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SEISMIC ANALYSIS OF BRIDGE STRUCTURE USING CSI BRIDGE SOFTWARE

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ABSTRACT

The most crucial components of transportation systems, bridges are susceptible to failure when structural flaws go undetected. Assessing the seismic susceptibility of existing structures has received a lot of attention in the wake of recent devastating and large-scale earthquakes. Bridge analysis and design are quite sophisticated, however, nowadays, earthquake durability and serviceability are increasingly important. A sizable portion of the bridges built across the world was created at a time when the seismic safety regulations for bridges either didn't exist or were insufficient by today's standards. In addition, aging and growing vehicle loads in volume and magnitude are degrading a number of India's older bridges. Today's girder-type bridge network is utilized extensively all over the world, and it is also frequently employed to ignore severe loads across other bridge networks over extended spans. Using CSI Bridge version 21.1.0, the dynamic responses of the Girder Bridge are analyzed. The primary goal of this investigation is to assess and investigate multi-span seismic involving up to five bridge frame spans. The amplitude and acceleration of the ground motion at its peak determine how difficult the Girder Bridge's seismic performance will be. This is accomplished by using the non-linear Push over analysis modelling approach. The response data depicts the deformed shape, relative acceleration, base shear, base reaction, shear force stresses, base moment, and relative displacement.

Keywords: Earthquake, Girder Bridge, CSi Bridge, Deformed Shape, Seismic Response and Response Spectrum, and Pushover Analysis.

I. INTRODUCTION:

Every architecture represents the current state of mortal knowledge on material applications. An efficient link between two corridors that are separated by swash or other ground impediments requires the presence of a bridge. By splitting the bottleneck in the bridge lane and ground Position thruway, it connects two corridors across a body of water or those in a megacity. As time went on, bridge design became less complex because engineers wanted to combine usefulness for truly great distances with aesthetic appeal. Every building is significantly vulnerable to unforeseeable natural calamities. Therefore, it is crucial to protect the beautiful edifice from any natural disaster to guarantee the safety of people and the nation's economy. To improve the construction and increase its resilience to earthquake and wind effects, several studies are conducted.

In contrast to structures, the collapse of the entire bridge structure is more likely to result from the failure of one structural component or link between the components inside the

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bridge. Due to recent earthquake-related structural damage and bridge failure, it is now known that retrofit procedures need be taken to analyse and modify the bridges' structural susceptibility. The weight will climb significantly as the span rises. In order to reduce the load, unneeded material that isn't fully utilised is eliminated from the section; depending on whether shear deformations are frequently ignored or not, this results in the shape of girder or cellular constructions. A bridge is referred to be a beam bridge if the majority of its beams are made up of rectangle-shaped girders. Typically, prestressed concrete, steel, or a combination of reinforced concrete and steel make up the beam. In motorway and bridge systems, girders are widely used because of their structural effectiveness, improved stability, serviceability, cost-effectiveness during construction, and attractive aesthetics. opposing directions. The road bridges in our nation are constructed in accordance with the specifications and recommendations set forth by the Indian Road Congress (IRC).

II. LITERATURE REVIEW

Galuta and Cheung (1995) In order to examine box-girder bridges, a hybrid analytical approach that incorporates the boundary element technique with the finite-element method was created. The bridge's webs and bottom flange were modeled using the finite-element method, while the deck was modeled using the boundary-element method. Comparing the results with the finite element solution, it was discovered that the bending moments and vertical deflection were in good agreement.

Zasiah Tafheem and Khan Mahmud Amanat (2011) the findings of this search that's been carried out using a 3 concrete deck girder bridge as it was being subjected to seismic pressure. To explore the deck girder bridge, a finite element model was made using the finite element application ANSYS. The response spectrum approach should be used for the seismic load analysis of the bridge, according to the overall findings, in order to get a more dependable and secure design. Bridges were an essential part of every type of contemporary transportation system. The technical understanding of earthquake engineering has significantly improved during the last half-decade. Results from the bridge were crucial both before and during an earthquake. Therefore, it must continue to operate long after the earthquake event has passed in order to serve both security and relief purposes.

Godse P.A. (2013),Ghosh et al. (2014), examined how composite tectonic and live loads adversely affected the estimation of the highway bridges' seismic dependability. The researcher initially created the probabilistic seismic demand model from statistical analysis of the non-linear time history response of the bridge in order to discover the connection between the median of the peak seismic response of the bridge component and, consequently, the intensity of the seismic excitation. Second, the bridge fragility curve was designed with the assumption that the bridge is a collection of interconnected systems, suggesting that the failure of a single component will cause the structure to collapse. The model and analysis used the assumption that there is only one vehicle present in the deck at any one moment under free-flowing traffic. The study's findings demonstrated that bridges were more susceptible to failure when subjected to seismic stress.

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The focus of the article is on the bridge piers' base shear capacity and city-to-demand capacity ratio. All evaluations were completed while there was intense seismic activity and a high volume of traffic on the bridge. For the type of bridge chosen, the demand capacity ratio was assessed; however, hash has not been investigated with the suggested material. Software called "CSI Bridge" was used to analyze the bridge under study. The behavior of the bridge under seismic loading is well demonstrated in the study. Because the assessment location is primarily vulnerable to seismic activity, research was done.

Research has previously shown that reinforcing bars are susceptible to buckling when subjected to tensile strain. Feng et al. (2015) established a hybrid analytic approach to evaluate the impact of seismic stress on the buckling of reinforcing bars in order to quantify this effect. For the nonlinear time history analysis of 40 earthquake ground movements, a fiber-based model was created. In order to create design equations that will offer strain constraints prior to the bar buckles, they also conducted parametric research.

III. METHODOLOGY

There are several ways to do seismic analysis on a concrete girder bridge with a span length of 100 meters; CSi Bridge V 21.1.0 software was employed. The deformed shape, relative acceleration, relative velocity, base shear, base reaction, shear forces, stresses, base moment, torsion, and relative displacement are all included while analyzing the seismic response of a girder bridge. The equivalent static seismic force technique, time history analysis method, response spectrum method, and non-linear static pushover analysis are some of the approaches used to quantify the seismic reaction of a bridge structure. In this study, the seismic response of the structure is examined using the response spectrum approach and the pushover analysis method. Therefore, rather than only considering a structure's strength, its components and maximum allowable inelastic displacements (also known as goal displacements or performance points) are considered. The structure is only tested for strength at the global and component levels when it satisfies the specified performance requirements. The development of powerful processing power and the accessibility of advanced analytical tools have made it much simpler to introduce and advance this strategy.

3.1 DATA ANALYSIS

The structural response of the Bhuj earthquake was employed in this study to assess seismic analyses. An earthquake with a magnitude of 7.7 was recorded by the IMD strong motion seismograph, and the intensity in the affected area was as high as X (Extreme) on the MSK (Medvedev-Sponheuer-Karnik) scale of intensity. In 2001, an earthquake that lasted 22 seconds had its epicenter 16 kilometers under the Kutch area of Gujarat, India. Despite scientists' ability to forecast and forewarn earthquakes in advance and engineers' ability to create buildings that are earthquake-safe, hundreds of thousands of people have been murdered by earthquakes. Due to the development of earthquake analysis and design concepts the effects of the earthquake and structural damage. These are the several categories of earthquake analysis techniques.

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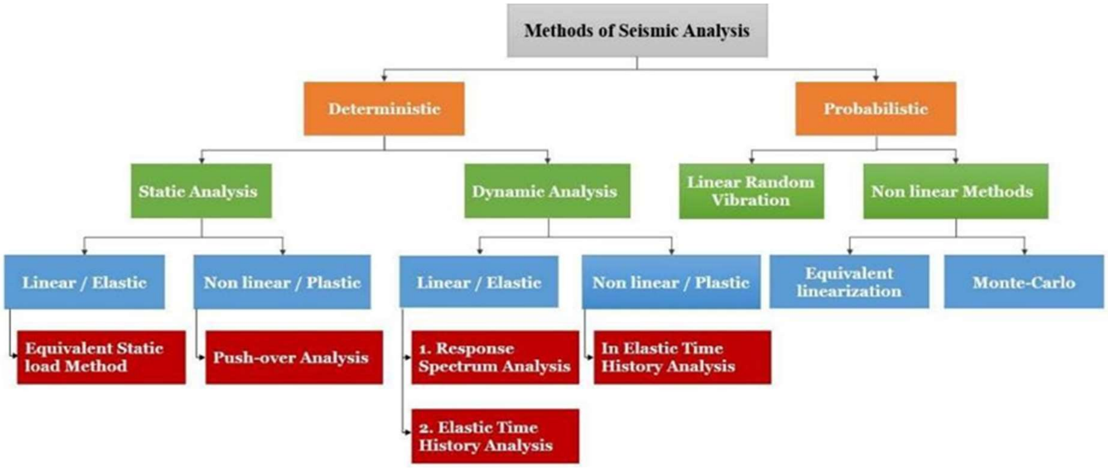

Figure 1: Classification of Seismic analysis method.

When an earthquake is strong, the linear static analysis or seismic coefficient approach, a traditional elastic design method, does not provide accurate results. To accurately depict how structures react to mild to strong earthquakes, non-linear analysis is required.

Site-specific ground motion investigations are necessary for nonlinear dynamic analysis (Time history analysis). The assessment of dynamic earthquake parameters is necessary yet computationally challenging, time-consuming, and impractical for the majority of actual applications.

Many important aspects that have a substantial impact on a building's seismic performance are believed to be impossible to account for using the traditional elastic design analysis technique. The structural behavior of a structure during seismic ground vibrations is determined by its ability to withstand inelastic deformations. As a result, while exploring a system, it's indeed crucial to consider the inelastic deformation that seismic stress needs. The nonlinear static method known as pushover analysis is increasingly used by structural engineers to evaluate seismic requirements for buildings. It is a routine method that yields respectable outcomes.

3.2 OBJECTIVES OF STUDY:

- To evaluate the demand capacity ratio (D/C) of the structure
- Detailed investigation of the concrete girder bridge structure considering Non-linear static push-over analysis
- Utilization of Advance diagnostic software to examine the horizontal and transverse load opposing structure and the displacement in all the 3-D.
- To decide the capacity and dynamic investigation in the terms of maximum displacement, Base Shear, Base moment and torsion of a structure subjecting to IS load combinations.
- To evaluate the seismic analysis of bridge Structure by applying the load combinations as per Indian standard IS 1893:2016.

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3.3 CSI Bridge Software

The finest computerized tools for meeting the needs of engineering professionals are incorporated into CSiBridge through the modeling, analysis, and design of bridge structures. The ease with which each of these activities may be completed makes CSI Bridge the most adaptable and effective piece of software in the sector.

IV.BRIDGE STRUCTURE MODEL AND ANALYSIS

To analyze the various components of a bridge model under seismic stress, a typical three-dimensional concert girder bridge with five continuous spans and a 100-meter-long concrete deck with one internal girder is used. The following factors are taken into account in relation to this.

Table 1: Geometrical Properties & Location Factors.

PARAMETERS	VALUE
Total span length	100m
No.of Spans	5
No.of Girders	2
Length of each span	20m
Bridge width	14.5m
Bridge depth	1.6m
Diameter of circular column	1.6m
Height of the column	10m
Soil type	Type-1 (Hard & Rock Soil) Pile and combined footing
Design criteria	Modal analysis using Response spectrum method for performance push-over analysis is to be determined for the maximum deformed zone
Zone considering	V
Zone factor	0.36
Response reduction factor	5(RC girder bridge with seismic isolation factor)
Importance factor	1.2
Support conditions for column	Fixed

Table 2: Design Codes and Standards.

Live load	IRC Class A
Regulation	IRC – 5,IRC – 6, IRC-18,IRC-112 & IRC-SP-114
Seismic loading	IS:1893-2016, IS:1893(Part -3)
Serviceability conditions	IS 1984 & IS 2007
Wind load	IS 875 Part(III)
Vehicle Loading	IRC-6
Geometry	IRC -112
Permissible Stress	IRC -18

Table 3: Section and Material Properties.

Column size	10 x 1.6 m

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Concrete slab thickness	0.225m
Abutment	4.2 x 1.6m
Cap bent	2 x 1.5m
Pile	1.8m

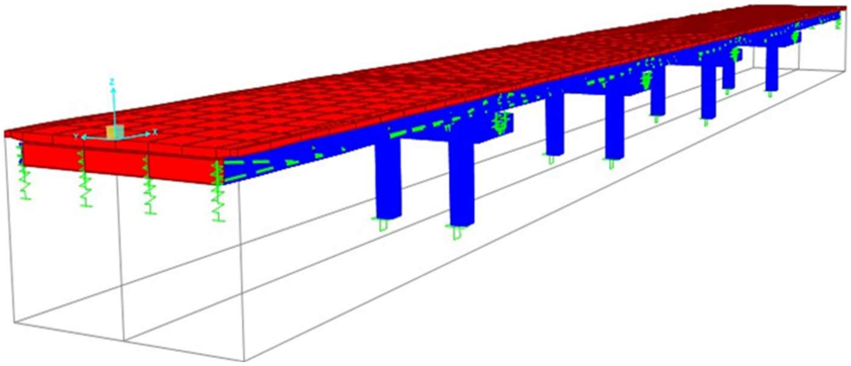

Figure 2: 3D view of Bridge Model

Fig. displayed a three-dimensional image of the whole bridge segment. Here, the bridge's longitudinal, transverse, and vertical directions are denoted by x, y, and z.

The bridge span is continuous in character and belongs to the integrated bridge category. Only IRC class A loading is considered for this investigation. The Bhuj Earthquake's Peak Ground Acceleration (PGA), which was measured at 1.0382 m/s2 at 46.940 seconds, was taken into consideration for the seismic analysis of the current study.

IV. RESULTS AND DISCUSSIONS

This paper discusses the five span Girder Bridge's seismic reaction. The Bhuj Tremors and the 100 m long Girder Structure prototype are being used as dynamic feed to assess the optimum seismic response of the girder deck. The following comparative figures illustrate the seismic response of the girder in terms of relative acceleration, relative displacement, relative velocity, torsion, forces, stresses, base moments, and base shear.

5.1 Maximum Shear Force (KN), Bending Moment (KN-m) , Torsion(KN-m) – loads

Particular	X-SF(KN)	Y-SF(KN)	X - M (KN-M)	Y - M (KN-M)	T - KNM
Interior Grid 1	623.013	529.68	1439.077	1555.024	75.261
Interior Grid 2	614.48	362.805	1439.07	1626.941	148.312
Interior Beam 1	1124.03	996.57	1202.25	1553.875	119.13

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Interior Beam 2	592.286	209.16	1195.05	1443.786	249.58
Interior Slab 1	597.881	344.39	717.36	1496.371	384.986
Interior Slab 2	557.87	432.65	717.36	1652.229	130.653
All Beams	1544.403	1344.2	1377.98	1436.77	362.04
All Slabs	1223	1036.8	1712.8	1876.312	2888.974
All Girders	1628.5	1271.414	1493.92	1552.8	2414.85

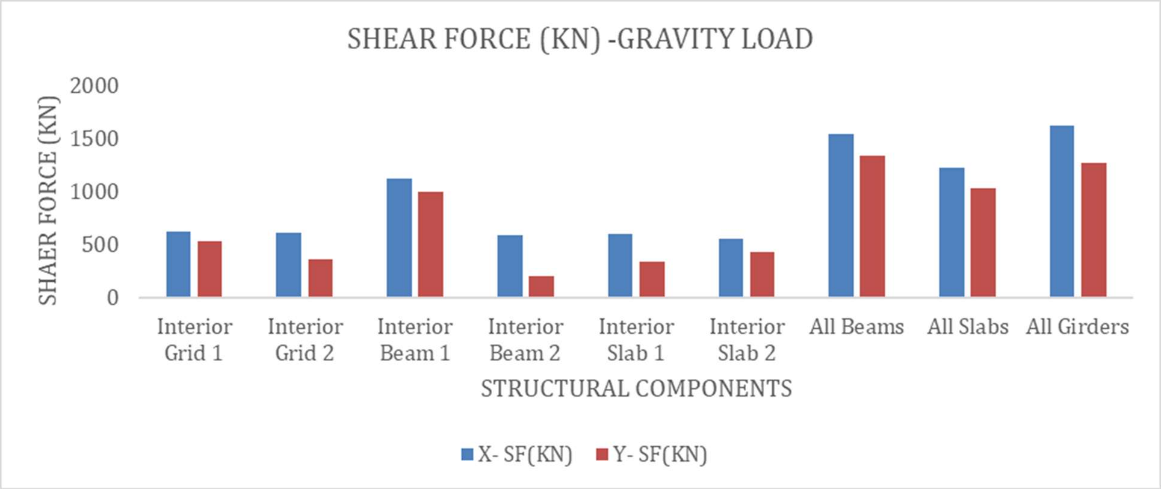

Figure 3: shear force (KN) of Structural components due to gravity load

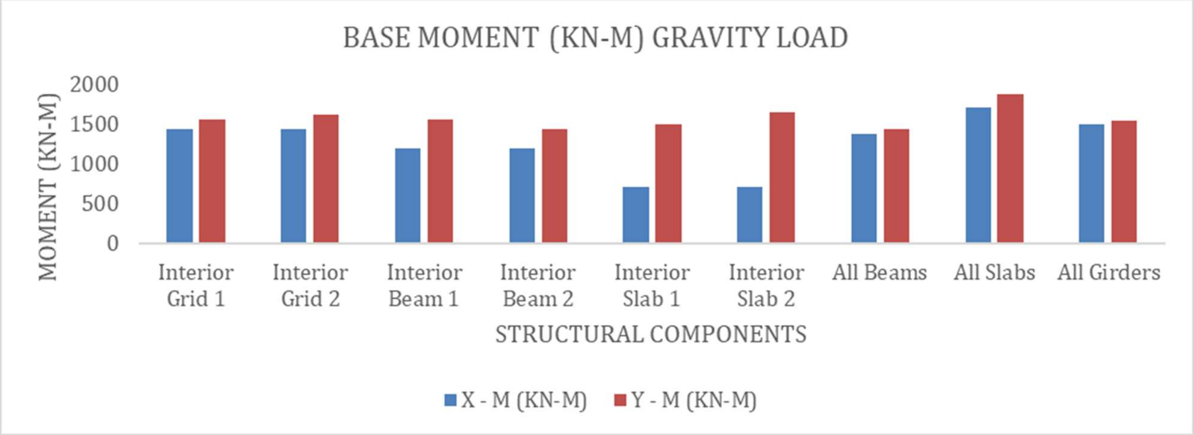

Figure 4: Base moment(KN-M) of Structural components due to gravity load

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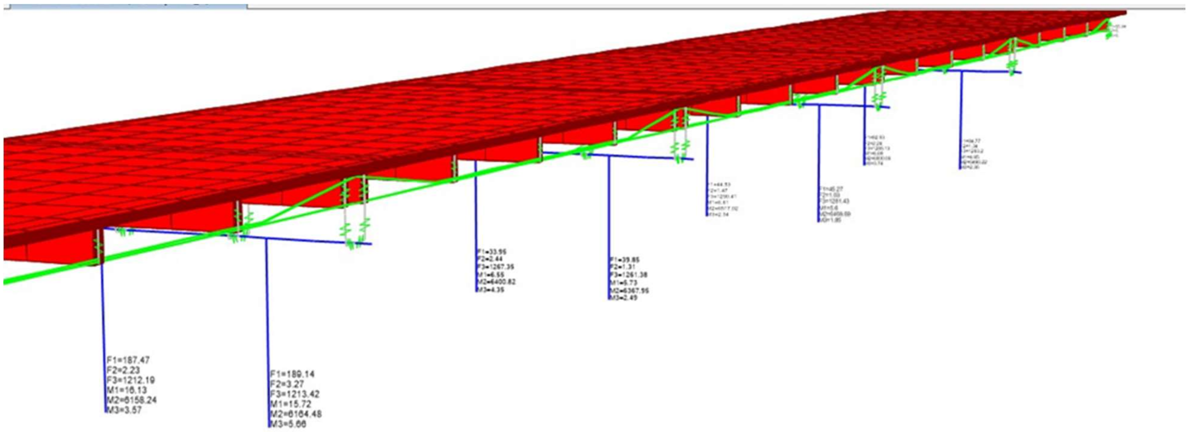

Figure 5: Maximum Shear Force (KN), Bending Moment (KN-m) , Torsion(KN-m) –

Dead Loads

The pushover analysis method was used to examine the chosen model. Pushover analysis was first carried out by taking into account response spectrum analysis to define gravity and the imposed load case for seismic zone (V), and then a lateral non-linear pushover analysis was carried out in a displacement control manner for the zone where the response spectrum analysis has the greatest seismic impact on the RC framed structure.

a) Response Spectrum of Analysis – Mode shapes analysis is a technique for assessing the structural behavior of short, pseudorandom, time-dependent- dependent disturbances. Such catastrophes comprise earthquakes and disturbances. To use specified time information, a response spectrum is created. the study analyzed the effects using a unique response spectrum This analysis is carried out when patterns other than the vital one have a measurable influence on how the structure reacts. Thus every mode shape response in this instance is derived from the spectroscopic information of the Single-Degree-of-Freedom System, and the response of the Multiple Degree-of-Freedom System (MDOF) is depicted as a superposition of multimodal replies (SDOF). By collecting all of these, the overall response is computed.

b) Non-Linear Static Analysis (Pushover Analysis) – "Pushover analysis" is another term for this approach. It outperforms traditional static or dynamic modeling because it addresses the structure's elastoplastic character. The technique is incredibly easy to use and provides data on the structure's strength, deformation, and ductility as well as the distribution of demands. This makes it possible to identify the key components that will likely experience limit states during an earthquake and to which special attention should be paid throughout the design and detailed phases. This, technique however is based on a variety of fallacies that overlook differences in loading patterns, the impact of higher modes of vibration, and the impact of resonance. However, one feature of the technique stays constant: it assumes a set of static incremental lateral loads that are constant over the height of the structure.

c) Even this technique gives a precise estimation of global deformation, notably for structures that primarily react to the initial mode. A non-linear structural model is treated as a sequence of forces, and the cumulative force is represented in ratio to displacement to show a

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capacity curve. The issue can therefore be minimized by integrating it with a demand curve, most frequently in the form of an ADRS (Acceleration-Displacement Response Spectrum).

d) A time history analysis is the most precise technique for estimating inelastic displacements. However, it is computationally costly and requires a lot of work to thoroughly examine the vast data that is produced. Additionally, this approach provides information on strength, deformation, ductility, and the distribution of demands while being much easier. Along with benefits, it also has some drawbacks, such as the fact that it ignores variations in loading patterns as well as the impact of resonance and higher modes on a structure.

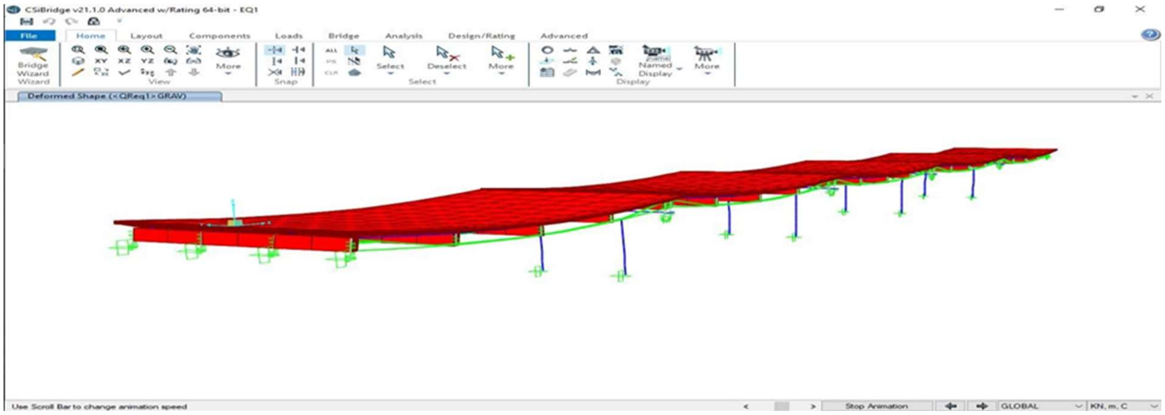
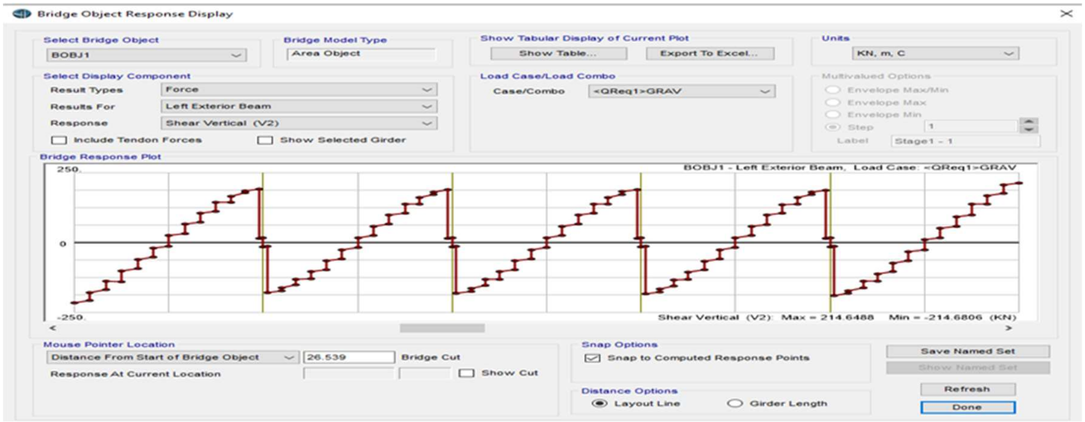


Figure 6: Deformation of the Conventional structure –Dead Load.

5.1.1 GRAVITY LOAD ON Y-AXIS SHEAR FORCE(V2) KN

S.NO	SHEARFORCE(V2) KN	FORCE (KN-M)
1.	MAXIMUM	214.6488
2.	MINIMUM	-214.6088



Bridge Object Response Display

Select Bridge Object: BOBJ1
Bridge Model Type: Area Object
Units: KN, m, C
Result Types: Force
Results For: Left Exterior Beam
Response: Shear Vertical (V2)
☐ Include Tendon Forces ☐ Show Selected Girder
Case/Combo: <QReq1>GRAV
Step: 1
Label: Stage1 - 1
BOBJ1 - Left Exterior Beam, Load Case: <QReq1>GRAV
Shear Vertical (V2): Max = 214.6488 Min = -214.6806 (KN)
Distance From Start of Bridge Object: 26.539
☑ Snap to Computed Response Points
● Layout Line ○ Girder Length

Fig. 7 Shear forceV2 (KN) On Left Exterior Beam –Dead Loads

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5.1 vehicle live load

Load Pattern	Vehicle Class	Lane	Station(m)	Start time(sec)	Direction	Speed (m/s)
Truck	IRC A	1	0	0	Forward	35
Truck	IRC A	1	0	0.5	Forward	30
Truck	IRC A	2	100	0	Backward	35
Truck	IRC A	2	100	0.5	Backward	30

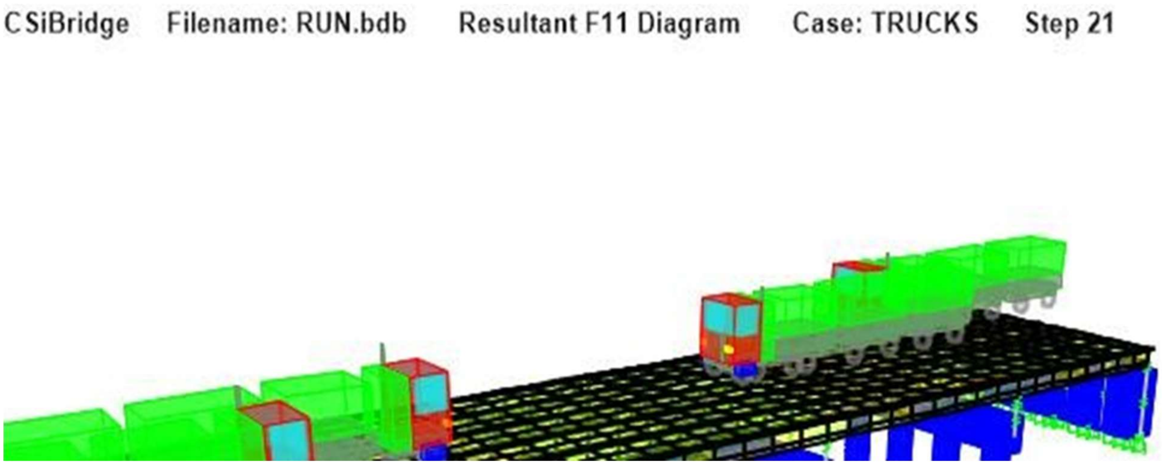

Fig 8: Bridge Vehicular Load

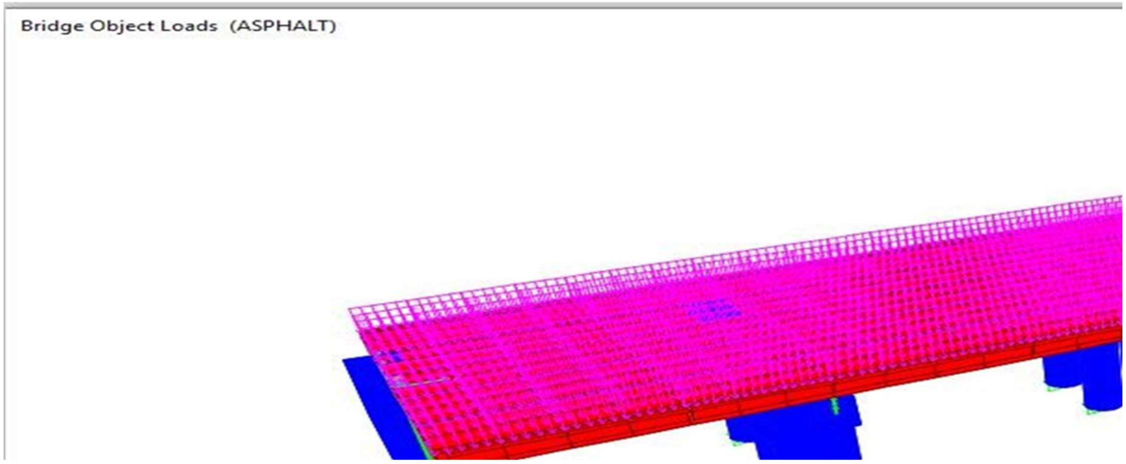

Fig 9: Moving Loads

5.2 RESPONSE SPECTRUM ANALYSIS

Frequency response analysis is a technique for examining the overall structural response to transient, stochastic, transient events. Seismic and sudden shocks are two examples of these occurrences. a response spectrum is produced using a specified time history. the use of a specific response spectrum to structural analysis.

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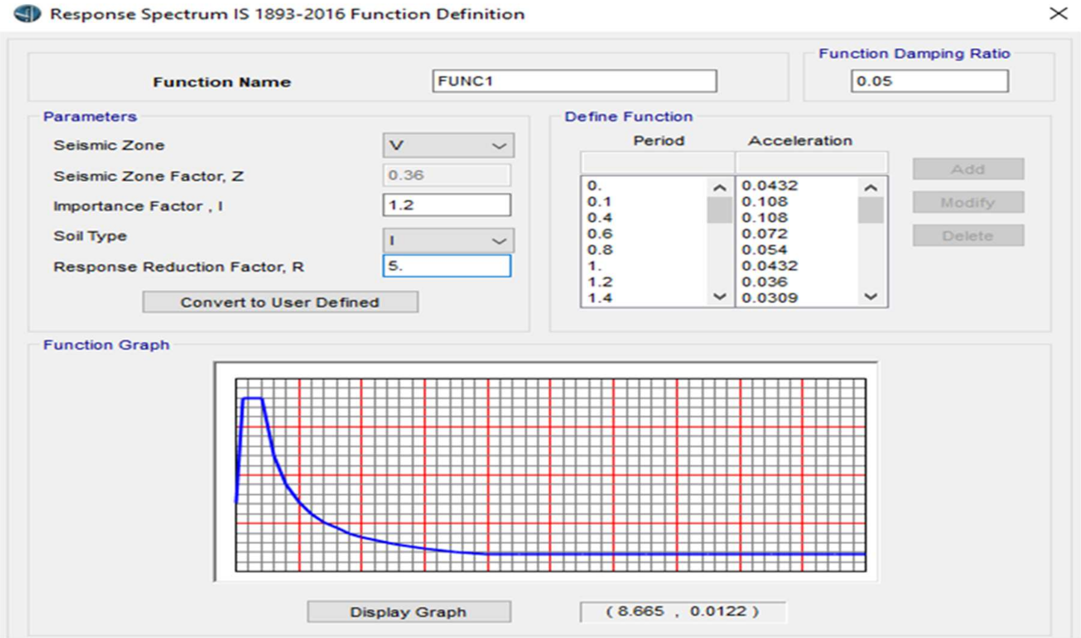
5.2.1 RESPONSE SPECTRUM FUNCTION

The CSiBridge Run Analysis command was used to analyze the bridge object. Very complicated bridge structures may be analyzed using CSiBridge under any loading scenario. Analysis was carried out for all loads and load combinations, and the analysis IS-1893:2016 Design spectrum function for seismic zone V and stiff soil was the reaction spectrum function utilized in the pushover study. The AASHTO LRFD 2002 seismic design code for bridges was used to construct the seismic design request, which selected seismic design category D and used the previously established response spectrum as a function for pushover analysis. The complete structure was first placed under a dead load, and multiple iterations were made to determine the fracture section's attributes. Response spectrum analysis and pushover analysis were applied relying on such fracture section characteristics.

The response spectra for the proposed area's soil type and seismic zone V are displayed in Fig.

Fig. 10 Response Spectrum Function



Response Spectrum IS 1893-2016 Function Definition

Function Name: FUNC1

Function Damping Ratio: 0.05

Parameters

Seismic Zone: V

Seismic Zone Factor, Z: 0.36

Importance Factor , I: 1.2

Soil Type: I

Response Reduction Factor, R: 5.

Define Function

Period	Acceleration
0.	0.0432
0.1	0.108
0.4	0.108
0.6	0.072
0.8	0.054
1.	0.0432
1.2	0.036
1.4	0.0309

Function Graph

(8.665 , 0.0122)

For RC structures with specific moment-resisting frame conditions, the response reduction factor was used, and the importance factor was determined in accordance with IS-1893:2016.

5.2.2 Maximum Forces on X-axis (RESPONSE SPECTRUM)

Particular	X-SF (KN)	Y-SF(KN)	X-M(KN-M)	Y-M(KN-M)	T (KN-M)
Interior Girder 1	441.7372	133.752	549.027	669.829	443.286
Interior Girder 2	520.811	116.05	535.4365	669.8294	454.927

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Interior Beam 1	66.988	70.52	236.9789	344.6333	99.38
Interior Beam 2	64.6588	60.0147	236.3901	344.4713	101.82
Interior Slab 1	429.79	63.335	235.5904	269.237	444.816
Interior Slab 2	523.41	56.7076	234.597	267.2633	454.43
All Beams	66.98	108.6071	636.9769	566.3011	172.27
All Slabs	528.41	63.335	585.8904	491.8506	454.395
All Girders	1151.177	133.752	1808.778	1946.831	454.927
ENTIRE Bridge Section	441.7372	133.752	1908.778	1994.928	99.064

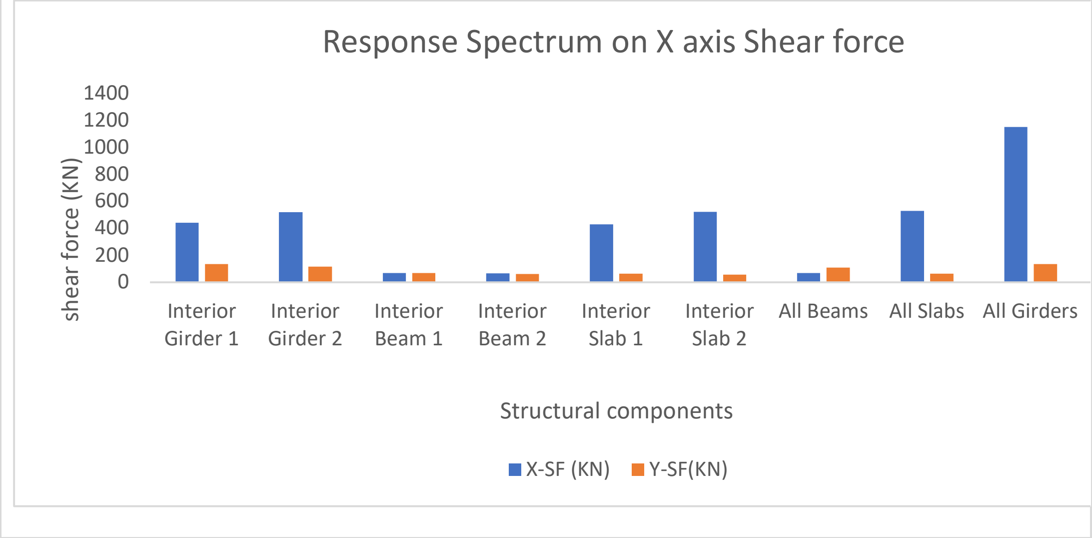

Fig. 11 shear force (KN) of Structural components due to RS Analysis

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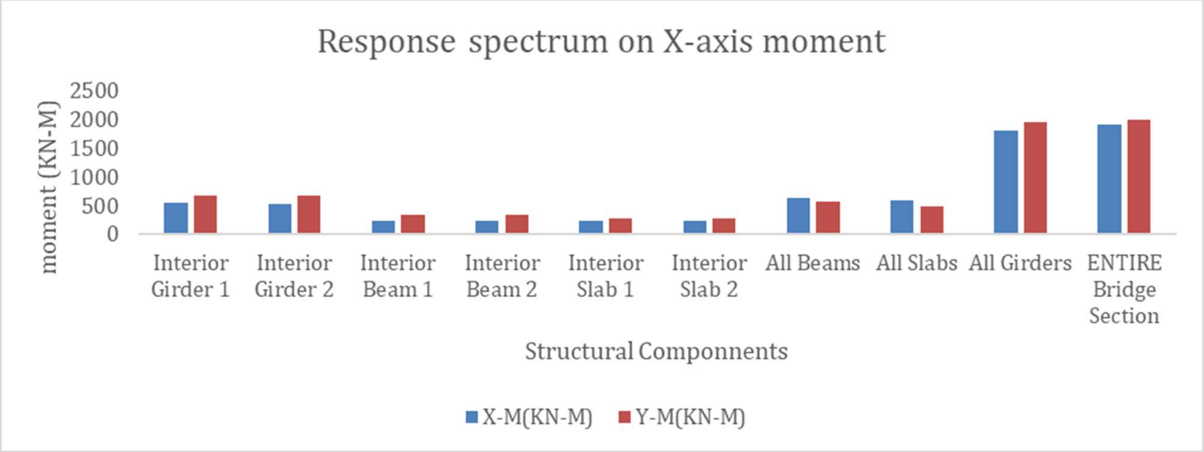
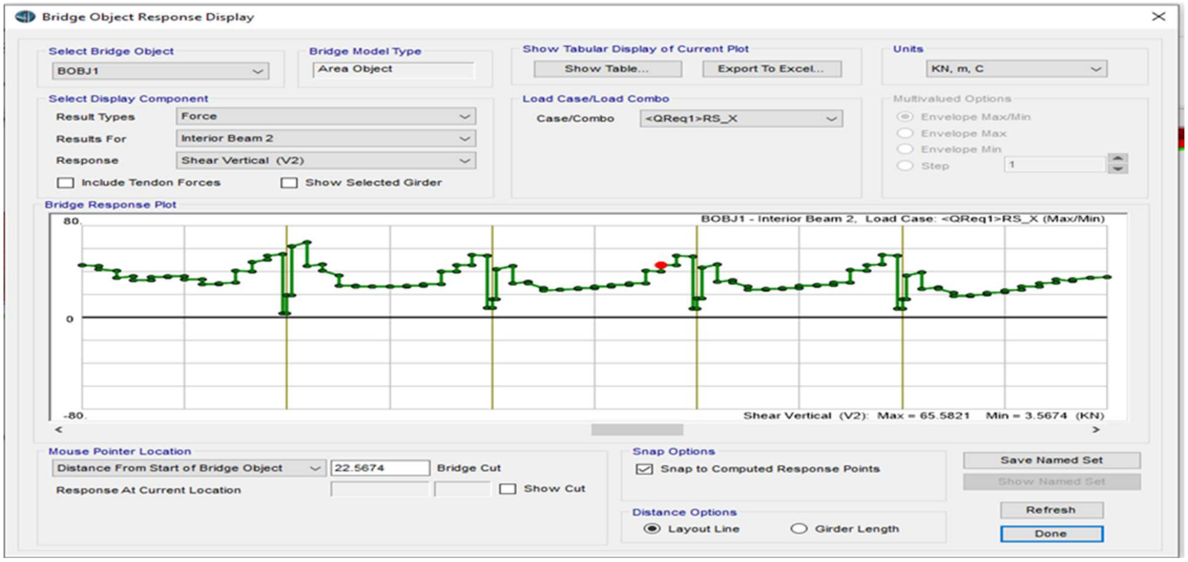


Fig. 12 Moment(KN-m) of Structural components due to RS Analysis

5.2.3 RESPONSE SPECTRUM ON X-AXIS SHEAR FORCE (V2) KN

S.NO	SHEAR FORCE (V2) KN	FORCE (KN)
1.	MAXIMUM	65.5821
2.	MINIMUM	35.674



Select Bridge Object: BOBJ1
Bridge Model Type: Area Object
Units: KN, m, C
Result Types: Force
Results For: Interior Beam 2
Response: Shear Vertical (V2)
☐ Include Tendon Forces ☐ Show Selected Girder
Case/Combo: <QReq1>RS_X
Step: 1
BOBJ1 - Interior Beam 2, Load Case: <QReq1>RS_X (Max/Min)
Shear Vertical (V2): Max = 65.5821 Min = 3.5674 (KN)
Distance From Start of Bridge Object: 22.5674 Bridge Cut
Response At Current Location ☐ Show Cut
☑ Snap to Computed Response Points
● Layout Line ○ Girder Length

Fig. 13 shear force (KN) of Structural components due to RS Analysis

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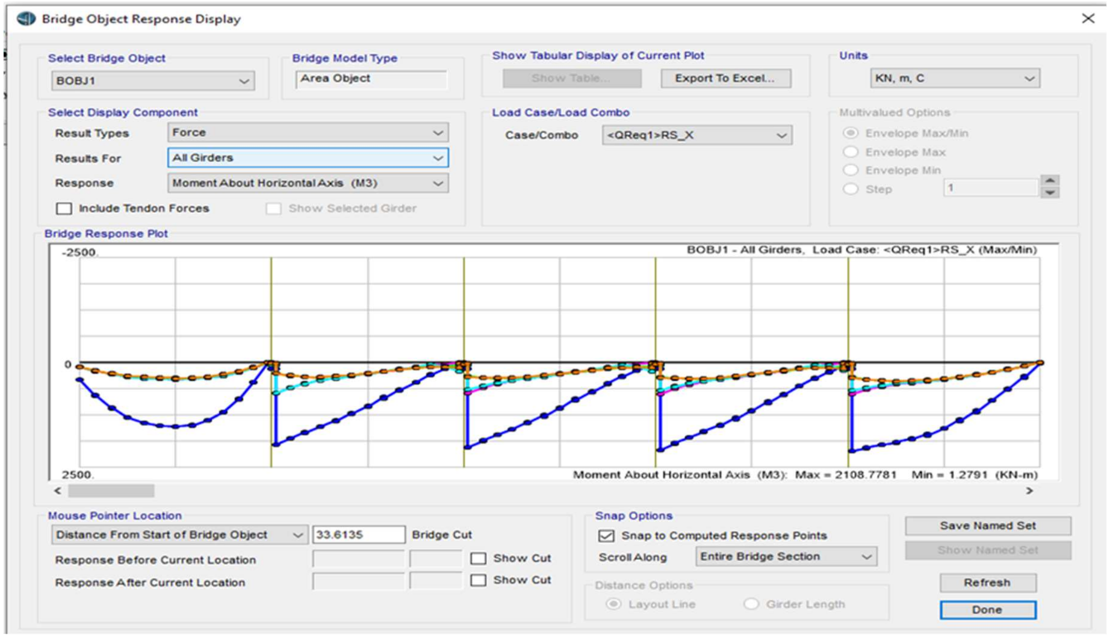
Bridge Object Response Display

Select Bridge Object: BOBJ1
Bridge Model Type: Area Object
Units: KN, m, C
Select Display Component
Result Types: Force
Results For: All Girders
Response: Moment About Horizontal Axis (M3)
☐ Include Tendon Forces
☐ Show Selected Girder
Load Case/Load Combo
Case/Combo: <QReq1>RS_X
Multivalued Options
● Envelope Max/Min
○ Envelope Max
○ Envelope Min
○ Step 1
Mouse Pointer Location
Distance From Start of Bridge Object: 33.6135 Bridge Cut
Response Before Current Location ☐ Show Cut
Response After Current Location ☐ Show Cut
Snap Options
☑ Snap to Computed Response Points
Scroll Along: Entire Bridge Section
Distance Options
● Layout Line ○ Girder Length

Fig. 14 Base moment(KN-M) of Structural components due to RS Analysis

5.2.4 Maximum Forces on Y-axis (RESPONSE SPECTRUM)

Particular	X-SF (KN)	Y-SF(KN)	X-M(KN-M)	Y-M(KN-M)	T (KN-M)
Interior Girder 1	159.8694	91.304	263.2833	365.449	219.16
Interior Girder 2	157.5689	91.34	273.665	430.1029	189.06
Interior Beam 1	83.91	65.37	77	447.7021	13.54
Interior Beam 2	84.17	65.5821	94.9	417.78	9.66
Interior Slab 1	59.1678	36.229	91.408	357.75	191.588
Interior Slab 2	55.669	36.7691	63.93	433.43	177
All Beams	78.149	65.5821	53.85	447.04	13.254
All Slabs	59.1687	36.7691	56.13	433.01	191.588
All Girders	359.8667	344.7762	62.29	865.3	1477.56

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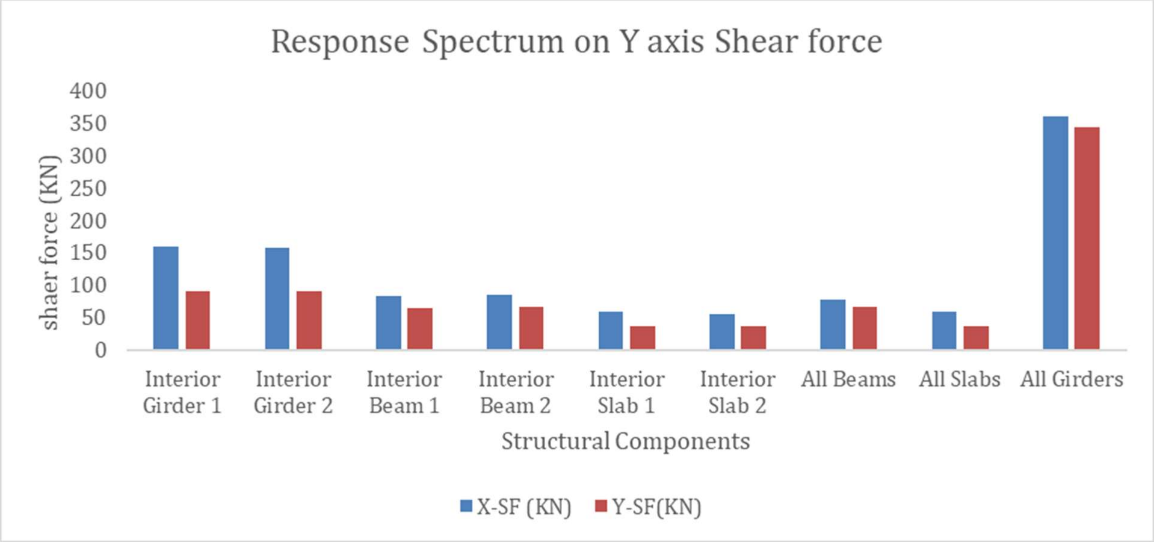

Fig. 15 shear force (KN) of Structural components due to RS Analysis

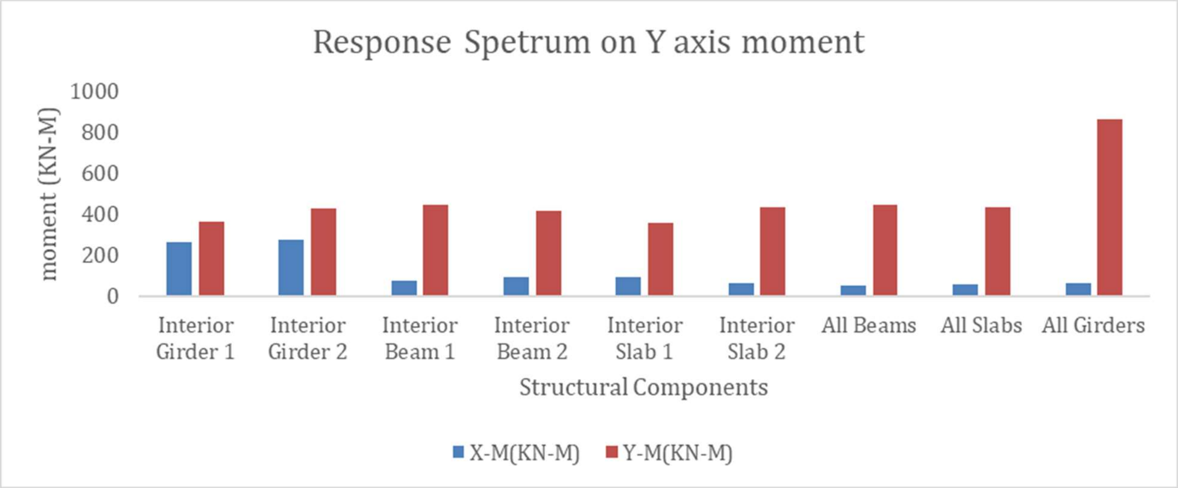

Fig. 16 Moment (KN-m) of Structural components due to RS Analysis

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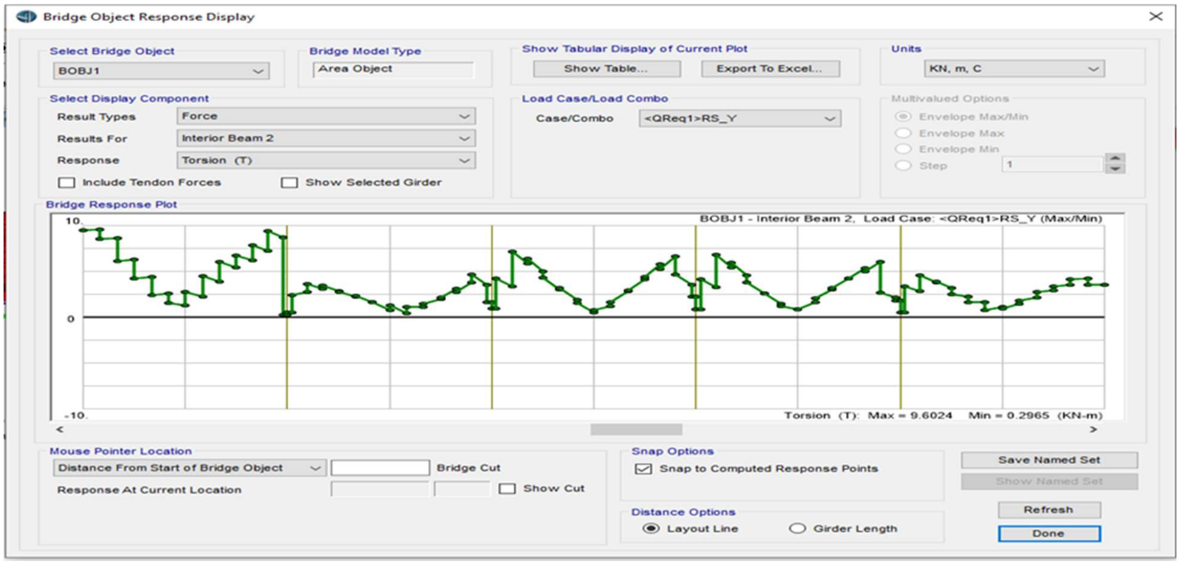


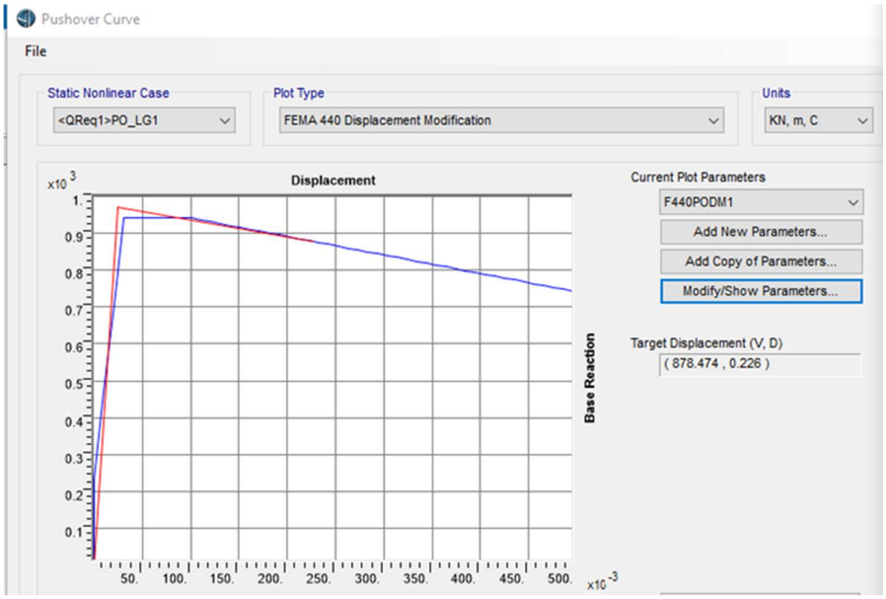
Select Bridge Object: BOBJ1
Bridge Model Type: Area Object
Units: KN, m, C
Result Types: Force
Results For: Interior Beam 2
Response: Torsion (T)
☐ Include Tendon Forces
☐ Show Selected Girder
Case/Combo: <QReq1>RS_Y
BOBJ1 - Interior Beam 2, Load Case: <QReq1>RS_Y (Max/Min)
Torsion (T): Max = 9.6024 Min = 0.2965 (KN-m)
Mouse Pointer Location: Distance From Start of Bridge Object
☐ Show Cut
☑ Snap to Computed Response Points
Distance Options: ● Layout Line ○ Girder Length

Fig. 17 Torsion(KN-M) of Structural components due to RS Analysis

5.4 NON-LINEAR STATIC PUSHOVER ANALYSIS

a) TARGET DISPLACEMENT RESULTS

Displacement (mm)	266.78
Shear (KN)	87447.7
Inherent Damping	0.05



Static Nonlinear Case: <QReq1>PO_LG1
Plot Type: FEMA 440 Displacement Modification
Units: KN, m, C
Current Plot Parameters: F440PODM1
Target Displacement (V, D): (878.474 , 0.226)

Fig.18 Base Shear vs displacement According to FEMA 440 tables

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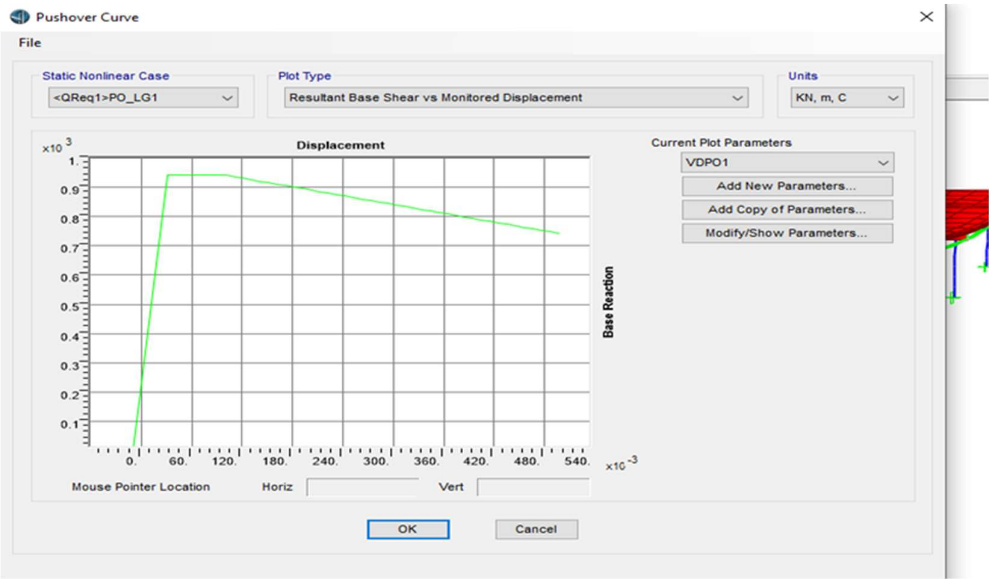

Pushover Curve

Static Nonlinear Case: <QReq1>PO_LG1

Plot Type: Resultant Base Shear vs Monitored Displacement

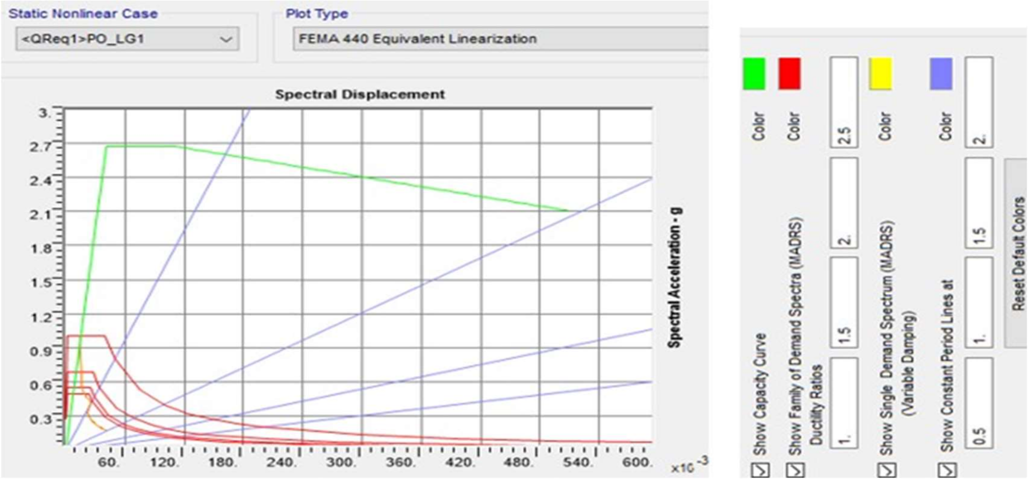
Units: KN, m, C

Current Plot Parameters: VDPO1

Fig.19 Base Shear vs displacement According to Push over analysis in Longitudinal direction

b) PERFORMANCE POINTS RESULTS

Displacement (mm)	250.3 mm
Shear (KN)	35914.3
Spectral Displacement sd	157.36 mm
Spectral Acceleration sa	0.0425
T secant (sec)	3.143
T effective (sec)	3.075
Damping Ratio, Beff	0.089


Static Nonlinear Case: <QReq1>PO_LG1

Plot Type: FEMA 440 Equivalent Linearization

☑ Show Capacity Curve

☑ Show Family of Demand Spectra (MADRS) Ductility Ratios: 1., 1.5, 2., 2.5

☑ Show Single Demand Spectrum (MADRS) (Variable Damping)

☑ Show Constant Period Lines at: 0.5, 1., 1.5, 2.

Fig.20 Spectral acceleration vs Spectral displacement

c) Performance points results in Transverse Displacement

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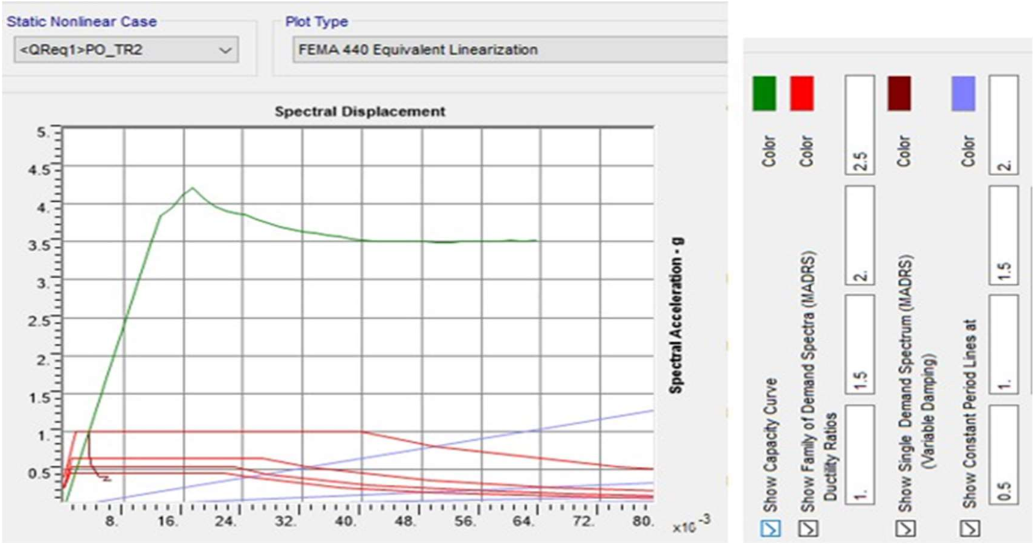
Displacement (mm)	233.83 mm
Shear (KN)	35185.3
pectral Displacement sd	137.36 mm
Spectral Acceleration sa	0.182
T secant (sec)	2.12
T effective (sec)	2.0687
Damping Ratio, Beff	0.089


Static Nonlinear Case <QReq1>PO_TR2
Plot Type FEMA 440 Equivalent Linearization

☑ Show Capacity Curve — Color 🟩
☑ Show Family of Demand Spectra (MADRS) — Color 🟥
Ductility Ratios: 1., 1.5, 2., 2.5
☑ Show Single Demand Spectrum (MADRS) (Variable Damping) — Color
☑ Show Constant Period Lines at: 0.5, 1., 1.5, 2. — Color

Fig.21 Spectral acceleration vs Spectral displacement

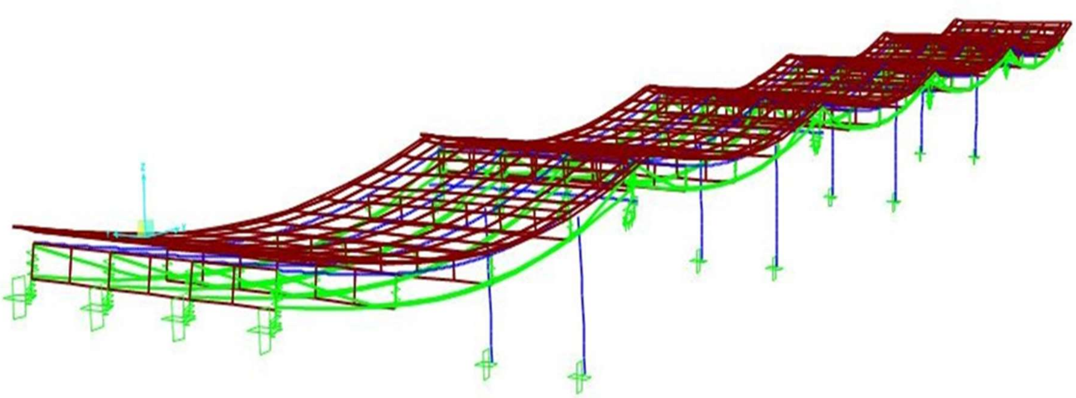


Fig.22 Displacement results of Push Over Analysis

5.5 DEMAND CAPACITY RATIO

When exposed to a seismic event, it is crucial to assess the seismic vulnerability of bridges. The demand to capacity (D/C) ratio is the ratio between the structure's demand under the given conditions and the ability of the structure to withstand external pressures throughout the course of its lifetime. This phrase is used in the research to assess how well the framework is working. D/C ratio 0 indicates no structural damage, whereas 1 indicates imminent structural failure.

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according to the pushover load used in the study, the structure's capacity and demand. BT is represented by the Bent Cap region in the graph. the corresponding bent cap parts in 1, 2, 3, and 4. The directions are indicated by the letters LG and TR. As we can see, the capacity in both directions exceeds the demand, which is ideal for the structure's safety. The bent cap section's capacity is significantly bigger in the longitudinal direction than in the transverse direction. The demand-to-capacity (D/C) ratio for the bridge under consideration is shown in Fig. The D/C ratio was found to range between 0.186 and 0.708, respectively. It was discovered that all bent cap sections have the same D/C ratio in the transverse direction, which is 0.25. Even the highest D/C ratio is below the structure's safe limit of 1, which is 1. Therefore, the bridge can withstand all dead, living, and moving loads extremely well. In addition, the bridge can also fully withstand external seismic pressures.

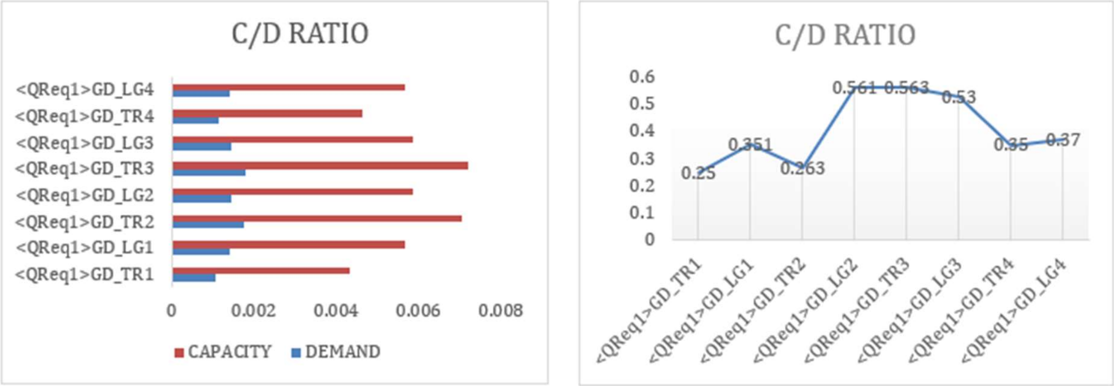

Fig. 23: D/C RATIO

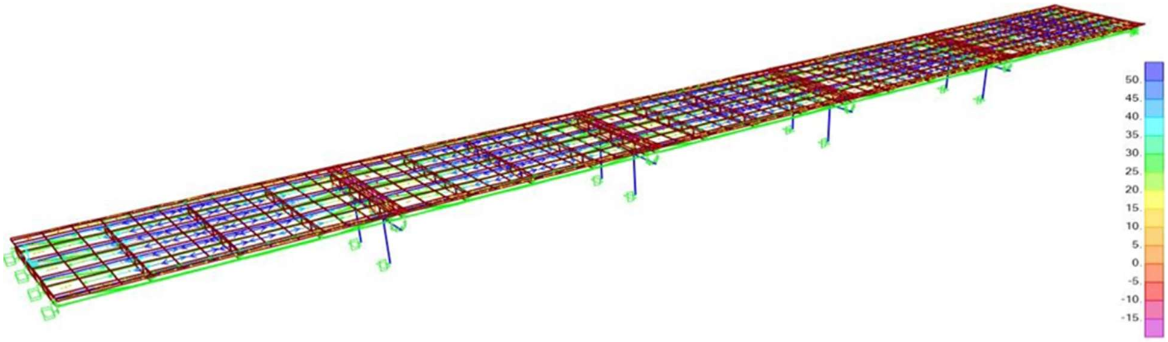

Fig. 24: Relative Displacement of Deformed Bridge Section

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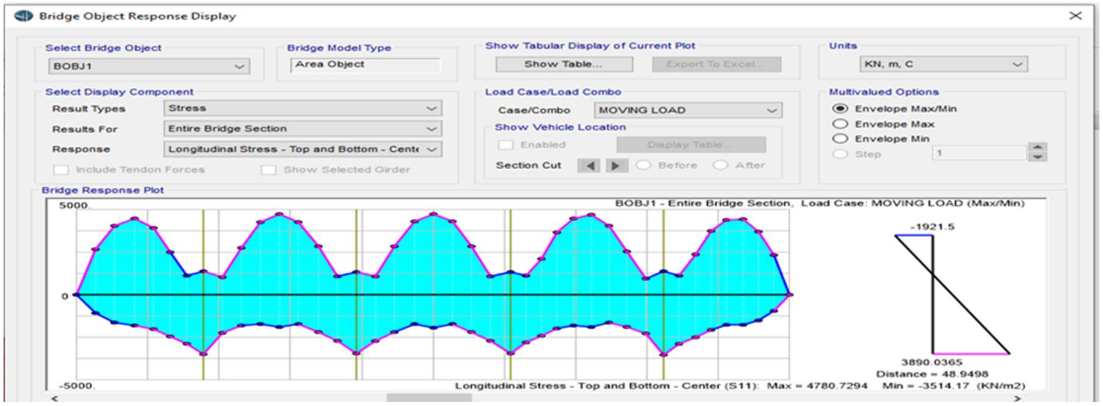

Bridge Object Response Display

Select Bridge Object: BOBJ1
Bridge Model Type: Area Object
Units: KN, m, C

Select Display Component
Result Types: Stress
Results For: Entire Bridge Section
Response: Longitudinal Stress - Top and Bottom - Cent

Load Case/Load Combo
Case/Combo: MOVING LOAD

Multivalued Options
● Envelope Max/Min
○ Envelope Max
○ Envelope Min
○ Step 1

BOBJ1 - Entire Bridge Section, Load Case: MOVING LOAD (Max/Min)

Longitudinal Stress - Top and Bottom - Center (S11): Max = 4780.7294 Min = -3514.17 (KN/m2)

Fig. 25: Longitudinal Stress diagram of Deformed Bridge Section due to seismic load

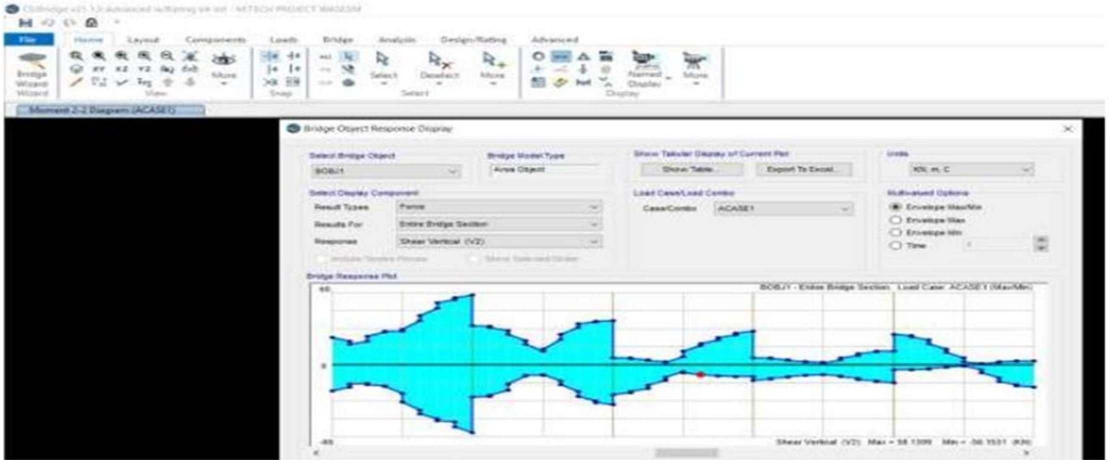

Fig. 26: Shear Vertical diagram due to Seismic action

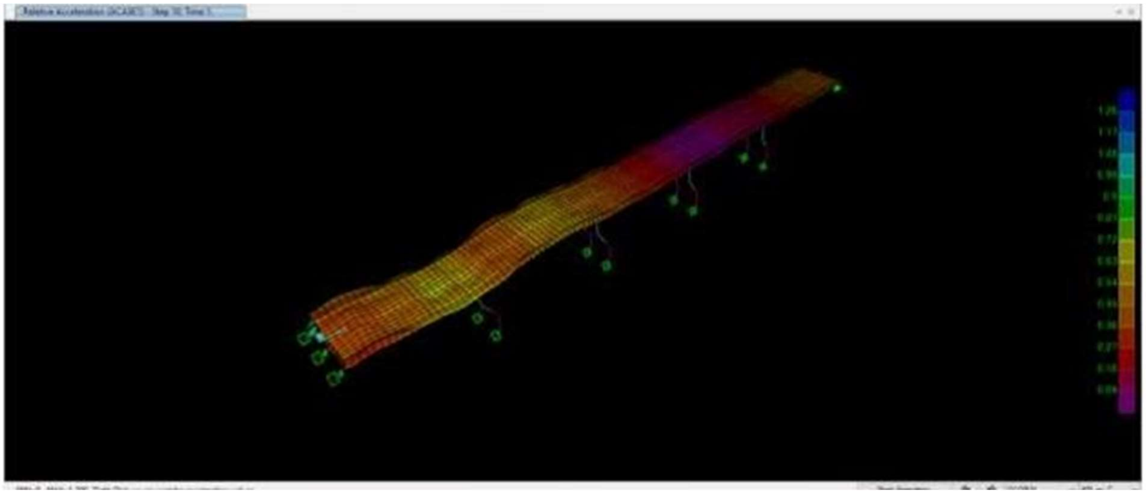

Fig. 27: Relative Acceleration of Deformed Bridge Section

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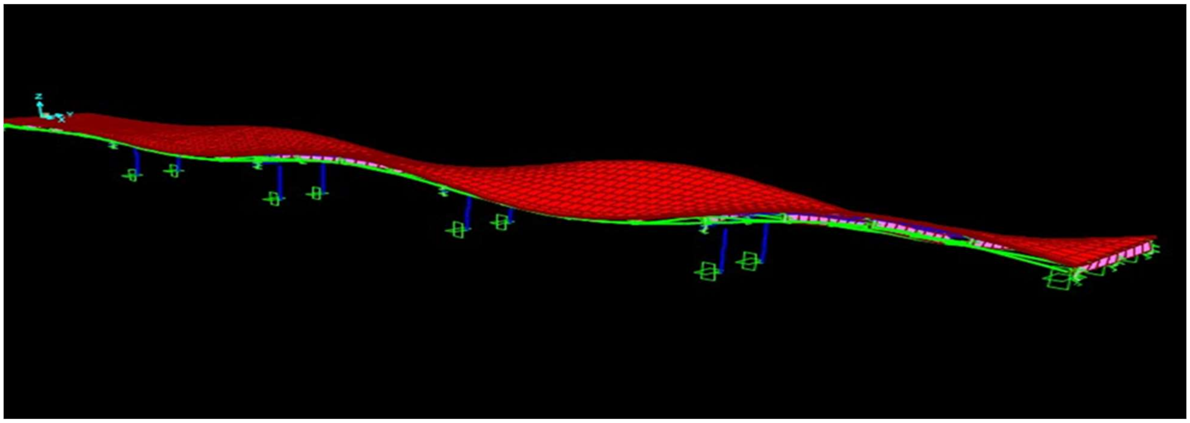

Fig. 28: Deformed shape of structure due to Seismic action

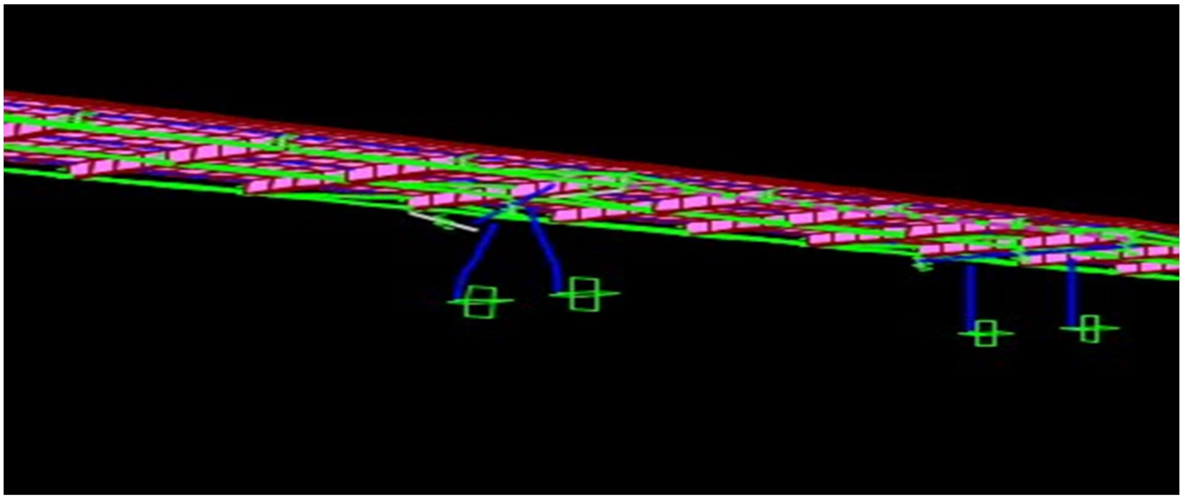

Fig. 29 Joint displacement of columns due to seismic action

V. CONCLUSIONS

For both components at the same joints of the bridge structure, the values of acceleration, base shear, and displacement have been canted from this study. A comparison graphic of the results is displayed above. The results allow for the following conclusion to be made:

- ✔ According to the aforementioned findings, the acceleration, displacement, and base shear values with respect to time in the x-direction are greater than those with regard to time in the y-direction.
- ✔ In terms of time, the base moment in the Y direction becomes greater than that of the base moment in the X direction.
- ✔ In response to this assessment, the structure's optimum demand-to-capacity D/C ratio in both orientations was 0.56, which falls within the acceptable threshold, or 1.
- ✔ The bridge deck's acceleration depends on the bridge characteristics of the bridge deck depends on characteristics of the bridge and the applied ground motion.

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- ✔ The findings indicate a satisfactory correlation among measured ground motion data and the acceleration, base shear, and displacement in both directions of the superstructure's dynamic excitation.
- ✔ Likewise, this indicates that the base shear has contributed significantly to the bridge deck's tectonic reactions' major influence on the seismic action of the bridge deck. It provides resistance to lateral loads.

The dynamic response of the concrete girder bridge is examined in the seismic study using CSi Bridge v 21.0.0. Push over Analysis Method demonstrates seismic impacts in both X and Y directions, and Frequency Response Method uses bridge construction geometry to estimate motion danger.

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