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Seismic analysis of box girder bridge

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ABSTRACT

Nowadays the box Girder Bridge is a frequently used bridge system worldwide. Actually, the box Girder Bridge is commonly used for the long span for the ignoring the heavyweight as compared to the other bridge girder system. CSi Bridge v 20.0.0 is used for analyzing the dynamic response of box Girder Bridge. The main objective of this study is analyzing and investigating seismic performance of multi-span with up to five spans 92-meter-long box Girder Bridge. The seismic performance of box Girder Bridge is very complex and performance depends on the peak ground motion and, ground motion acceleration. It is done by the non-linear time history analysis method. In this study, the three-dimension model and the data of the Kobe earthquake are used for dynamic characteristics and showing the maximum response of box girder deck. Response results indicate in terms of deformed shape, absolute acceleration, base shear, base reaction, total energy component and displacement. Thus, the paper suggests that the construction of bridge based on time history analysis will sustain the earthquake up to 6.9 magnitudes.

Keywords— Box girder, Bridge model, Ground motion, Seismic response, Kobe earthquake

1. INTRODUCTION

Box Girder Bridge is most common in worldwide and box Girder Bridge is better stable, serviceable and economical. Box Girder Bridge have exceptional rigidity resulting in better transverse load distribution. Box Girder Bridge is very complex because it is the three-dimensional and transverse direction. Mostly several types of bridge failure have been noticed during the earthquake and some deck, pier buckled some collapsed. There is a big problem. a common failure deck slid off their substructure support due to strong ground motion as in SHOWA BRIDGE in the 1964 NIIGATA earthquake with magnitude M=7.5 and the NISHINOMIYA BRIDGE in the 1995 KOBE earthquake with magnitude M=6.9 in Japan. Therefore, need to design effective when induced strong ground motion. Actually, some earthquake magnitude is predicted in the various intensity, therefore, it is must know to study the various seismic behavior for different in term of various response. Last few years, theoretical and experimental work performed and investigated seismic behavior using time history analysis method and examine the effect of seismic response.

In this study, we have taken 92 m long bridge deck with multiple spans. The value of peak ground acceleration PGA, peak ground velocity PGV, peak ground displacement of fault normal and fault parallel component are examined for determining of seismic response of box Girder Bridge. Non-linear time history analysis method is used in the current study to carry out the seismic response of box Girder Bridge.

2. METHODS USED IN STUDY

There are various method to use to measure the seismic response of bridge structure. They are Equivalent static seismic force method, the response spectrum method, time history analysis method, and pushover analysis. We have used the time history analysis method in our study.

Time history analysis method is very wide and complex field of study. There are two types of time history analysis method i.e. boundary non-linear time history analysis and inelastic time history analysis. Time history analysis is a dynamic analysis which considers material non-linearity of the structure. Considering the efficiency of the analysis, the non-linear element is used to represent important parts of the structure, and the remainder is assumed to behave elastically. Time history analysis method is applied for the determining the seismic behavior of bridge structure under dynamic loading of the earthquake.

3. DATA ANALYSIS

Kobe earthquake was one of the most destructive earthquakes in Japan with the magnitude of 6.9. The earthquake caused extreme damage in Kobe city and its surrounding area. The tremor lasted for approximately 20 second and the locus of the earthquake was located 17 km beneath its epicenter. Approximately 6434 people lost their lives in this disaster and around 4600 people there from Kobe city.

Characteristics of field ground motion which is used in the analysis:
Earthquake- Kobe earthquake
Station- Kakogawa japan
Magnitude- 6.9
Distance- 22.5 km

4. BRIDGE STRUCTURE MODEL AND ANALYSIS

Typical 3-dimensional concrete box Girder Bridge with up to five spans consist of a continuous 92-meter-long box girder deck with 1 intermediate girder are examine the different elements of the bridge model and seismic loading. in this study, the following parameter is considered.

Bridge geometry:
Bridge span- 92 m
Span ratio- 1.0
No. of girder- 4
Bridge width- 9.7 m
Bridge depth- 1.5 m
Concrete slab thickness- 225 mm
Diaphragm depth- 1.5 m
Abutment- 4 m depth and 1.5 m width
Pier cap- 1.5 m depth and 1.2 m width
Live load- IRC class and IRC class70R two-lane traffic
Regulations- IRC: 5, IRC: 6, IRC:21 and IRC;112
Materials- Untensioned steel HYSD bars grade Fe415 conforming to IS; 1786, controlled concrete M40 and M55.

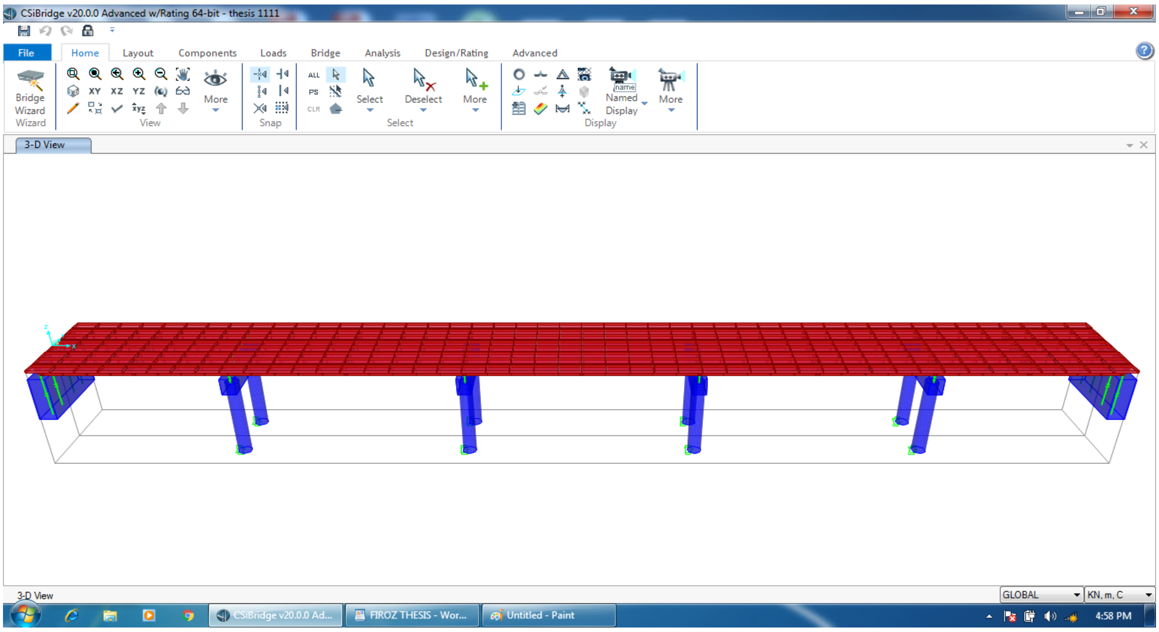


Fig. 1: 3D Bridge model – CSIBridge

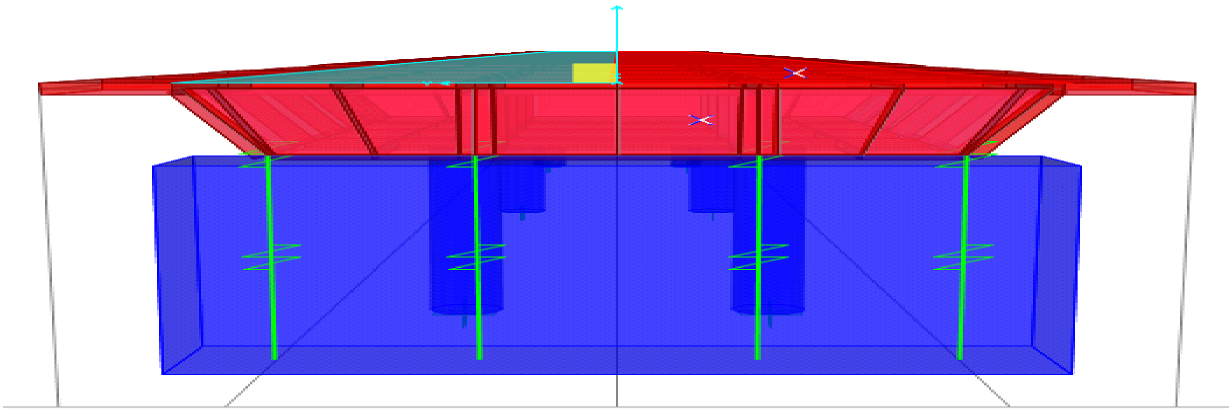


Fig. 2: 3-D Bridge model, superstructure & substrcture- CSIBridge

4.1 Integrating of the bridge

Since all the bridge component has been defined step by step. The reference line defines the abutment and pier cap. Since the model has 5 spans, the reference line has set to have 5 spans by modifying the value of the start and end station considering 92-m span length shown in the figure.

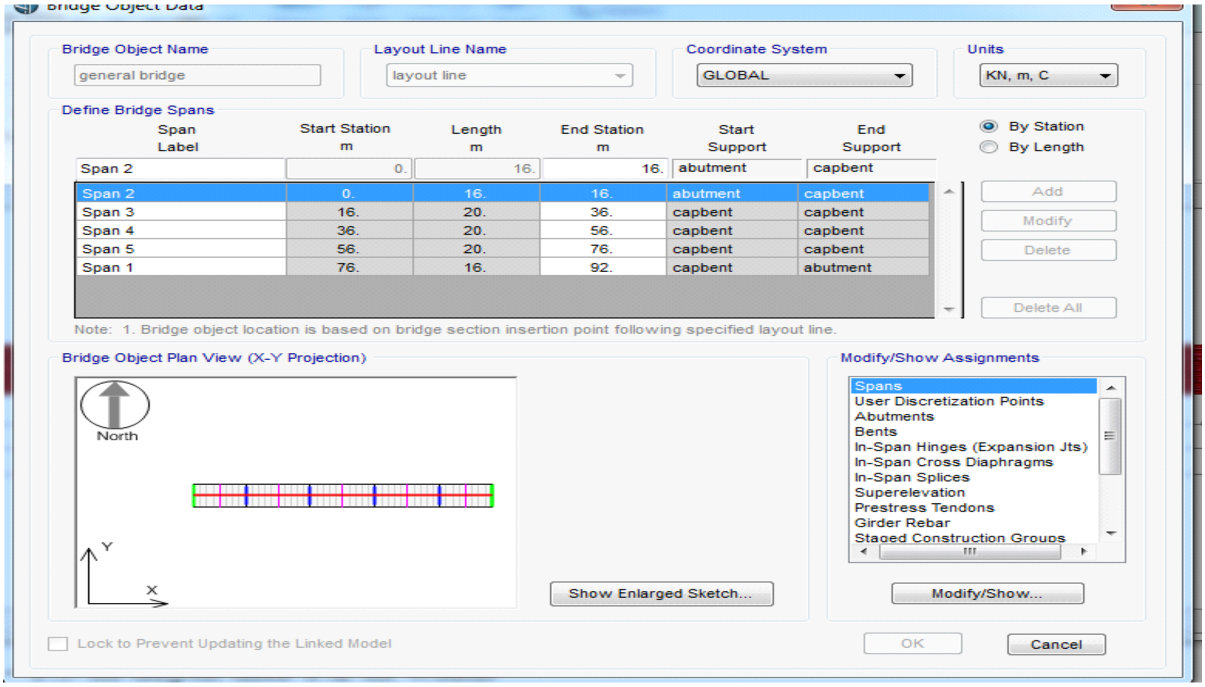


Fig. 3: Start- end station of the bridge span

We have assumed column bent with length 7.5m with a circular column diameter of 1.5m and height 12m. For this study, vehicles loading are taken from IRC: 6 and geometry from IRC: 112. In this bridge, we are analyzing for the maximum bending moment to loading AA and loading 70R. Seismic loading considered from IS: 1893-2016 and the maximum normal and shear stresses for concrete box girder at the critical section. We have taken permissible stress as per section IRC: 18. The time history technique is used for the parametric analysis and resulting higher seismic response.

5. MODEL ANALYSIS RESULTS

Seismic response of the box Girder Bridge, Earthquake forces selected to be EQX and EQY has been defined in load cases and other loads cases that is a kerb, parapet wall, footpath and wearing a coat with gravity direction. Seismic response of the box Girder Bridge deformed shapes are shown below.

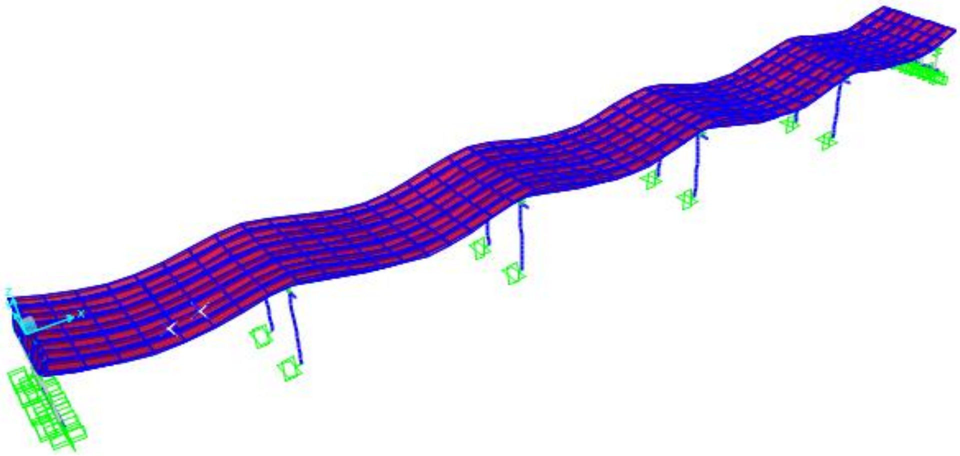


Fig. 4: deformed shape (wearing coat)

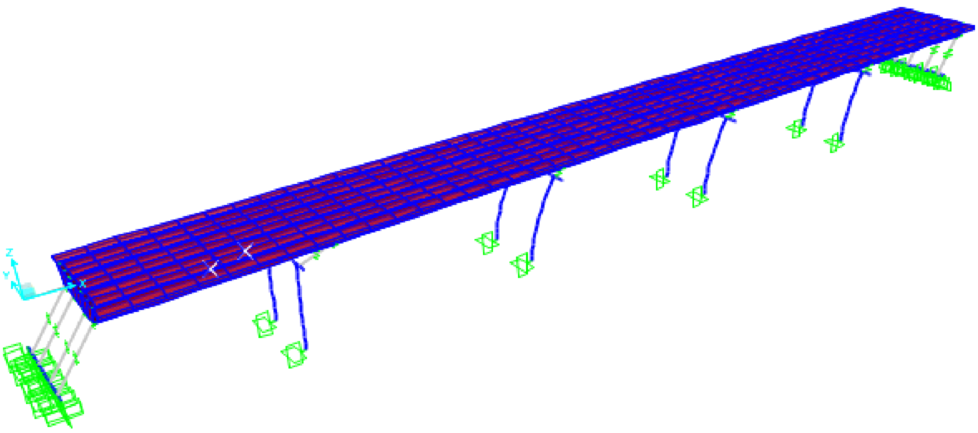


Fig. 5: Deformed shape (eq)

6. SEISMIC ANALYSIS RESULTS

The seismic response of the multi-span box Girder Bridge is discussed in the above study. The 92m long box Girder Bridge model using 3-dimensional and Kobe earthquake are used as dynamic input to calculate the maximum seismic response of the box girder deck. The non-linear time history analysis output is shown in the term of the displacement and base shear studies. Seismic response of the box girder in the term of acceleration, displacement, velocity and base shear shows in the comparative diagram is given below.

Base Reactions

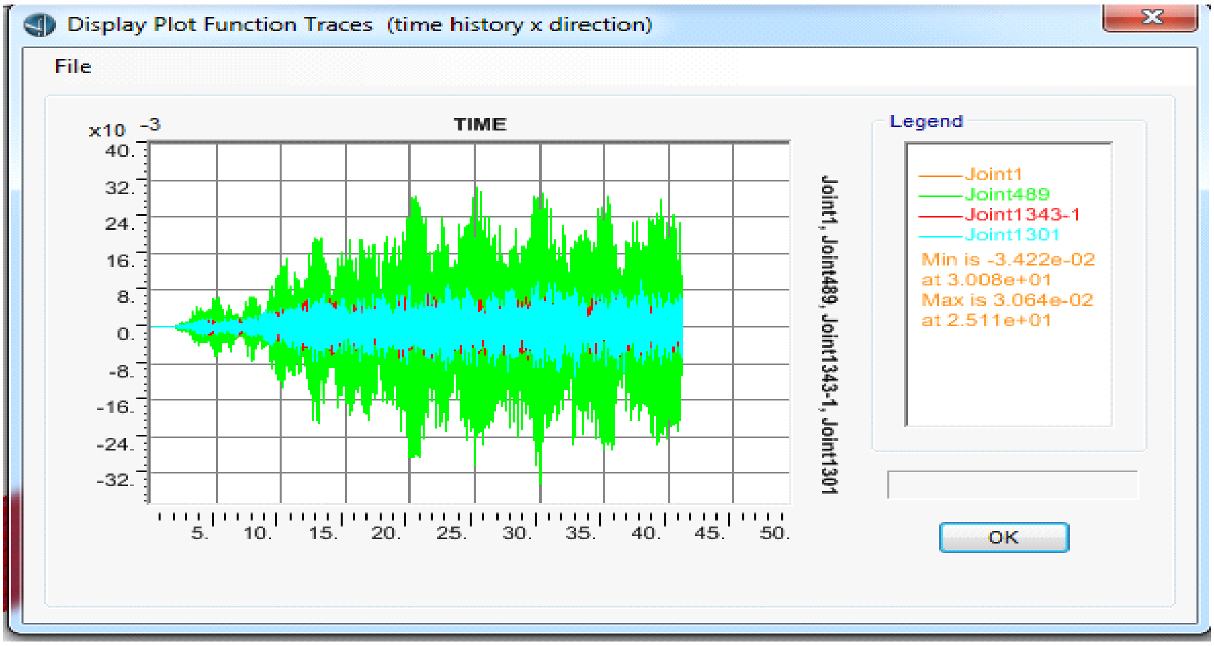
File View Edit Format-Filter-Sort Select Options

Units: As Noted

Filter:

OutputCase	CaseType Text	StepType Text	GlobalFX KN	GlobalFY KN	GlobalFZ KN	GlobalMX KN-m	GlobalMY KN-m	GlobalMZ KN-m
ULS basic c...	Combination	Max	3.296E-08	7.925E-09	31511.77	6619.4889	-1289730.15	-5.253E-07
ULS basic c...	Combination	Min	-1.313E-08	-1.655E-08	27981.376	7.624E-08	-1354924.76	-8.606E-07
ULS siesmic...	Combination	Max	-1644.867	5.637E-09	31511.77	6619.4889	-1288245.55	-2.499E-06
ULS siesmic...	Combination	Min	-1644.867	-1.883E-08	27981.376	7.357E-08	-1353440.16	-2.835E-06

Fig. 6: Table of base reaction



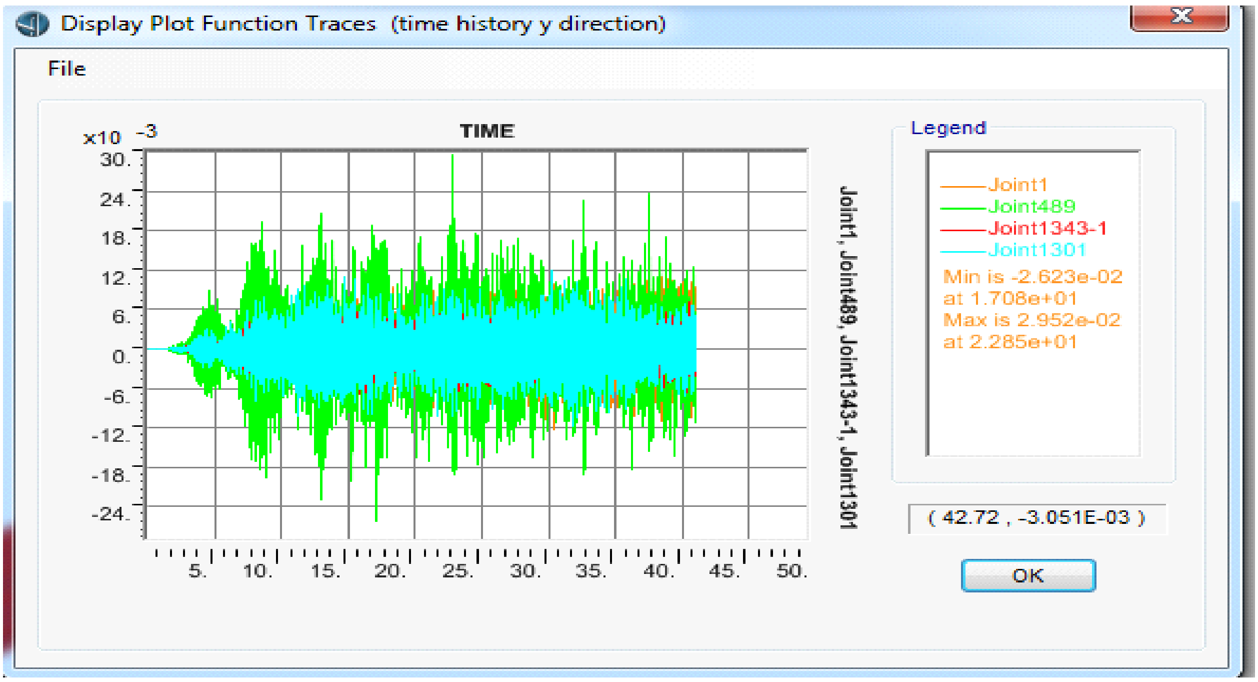
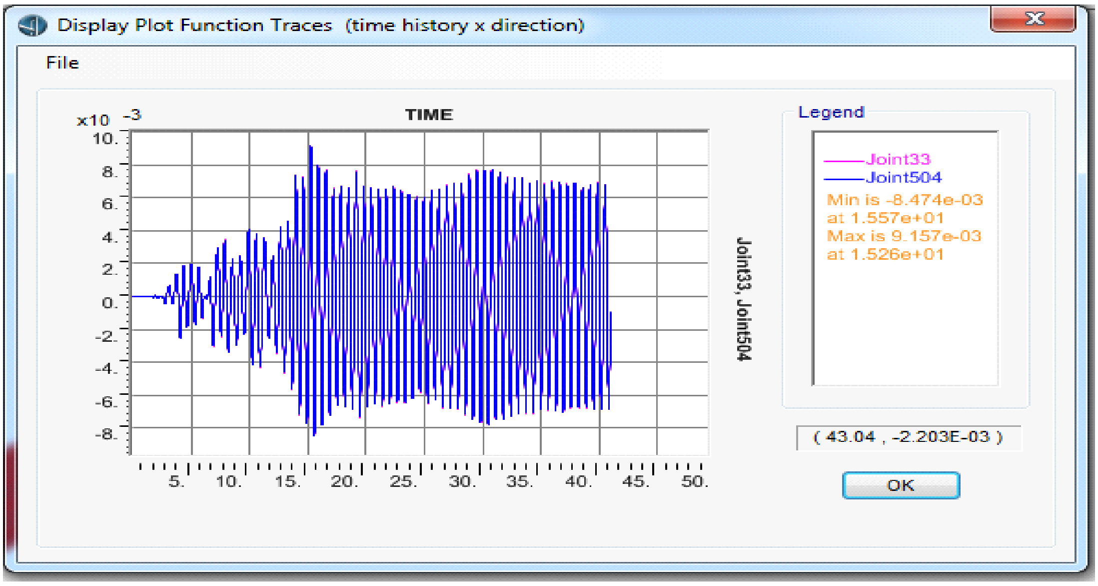


Fig. 7: Acceleration v/s time in X and Y direction



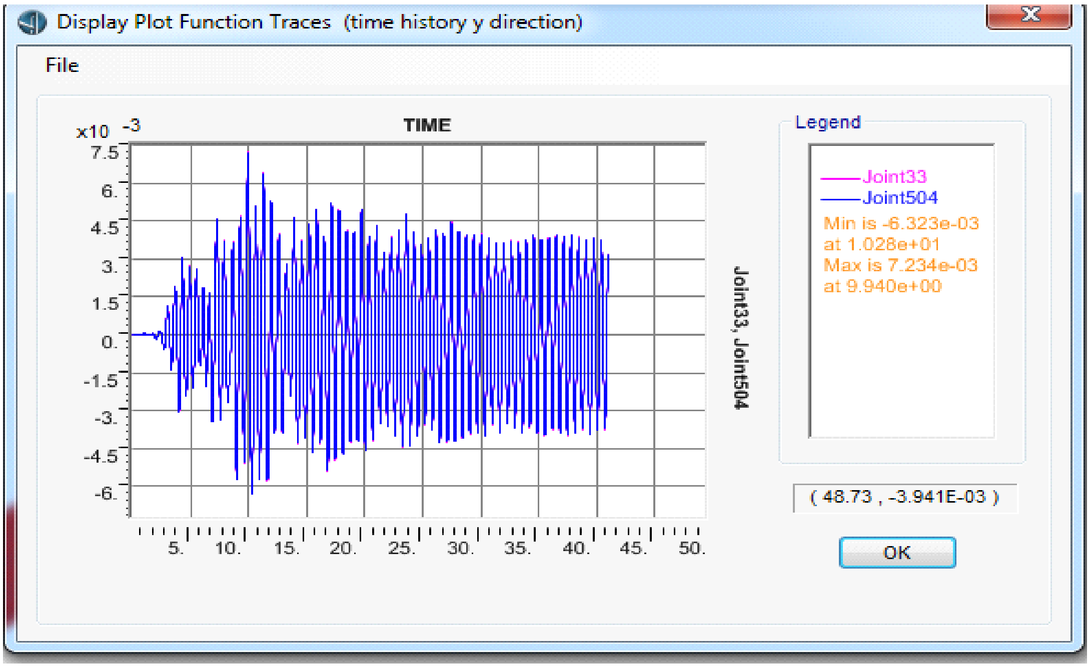


Fig. 8: Velocity v/s time in X and Y direction

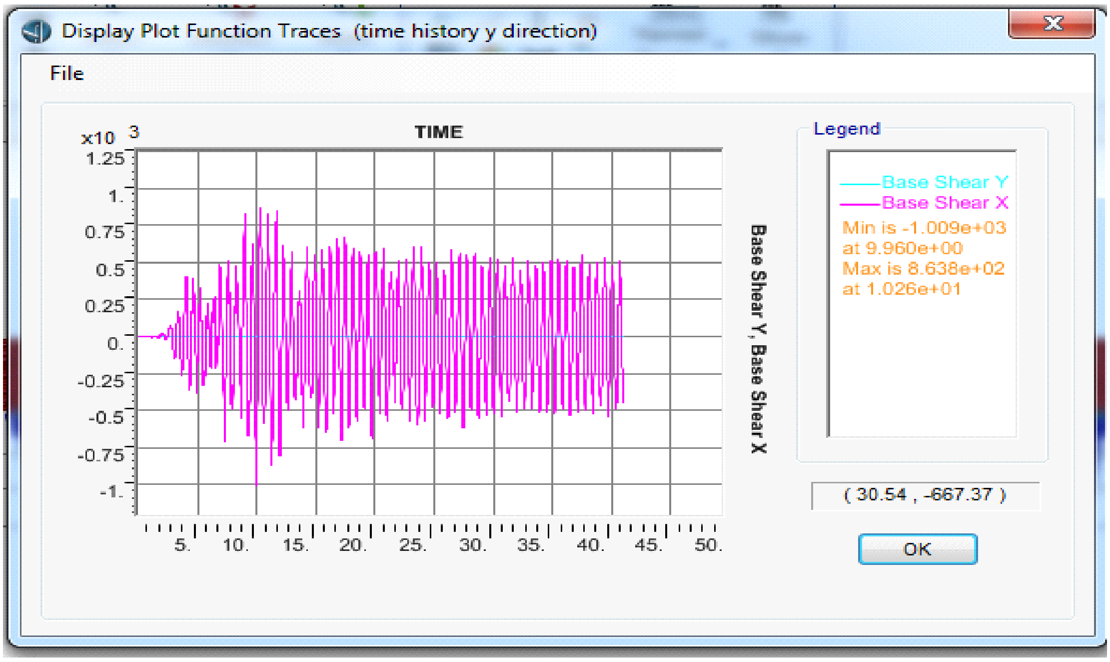


Fig. 9: Base shear v/s time in X and Y direction

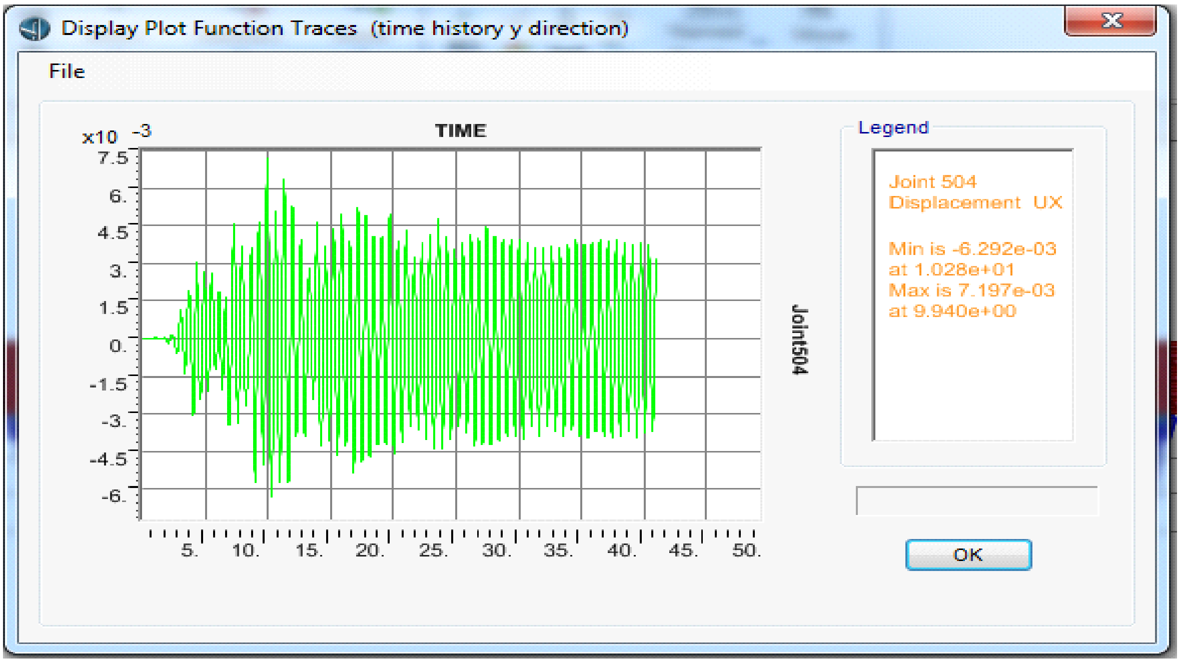


Fig. 10: Displacement v/s time in X and Y direction

7. CONCLUSION

From this study value of the acceleration, base shear, velocity and displacement have been determined for both components at the same joints of the bridge structure. Above results are shown in the form of a comparative diagram. According to the results following conclusion can be drawn.

- According to the above results, the value of the acceleration, displacement, velocity and base shear with respect to the time in the x-direction is higher than acceleration, displacement, velocity and base shear with respect to the time in the y-direction.
- Acceleration response of the bridge deck depends on the characteristics of the bridge and applied ground motion.
- Results show that the seismic response of the superstructure good agreements with recorded ground motion data in the term of the acceleration, base shear, velocity and displacement in both directions.
- It also the indication that the base shear has played an important role in the seismic response of the bridge deck. It provides resistance to lateral load.

In the seismic analysis, CSi Bridge v 20.0.0 is used for analyzing the dynamic response of box Girder Bridge. Motion hazard is determined by the using bridge structure geometry with the help of a time history analysis method and shows seismic effects in both X and Y direction.

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