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Analysis of concrete T-girder using MIDAS

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Abstract: The concept of pre-stressed concrete appeared in the year 1888. In this present engineering technology, durable and sustainable bridges play an important role for the socio-economic development of the nation. Owners and designers have long recognized the low initial cost, low maintenance needs and long-life expectancy of pre-stressed concrete bridges. This is reflected in the increasing market share of pre-stressed concrete,which has grown from zero in 1950 to more than 55 percent today. This growth continuesvery rapidly, not only for bridges in the short span range, but also for long spans with excessive length which, here therefore, has been nearly the exclusive domain of structuralsteel. Many bridge designers are surprised to learn that precast, pre-stressed concrete bridges are usually lower in first cost than all other types of bridges coupled with savings in maintenance, precast bridges offer maximum economy. The precast pre-stressed bridge system has offered two principal advantages: it is economical and it provides minimum downtime for construction.

Keywords: Design mix, Reinforced Cement Concrete, Nominal Mix, Concrete Aggregate

Introduction:

Bridge design is an important as well as complex approach of structural engineer. As in case of bridge design, span length and live load are always important factor. These factors affectthe conceptualization stage of design. The effect of live load for various span are varied. In shorter spans track load govern whereas on larger span wheel load govern. Selection of structural system for span is always a scope for research. Structure systems adopted are influence by factor like economy and complexity in construction. Code strategy engages us to pick structural system i.e. T-Beam Girder of 37.0 m span as selected for this study. In 37.0 m span, code provisions allow as to choose a structural system i.e. PSC T- beam. This study investigates the structural systems for span 37 m and detail design has been

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carried out with IRC loadings and IS code books. The choice of economical and constructible structural system is depending on the result.

Bridge design is a goal and what's more personalities boggling approach for the structural design. Bridge is life line of road network, both in urban and rural areas. With rapid technology growth the conventional bridge has been replaced by innovative cost effective structural system. One of these solutions presents a structural PSC system that is T-Beam.

PSC T-beam, have gained wide acceptance in freeway and bridge systems due to their structural efficiency, better stability, serviceability, economy of construction and pleasing aesthetics. PSC beam design is more complicated as structure is more complex as well as needed sophisticated from work. In the place of PSC T- beam if we talk about RCC T- beam geometry is simple and does not have sophisticated in construction.

T-BEAM

T-beam utilized as a part of construction, is a load bearing structure of reinforced cement concrete, wood or metal, with a t-formed cross area. The highest point of the t-molded cross segment fills in as a flange or pressure part in opposing compressive stress. The web (vertical area) of the beam beneath the compression flange serves to oppose shear stress and to give more noteworthy detachment to the coupled strengths of bending

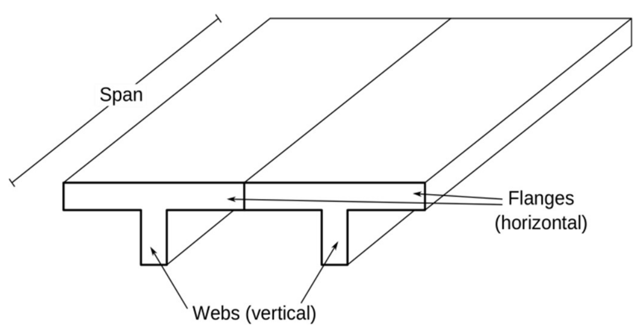

Fig 1: T-Beam

T-beam, used in construction, is a load-bearing structure of reinforced concrete, wood or metal, with a t-shaped cross section. The top of the T-shaped cross section serves as a flangeor compression member in resisting compressive stresses. The web of the beam below the compression flange serves to resist shear stress and to provide greater separation for the coupled forces of bending.

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A beam and slab bridge or T- beam bridge is constructed when the span is between 10 -25 m. The bridge deck essentially consists of a concrete slab monolithically cast over longitudinal girders so that the T-beam effect prevails. To impart transverse stiffness to the deck, cross girders or diaphragms are provided at regular intervals. The number of longitudinal girders depends on the width of the road. Three girders are normally provided for a two-lane road bridge. T-beam bridges are composed of deck slab 20 to 25cm thick and longitudinal girders spaced from 1.9 to 2.5m and cross beams are provided at 4 to 5m interval.

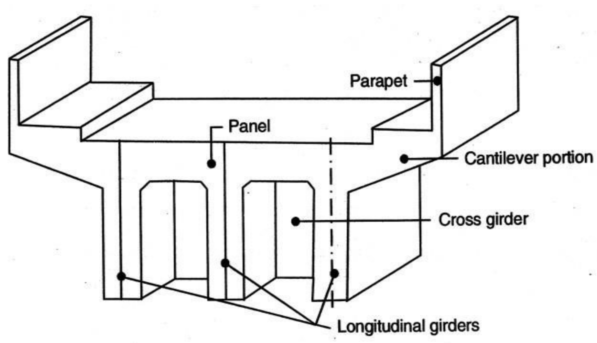

Fig 2: Components of T-Beam Bridge

ADVANTAGES

- ✓ Beam bridges are helpful for short spans.
- ✓ Long distances are normally covered by placing the beams on piers.
- ✓ It has simply geometry.
- ✓ Easy to cast in construction.
- ✓ It is mostly adopted Bridge.
- ✓ Slab act monolithically with beam

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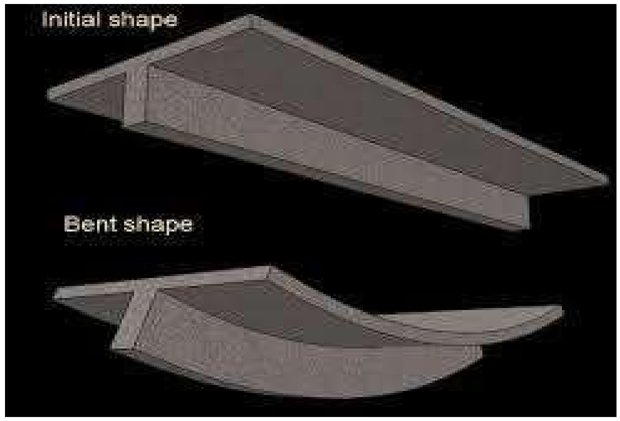

Fig 3: T-Girder

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CALCULATION OF PRESTRESSING FORCE

After selecting the cross section of the members all the parameters such as centroid, area, moment of inertia, section modulus and the inferior and superior stresses are calculated. Then from inferior and superior stresses the prestressing force is calculated as follows,

$$P= (A*f_{inf}*Z_b)/(Z_b+A*e)$$

Where,

P= prestressing force

A= area of section

f_{inf}=inferior stress at the section

Z_b=section modulus at bottom of centroidal axis

e=eccentricity of the cable

RESEARCH METHODOLOGY

General Hypotheses

Model Simulation of T-girder Longitudinally

Principle of Modeling

Description of Midas Software

Loads Applied in Modeling

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Midas Input

Prestressing Layout of T-Girder

Construction Sequence

Model Simulation of T-Girder Deck Slab Transversely

External Loads Applied in Modeling (with OHE)

External Loads Applied in Modeling (without OHE)

Live Load

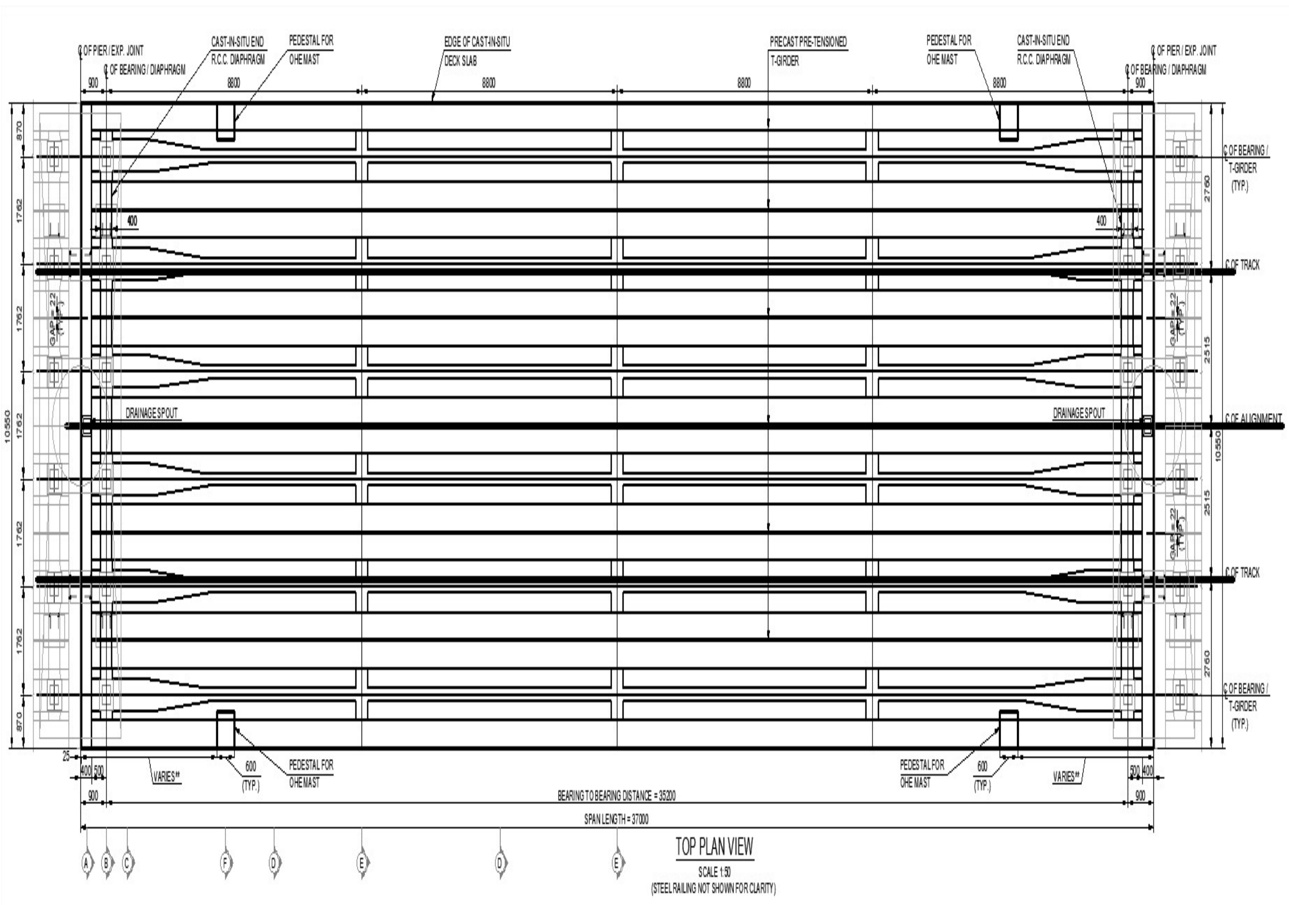

Fig. 4 Plan view of 37m Span (6 – T Girder Straight Span)

This design note includes:

- ✓ Verification of flexural stresses along T-Girder in construction and in service stages.
- ✓ Verification of maximum permissible shear stresses & reinforcement
- ✓ Verification of Shear Connector reinforcement.
- ✓ Verification of Ultimate bending moment capacity.

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The superstructure consists of Precast Pre-Tensioned T-Girder of 36.2m length, for span length of 37.0m. Bearing to bearing length distance is 35.2m. The plan view shown in fig. 4 and cross-sectional view presented in fig. 5.

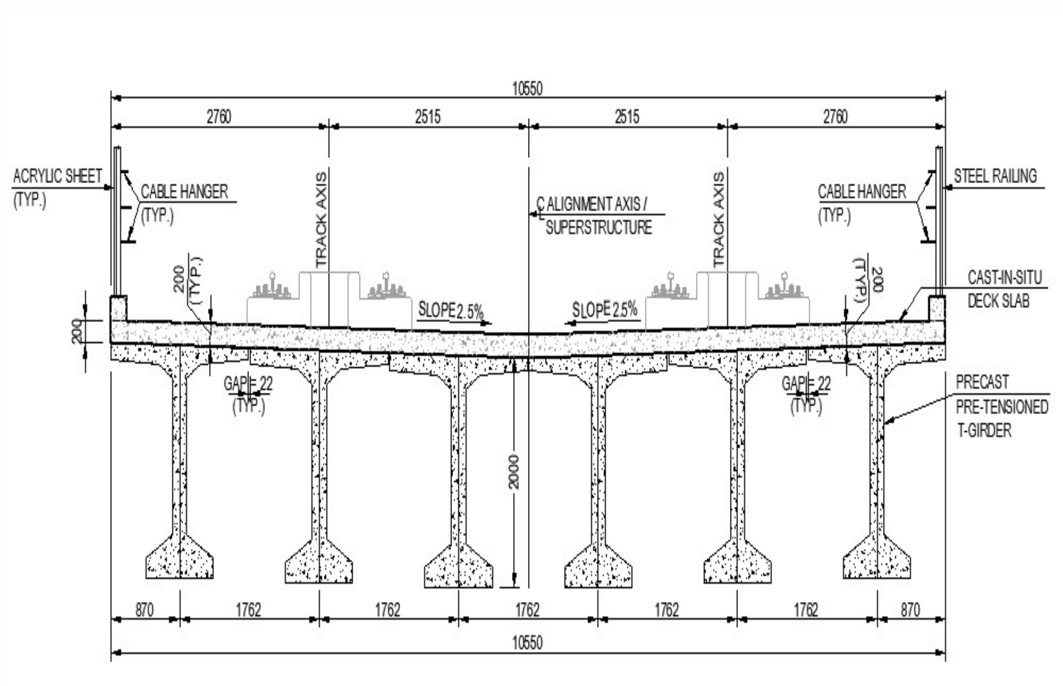

Fig. 5 Cross Sectional View

MODEL SIMULATION OF T-GIRDER LONGITUDINALLY:

Principles of Modeling

The T-girder is modeled as a grillage model is depicted in fig. 7 using MIDAS CIVIL 2020 (Ver 1.2) software. The exactLayout of Prestressing and exact sequences of construction are considered. View from MIDAS Software is represented in fig. 6.

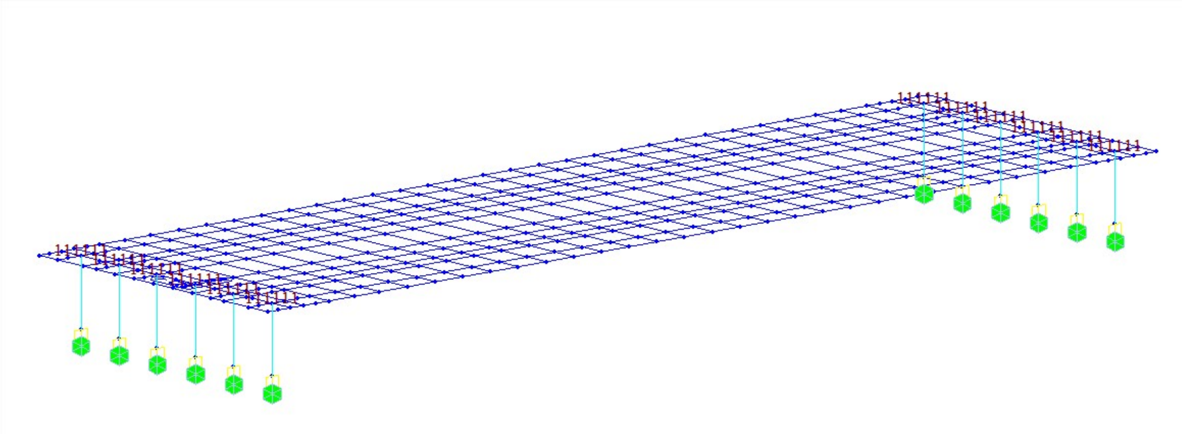

Fig. 6 Grillage Model Showing Iso-Metric View

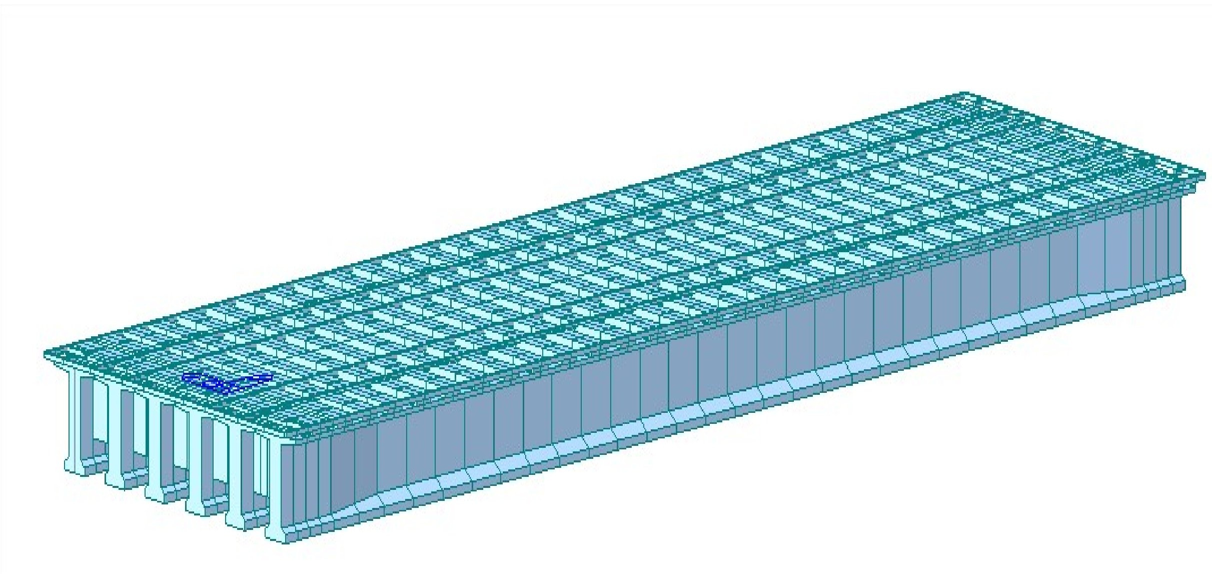

Fig. 7 Grillage Model Showing 3-D-Iso-Metric View

Description of MIDAS Software:

MIDAS is an Finite elements Method programme. The sofware generates the forces (BM, SF etc) at each section and combines them in accordance with the defined combination. To transmit the loads from one T-Girder to next T-Girder, cross-girder and slab elements are modelled in transverse direction. Bearing support is provided under each T-Girder to estimate the exact forces under each bearing.
All the loads (i.e. SIDL and Live Loads) are applied at their exact point of application with their correct

magnitudes in order to have the actual reactions on each bearing, and also to have the actual behavior in longitudinal flexure of each T-Girder and Diaphragm. Table-1 is tabulated the SIDL. And wind load considered in this study is explain in table-2 while the figure. 8 is representing the modelling of SIDL and figure. 9 is graphically explaining the modelling of wind load.

Main Input Data:

Material characteristics including time effects

Geometry of the structure during the different stages of the erection

Prestressing layout

External loading

Superimposed dead load Moving loads definition if any

Main Output Data:

Normal stress at top and bottom fibres

Forces

Shear stress

Displacements and reactions

Envelopes of all these results

Loads Applied in Modeling:

Dead Load

For assessment of dead load calculation, the following mass density has been considered : Prestressed Concrete (PSC) : 25 KN/m^3= 2.55 T/m^3

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Super Imposed Dead Load

The following SIDL loads are applied as per OSD.

Table:1 SIDL

S.No.	Element	Unfactored Load	Location
1	Parapet/Railing	0.2 t/m	end
2	Plinth	3.40 t/m	mid
3	Rail+Pads (All 4)	0.30 t/m	mid
4	Cables	0.07 t/m	end
5	Cable trays#	0.01 t/m	end
6	Deck drainage concrete (Avg. thk. 62.5mm)	0.24 t/m	mid
7	Miscll. (OHE Mast, Signalling , etc.)	0.40 t/m	end
8	Solar Panel (wherever applicable)	30kg/sqm (0.092 t/m)	end
9	Noise Barrier (wherever applicable)	0.2 t/m	end
10	PTM Pipe Line	0.06t/m	end
	Sum of Load applied at Plinth location	3.94 t/m	mid
	Sum of Load applied at edge of deck	1.039 t/m	end

The application of total SIDL is as explained below : -

Load applied in midas model per Plinth	=	3.94/4	= 0.985 T/m
Say	=	1.0 T/m	
Load applied in midas at edge of deck	=	1.039/2	= 0.516 T/m
Say	=	0.52 T/m	

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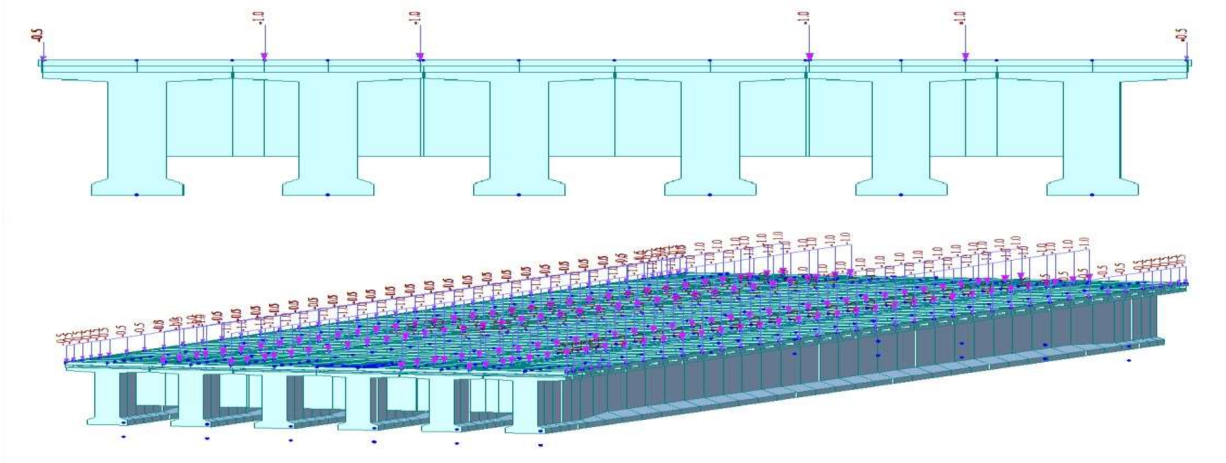

Fig. 8 MODEL SHOWING APPLICATION OF SIDL

Wind Load

Table:2 Wind Load

Vertical wind load on super-structure				
Hourly mean wind speed	Vertical wind pressure as per IRC-6 Table 12 corresponding to 25m Height	Pz	1309.46	N/m^2
Gust factor		G	2	
Lift coefficient		C_L	0.75	
Vertical Wind Pressure on deck			1.964	KN/m^2
Vertical Wind Load on each T-Girder (e.g. Pressure x 10.55 / 6 Nos.)			3.454	KN/m

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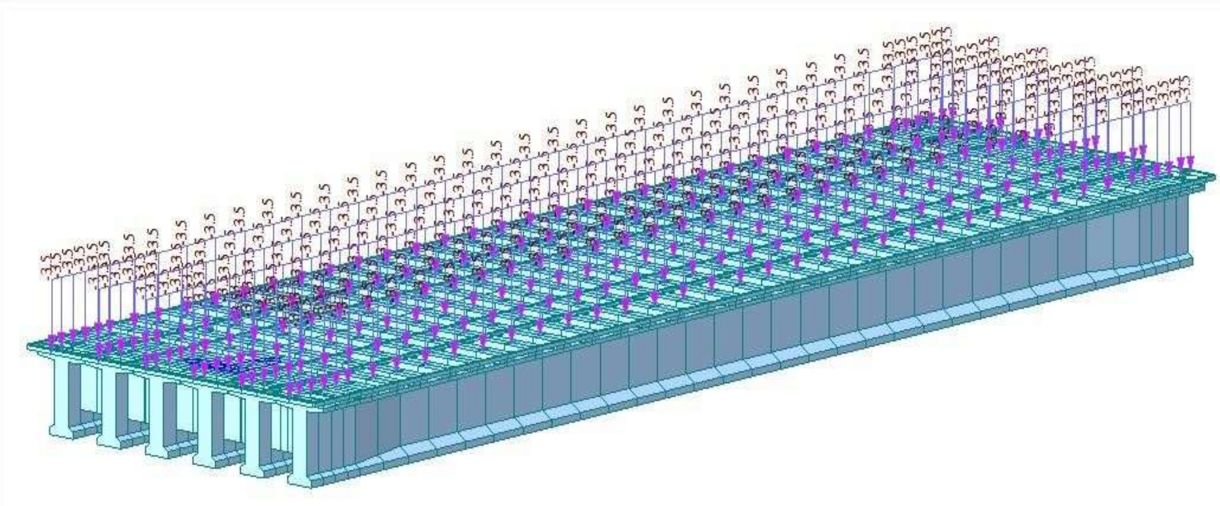

Fig. 9 Model Showing Application Of Wind Load

Seismic Load

VERTICAL SEISMIC
SEISMIC COEFFICIENT FOR VERTICAL SEISMIC ACCORDING TO

Z=	0.16
I=	1.50
R=	1.0
Sa/g=	2.500
Ah=	0.300

$$T_V = \frac{2}{\pi} l^2 \sqrt{\frac{m}{EI}}$$

Seismic load is taken as : - 0.3 x (Dead Load + SIDL + 50% Live Load)

CONCLUSION:

- Bending moments and Shear force for PSC T-beam girder are lesser than RCC T-beamGirder Bridge.
- PSC T-Beam Girder has less heavier section than RCC T-Girder for 37 m span
- Shear force resistance of PSC T-Beam Girder is more compared to RCC T-Girder.

Data Availability Statement

All data, models and code generated or used during the study appear in the submitted article.

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Conflict of Interest:

The authors declare that there are no conflicts of interest.

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