

# Study on Seismic Isolation of Long Span Double Deck Steel Truss Continuous Girder Bridge

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**Abstract-** *The best options for enhancing India are generally those that have experienced significant earthquakes in the past century. Over half of the country is deemed vulnerable to destructive earthquakes. Attention is being paid nationwide to the seismic behaviour of existing structures. On the other hand, bridges are crucial parts of any nation's transportation system. The majority of Indian bridges were inadequately built to resist earthquake and wind stresses due to outdated building regulations. With an aspect ratio of two to three, the design shear capabilities for short piers are found to be smaller than the equivalent under flexural shear demand over strength conditions. A double decked bridge located in zone V is subjected to a seismic load, but no research or discussion has been conducted on the layout and seismic performance of the double-decker bridge metro pier. With the use of CSI Bridge software, the analysis process is later finished. For the double-decked bridge, calculations are made for bending moment, shear force, period, and displacements.*

**Keywords-** double deck truss; continuous girder bridge; response spectrum analysis, pushover analysis combined seismic dissipation and isolation.

## I. INTRODUCTION

Natural disasters that cause abrupt and significant devastation include earthquakes. Even the framework of a building may collapse due to the activity of infrequent earthquakes, endangering human safety. While double-deck bridges have made city traffic somewhat easier in recent years, the ensuing seismic issues are concerning. The lower deck experienced excessive lateral displacement under the earthquake action, causing it to collide with the supporting column and suffer shear failure. The upper supporting column of the bridge broke during the Loma Prieta earthquake in 1989, and it fell onto the lower deck of the double deck viaduct structure in San Francisco, USA. The following issues must therefore be considered while designing a double-layer bridge: (1) The upper and lower deck's vertical support columns should be able to withstand significant deformation, which calls for the use of ductile components in their design; (2) the relative displacement of

the upper and lower deck joints should be considered to prevent shear failure; and (3) the upper and lower deck beams and joints should be designed with capacity protection in mind.

The bridge plays a significant role in the nation's infrastructure. Connectivity between two locations is the primary goal of this structure. The bridge's design term, which spans 25 to 100 years, is how long it is intended to function.

On the other hand, natural risks could cause the structural system to fail within the time frame for which it was designed. An earthquake is one of these natural disasters, which can result in significant losses and harm to a variety of elements, including the building itself, as well as to people both initially and over time. Because they can vary in size, duration, magnitude, time, and other factors, earthquakes have shown to be unpredictable. Although seismic analysis was not done before, it has become more popular in recent years following the Gujrat and Kashmir earthquake, which caused significant property damage and fatalities. By updating the Indian codes, later attempts were made to enhance the performance of structures in seismic circumstances. A structure's response to seismic events is elaborated through seismic analysis, which directs the design of earthquake-resistant structures. The four primary techniques used in seismic analysis fall into two categories: static and dynamic loading with respect to structural linearity and nonlinearity. There are four techniques for seismic analysis: linear static analysis, linear dynamic analysis, nonlinear static analysis, and nonlinear dynamic analysis. When dealing with structures that are small in height, linear static analysis is used. When estimating the demands of a structure whose fundamental mode dominates its response, this method is employed. An analysis technique called linear dynamic analysis is used to evaluate the demands of any structure whose response is dominated by multiple nodes. Elastic time history and response spectrum methods are two further classifications for this approach. For assessing the deformations, nonlinear static analysis is performed with a vertical load as the major load and with a minor increase in force. Through the use of capacity curves, the structure's

performance is evaluated. Pushover analysis is another name for nonlinear static analysis..A combination of ground motion and a thorough structural model is the nonlinear dynamic analysis



Fig: 1: Multi-girder composite bridge

Beam bridges can occasionally be further divided into slab bridges, beam bridges, and girder bridges. Girder bridges are bridges having both longitudinal and transverse structural elements beneath the deck, beam bridges are bridges with only longitudinal support below the deck and slab bridges are spans without support below the deck. Since their weight transmission systems are identical, all three of these groups are categorized as belonging to the same kind.

## II. OBJECTIVES OF THE RESEARCH

- The main objective of designing of double deck Fly-over Bridge on major junction to avoid excessive traffic.
- The Pier is designed for the axial dead load and live load from the slab, girders, deck beam. Foundation designed as footing for the safe load bearing in the soil.
- Design and analyse the double decker flyover using software Cs Bridge.
- Study the displacement of bridge deck under vehicular load and seismic load combination and forces developed in various components of the bridge.

## III. REVIEW OF LITERATURE SURVEY

**Shenchun Qian et.al (2024)** The steel box girder bridge with an LSCGB is used as an example in this research to determine how seismic motion factors affect the seismic response of curved girder bridges. The first step is to do modal analysis and create a dynamic FEM. The impact of the vertical component of ground motion, site category, and seismic wave incidence angle on its seismic response was then examined.

As the vertical seismic components rise, so does the seismic reaction of the components. The structural seismic response increases by 9.34%\*27.87% when the vertical seismic component doubles in size compared to when it is not taken into account. The softening of the site soil tends to increase the seismic sensitivity of the components. There is a 48%–71% increase in structural seismic reactivity when soft soil sites are compared to stiff site conditions. Thus, it is impossible to overlook the impact of site category and the vertical component of ground motion while doing seismic response analysis for LSCGBs.

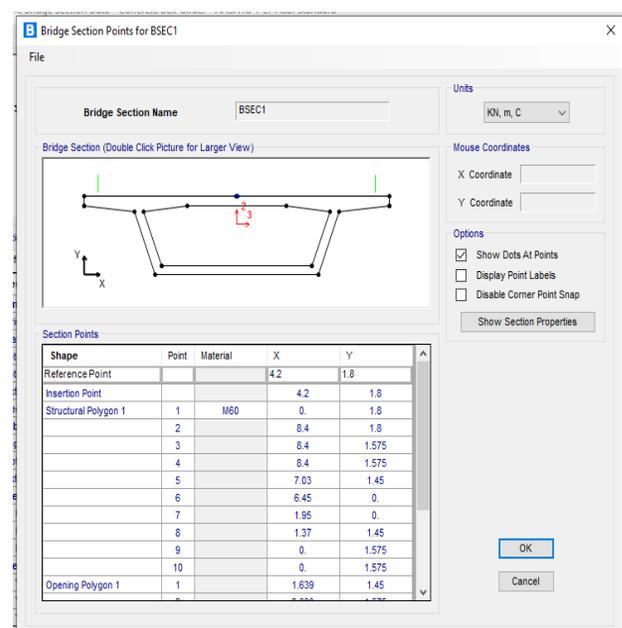
## IV. METHODOLOGY

### STEPS OF THE ANALYSIS

Step 1 The initial steps include a summarization of research papers from researchers and authors who have primarily focused on analysis of elevated bridges considering lateral loads using Finite Element Methodology. The primary focus was made towards analysis of double deck bridge and the objectives were identified and scope of research.

Step 2 Determining the unit of measurement for the model initialization, which is Metric SI, is part of this stage. IS 800:2007 and IS 456:2000 are the locked codes for steel and concrete design, respectively.

Step 3: The case study of the double deck bridge was modelled using the Csi Bridge application providing an option of the quick template where the layout can be geometrically categorized to obtain a grid overview of the model.



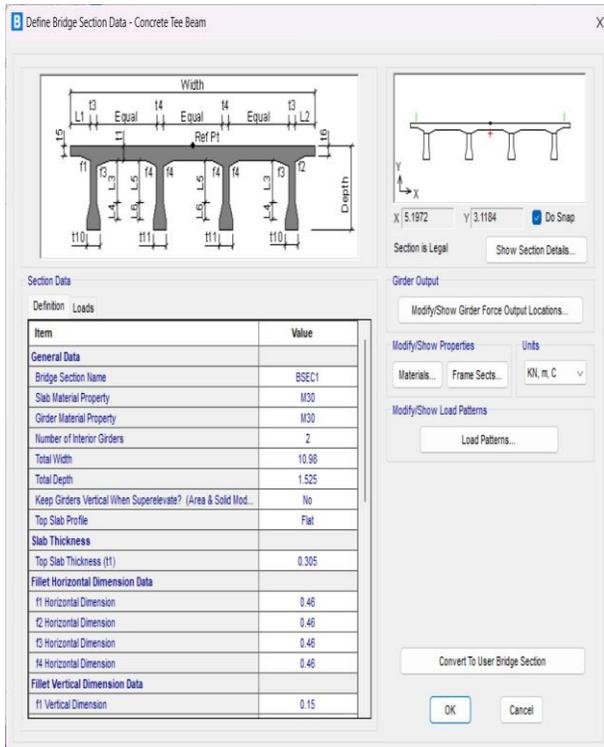


Fig 2: modelling of bridge in csi bridge tool

- Step 4: Csi Bridge provides the option to select construction materials opting for the right grade of concrete and steel and fragmenting its placement as per Indian Standards.
- Step 5: Assigning Loading conditions to the model Precast Segmental beam.
- Step 6: Defining Vehicular Loading
- Step 7: Defining Seismic loading as per IS 1893:2016 Part I
- Step 8: Analyzing the stress on the structure

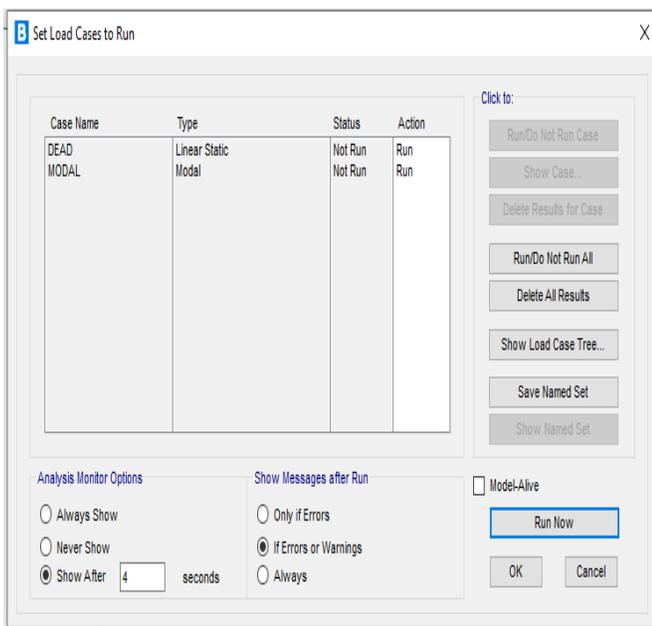


Fig 3: running load cases

## V. STUDY

With plans to build the metro base directly on the bridge's pillars, the Bairagarh double-decker bridge project in Bhopal, Madhya Pradesh, is an elevated, roughly 3-kilometre-long bridge that is expected to cost about 306 crore rupees and is thought to be the first of its kind in the state. The bridge is designed to support both vehicular traffic on the lower deck and a future metro line on the upper deck.

Important information regarding the Bairagarh double-decker bridge:

- **Location:** Bairagarh area of Bhopal, Madhya Pradesh.
- **Design:** Elevated double-decker bridge with separate levels for road traffic and future metro operations.
- **Length:** Approximately 3 kilometers.
- **Construction cost:** Around 306 crore rupees.
- **Special feature:** The metro base will be built directly on the pillars of the double-decker bridge.



Fig 4: 3d Image of proposed bridge

Table 1: Geometrical details

PARAMETERS	VALUE
Total span length	25.32m
Effective Spans	24.73m
No. of Girders	2
Length of each span	20m

Bridge width	14.5m
Bridge depth	1.6m

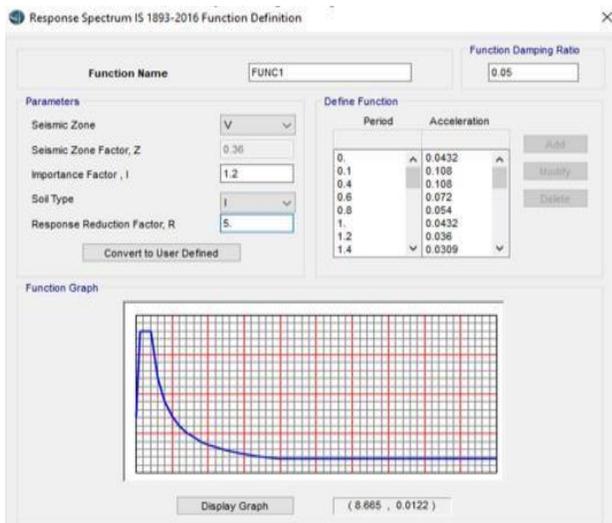
## VI. CONCLUSION

The double-decked bridge was analyzed for response spectrum and pushover analysis on parameters of axial load, torsion moment, bending moment and shear force. Based on the findings, the following conclusion can be drawn:

### ANALYSIS RESULT:

Bending Moment in KN-m		
Particulars	X-Direction	Y-Direction
Interior Grid I	1550.087	1657.034
Interior Grid II	1550.087	1737.951
Interior Beam I	1313.21	1664.81
Interior Beam II	1306.06	1554.796
Interior Slab I	828.346	1607.381
Interior Slab II	828.346	1763.239
Beams	1488.99	1547.78
Slabs	1828.81	1987.322
Girders	1604.93	1663.81

- Under the earthquake action, for this kind of double deck overpass bridge, seismic response patterns of along bridge direction are as follows: the displacement response of each key point of the pier increases gradually from the bottom of pier to the top of pier, and the bending moment of each control section decreases gradually from the bottom of pier to the top of pier.
- The response of bridges is used to determine their characteristic qualities through modal analysis and identification. Bridge deterioration may manifest as alterations in the inherent frequencies or modes of vibration of the bridge. The frequency tends to rise as mode 12 rises, with the data showing an effective difference of 1.2%–4.7%.
- Inclusion of vertical component of ground motion has negligible effect in variation of longitudinal displacement. However, there is remarkable effect in axial force variation.
- When a bridge is designed to safely withstand its intended load, the internal force that develops within the bridge structure when external loads are applied causes it to bend. This internal force is known as the "bending moment" of the bridge. It is essentially a measure of the "bending stress" the bridge experiences due to the weight it carries, and it is calculated by multiplying the force applied by the distance from the point of application.



Response spectrum Graph

Displacement (mm)	281.56
Shear (KN)	88447.7
Inherent Damping	0.05

## VII. FUTURE SCOPE

- To analyse the bridge under non-linear time history analysis.
- To analyse the bridge considering soil structure interaction at piers of bridge.
- To analyse the damaged bridge structure after applying retrofitting techniques to check the serviceability conditions.
- Further research can be carried out on the different angles of curves on the bridge while considering vehicular loads.

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