iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 11 **Issue:** III **Month of publication:** March 2023

DOI: https://doi.org/10.22214/ijraset.2023.49738

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue III Mar 2023- Available at www.ijraset.com

Seismic Behaviour PSC Box Girder and PSC Precast I Girder Bridge

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Abstract: ***Bridge is the structure that provide passage over an obstacle. The prestressed concrete bridges have excellent riding characteristics that minimize traffic vibrations, torsional rigidity, less likely to crack prematurely continuous span, strength and the most noteworthy characteristic is natural frequency of vibration hardly matches with vehicle frequency therefore attained spacious acceptance in freeway, highway flyovers, and in modern metro rail systems.***
As bridges are the important structures should be capable to withstand static as well as dynamic loads specially, earthquake-induced load to achieve a structure that behave at the level of life safety under enormous earthquakes.
There are different types of bridge structure base on material & geometric parameters, from which prestress concrete precast I girder bridge and box girder bridge are widely used for medium to long span rang. Box girder bridge are the bridge where the main beam consists of girder in hollow shape, where as in I girder bridge main beam consist of I-shape girder are used as main girder beam.
In this research article study about dynamic analysis of PSC precast I-girder bridge and PSC box girder bridge for different parametric variation and different span range have been studied. Response spectrum analysis has been performed by using FEM based software. The parameters are geometric parameters, span range, bending moment, shear force, displacement, base shear, base moment, time period, natural frequency, and method of analysis based on different codes. On the above parameters base reaction, base moment, time period, natural frequency, absolute displacement and girder forces of bridge is essential and major concern for the analysis of bridge structure.
Keywords: Box girder, Prestressed concrete, PSC I girder, CSI Bridge.

I. INTRODUCTION

Bridges are the structure that provide passage over an obstacle. There are different types of bridge structure base on material & geometric parameters, from which prestress concrete I girder bridge and box girder bridge are widely used for medium to long span rang. Analysis of box girder and PSC I girder in a systematic manner is very necessary in the present condition. So far there are many journals published on analysis of box girder & PSC I girder on different aspects. There are papers published on parametric study, & performance analysis alone. In this research, analysis of box girder & PSC I girder bridge is carried down in a systematic manner. finally, a Response spectrum for various span has done. Box girders are known for their structural efficiency. Major add-ons of using box girders are that they have high stability, high aesthetic beauty, high serviceability and better economy in construction. Analysis of box girders is complex due to bending, torsion and distortion in both transverse and longitudinal direction. Box girders can be classified under different basis such as shape, use, method of construction.
The present study focus on comparative analysis of PSC I girder bridge and PSC box girder bridge for different span range. Response spectrum analysis have been used as per IS 1893:2016 & IRC 112:2011 for earthquake zone V and soil type II. Loading condition are based on IRC 6:2016. IRC class A and IRC class AA wheel vehicle have been used.

A. Prestress Precast I Girder Bridge

Girder is a term used in construction to refer to a supporting, horizontal beam that can be made from a variety of construction materials such as stainless steel, concrete, or a combination of these materials. A girder bridge is a basic, common type of bridge where the bridge deck is built on top of such supporting beams, that have in turn been placed on piers and abutments that support the span of the bridge. The types of beams used for girder bridges are usually either I beam girders or T beam girder, so called because their shape is reminiscent of a capital Roman letter I or T respectively. The precast prestressed concrete girders of I-type section are frequently employed to design the short-to-medium span bridges. However, its beam depth is greatly increased as its span length is increased over about 30 m. Therefore, the economic and aesthetic effectiveness is rapidly decreased in the case of the span length over 30 m.

B. Prestress Concrete Box Girder Bridge

A Box Girder Bridge is a Bridge in which the primary Beam involve girder in the shape of an hollow box. The box girder typically involves either prestressed concrete, structural steel, or a composite of steel and reinforced cement. The box is ordinarily rectangular or trapezoidal in cross-area. Box Girder Bridge is generally utilized for highway flyovers and for present day elevated structures of light rail transport. Although regularly the crate box girder bridge is a type of beam bridge, box girder may likewise be utilized on cable stayed bridges and different structures.

II. MODELLING AND ANALYSIS

As per Indian standard, the prestress concrete precast I girder bridge and prestress concrete box girder bridge are analyzed. Static and dynamic analysis has performed. In static analysis dead load and live analysis has perform as per IRC 6:2016 whereas in dynamic analysis response spectrum analysis has performed as per IS 1893 (part 3) for earthquake zone 5the and soil condition as type II. Three span bridge are considered where as having span length as 30 m, 40 m, & 50 m. in dead load analysis self-weight of structure and superimposed dead load of the structure is considered, whereas in Live load analysis IRC class A & IRC class AA vehicle (as per IRC 6:2016) is considered. The design parameter are consider as per IRC 112:2011, & IRC 18 specifications.

The analysis of post tensioned box girder bridge and precast I girder bridge is done using CSI bridge 2021 software and prestressed with parabolic tendons. The Freyssinet system of post tensioning anchorages is selected for the present study.

Table 1 Geometric Parameter

SPECIFICATION	PSC BOX GIRDER BRIDGE/ I GIRDER BRIDGE	
Span	30 M, 40M, 50M,	
No. of span	3	
Width of deck section	10.4 M.	
Depth of deck section	2 M.	
Width of carriageway	7 M.	
Center line offset	1.875 M.	
Width of barrier	0.2 M.	
Width of footpath	1.25	
Span /depth ratio	15	
No. of overhang	2	
No. of interior girder	2	
Precast girder type	ASSTHO type VI	
Diaphragm	Depth	1.8 m.
	Thickness	0.3 m.
Bent	Width	1.2 m.
	Depth	15 m.
Abutment	Width	1.2 m.
	depth	1.5 m.
Pier	Dimeter	1.2 m.

Table 2 Material Property (Concrete)

Grade of concrete	M 40for super structure & M25 for substructure
Unit weight of concrete ¥c	25 (KN/m³)
modules of elasticity Ec	31622.78(MPa)
Poisons ratio (U)	0.2
Coefficient of thermal expansion	$5.50X10^{-6}$
Shear modules of elasticity G (MPa)	13176.157 (MPa)

Table 3 Material Property (Steel Rebar)

Types of tendons	Uncoated stress relived strand
Modules of elasticity E	$1.965x10^{5}$ (MPa)
Coefficient of thermal expansion	$1.170x10^{-5}$ /ºC
Ultimate tensile strength	1861.54 (MPa)
Minimum yield strength	1689.90 (MPa)
Strand dimension	15.2mm 7-ply strand
Nominal cross section area of strand	140 mm^2
0.2% proof load	221.5 KN
Braking load	260.7 KN

Table 4 Primary Load Case

Dead load	Automatic taken by CSI bridge software
Barrier load	3KN/m
Pedestrian live load	$5KN/m^2$
Dead load due to wearing coarse	$1.75KN/m^2$
Vehicle live load	IRC CLASS AA & IRC CLASS A WHEEL VEHICAL as per IRC 6:2016

Table 5 Seismic Properties

Seismic Zone	V
Zone Factor (Z)	0.36
Response Reduction Factor (R)	2.5
Importance Factor (I)	1.2
Soil Type	II
Damping Ratio	0.05
Analysis Software - CSI Bridge 2021	

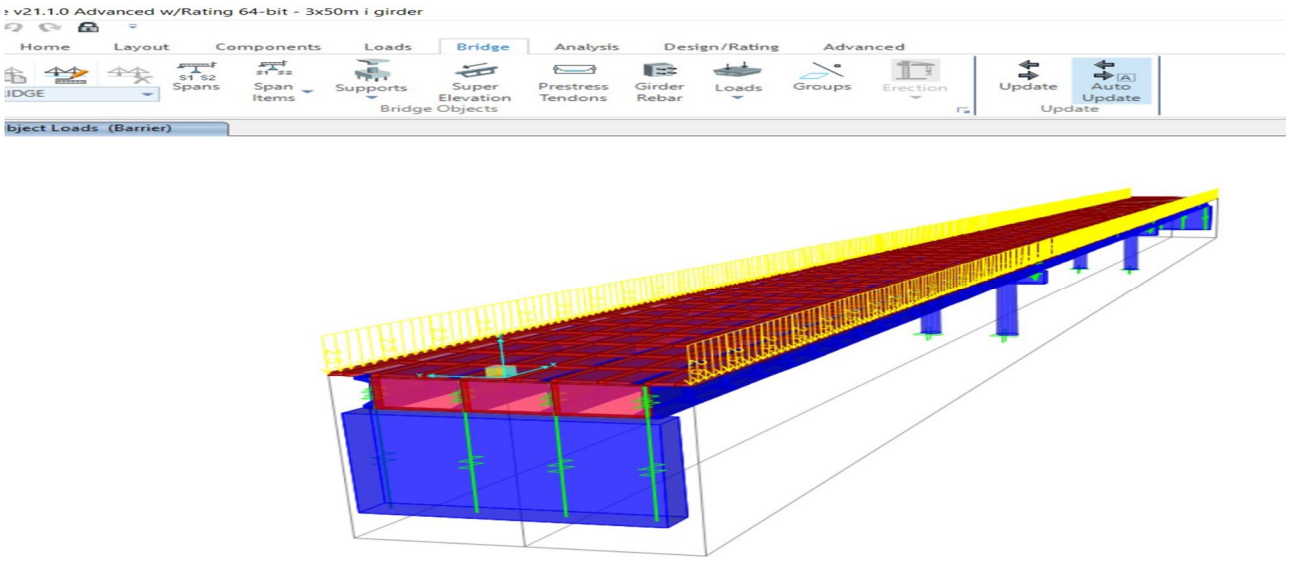

Fig 1 3D View of Prestress Concrete Box Girder Bridge

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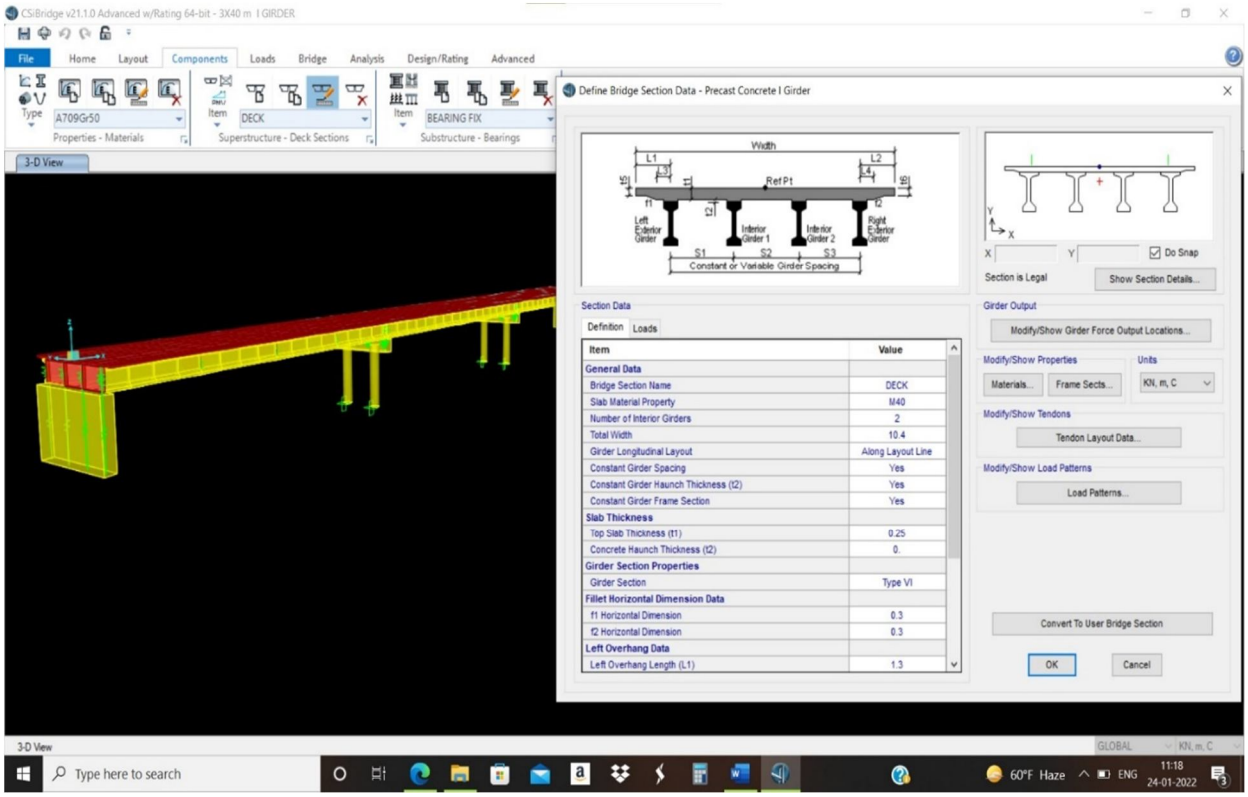

Fig.2 Dimentional View Of PSC Precast I Girder Bridge

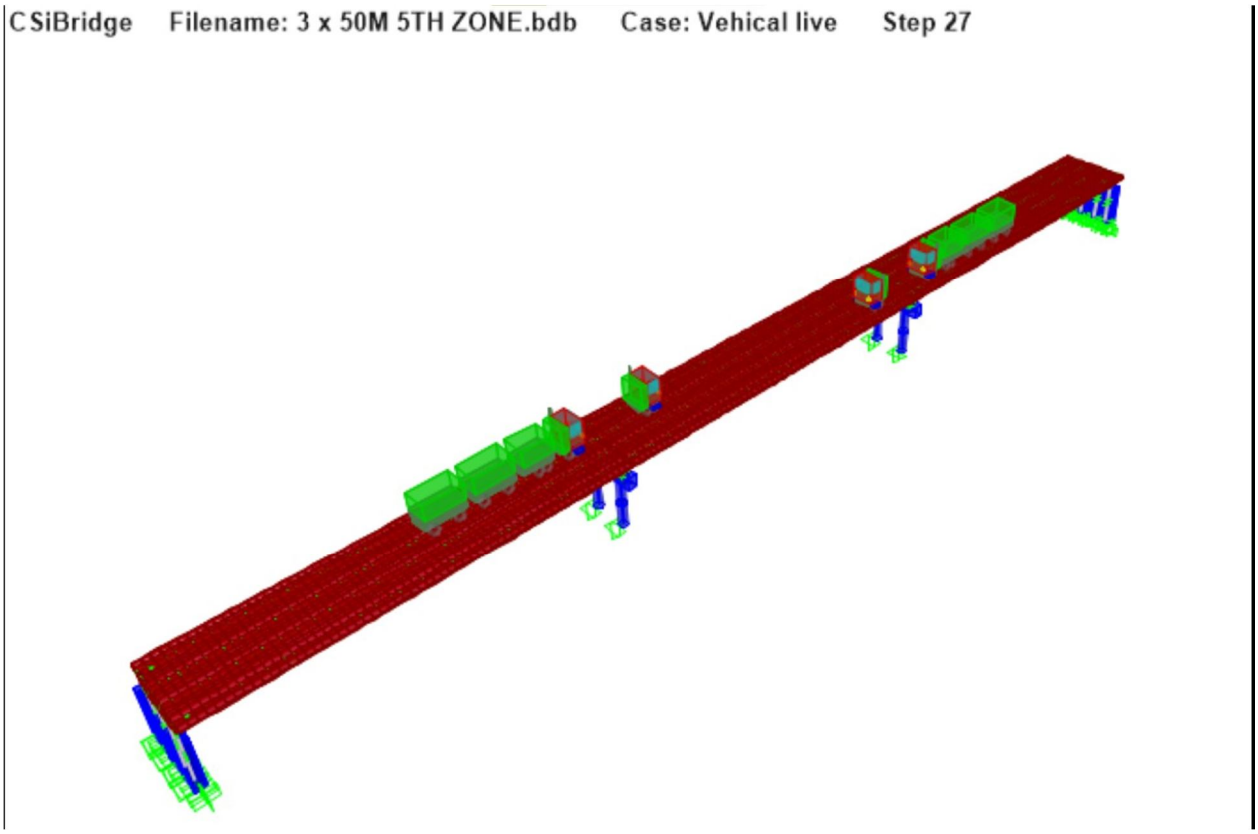

Fig.3 Vehicle Live Load Movement

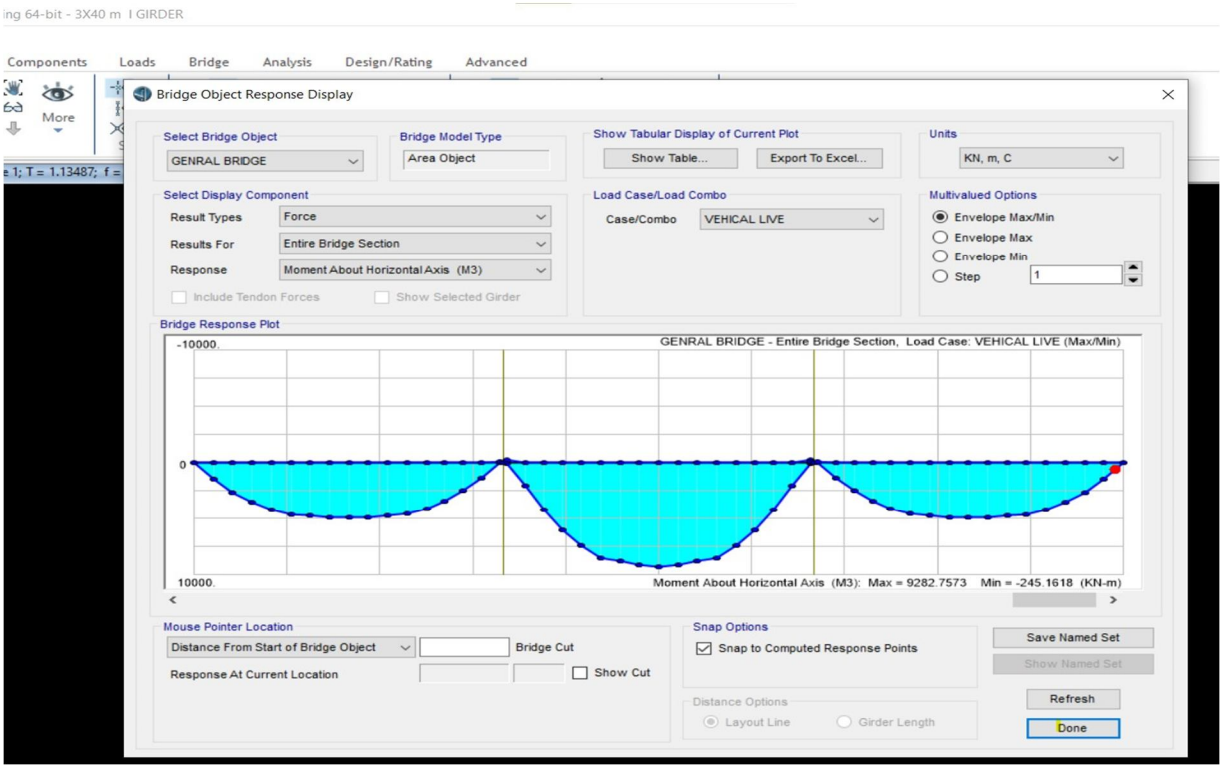

Fig.4 Bending Moment Diagram Due to Vehicle Live Load

III. RESULT AND DISCUSSION

Prestress concrete BOX girder bridge & prestress precast I girder bridge are analyzed by static and dynamic analysis method conducted for different six model using CSI Bridge 2021. The results are obtained after analysis, which has been discussed in this chapter. By static and dynamic analysis of seismic load are being carried out in accordance with Indian Codes. The result of time period, frequency and Base shear are compared in Modal Analysis. Also, in static analysis bridge object girder forces as bending moment, shear forces and girder displacement are compared for 30 m., 40m and 50 m span.

A. Model Analysis

The modal participation time period of six models is compared in figure in 4.1. & 4.2 The model time period of box girder for 30-meter span is 1.09 sec. it has been increases to 1.254 for 40m. span MODAL and 1.399 for 50 m span bridge, whereas model time period for precast I girder bridge model for 30-meter span is 1.09 sec. it has been increases to 1.254 for 40m. span MODAL and 1.399 for 50 m span bridge. For each span first mode shape gives least frequency and max. time period. For shorter span frequency is on higher side which goes in reducing with the increase in span and with the increase in span, time period goes on increasing.

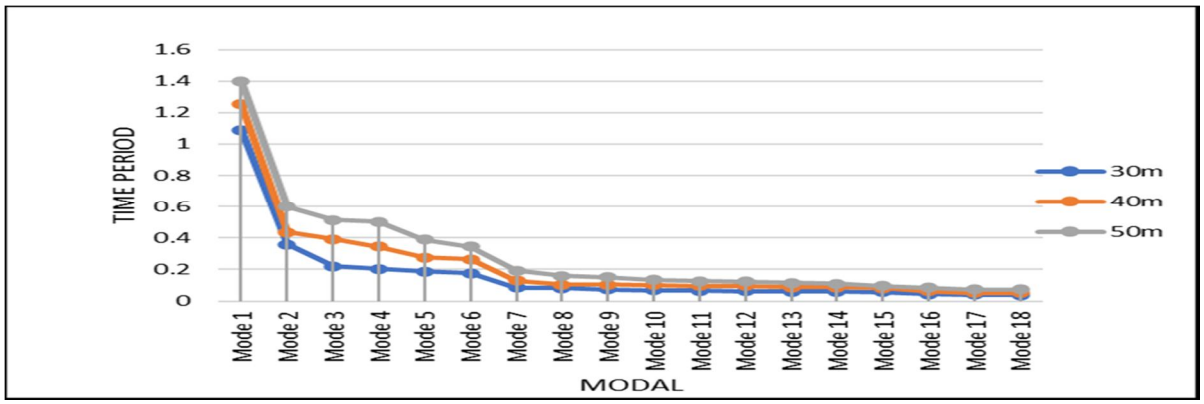

Fig 5 Time Period of Box Girder Bridge in Various Modes

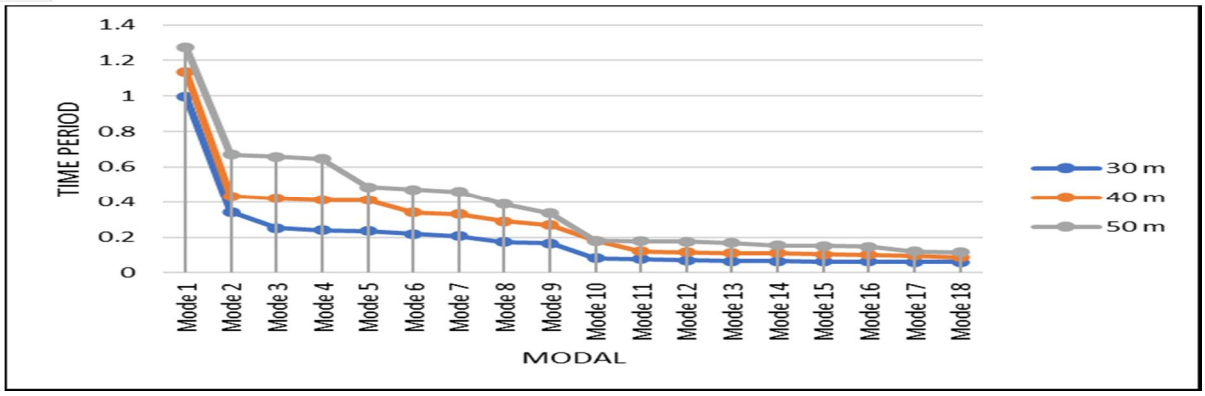

Fig 6 Time Period of Precast I Girder Bridge In Various Modes

B. Response Spectrum Analysis

The maximum displacements at the top of the bent cap and base shear in both X and Y directions are shown in table 4.4. It is also observed that the displacement and base shear increases with increasing span of the bridge because of seismic weight increasing.

Table 6 Maximum Displacement Comparison of Box Girder and I Girder Bridge

SPAN	Max. Displacement in X direction (mm)		Max. Displacement in Y direction (mm)	
	BOX GIRDER	I GIRDER	BOX GIRDER	I GIRDER
30 m.	7.82	5.92	2.06	1.54
40 m.	8.81	6.75	3.16	2.32
50 m.	9.91	7.54	4.29	2.64

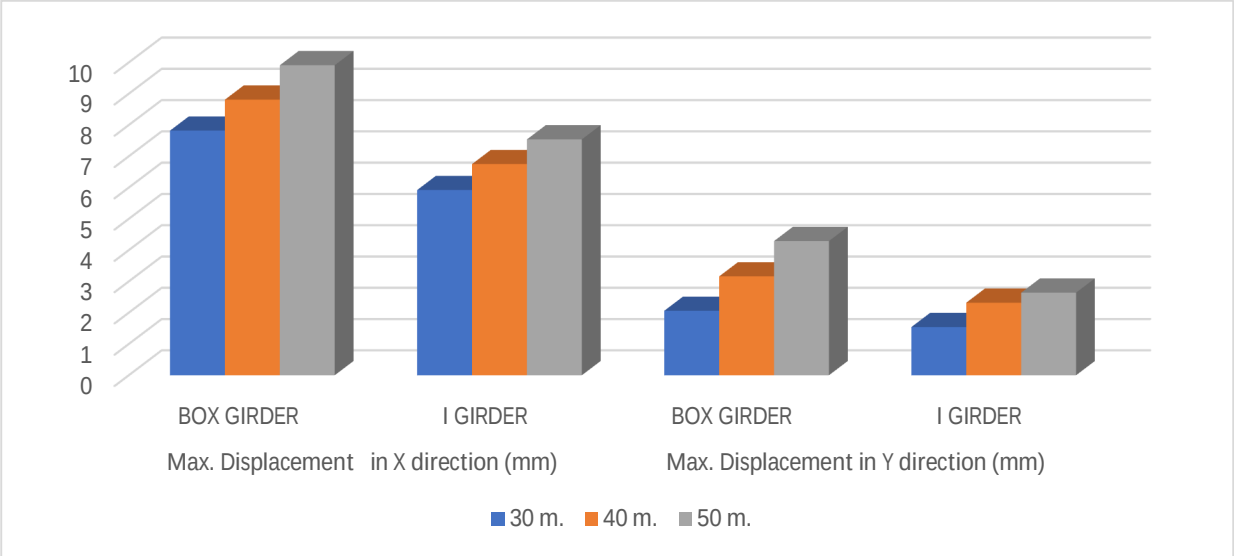

Fig.7 Maximum Displacement in PSC Box Girder and Precast I Girder Bridge

Table 7 Maximum Base Shear Comparison of Box Girder and I Girder Bridge

SPAN	Max. Base Shear X direction (KN)		Max. Base Shear Y direction (KN)	
	BOX GIRDER	I GIRDER	BOX GIRDER	I GIRDER
30 m.	444.271	401.355	726.769	586.274
40 m.	506.139	456.23	958.607	818.90
50 m.	560.569	504.89	1193.635	983.18

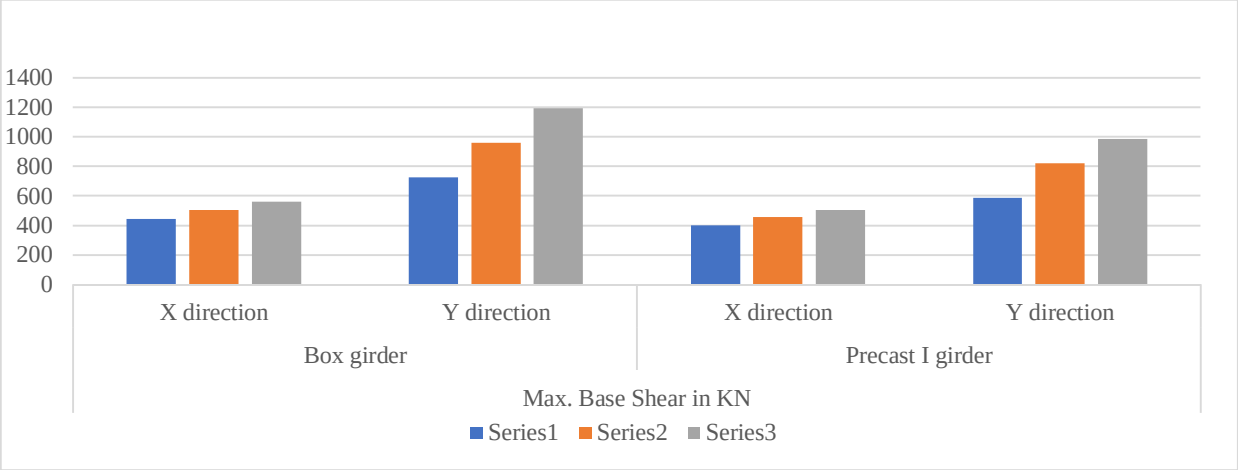

Fig.8 Maximum Base Shear in PSC Box Girder and Precast I Girder Bridge

IV. CONCLUSION

According to result of investigation conduct the following are the salient conclusion obtain from the present study.

1) According to the result obtain with increase in span natural time period of bridge are also increasing and natural frequency goes on decreasing. Also, the natural time period of box girder is higher than natural time period of I girder bridge. For 30 m span natural time period of box girder is 9.55% higher than the natural time period of PSC Precast I girder bridge.

2) With increase in span base shear is also increasing. The base shear in Y direction is higher than the base shear in X direction. For 30m span base shear of box girder is 10.62% higher than the PSC I girder bridge.

3) The displacement at top of bent cap also increasing with increasing span. Also, the displacement of box girder bridge is higher than the displacement of precast I girder bridge. For 30m span the displacement at top of bent cap of box girder is 9.55% higher than the I girder bridge. also, the displacement of bent cap in X direction is higher than the displacement in Y direction for both box girder and I girder bridge.

4) For box girder bridge the moment due to all load (Dead load super imposed dead load live load) are on higher side than the I girder bridge. The girder forces increasing when increasing the span of the bridge since the mass of super structure is increasing.

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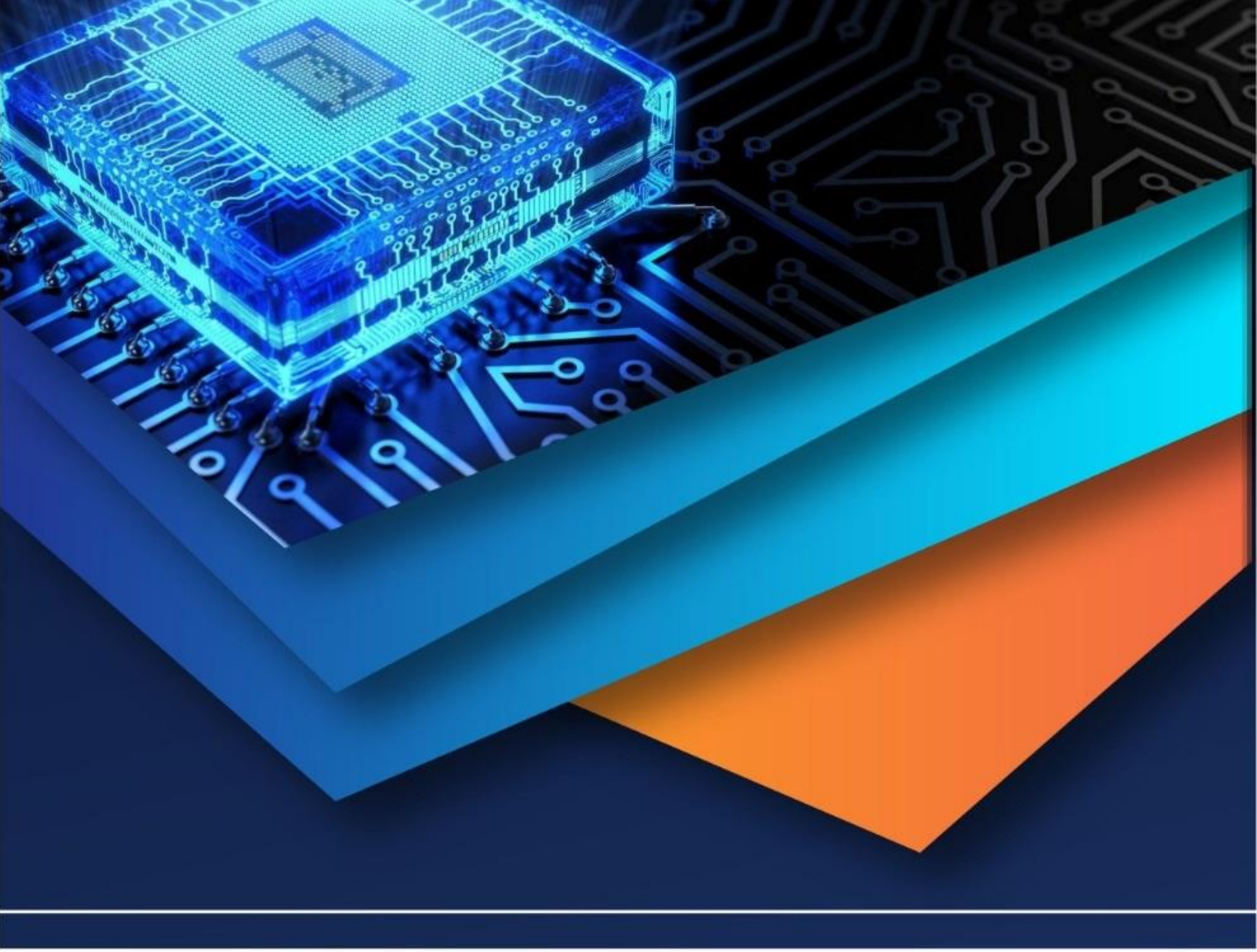

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