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RESPONSE SPECTRUM ANALYSIS OF T-BEAM BRIDGE SUPPORTED ON PIERS

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Abstract: The present study corresponds to response spectrum analysis of a T- Beam bridge supported over piers. The analysis shows the response of RC bridge to seismic loads acting in both the directions. Linear response spectrum analysis is performed with the general purpose FE-program SAP2000. The modal periods and frequencies, and deformed shape corresponding to EQ X, deformed shape corresponding to EQ Y, spec X deformed shape, spec Y deformed shape, different mode shapes, and variation of axial force under earthquake load have been investigated. This study focuses on the seismic analysis and behaviour of T bean bridges supported by piers.

Keywords: Response spectrum, modes, SAP2000, frequency, time period, mode shape, T Beam Bridge

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INTRODUCTION

India had experienced a no of world's greatest earthquakes in past years most of which have been of magnitude more than 7.0 on Richter scale in which Dec 26, 2004 Indian Ocean earthquake that killed 15000 people in India was the third deadliest earthquake in the history of world. More than 50% of the country is considered as prone to damaging earthquake. After happening of Gujarat (2001) and Kashmir Earthquake (2005), there is a nation-wide attention to assessment of the seismic vulnerability of existing buildings. Many literatures are available on the seismic evaluation procedures of multistoried buildings using pushover analysis.

Bridge is an important structures and failure of bridge may create catastrophic damage that lead to loss of life and property. It will destroy the communication system of the country and affect the economy and disturb the pace of life. It is important to perform seismic health evaluation of existing bridges for repairing and retrofitting. In this study, an existing bridge has been analyzed to explore its seismic response by using response spectrum analysis.

Following are the main objectives of the present study:

a) To understand the Response spectrum analysis procedures for the bridge under consideration

b) To carry out a detailed study of a reinforced concrete bridge under seismic loading

The methodology adopted for the study is as follows:

a) A thorough literature review to understand the seismic evaluation of brides and application of response spectrum analysis

b) Select an existing RC bridge with geometrical and structural details

c) Model the selected bridge in computer software SAP2000.

d) Carry out Response spectrum analysis analysis to obtain the response of the bridge subjected seismic loading

2. Literature Review

Seismic analysis of bridges has been a topic of interest to many researchers in past years. Lan Lin, Nove Naumoski and Murat Saatcioglu [1] performed study on the Seismic behavior of the Confederation Bridge. The Confederation Bridge was opened for traffic in June 1997. It is

12,910 m long and is one of the longest reinforced concrete bridges built over water in the world. The Bridge is located in a region known for very harsh environmental conditions.

It is covered by ice approximately three to four months in a year often experienced wind in above 100 km/h. For the seismic evaluation of the bridge, response spectrum and time history analyses were conducted on the bridge model to determine the responses due to seismic actions represented by the uniform hazard spectrum and the selected sets of records. The bending moments, shear forces, axial forces, and displacements were obtained from the analysis.

Effect of seismic isolation systems on dynamic behavior of bridges under earthquake loading was studied by Majid and Mohsen [2]. The dynamic analysis was performed to know the response of bridge with isolation system and designing it. The papers also include the analysis of the behavior of materials and isolators that assumed to be linear. The parametric study for stiffness variation of deck, piers and elastomeric bearings were also performed. The nonlinear behavior for isolators has also been analyzed.

Jeng-Wen Lin, Cheng-Wu Chen, and Shang-Heng Chung [3] used data from Mao-Lou-Hsi Bridge to study the bridge structure for formulating guidelines for bridge maintenance with the help of a set of developed alarm and action. The bridge was excited by external dynamic load to evaluate the dynamic properties of the bridge. The dynamic 3D analysis was performed with and without considering the soil structure interaction.

Joan R. Casas, and José L. Chambi [4] described the methodology for a reliability-based procedure and proposed partial safety factor and compared with that is given in existing code for strengthened or seismic retrofitted bridge piers using fiber reinforced polymers (FRP). The use of FRP increases confinement of concrete and the application of it is easy. It is having excellent mechanical and chemical properties.

J.M. Jara, J.R. Reynoso, B.A. Olmos, and M. Jara [5] presented the parametric study on irregular RC bridge supported on piers under strong ground motions. The parameters such as height of piers, soft and hard soils are studied on the seismic response of the sub-structures and super-structures. They concluded from their study that the piers adjacent to the tallest piers are mostly affected by the irregularity.

3. MODELING

The bridge modelling is carried out by using SAP (2000) software. This section provides model geometry information (figure 1).

Finite element model:

Total span = 65.5m (10.25 m, 22.5 m, 22.5 m, 10.25 m)

Bridge type = T beam bridge

Material = Concrete (M30)

Poisson's ratio = 0.3

Pier cross section = Circular (1.2 m diameter)

Material properties =As per IS: 456

4. RESULTS AND DISCUSSION

The selected bridge is analyzed using Response spectrum analysis method. Bridge response to the ground motion is found out by spectrum method. The modal period and frequencies are tabulated below (table 1). The deformed shape and mode shapes are determined shown in figures 2, 3, 4, 5 and 6. The response of the bridge also evaluated from the analysis (figure 7).

Table 1 Modal Periods and Frequencies

StepType	StepNum	Period	Frequency
Text	Unitless	Sec	Cyc/sec
Mode	1	0.317639	3.1482
Mode	2	0.214211	4.6683
Mode	3	0.18839	5.3081
Mode	4	0.175087	5.7115
Mode	5	0.163787	6.1055
Mode	6	0.149989	6.6672
Mode	7	0.143463	6.9704
Mode	8	0.098347	10.168
Mode	9	0.09182	10.891
Mode	10	0.087501	11.428
Mode	11	0.084749	11.8
Mode	12	0.071862	13.916

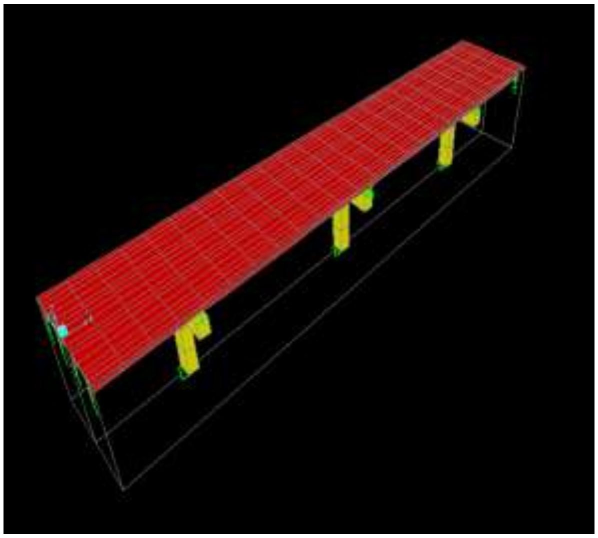


Figure 1: Extruded View

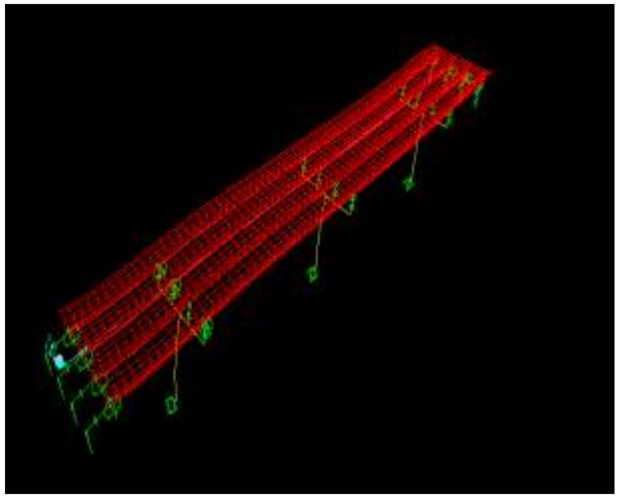


Figure 2: Deformed Shape Corresponding to EQ X

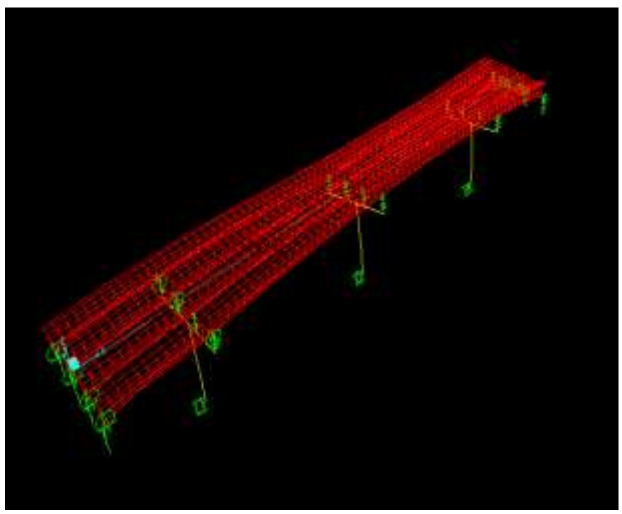


Figure 3: Deformed Shape Corresponding to EQ Y

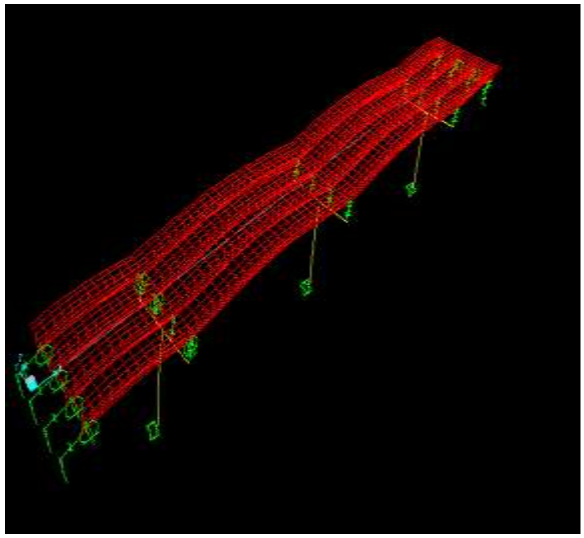


Figure 4: Spec X Deformed Shape

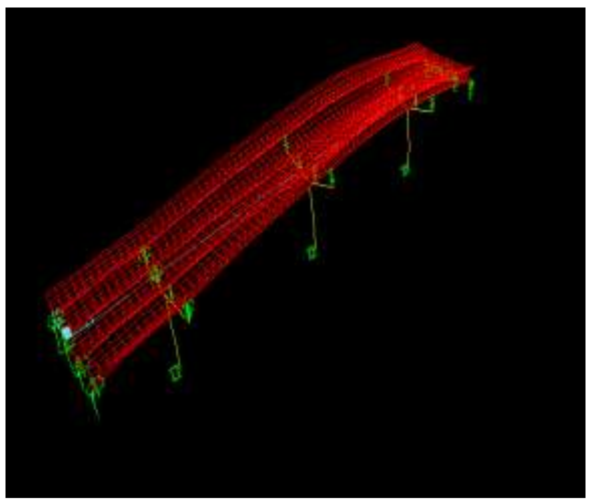
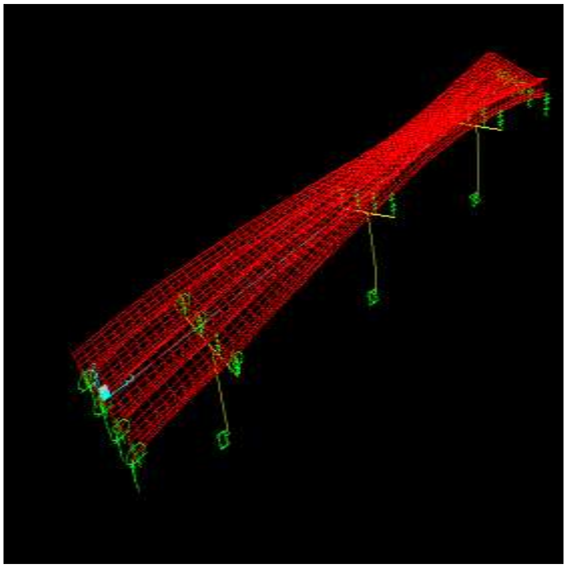
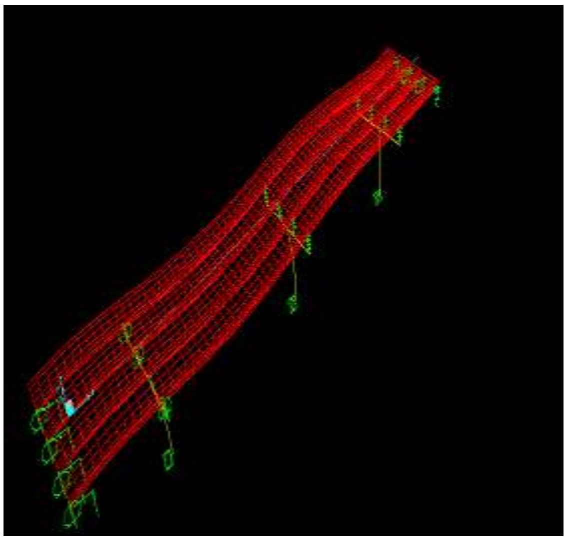


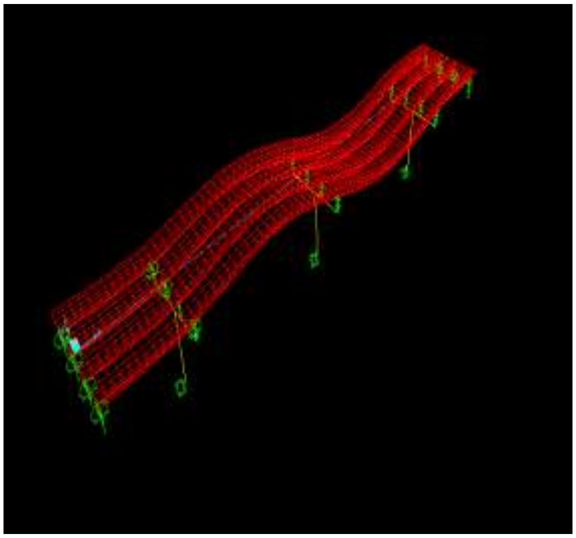
Figure 5: Spec Y Deformed Shape



(Mode 1)



(Mode 2)



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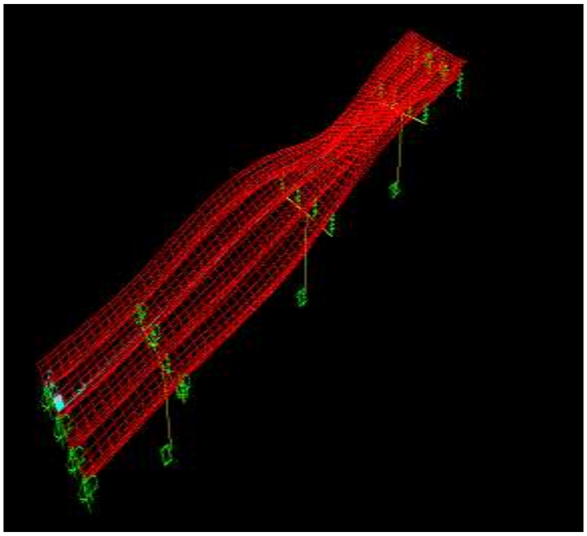

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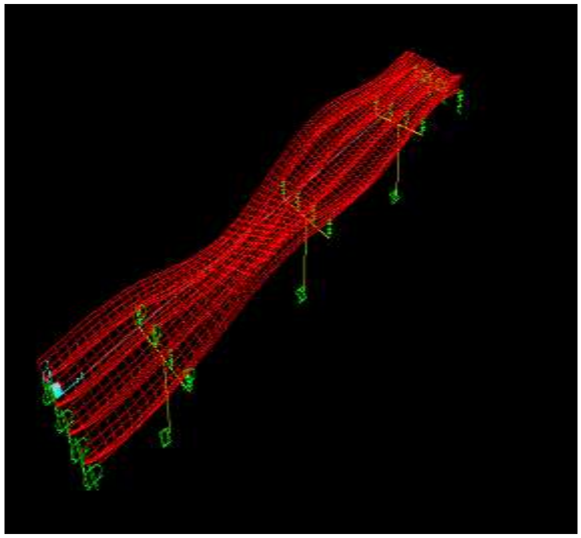

(Mode 5)

Figure 6: Mode Shapes 1, 2, 3, 4, and 5

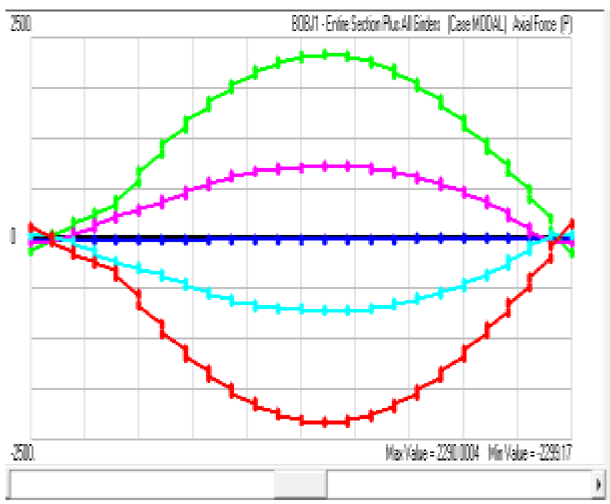

Figure 7: Variation of Axial Force for Entire Section and All Girders

5. CONCLUSION

In this study, response spectrum analysis of T-beam bridged supported on the piers is performed. From the analysis, modal periods and frequencies are obtained and tabulated. Similarly, deformed shape corresponding to EQ X, deformed shape corresponding to EQ Y, spec X deformed shape, spec Y deformed shape, different mode shapes, and variation of axial force under earthquake load for all girders and deck section are graphically presented for the bridge. If the fundamental period of the bridge is same with that of ground motion, huge deformation and base shear are induced in the bridge.

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