	34.00	693.60	26.20	412.80
80	34.40	711.20	26.90	433.30
90	34.90	729.00	27.50	454.20
100	35.30	747.00	28.20	475.60

where

H = the average height in metres of exposed surface above the mean retarding surface (ground or bed or water level)

V_z = Hourly mean speed of wind in m/s at height H

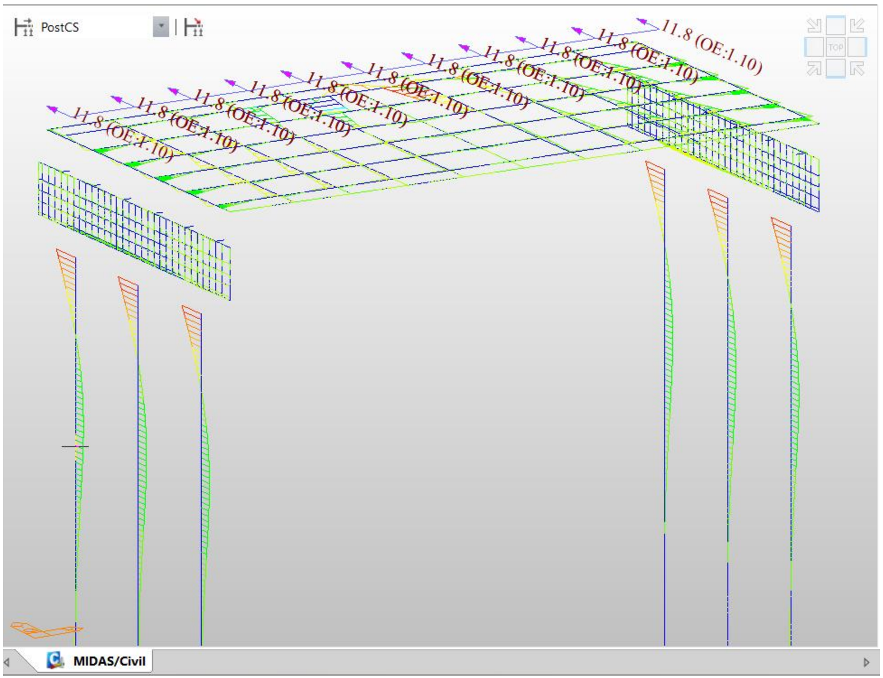
P_z = Horizontal wind pressure in N/m² at height H

- The Transverse wind force is taken as acting at the centroids of the appropriate areas and horizontally.

$$F_T = P_z \times A_1 \times G \times C_D$$

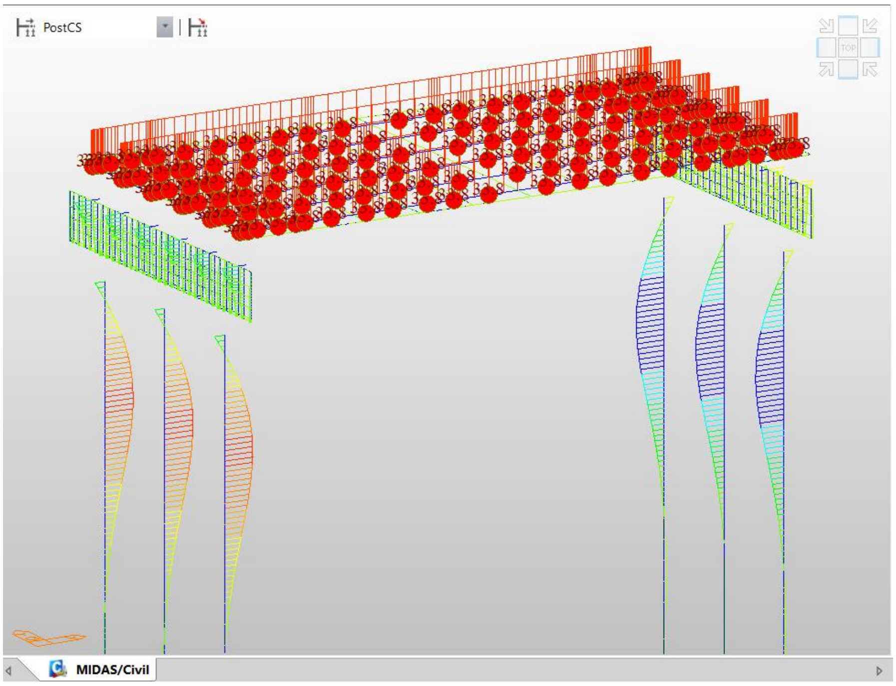
where, P_z is the hourly mean wind pressure in N/m² (see **Table 12**) , A_1 is the solid area in m² (see Clause **209.3.2**), G is the gust factor and C_D is the drag coefficient depending on the geometric shape of bridge deck.

- BMD for wind force is as follows:



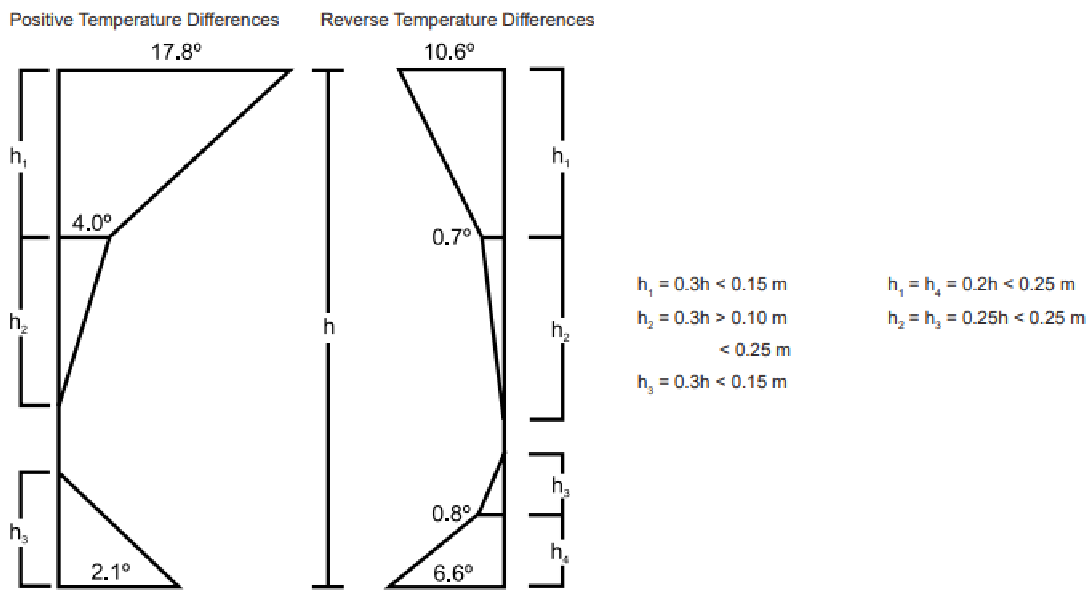
In the above figure, wind is acting in the Y direction which causes the columns to become critical.

8. Temperature forces :- This refers to two kind of temperature loads:
    - Uniform Temperature-This refers to the seasonal changes in temperature during summers and winters. Due to this superstructure will expand or contract. Our case is of an Integral Bridge where substructure is monolithic with superstructure so the substructure will deflect. This will cause forces (shear force and bending moments) in substructure which needs to be accounted for in the design. BMD due to uniform temperature is shown below:

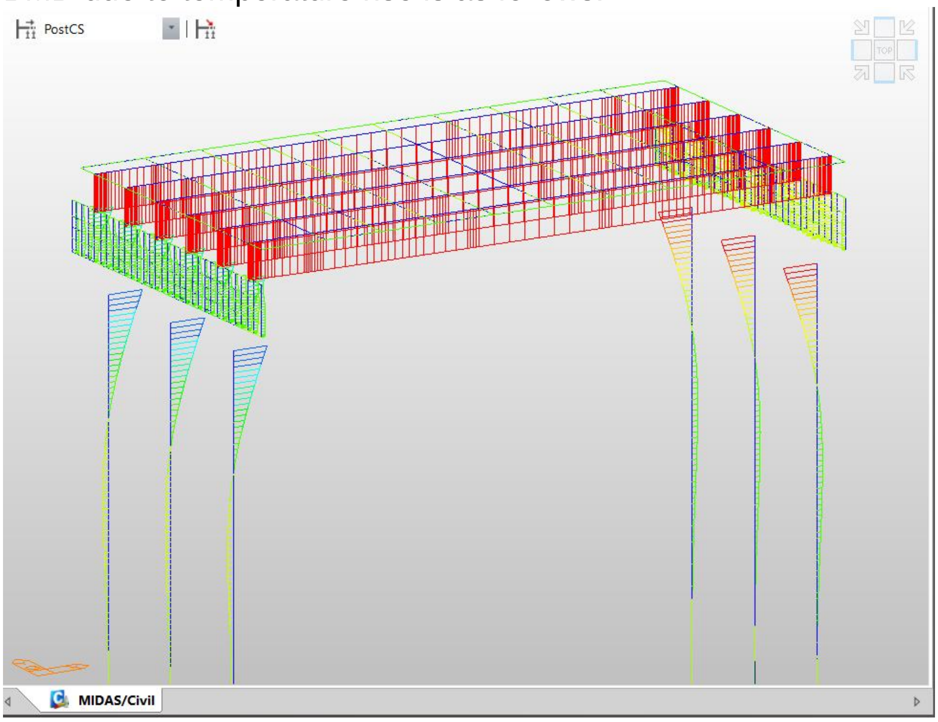


    - DTR/DTF (Differential Temperature Rise/Fall) - This refers to the day and night temperature variations which causes non-uniform heating of the bridge deck. In the day time, the top portion of the deck will get heated more as compared to the middle portion and vice-versa at night. This causes stresses along the depth of the bridge deck (girder + deck slab).

The temperature gradient for Rise and Fall is given in IRC:6 as follows:



BMD due to temperature rise is as follows:



9. Seismic Loads:-
    - Our country has been divided into 4 seismic zones and depending on the zone, the zone factor is applied.

Table 16: Zone Factor (Z)

Zone No.	Zone Factor (Z)
V	0.36
IV	0.24
III	0.16
II	0.10

- Earthquake loads are applied in all 3 directions - X, Y and Z. While analyzing earthquake in a particular direction 0.3 times the force resultant in the other 2 orthogonal directions is considered in addition to that particular direction.
- The graph of Sa/g vs Time Period is given in IRC:6 as follows:

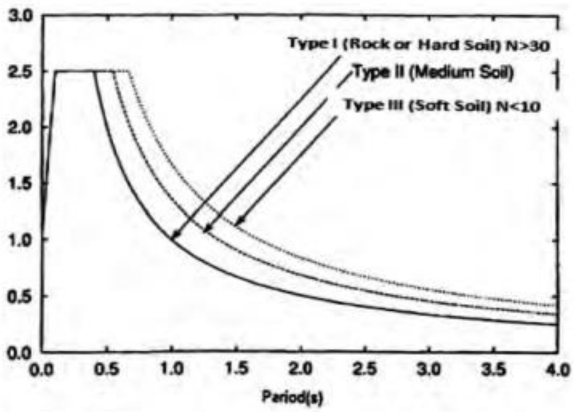


Fig. 19: Response Spectra

- The horizontal seismic forces acting at the centers of mass shall be computed as follows:

$$F_{eq} = A_h \text{ (Dead Load + Appropriate Live Load)}$$

where

F_{eq} = seismic force to be resisted

A_h = horizontal seismic coefficient = $(Z/2) \times (I) \times (S_a/g)$

Appropriate live load shall be taken as per Clause **218.5.2**

Z = Zone factor as given in **Table 16**

I = Importance Factor (see Clause **218.5.1.1**)

T = Fundamental period of the bridge (in sec.) for horizontal vibrations

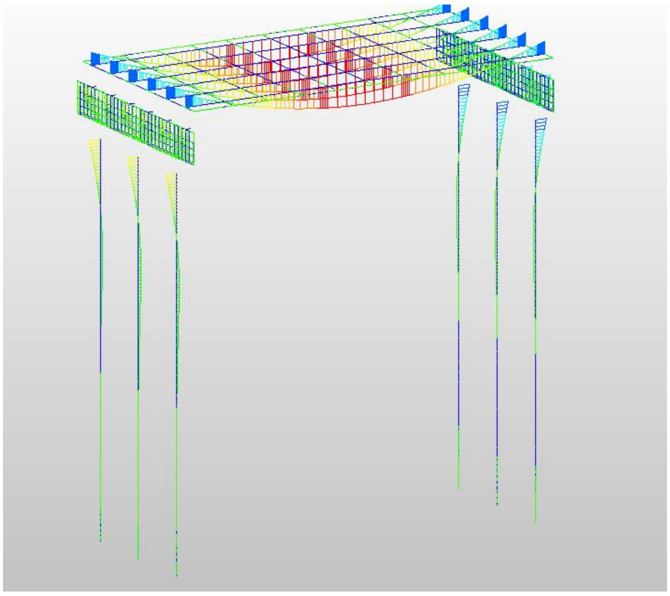
- Importance factor – Bridges are designed to resist earthquake depending on the repercussions of damage or failure from seismic events. Thus design force is obtained by multiplying (Z/2) by a factor of 'I' called the importance factor.

Table 19: Importance Factor

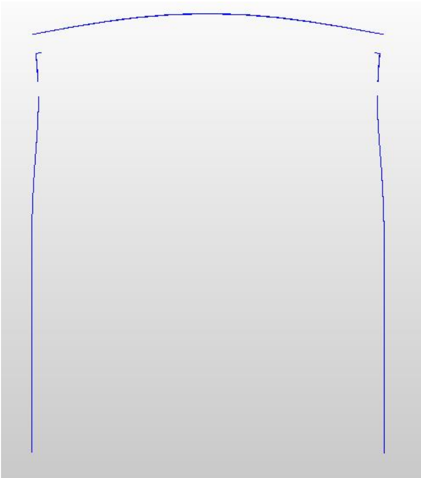
Seismic Class	Illustrative Examples	Importance Factor 'I'
Normal bridges	All bridges except those mentioned in other classes	1
Important bridges	a) River bridges and flyovers inside cities b) Bridges on National and State Highways c) Bridges serving traffic near ports and other centers of economic activities d) Bridges crossing railway lines	1.2
Large critical bridges in all Seismic Zones	a) Long bridges more than 1km length across perennial rivers and creeks b) Bridges for which alternative routes are not available	1.5

RESULTS AND ANALYSIS

- Deflections and bending moment diagrams were analyzed for different loadings and load combinations.
- Attached below is the BMD corresponding to the Dead Load which is similar to that of a Portal Frame as expected. The beam has a sagging moment at the midspan as expected by the vertically downward dead load.



- Elevation of deflection due to prestressing is as shown below:



- BMD for prestressing load should give a hogging moment at the midspan and is as expected: