International Journal of Research in Social Sciences
Vol. 9, Issue 4, April - 2019,
ISSN: 2249-2496 Impact Factor: 7.081
Journal Homepage: http://www.ijmra.us, Email: editorijmie@gmail.com
Double-Blind Peer Reviewed Refereed Open Access International Journal - Included in the International Serial Directories Indexed & Listed at: Ulrich's Periodicals Directory ©, U.S.A., Open J-Gate as well as in Cabell's Directories of Publishing Opportunities, U.S.A

Seismic Response of Box Girder Bridge

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ABSTRACT

The Box Girder Bridge is now a widely used bridge structure worldwide. Currently, the Box Girder Bridge is generally used for the long span for ignoring the heavyweight as related to the other bridge girder system. For analysis of the dynamic response of the Box Girder Bridge, CSi Bridge v 21.1.0 is used. The primary objective of this analysis is to evaluate and examine multi-span seismic output with up to five 100 m long Box Girder Bridge spans. Box Girder Bridge's seismic performance depends on peak ground motion and acceleration of ground motion. It is achieved by the approach of non-linear time history analysis. For dynamic characteristics and showing the maximum response of the box girder deck, the three-dimensional model and data of the Bhuj earthquake are used in this analysis. Response analyses are indicated in terms of displacement, moments, joint velocity and joint acceleration.

Keywords: Bridge, Displacement, Ground motion, Response, Span

INTRODUCTION

The Box Girder Bridge is the most common in the world. Box Girder Bridges have gained wide acceptance due to their structural efficiency, better stability, serviceability, economy of construction and pleasing aesthetics. The Box Girder Bridge has exceptional rigidity, resulting in better distribution of transverse loads. During the earthquake, mostly many forms of bridge failure have been found and some deck, pier buckled some collapsed. The 1971 M6.6 San Fernando Earthquake, 1989 M7.1 Loma Prieta Earthquake, 1994 M6.7 Northridge Earthquake, 1995 M7.2 Hanshin-Awaji Kobe Earthquake, and 2011 M9.0 Tohoku Earthquake (Japan), are few earthquake to call which have caused drastic damage to a substantial number of bridges that had lack of design consideration to seismic counteraction, followed by huge loss of lives and economy. The 2001 M7.6 Bhuj Earthquake that shook up the Indian Province of Gujarat was the foremost deadly in India's recorded history. The foremost recent 25 April 2015 M7.8 Nepal earthquake caused damage to the several poorly built and weak masonry structures for the reported shaking intensity of VII on MMI scale but there was no damage within the bridges constructed near the fault area.

It is therefore important to design effectively when strong ground motion is induced. Actually, in the different intensity, some earthquake magnitude is expected, so it is important to know how to study the different seismic behaviour in terms of different response. Seismic activity has been performed and studied in theoretical and experimental work over the last few years using the time history analysis approach and exploring the impact of seismic response.

A 100 m long bridge deck with five spans is used in this analysis. In the current study, the non-linear time history analysis approach is used to perform the box Girder Bridge seismic response.

METHODOLOGY

Different techniques are used to evaluate the seismic response of the bridge structure. The time history analysis technique is used in this study. The method of analyzing time history is a very wide and complex field of study. There are two kinds of methods of time history analysis i.e. non-linear time history boundary analysis and time history inelastic analysis. The analysis of time history is a dynamic analysis which considers the structure's material non-linearity. The non-linear portion is used to represent important parts of the structure, considering the efficiency of the analysis and the rest is presumed to behave elastically. The method of time history analysis is used to evaluate the seismic activity of the bridge system under the earthquake's dynamic load. To carry out the seismic analysis of 100 m Concrete Box Girder Bridge, CSiBridge v 21.1.0 Software is used.

Data Analysis

In this study, Bhuj Earthquake ground motion was used for the seismic analysis. A strong motion seismograph, IMD recorded earthquake with a magnitude of 7.7 and the intensity of the affected region ranged up to X (Extreme) on the MSK scale of intensity. The tremor lasted for 22 seconds and the focus of the earthquake was 16 km beneath its epicenter of Kutch district of Gujarat, India in 2001. The earthquake killed between 13,805 and 20,023 people, injured another 167,000.

Bridge geometry:

No. of span = 5

Span length = 100 m

Length of each span = 20 m

Bridge width = 10 m

Bridge depth = 1.6 m

Concrete slab thickness = 0.225 m

Abutment depth = 4.2 m

Abutment width = 1.6 m

Diameter of circular column = 1.6 m

Height of column = 10 m

Live load = IRC class A

Regulations = IRC-5, IRC-6, IRC-18, IRC-112 and IRC-SP-114

Seismic loading = IS: 1893-2016, IS:1893 (Part-3)

Material properties

Modulus of Elasticity (M40) = $31x10^9$ N/m^2

Density = 25000 N/m^3

Untensioned steel HYSD bars grade Fe415 conforming IS: 1786, controlled concrete M40

Poisson's ratio = 0.2

Damping ratio = 5%

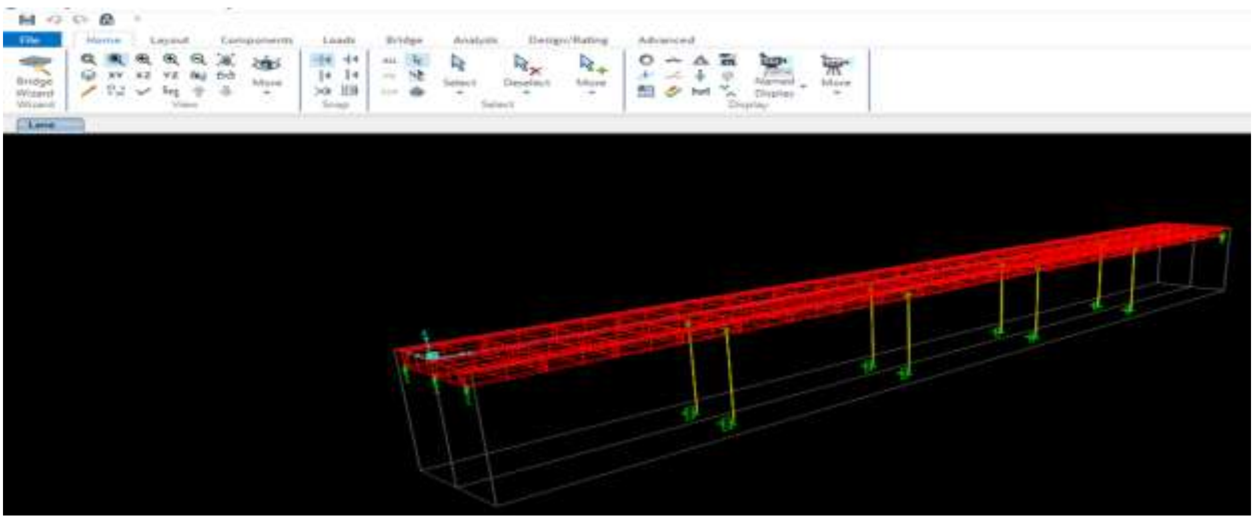

Fig. 1: 3-Dimensional Bridge Model

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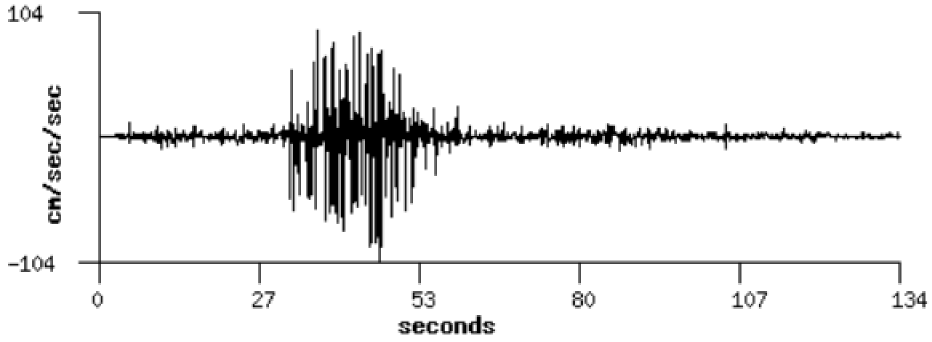

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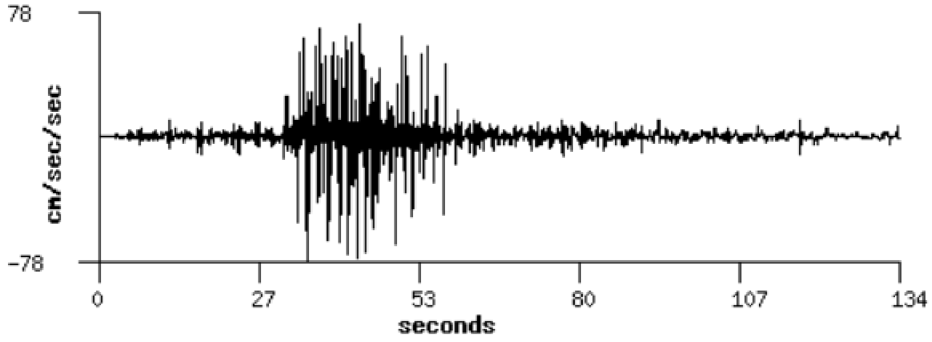

Fig. 2: Earthquake ground motion of Bhuj Earthquake, 2001

Results and Discussion

The seismic response of the five spans Box Girder Bridge is discussed in this study. The 100 m long Box Girder Bridge model using 3-dimensional and Bhuj Earthquake are used as dynamic input to calculate the maximum seismic response of the box girder deck. Seismic response of the box girder in the term of displacement, moments, joint velocity and joint acceleration shows in the comparative diagrams are shown below.

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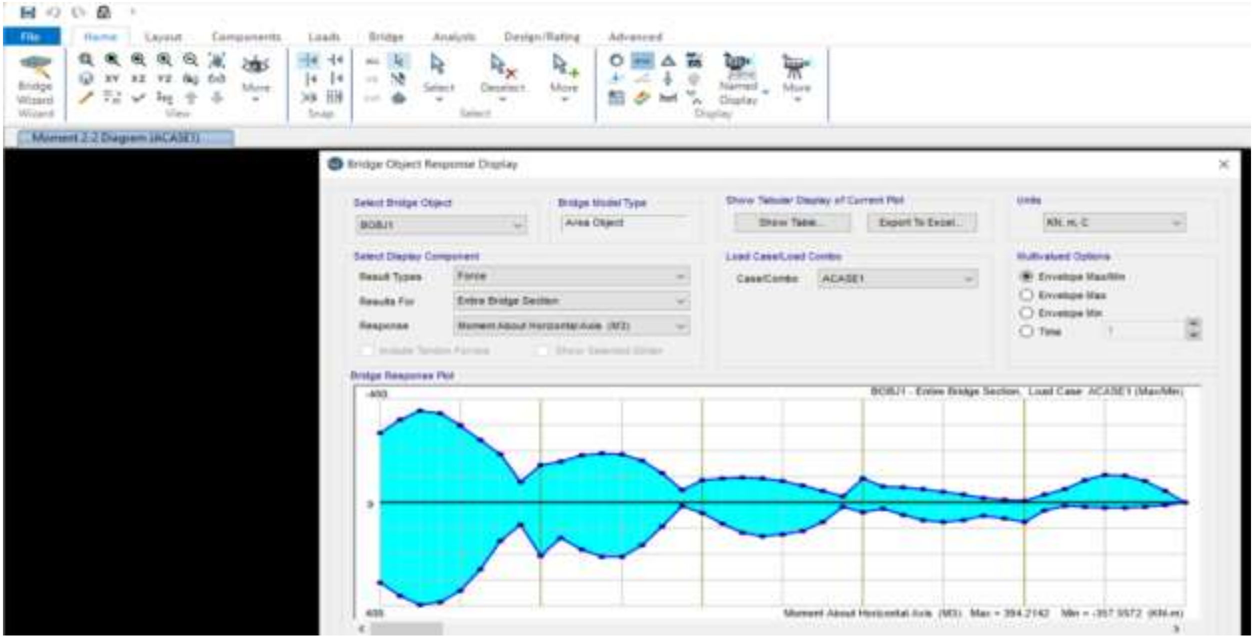

Fig. 3: Moment about Horizontal Axis diagram due to Seismic action

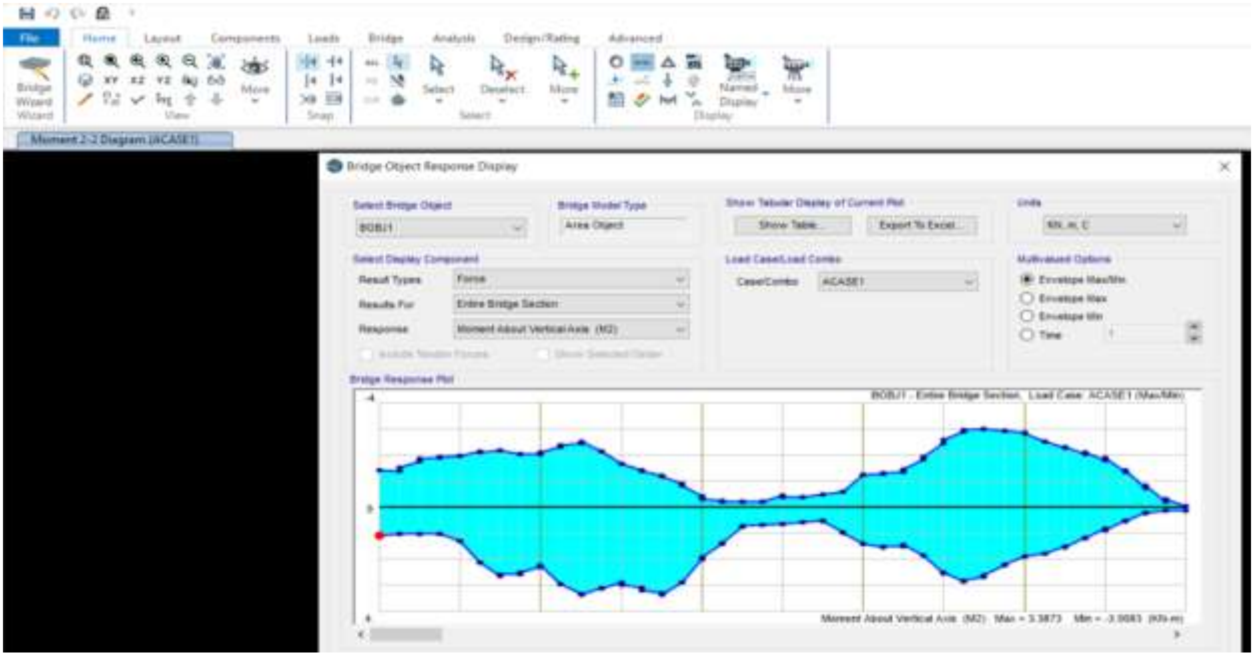

Fig. 4: Moment about Vertical Axis diagram due to Seismic action

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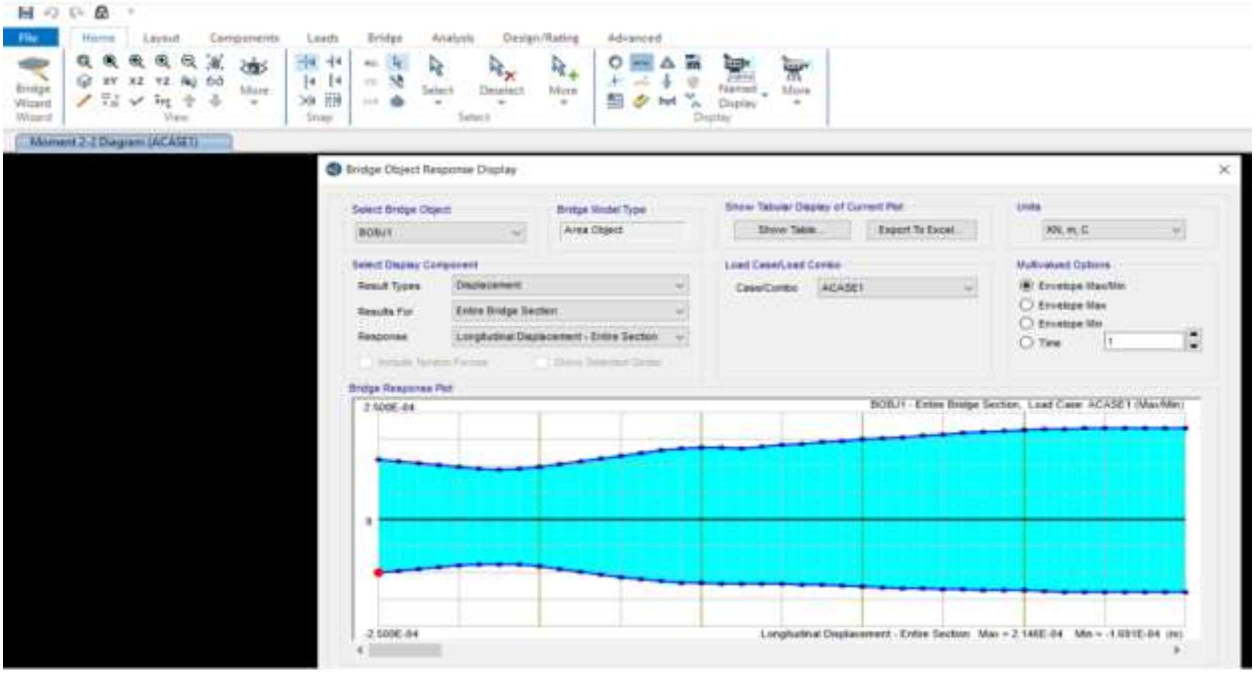

Fig. 5: Longitudinal Displacement diagram due to Seismic action

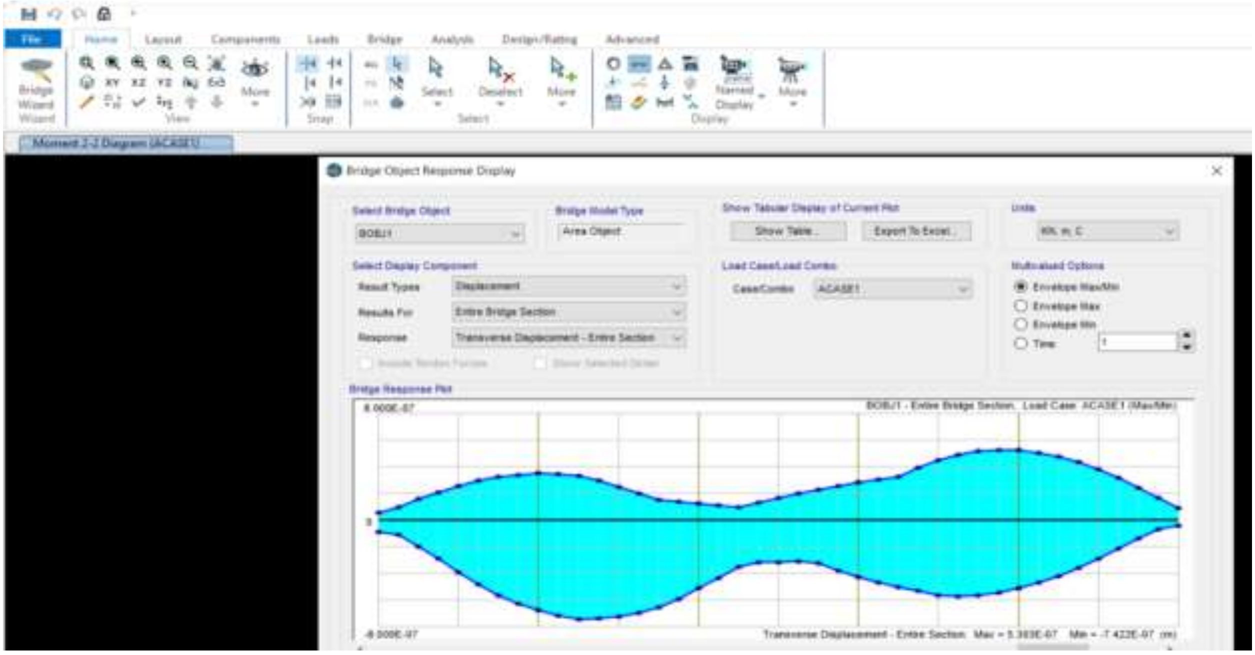

Fig. 6: Transverse Displacement diagram due to Seismic action

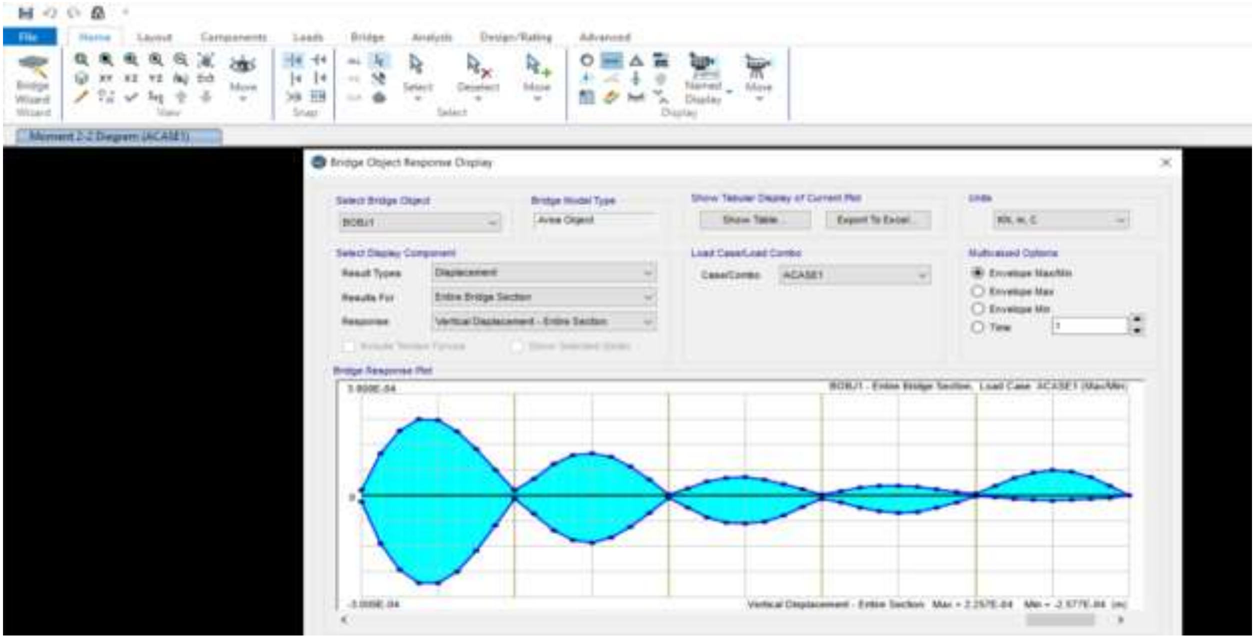

Fig. 7: Vertical Displacement due to Seismic action

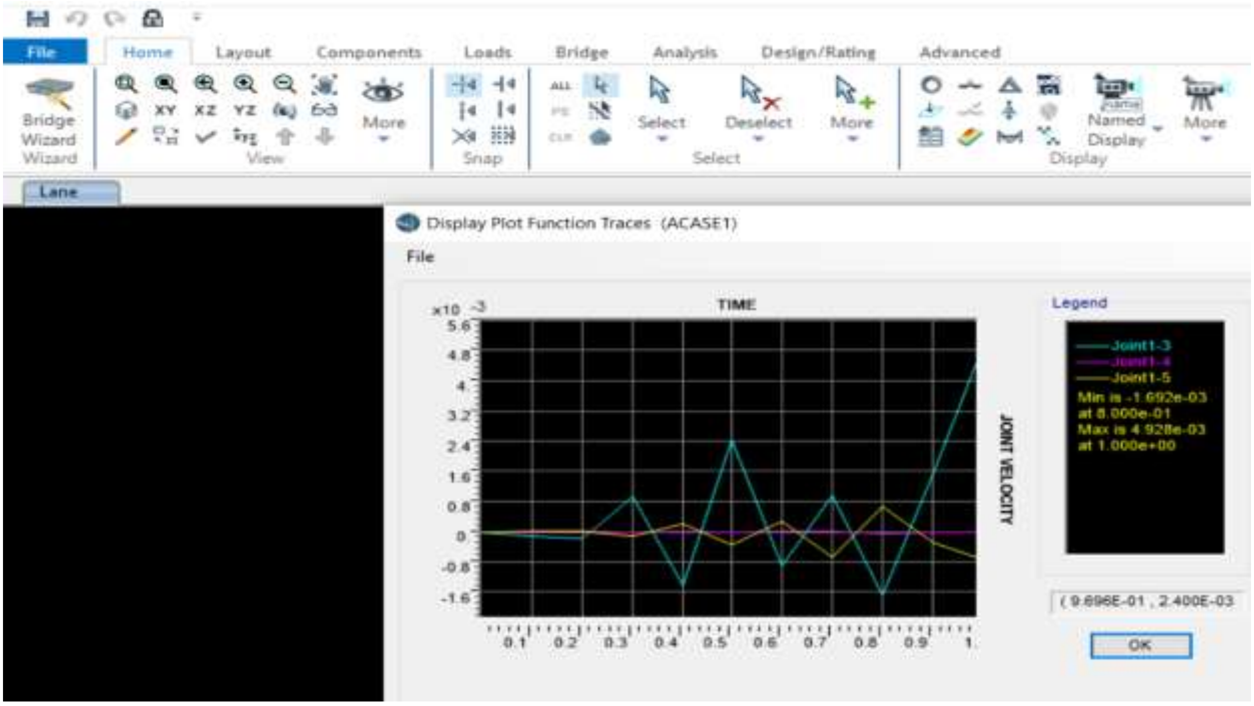

Fig. 8: Graphical representation of Joint Velocity along three directions

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Fig. 9: Graphical representation of Joint Acceleration along three directions

Conclusions

From this study the value of moment about horizontal axis is greater than vertical axis. Also, the displacement is maximum in vertical direction and the least is in transverse direction. The values of joint velocity and joint acceleration in x-direction are more than remaining two directions.

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