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COMPARISON BETWEEN T- BEAM BRIDGE AND I GIRDER BRIDGE ON THE BASIS OF SEISMIC VULNERABILITY

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Abstract—*Severe past earthquakes have had a significant impact on road network systems as well as considerable catastrophic effects on human life, buildings and economy so we can't ignore the deadly effect of seismic excitation. Earthquake brings great devastation in terms of life, money and failures of structures so optimized structures should be made in order to resistant the seismic activity as per IS 1893(Part I): 2016 is really of great importance. In order to bring the seismic resistance of structures up to a sufficient level detailed seismic evaluation and assessment of the seismic vulnerability of the structure are the key ingredients. In this paper T-beam bridge model is being compared with I girder bridge model under the effect of seismic excitation. The seismic zone considered is zone IV while other seismic parameters are as per IS 1893 (Part I): 2016, soil type-III (soft soil) and the vehicular loads [IRC 70R (tracked loading) & IRC AA (wheeled and tracked loading)] as per IRC 6-2014 are being considered. The analysis is done on CSi bridge software using response spectrum method. Both the bridge models are being compared on the basis of the following parameters- axial force, shear vertical, shear horizontal, moment about vertical axis, moment about horizontal axis and torsion over entire bridge section under seismic excitation. After comparing the values of the above- mentioned parameters optimized model is being suggested.*

Keyword: *Bridges, T- beam bridge, I girder bridge, Road network systems, Response spectrum method, Seismic vulnerability, Seismic excitation, CSi bridge software.*

1. INTRODUCTION

Bridge is a structure which provides passage way over an obstacle without closing the way beneath. Bridge plays a vital role in modern highway and railway transportation systems and serves as a "lifeline" in the social infrastructure systems. Bridge engineering is that field or branch of engineering (particularly a significant branch of structural engineering) which deals with the surveying, planning, designing, analysing, constructing, managing and maintaining of the bridges that supports or resist moving loads. In macro scale roadway networks, bridges play the key point-site component and it is the most vulnerable element in case an earthquake occurs. Knowing this weakness, the proper assessment and analysis of the seismic vulnerability of the bridges is of very high importance.

Designing of bridge mainly depends upon the functions it has to perform, the nature of the terrain where the bridge has to be constructed and anchored, the availability of the materials and funds used to build it. Bridges can be classified on the basis of how the axial forces, shear stresses, bending moments and torsion are distributed in the bridge. Reinforced concrete is very widely used for highway bridge constructions because of its durability, rigidity, economy, ease of construction and its pleasing appearance. In this study the main focus is on the comparison of the T- beam bridge model and I girder bridge model on the basis of the change in the maximum values of the axial force, shear force, moment and torsion over the entire bridge section under seismic excitation as per IS 1893(Part I): 2016 and to get the optimized bridge model out of them.

2. OBJECTIVES OF WORK

A. To study the seismic behaviour of I girder bridge under the combination of seismic loads as per IS 1893:2016 and vehicular loads as per IRC 70R (tracked loading) & IRC AA (wheeled and tracked loading).

B. To study the seismic behaviour of T-beam bridge under the combination of seismic loads as per IS 1893:2016 and vehicular loads as per IRC 70R (tracked loading) & IRC AA (wheeled and tracked loading).

C. To evaluate the values of axial force, moment about vertical axis, moment about horizontal axis, shear vertical, shear horizontal and torsion over entire bridge section for both the bridge models under seismic excitation.

D. To compare the maximum and minimum values of axial force, moment about vertical axis, moment about horizontal axis, shear vertical, shear horizontal and torsion over entire bridge section for both the girder systems and to get the optimized bridge model out of them.

3.s DESCRIPTION OF BRIDGE

1.	Total length of the bridge	40m
2.	Number of spans Span length	2 20m each
3.	Basic properties: a) Material • Grade of concrete used • Rebar b) Frame sections • Column diameter • Column height • Cap beam length • Cap beam thickness • Cap beam depth	 M30 HYSD415 0.8m 8m 10.5m 1m 0.6m
4.	Deck section considered	T Beam Girder and I Girder
5.	Deck width	12m
6.	Number of girders	4
7.	Number of columns	3
8.	Abutment beam length	10.5m
9.	Lane data • Number of lanes • Lane width	 2 3.75m
10.	Vehicle class	IRC 70R (tracked loading) & IRC AA (wheeled and tracked loading)

3.1 Seismic Data

1.	IS code	IS 1893 (Part I):2016
2.	Method of earthquake analysis	Response spectrum function
3.	Seismic zone	IV
4.	Soil type	Type-III (soft soil)
5.	Response reduction factor	5
6.	Function damping ratio	0.05

4. RESPONSE SPECTRUM METHOD

In this method we consider the multiple modes of response of the bridge. This method is applicable for the various bridge codes except for very simple bridge structures. The response of the bridge can be defined by the combinations of the 12 special shapes termed as modes or mode shapes. Analysis of these modes can be done using computer. For every mode, a response is readied and analysed from the design spectrum, based on the modal frequency and the modal mass. After obtaining all the responses a combined total response of the bridge is obtained.

In extreme cases where either the structures are too irregular or too tall or of significance to a community in disaster response, the suitability of response spectrum approach is no longer exist so more complex analysis such as non-linear static or dynamic analysis is required.

5. MODELLING

MODEL 1: T-Beam Bridge

MODEL 2: I Girder Bridge

Modelling done with the help of CSi bridge software.

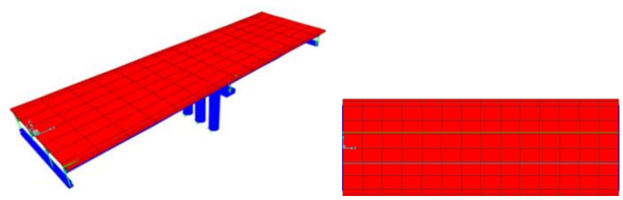


Fig. 1: Plan and 3D view of bridge

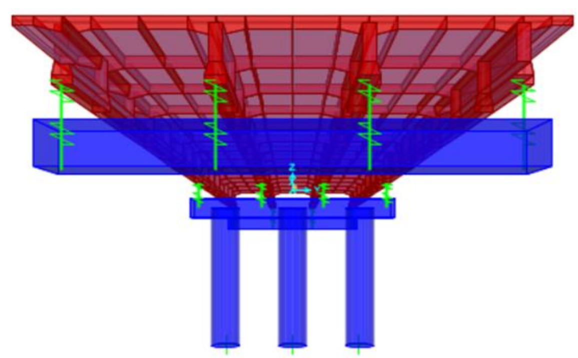


Fig. 2: Section view of bridge of model 1

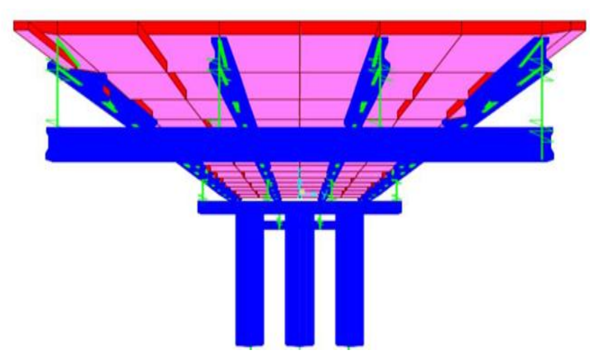


Fig. 3: Section view of bridge of model 2

6. ANALYSIS

6.1 Axial Force(P)

Axial force acts parallel to the longitudinal axis of the member and its nature is of push and pull type. If it is a pushing force it creates compression and if it is a pulling force it creates tension.

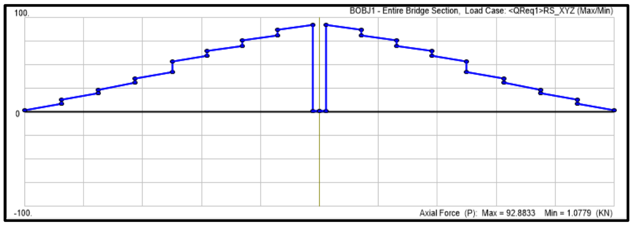


Fig. 4: Axial Force(P) for model 1

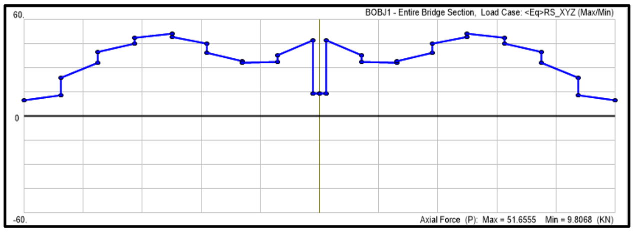


Fig. 5: Axial Force(P) for model 2

6.2 Moment about Vertical Axis(M2)

When a load is applied perpendicular to the longitudinal or neutral axis then a force is generated in the entire bridge members termed as bending force. These perpendicular loads create a moment, which causes members to bend.

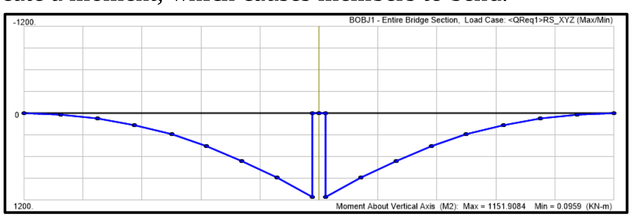


Fig. 6: Moment about Vertical Axis(M2) for model 1

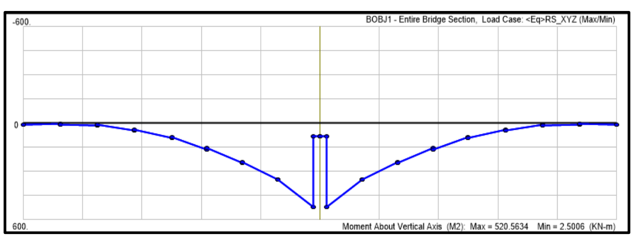


Fig. 7: Moment about Vertical Axis(M2) for model 2

6.3 Moment about Horizontal Axis(M3)

The governing factor which helps in determining the sizes and materials of the members to be used is generally the greatest bending moment that a beam can resist. Bending moment can be of any nature (positive or negative) and can produce any type of forces either compression forces or tension forces at different positioning of the members of the bridge.

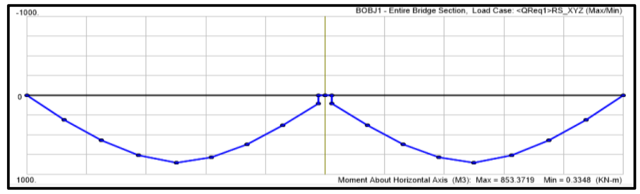


Fig. 8: Moment about Horizontal Axis(M3) for model 1

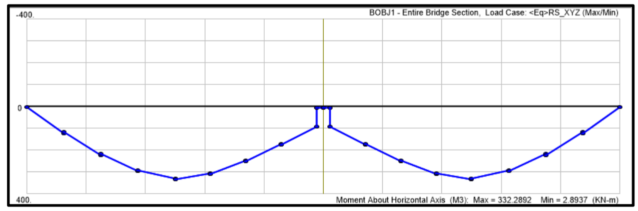


Fig. 9: Moment about Horizontal Axis(M3) for model 2

6.4 Shear Vertical(V2)

Shear force results from opposite transverse forces of equal magnitude, which has the tendency to slide one section or part of the member over an adjacent section or part. The transverse forces generate the shear stress which is manifested in the horizontal shear stress, which is accompanied by an equal magnitude vertical shear stress.

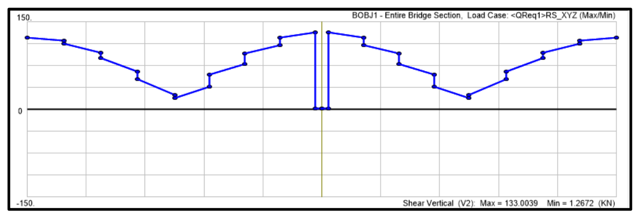


Fig. 10: Shear Vertical(V2) for model 1

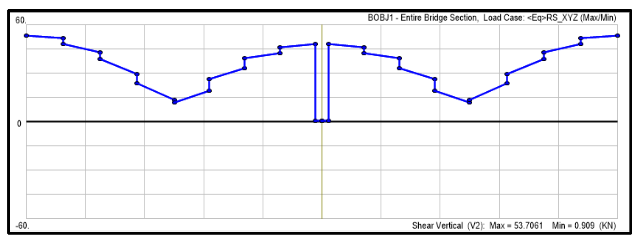


Fig. 11: Shear Vertical(V2) for model 2

6.5 Shear Horizontal(V3)

To keep the members in equilibrium (not moving) horizontal shear forces are essentially required. Usually vertical shear strength is considered in every design criteria.

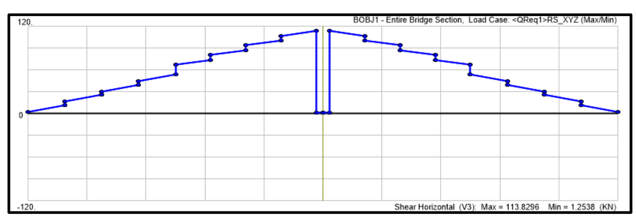


Fig. 12: Shear Horizontal(V3) for model 1

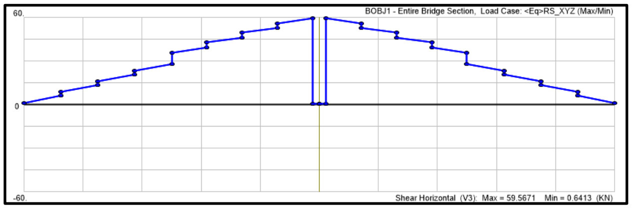


Fig. 13: Shear Horizontal(V3) for model 2

6.6 Torsion(T)

When the external moments are applied over the member it creates rotation or twisting of the member about its longitudinal axis. This generates a force termed as torsion and the torsional force is usually termed as torque.

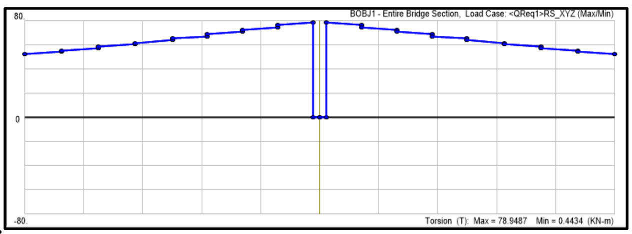


Fig. 14: Torsion(T) for model 1

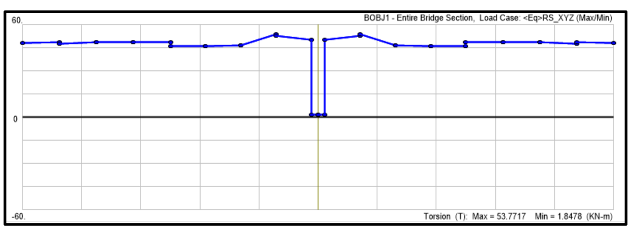
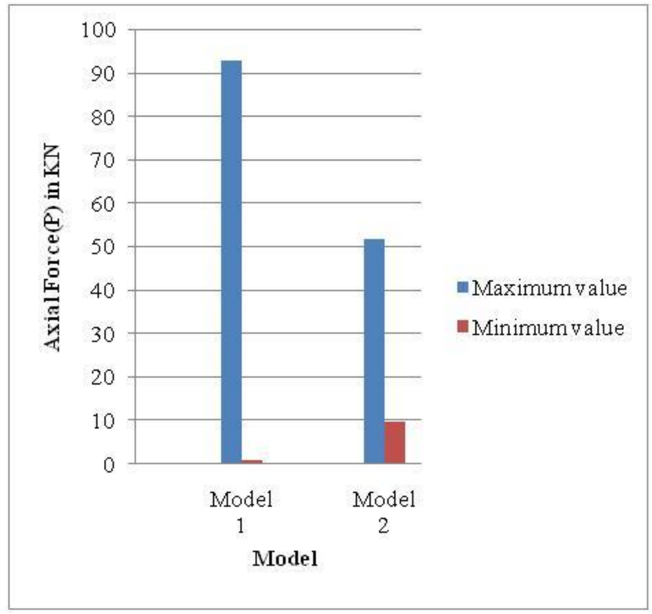


Fig. 15: Torsion(T) for model 2

7. RESULTS AND DISCUSSIONS

7.1 Axial Force(P)

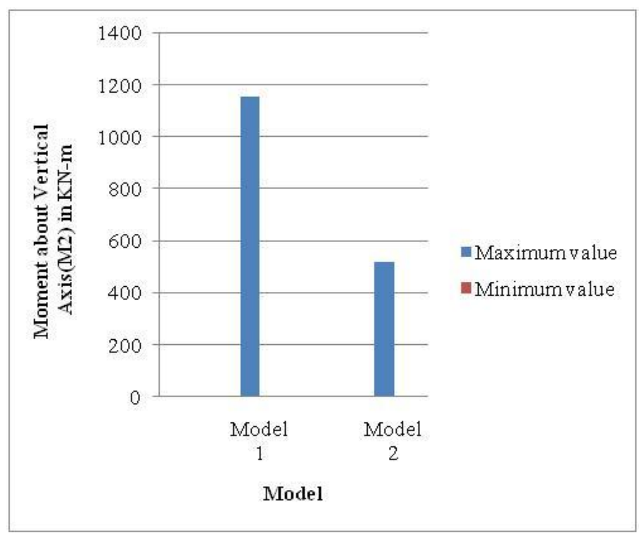
The axial force maximum value for model 1 is 92.8833KN while for model 2 is 51.6555KN and the minimum value for model 1 is 1.0779KN while for model 2 is 9.8068KN as shown in Graph 1.



Graph 1: Model vs Axial Force(P)

7.2 Moment about Vertical Axis(M2)

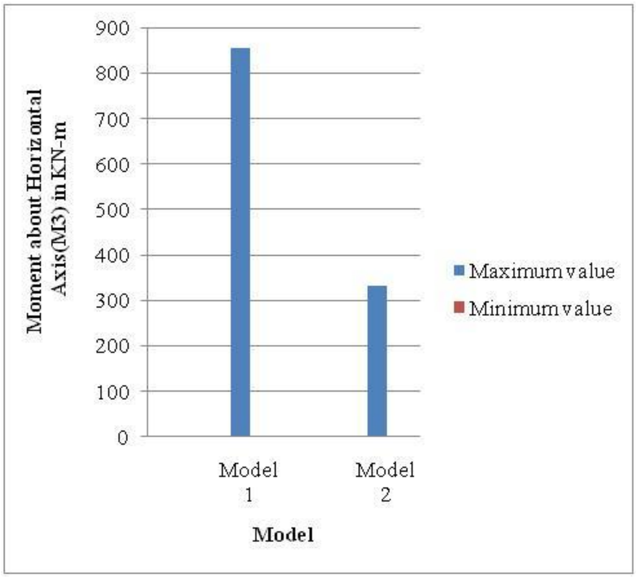
The moment about vertical axis maximum value for model 1 is 1151.9084KN-m while for model 2 is 520.5634KN-m and the minimum value for model 1 is 0.0959KN-m while for model 2 is 2.5006KN-m as shown in Graph 2.



Graph 2: Model vs Moment about Vertical Axis(M2)

7.3 Moment about Horizontal Axis(M3)

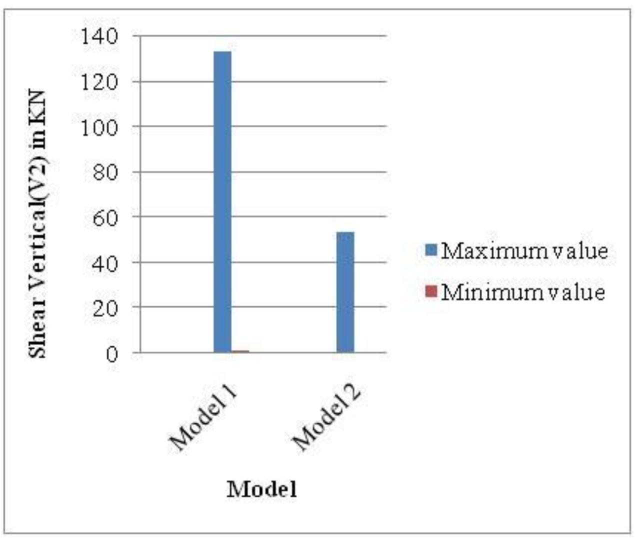
The moment about horizontal axis maximum value for model 1 is 853.3719KN-m while for model 2 is 332.2892KN-m and the minimum value for model 1 is 0.3348KN-m while for model 2 is 2.8937KN-m as shown in Graph 3.



Graph 3: Model vs Moment about Horizontal Axis(M3)

7.4 Shear Vertical(V2)

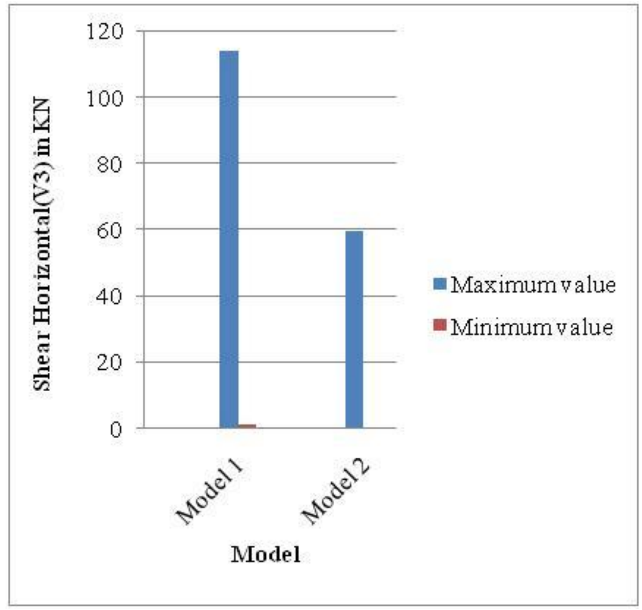
The shear vertical maximum value for model 1 is 133.0039KN while for model 2 is 53.7061KN and the minimum value for model 1 is 1.2672KN while for model 2 is 0.909KN as shown in Graph 4.



Graph 4. Model vs Shear Vertical(V2)

7.5 Shear Horizontal(V3)

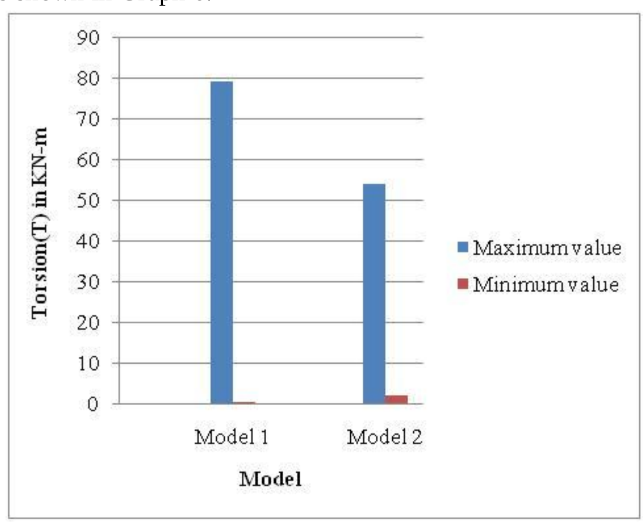
The shear horizontal maximum value for model 1 is 113.8296KN while for model 2 is 59.5671KN and the minimum value for model 1 is 1.2538KN while for model 2 is 0.64413KN as shown in Graph 5.



Graph 5. Model vs Shear Horizontal(V3)

7.6 Torsion(T)

The torsion maximum value for model 1 is 78.9487KN/m while for model 2 is 53.7717KN/m and the minimum value for model 1 is 0.4434KN/m while for model 2 is 1.8478KN/m as shown in Graph 6.



Graph 6. Model vs Torsion(T)

8. CONCLUSIONS

A. The maximum value of axial force(P) over entire bridge section under seismic excitation is lesser for model 2. The maximum value of axial force(P) for model 1 is 79.81% more than model 2.

B. The moment about vertical axis(M2) has its maximum value 1151.9084KN-m for model 1 which is 121.28% more than model 2.
C. The moment about horizontal axis(M3) has its maximum value 853.3719KN-m for model 1 which is 156.82% more than model 2.
D. The maximum value of shear vertical(V2) is much lesser for model 2 as compared to model 1 whose maximum value is 147.65% more than model 2.
E. The maximum value of shear horizontal(V3) for model 1 is 91.09% more than model 2.
F. The maximum value of torsion(T) over entire bridge section under seismic excitation is lesser for model 2. The maximum value of torsion(T) for model 1 is 46.82% more than model 2.

From above it is clearly evident that I girder bridge model has the lesser values of axial force, moment about vertical axis, moment about horizontal axis, shear vertical, shear horizontal and torsion over entire bridge section under seismic excitation than T-beam bridge model, so from analysis I girder bridge model prove to be the optimized bridge model.

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