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Influence of Span Length and Radius on Isolated Steel I-Girder Bridge under Different Ground Motion

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Abstract: Bridges are essential for transportation from many years, out of them Steel I-girder bridge is very old and frequently used in many parts of the world. The current practice of bridge required reduction in bridge demand and proper stability of bridge girder specially at horizontally curve bridge, these are more critical during earthquake. Therefore, it is crucial to understand the seismic behaviour of the Steel I- girder bridge under ground motion. This study investigates the effect of different span length and Radius of bridge, under seismic forces. 3D model of three span, two lane steel I-girder bridge having five number of longitudinal girders, which are interconnected by X-bracing used for analysis. Seismic performance of bridge has been improved by using Lead Rubber Bearing (LRB) as isolator. Time history analysis has been performed to carry out seismic analysis under different ground motion. Study compare both isolated and non-isolated bridge performance. Result help to establish relationship between base shear, span of bridge, radius of bridge, transverse displacement and time period with and without isolator. Result shows that base shear is 60-77% reduce by using LRB.
Keywords: Steel I-girder Bridge, LRB, Isolated bridge, Curve bridge, Time history analysis, Span of bridge

I. INTRODUCTION

The term "earth quake" refers to the brief ground movement or vibration. Seismic waves are produced when the earth's crust abruptly releases a particular amount of energy. A bridge is a crucial building for the nation's civilian population because it offers the most basic means of transportation for people and goods from one location to another. After an earthquake, it is necessary that the bridge remain stable and in proper functioning because it plays a crucial role in providing vital services to the affected area and helping people in returning to normal life quickly. we need to make bridge more stable under earth quake to avoid financial burden on nation. Different type of bridge behaves differently according to material and geometry. The critical parameter is span and radius of curve in bridge, if span is large than bridge is more susceptible in earth quake while sharp radius attracts more earth quake force another parameter may also play important role such as pier height, weight of bridge, width of bridge, number of piers etc.

Steel I-Girder Bridge is the special kind of bridge in which deck of the bridge is made of concrete and this deck is supported by steel I-girder. Due to its simplicity of construction and durability, this form of bridge is becoming increasingly common. Steel bridges are suited for long spans, due to light in weight, and capable of carrying heavy loads. This deck is rigidly connected with shear stud provided at top flange of I-girder. cross beam or bracing is provided to connect main girder to act as one unit. Mainly V-type and X-type cross bracing is used this bracing proved effective for both lateral loads and longitudinal load transfer. Lead rubber bearing is most suitable for most of the structure due to its flexibility in mechanical property and capacity of carrying heavy load. It is made out of vulcanized reinforced steel plates with a lead core in the middle and many layers of elastomeric material. This bearing allows both vertical and horizontal displacement, vertical axial stiffness is much high than horizontal stiffness. The energy dissipation effect of lead rubber bearing is mainly achieved by the elastic-plastic deformation of lead. The top and bottom structures' vibrations may be separated by the lead rubber bearing, which can also increase the duration of natural vibration and lessen seismic force. During an earthquake, the lead plug will slide along with the laminated rubber. However, this movement energy is converted into heat, which significantly lessens the structure's inertial force and reduces the structure’s vibration. Due to its strong elasticity, the rubber component will continue to hold its original shape. This lead rubber bearing is used below Steel I-girder to isolate the bridge super structure, while in case of non-isolated bridge roller support is provided at abutments and pinned support is used at pier, three different radius that is 150m, 250m, and 350mm taken under different ground motion and span of bridge is 25m and 30m. Nonlinear time history analysis is used to evaluate the performance of isolated and non-isolated bridge using CSI-BRIDGE software.

II. LITERATURE REVIEW

Afraa Labiba Hassan et al. (2020) investigate effect of ground motion duration on seismically isolated concrete I-girder bridge. Three different isolators are used for seismic analysis such as lead rubber bearing, friction pendulum system and shape memory alloy wire-based lead rubber bearing. The bridge having two pier of diameter of 1500 mm and thickness of concrete deck is 250 mm. Result shows that LRB isolator achieve maximum time period and displacement. The long duration of the movement will cause further damage to different bridges component As compared to short duration movements the components are as follows: An increase in deck speed, pier base shear and remaining displacement of the isolator. Similar Base Shears have been detected on bridge piers in the course of short duration motion. Regardless of the isolation system.

Ali Vatanshenas et al. (2018) study the effect of seismic isolation on precast concrete I-girder bridge response using time history analysis. Lead rubber bearing used for isolation of bridge. Span length of bridge is 20 m. Regarding deck displacement and slab acceleration, there was no significant difference in the seismic responses of these two bridges, and the results were highly dependent on the frequency content of the seismic records.

Ali Vatanshenas et al. (2020) evaluate the effect of length of span and earthquake directivity on the response of multi-span continuous girder bridges isolated by friction bearings. Time history analysis is performed for the bridge of span length 30m and 15 m span and width is 13.2 m. Three pier of diameter 1.07 with height of 7.6 m from ground to pier cap is considered for analysis. Through this analysis the outcomes of the modal examination indicate that the duration of structures employing the friction pendulum system is solely determined by the isolator's shape. The deck's displacement was not influenced by the length of the bridge span, but rather by the earthquake's directivity effect and frequency content.

Amir Gheitasi et al. (2015) the failure characteristic and ultimate load carrying capacity of composite steel I-girder bridge. Author takes 7.92m deck with and span of bridge is 27.43 m to make FEM to carry non-linear analysis. Result shows that Flexural cracks across the concrete deck spread in all directions as the external applied force is increased after the first cracking point. Deflection of girder increase with increase in load on it. The limited sensitivity analysis carried out in this study showed that the geometrical characteristics, boundary conditions, material properties, girder-deck bond properties, and even loading scenarios have a significant impact on the identified behavioral stages and corresponding failure characteristics in composite steel-concrete bridge superstructures.

Asif Hameed et al. (2008) examine of Lead Rubber Bearing property on the response of seismic-isolated bridges in this paper lead rubber bearing is used as isolators. Bridge have two span with 30 m length of each span, width of bridge is 12 m while deck is 250mm thick and girder spacing is 2.4m c/c. Pier height is 10 m and diameter of pier is 2 m. Author found that the reason for the decrease in MID is that when the Qd/W ratio rises, the isolation system becomes relatively stiff and the bearing displacements decrease. Base shear and deck acceleration reduce with reduction in Qd/W ratio. At low PGA/PGV ratio ground movements produce a high isolator force and isolator displacement. Deck acceleration and Pier base shears first decline, reach their lowest point, and then increase as the Qd/W ratio rises.

Daniel G. Linzell et al. (2011) in this paper author investigate the effect of curved, steel, I-girder bridge layout on cross frame member forces and girder end responses during seismic events. Finite element models of simply-supported bridges were made, and they were tested under seismic forces using non-linear time history analysis method, for this study three different radius of 61m, 107m, 229m is considered. X-type cross bracing is used to connect main girder to each other. Regardless of the variance in other parameters, uplift under seismic loads was proven to be an issue for the bridges that were studied at smaller radius. Result also show that normalized vertical reaction increase with increase in girder spacing.

Iman Mohseni et al. (2022) Improved frequency expressions for horizontally curved steel I-girder bridges employing HPSteel Girders are being studied. The analysis of bridge is perform using CSIBridge software. Author found that the fundamental frequency falls as the depth-to-span ratio increase. Natural frequency of bridge with X-type bracing is high as 12, 48, 54 % than with V-bracing, inverted V- and single beam bracing systems respectively. Author also suggest that suggested that to have a significant impact on bridge reactions, the bracing lines maximum spacing be restricted to 6 m.

Junwon Seo (2013) study curved I-girder bridge seismic response parameters determined statistically. Non-linear time history analysis is done on 240m radius curve bridge having middle span 38.3m and both end span of 30.8m. Time history analysis is used and developed fragility curve for different spacing & Radius that give the different seismic behavior.

M.sasan et al. (2011) study seismic effect on middle span steel I-girder bridge. Different analysis method is performed using ANSYS software. The span of bridge is 25m taken for analysis author evaluate that the Time history analysis method give the most accurate result but it consumes more time. Pushover analysis is give result based on the performance and response spectrum analysis method is recommended for time saving point of view.

Mahmoud Bayat et al. (2019) study seismic demand of isolated concrete girder highway bridges using fragility curve. Lead rubber bearing is used as isolator in straight concrete bridge. For the analysis of bridge incremental dynamic analysis is performed. The fragility function takes into account the correlation between earthquake intensity measures and the likelihood of exceeding a certain Damage State. concrete I-girder bridge with middle span length of 24.4 and end span length is 12.2 m is modeled for analysis. Author found that displacement of LRB is linearly increase with PGA and also develop fragility cure that shows failure probability increase with increase in PGA.

Moussa Leblouba (2022) study stability analysis of elastomeric bearing and LRB in bridge to reduce, wind loads, earthquakes load and vehicle vibrations. Author conclude that as normalized vertical stiffness reduce than horizontal displacement increase. As axial stress increases, the horizontal post-elastic stiffness significantly reduce. The top of the elastomeric bearing moves vertically under a constant axial load as the shear strain increase.

Mozhdeh Amani et al. (2016) investigate the flexural behavior of bridge structures having horizontally curve steel I-girders which are laterally braced by interconnected cross-frames. Author replace of complicated bridge system with single curve I-girder for simplifying analysis. ABAQUS software is used for analysis of bridge. The elastic vertical and lateral deflections of horizontally curved steel with the use of single girder modelling, bridge girders cannot be accurately predicted.

Murat Eroz et al. (2013) Study a typical multi-span uninterrupted concrete girder bridge's sliding and elastomeric seismic isolation performance should be evaluated. For the analysis of bridge three span continuous bridge of span 30.3m is taken under time history analysis. Author found that in comparison to the FPS, the LRB acquired 34% larger isolator displacements yet put 17% less strain on the columns. Compared to the FPS, the LRB system exhibited a more consistent distribution of lateral stiffness throughout the bridge. Vertical load variations had an impact on isolator forces of less than 5% in study situations where the LRB did not 21 flex. On the other hand, the analysis's maximum forces rise by 92% when vertical load effects were included in real-time.

Praveen Kumar Gupta et al. (2022) studied how LRB-isolated horizontally curved continuous reinforced concrete bridge responds to different earthquake loads. Author consider following parameters for evaluating the effectiveness of LRBs on the bridge response control included variations in ground motion characteristics, multidirectional effects and the intensity of seismic motion. for time history analysis three different ground motion data with both directional effects is consider in SAP 2000 software. As fundamental time period increases bearing displacement increase. The highest force transmission decrease was between 84 and 85% for unidirectional situations and between 93 and 95% for bidirectional cases.

Radek Wodzinowski et al. (2018) study free vibration of horizontally curve steel I-girder bridge. Author conduct sensitivity analysis for examine the effect of various design parameters for free-vibration response of curved steel I-girder bridges. ABAQUS software is used to carry out free vibration analysis. Total four different radius is taken by author that is 100 m, 150 m, 250 m and 450 m. X-type cross bracing is used to connect the main steel I-girder of bridge. Result shows that as number of cross bracing line increase the frequency of bridge is increase. Author also found that as span length increase than frequency of bride is decrease dramatically and curvature ratio L/R increase frequency of bridge decrease. In general, a 10% increase in bridge stiffness causes a 4% rise in fundamental frequency. Although the impact of main girder spacing and number on fundamental frequency is less pronounced, typically, fundamental frequency falls with increasing girder spacing and number.

S.S. Roy et al. (2018) examine dynamic behavior of multi span continuous prestress concrete girder bridge with different isolation bearings. Analysis is performed using nonlinear modal time history in SAP 2000-V14 software. Bridge having three span of 29 m and pier height and diameter is 3 m and 2.5 m respectively. Result shows that According to design response spectrum, using the LRB isolation system instead of the Pot-PTFE bridge results in a 74% reduction in base shear for the first mode of 22 vibration. In comparison to the Pot-PTFE type, the LRB bridge model is shown to have a greater natural time period.

Wei Wang et al. (2016) study fatigue design of steel bridges considering the influence of moving vehicle loading and overloaded trucks. A simply supported steel I-girder with spacing between main girder is 2.13m used for analysis. The width and span of bridge is 9.75 m and 16.76 m respectively with concrete deck of thickness of 0.20m is used for analysis. The result indicates that the average fatigue damage caused by trucks can be 11.74 times greater when vehicle dynamic loads are taken into account when vehicle dynamic loads are not taken into account. stress can be reduced by providing a smooth surface, which is high for defective road surface condition. The overloaded trucks together with poor road surface condition have a great impact on the fatigue life of steel bridges.

III. DESCRIPTION OF STRUCTURAL SYSTEM

A. *Modelling of Bridge*

Modelling of two span continuous steel I-girder bridge with and without isolator is performed using CSI-BRIDGE software using for different radius and span. Details of bridge component are given in table 1.

Table 1: Bridge configuration

No of lane	2
No of span	3
Width of Bridge Deck	9.8 m (7.5 C.W +2 X (0.85 road safety) +2 X (0.3 Crash barrier)
No of longitudinal Girder	5
Spacing between longitudinal Girder	2.1 m
Type of Cross bracing	X-Bracing
Spacing of cross bracing	2.5 m
Shape of pier	Circular
Dia. of pier	2.25 m
Height of pier	6 m
Thickness of concrete deck	300 mm
Grade of concrete	M35
Grade of steel	Fe350
Main Steel I-girder	Web 1000 X 18 mm Top Flange 400 X 22 mm Bottom Flange 400 X 30 mm
Section of bracing	L-Section :- 150 X 150 X 18 mm

1) Design of LRB is done separately for 25 m and 30 m span based on the load acting on the LRB. Here 15 layers of natural rubber with 8mm thickness and 14 layer of laminated steel plate of thickness of 2mm is arrange alternately between rubber layer. Thickness of top and bottom seal plate thickness is 31mm hence over all height of bearing is 210 mm. mechanical property of lead rubber bearing is given in table 2.

Table 2 : Mechanical property of LRB

LRB property for 25 m span bridge			LRB property for 30 m span bridge		
PARAMETERS	VALUE	UNITS	PARAMETERS	VALUE	UNITS
Qd/W	0.07		Qd/W	0.07	
Tr	120	mm	Tr	120	mm
dL	80	mm	dL	80	mm
Drubber	320	mm	Drubber	320	mm
hL	148	mm	hL	148	mm
Δsd	72	mm	Δsd	74	mm
Effective Stiffness	987	kN/m	Effective Stiffness	1144	kN/m
Yield force (Fy)	45	kN	Yield force (Fy)	55	kN
Elastic stiffness	4945	kN/m	Elastic stiffness	5943	kN/m
Stiffness Ratio	0.1		Stiffness Ratio	0.1	
Vertical Stiffness	57000	kN/m	Vertical Stiffness	67000	kN/m

2) *Time History data is as given below*

Ground motion Region	Station	Mw (Magnitude)	PGA (m/s/s)	Year	Code
Uttarkashi	Bhatwari	7	2.42	1991	A
Indian Burma Border	Diphu	6.4	1.003	1995	B
Chamoli	Gopeshawar	6.6	1.921	1999	C

3) In this study two bridge condition is taken that is isolated and non-isolated bridge in isolated bridge LRB is used as isolator to separate the superstructure from substructure while in case of non-isolated structure roller support is provided at abutments and pinned support is at pier of bridge and time history analysis is performed to know the seismic behavior of bridge.

Type 1:- Straigth bridge with span 25 m and 30 m

Condition 1:-Non-Isolated bridge

Condition 2:-Isolated bridge

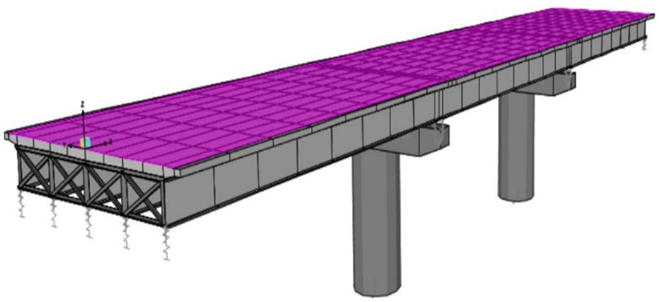

Figure 1 : Isometric view of straight bridge

Figure 2 : Lane width of bridge

Type 2:- Curve bridge with radius 150 m, 250 m, 350 m and span is 25m

Condition 1 :- Non-Isolated bridge

Condition 2 :- Isolated bridge

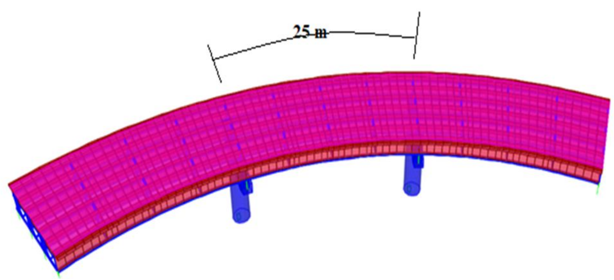

Figure 3:- Isometric view of curve bridge for 25 m span

Type 3:- Curve bridge with radius 150 m, 250 m, 350 m and span is 30 m

Condition 1:- Non-Isolated bridge

Condition 2 :- Isolated bridge

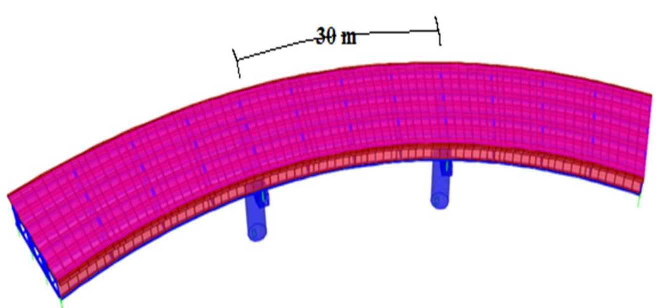

Figure 4 : Isometric view of curve bridge for 30 m span

B. *Objectives*

1) Influence of span length and radius on seismically isolated steel I-girder bridge under different ground motion.
2) Analyze effect of base isolation on longitudinal girder under seismic forces.
3) To determine the effect of LRB isolation on base shear.
4) Analyze Effect of base isolation (LRB) on horizontal curve.

C. *Scope Of Work*

1) Learning of CSI-BRIDGE
2) To perform validation procedure.
3) To perform seismic analysis for steel girder bridge using non-linear time history analysis.
4) Total three non-linear time history analysis shall be conducted considering various ground motion data.
5) To obtain transverse deflection on longitudinal steel girder for different span and radius of bridge, with and without isolation.
6) To obtain reduction in pier drift of isolated bridge.
7) Parameter such as varying span length and radius will be carried used for non-linear analysis.
8) Span of bridge
   25m
   30m
9) Radius of Bridge
   150m
   250m
   350m
10) *Total 48 models were prepared*

IV. ANALYSIS RESULTS

A. *Base Reaction*

1) Base reaction of isolated and non-isolated bridge for different span and Radius is as shown in figure below for both X-direction and Y-direction Ground motion.

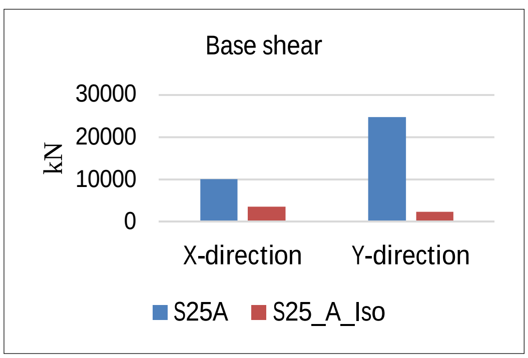

Figure 5 : Base shear for 25_A

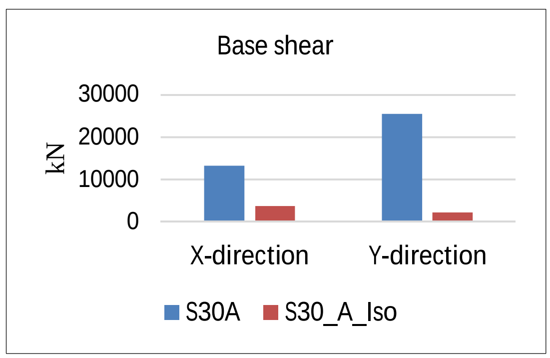

Figure 6 : Base shear for 30_A

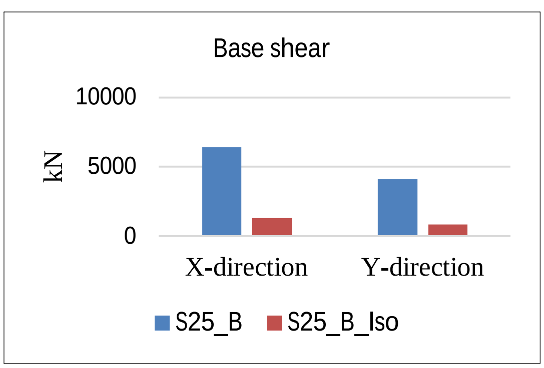

Figure 7 : Base shear for 25_B

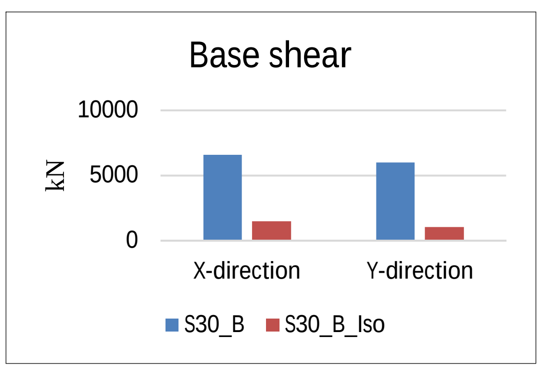

Figure 8 : Base shear for 30_B

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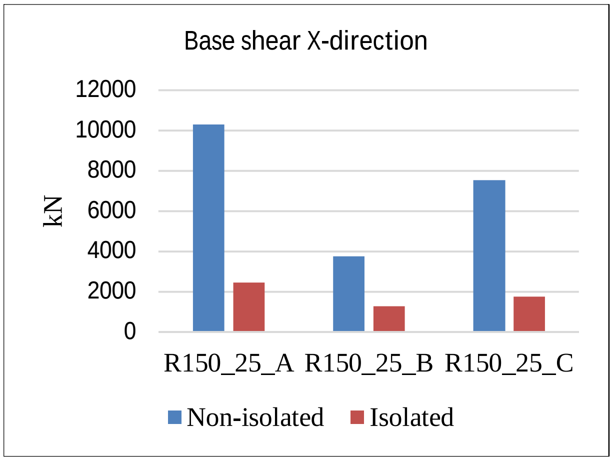

Figure 9 : Base shear for R150_25 in X-direction

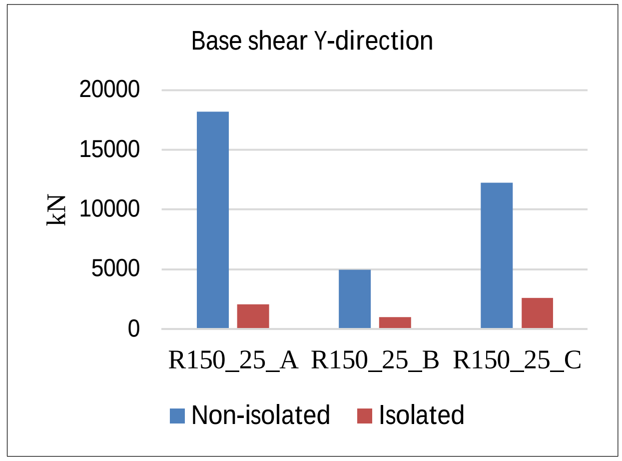

Figure 10 : Base shear for R150_25 in Y-direction

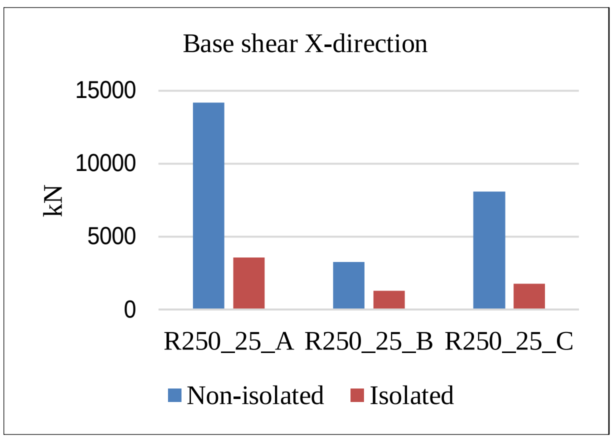

Figure 11 : Base shear for R250_25 in X-direction

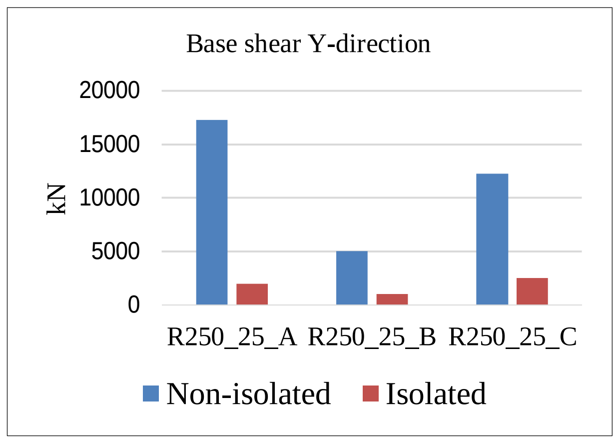

Figure 12 : Base shear for R250_25 in Y-direction

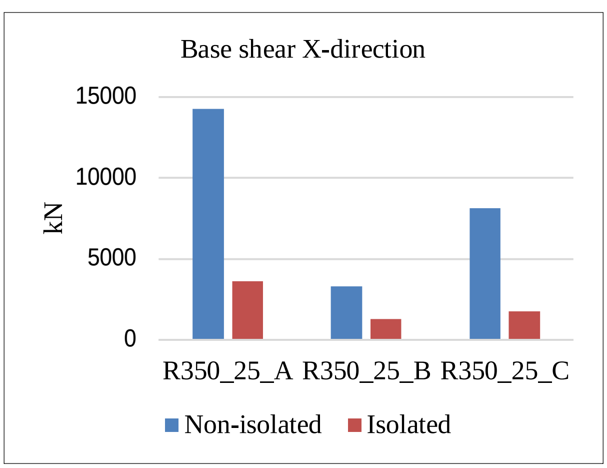

Figure 13 : Base shear for R350_25 in X-direction

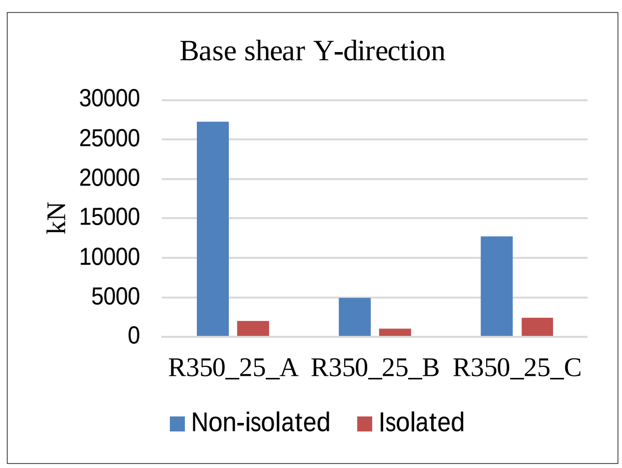

Figure 14 : Base shear for R350_25 in X-direction

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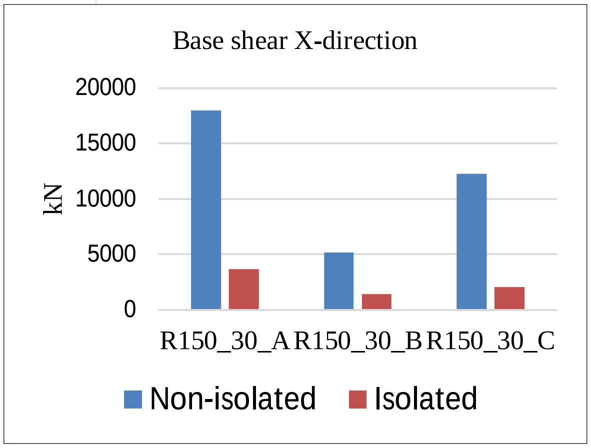

Figure 15 : Base shear for R150_30 in X-direction

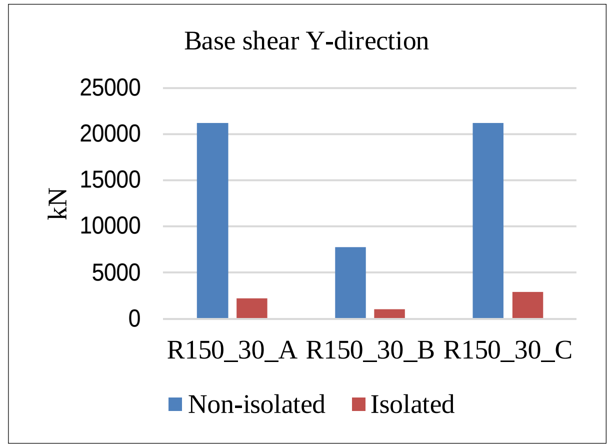

Figure 16 : Base shear for R150_30 in Y-direction`

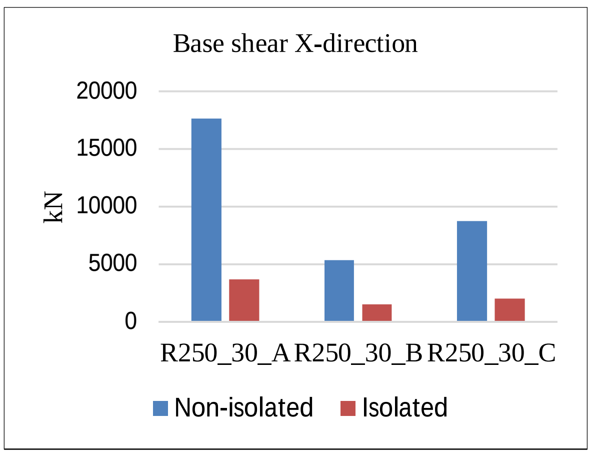

Figure 17 : Base shear for R250_30 in X-direction

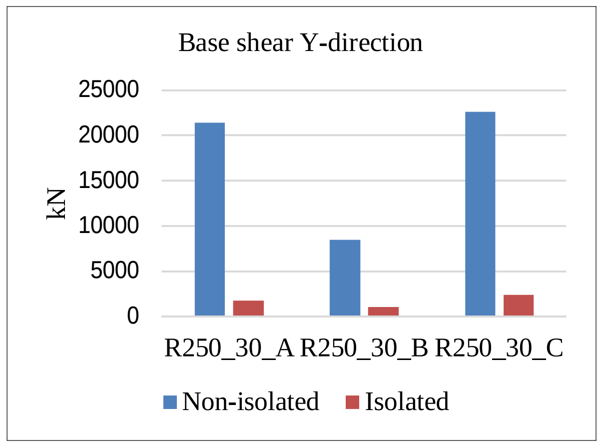

Figure 18 : Base shear for R250_30 in Y-direction

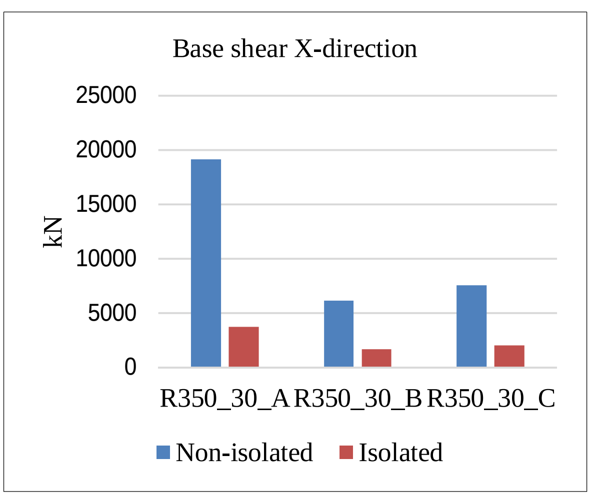

Figure 19 : Base shear for R350_30 in X-direction

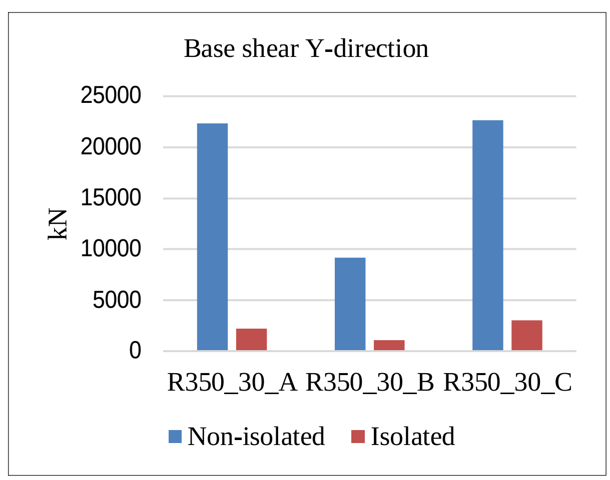

Figure 20 : Base shear for R350_30 in Y-direction

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B. Fundamental Time Period

The time period is a general feature that describes how a bridge responds to seismic stresses depending on mass and stiffness. Because of this, it is simple and practical to determine the overall demands placed on a bridge by a particular seismic input.

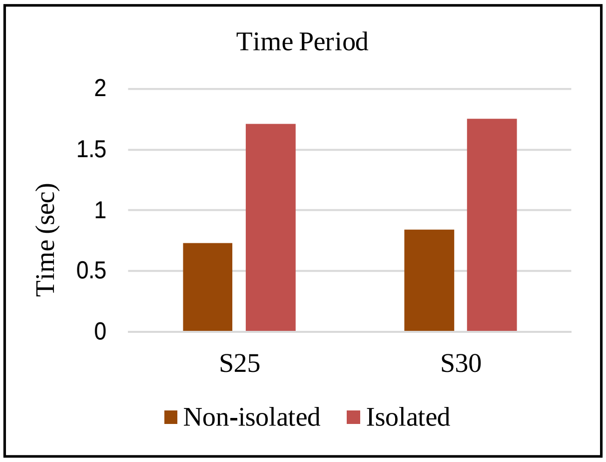

Figure 21 : Time period for S25 and S30

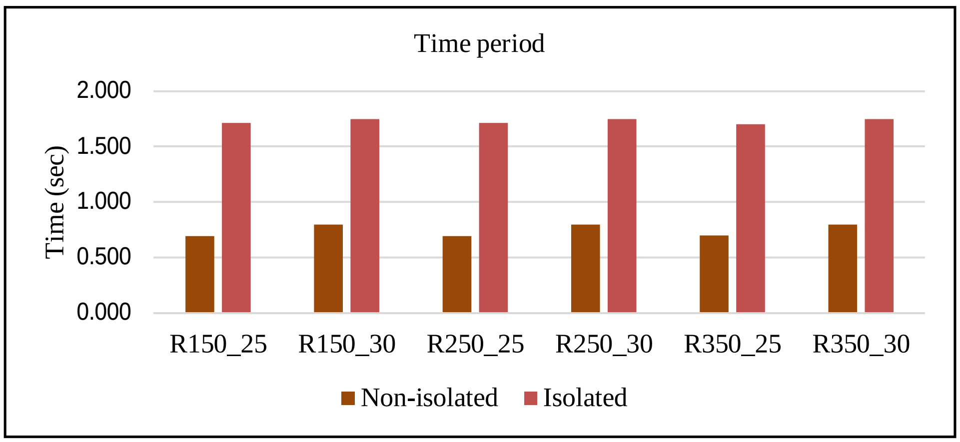

Figure 22 : Time period of curve bridge

C. Transverse deflection

Bridge deflection, which measures the total stiffness of the bridge structure and is directly connected to its bearing capacity and capability to withstand dynamic loadings like traffic, gusts, and earthquake, is a crucial criterion in the safety analysis of bridge constructions.

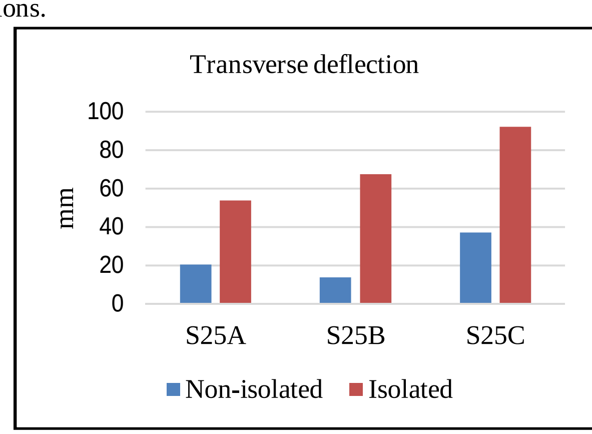

Figure 23 : Transverse deflection of S25 bridge

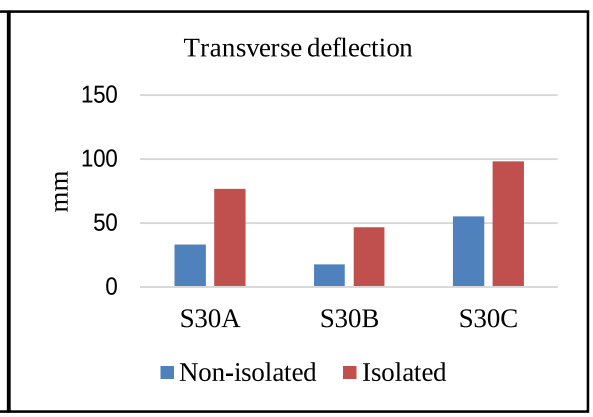

Figure 24 : Transverse deflection of S30 bridge

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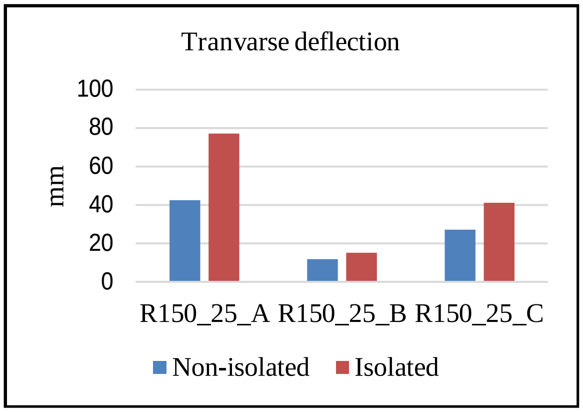

Figure 25 : Transverse deflection of R150_25 bridge

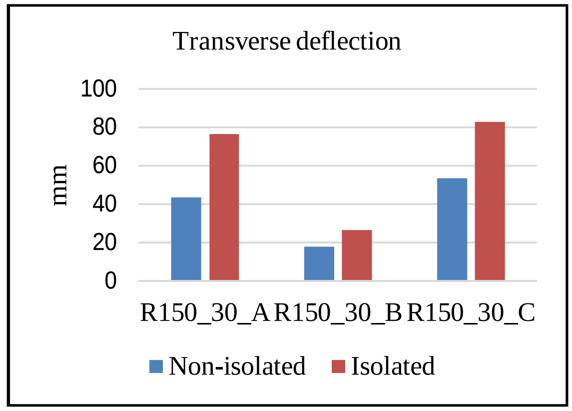

Figure 26 : Transverse deflection of R150_30 bridge

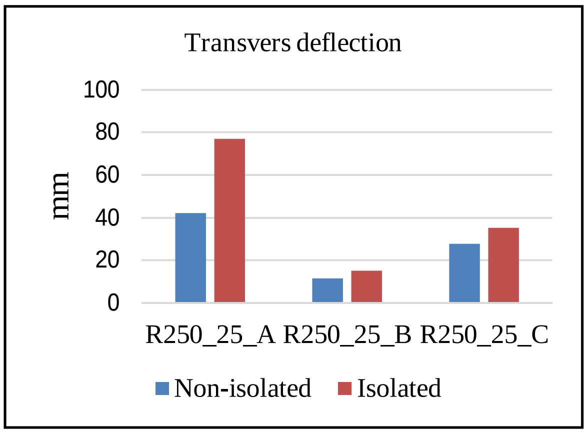

Figure 27 : Transverse deflection of R250_25 bridge

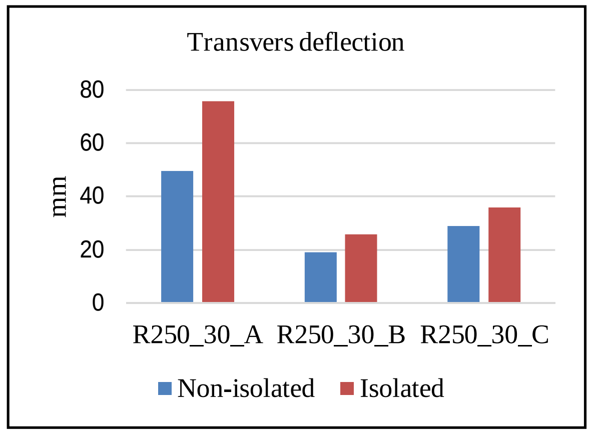

Figure 1 : Transverse deflection of R250_25 bridge

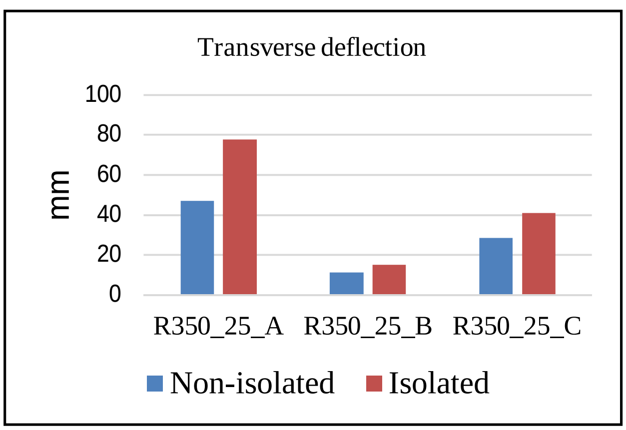

Figure 29 : Transverse deflection of R350_25 bridge

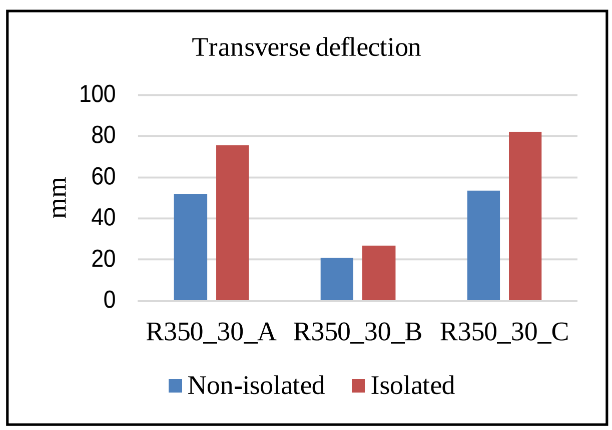

Figure 30 : Transverse deflection of R350_30 bridge

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D. Deck Acceleration

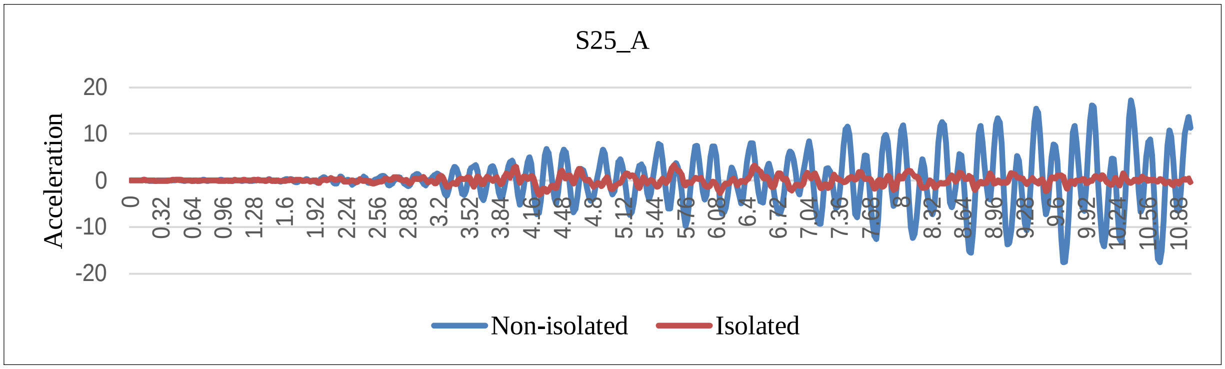


Figure 31 : Deck acceleration of S25_A

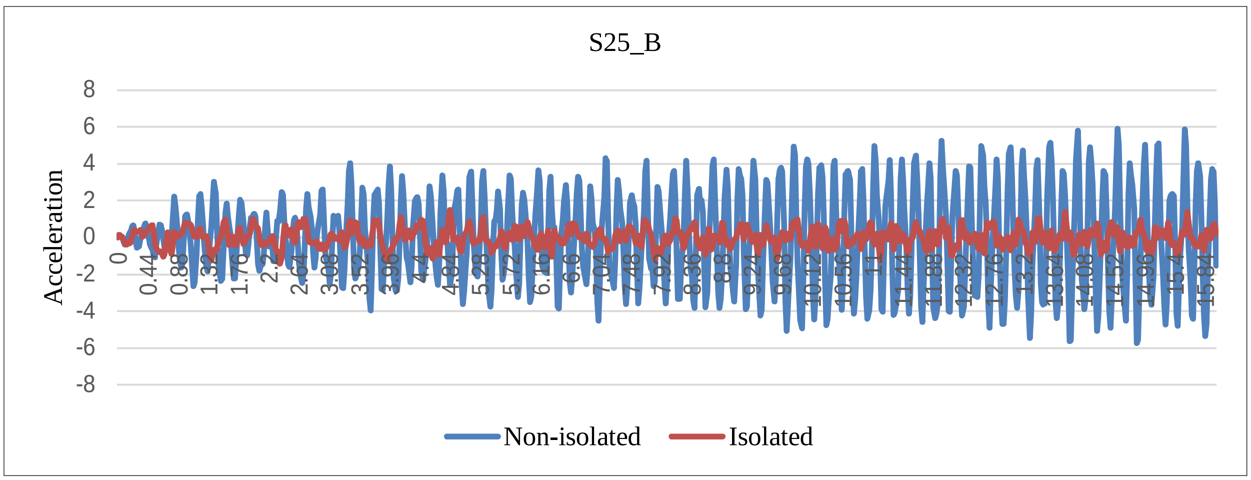


Figure 32 : Deck acceleration of S25_B

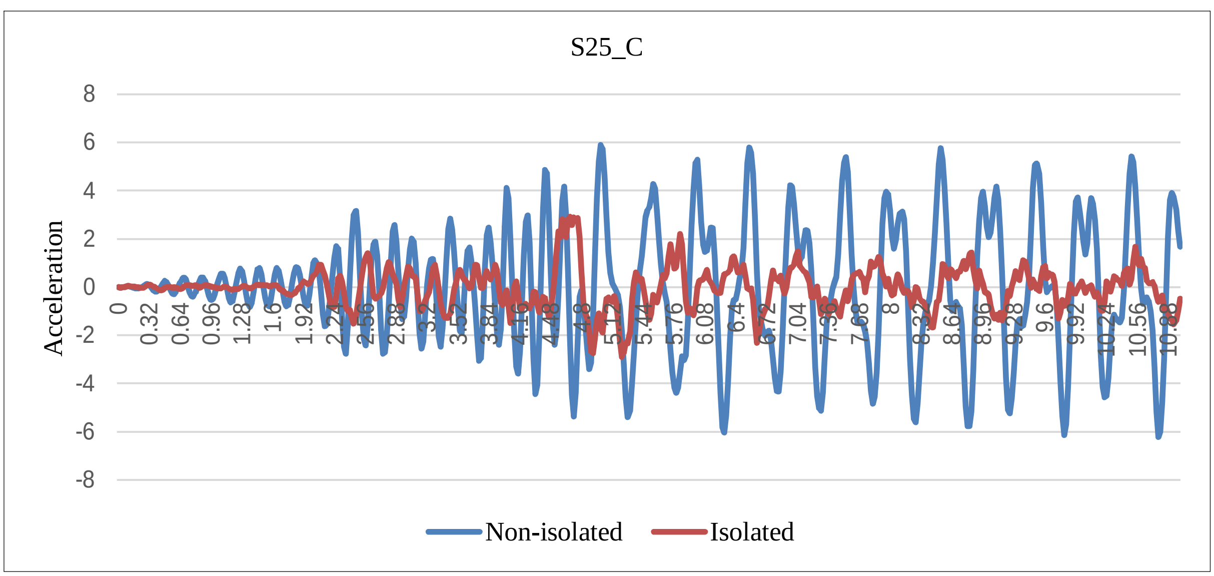


Figure 33 : Deck acceleration of S25_C

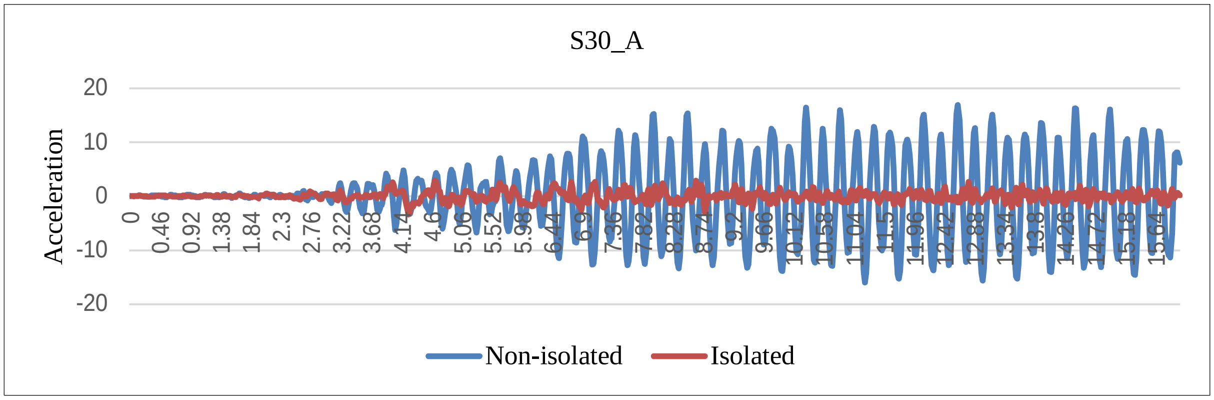


Figure 34: Deck acceleration of S30_A

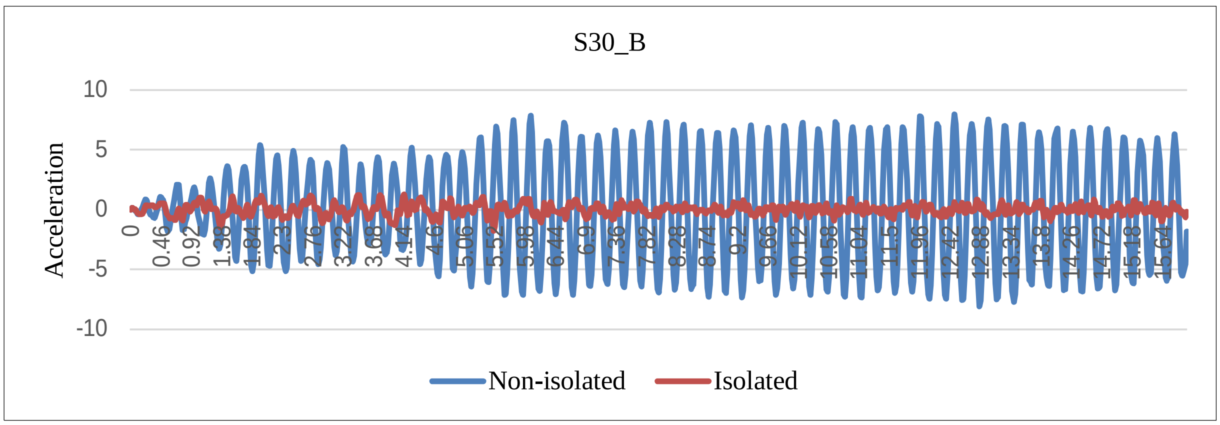


Figure 34: Deck acceleration of S30_B

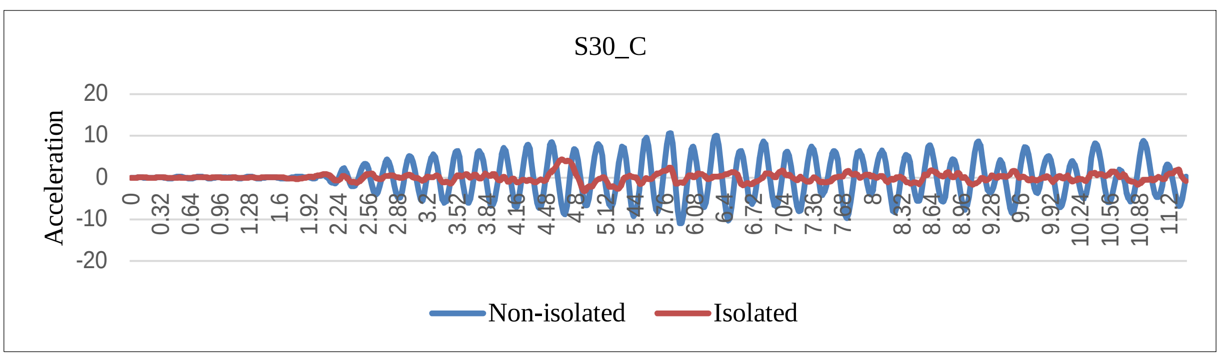


Figure 35: Deck acceleration of S30_C

V. CONCLUSION

In the present study both isolated and non-isolated bridge is compared using time history analysis under three different ground motion data.

1) LRB reduce 67% to 88% of base shear of bridge.
2) LRB is useful for both directional base shear reduction of bridge.
3) Base shear reduction is increase with increase in PGA.
4) Deck acceleration is reduced 27% to 74% for isolated bridge.
5) Pier drift is more effectively reduce by LRB.
6) As span length increases base shear of bridge increase.

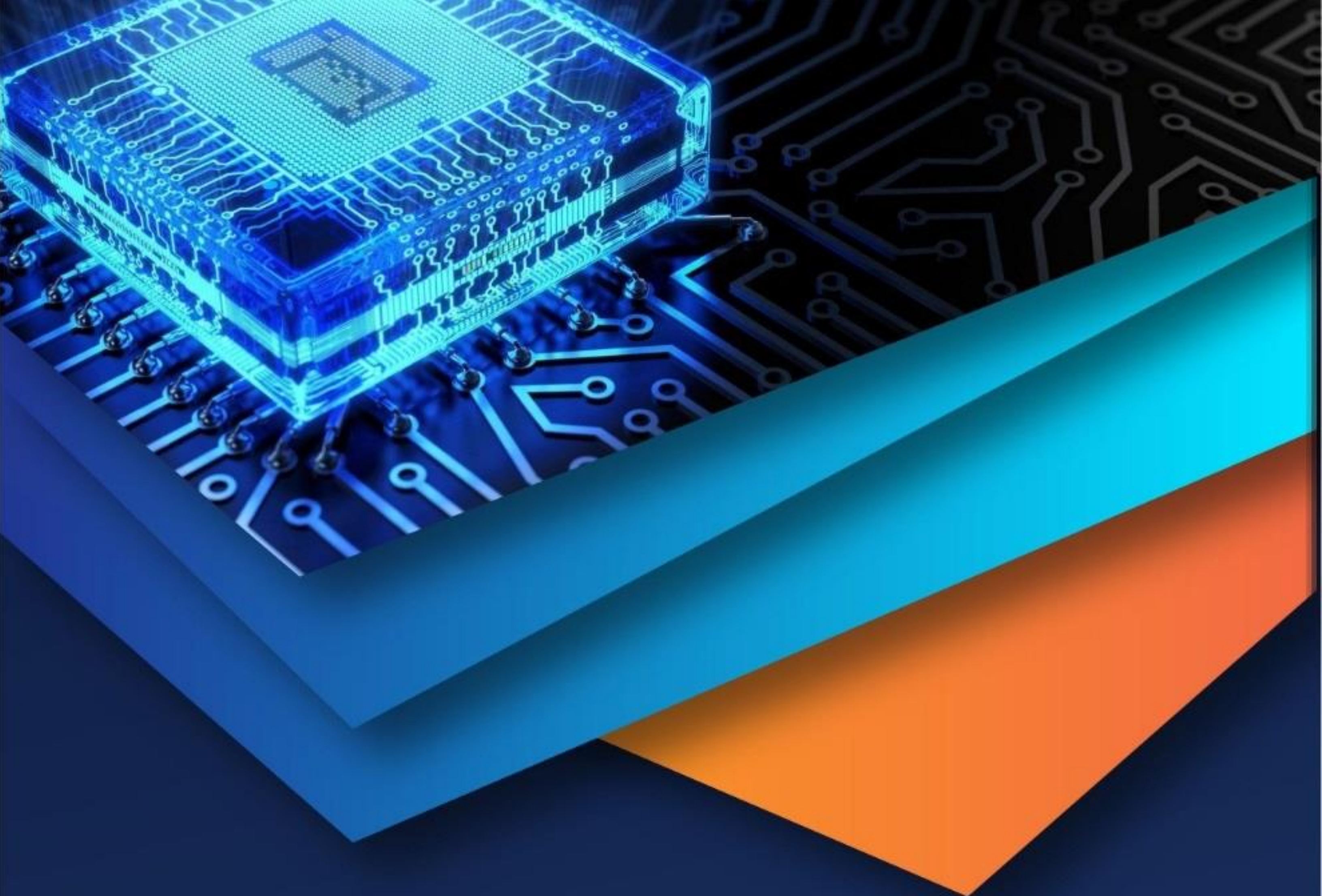
7) Transverse deflection is increase with increase in PGA.
8) LRB introduce flexibility in bridge so time period of structure is increase more than 200%.

VI. FUTURE SCOPE

1) Determine effect of base isolation system on horizontally curve steel I-girder bridge considering soil structure interaction.
2) Effect of tsunami on isolated steel I-girder bridge.
3) Development of fragility curve for isolated steel I-girder bridge.
4) Effect of blast load on isolated bridge.

REFERENCES

[1] Amani, M. and Alinia, M.M., 2016. The flexural behavior of horizontally curved steel I-girder bridge systems and single-girders. Journal of Constructional Steel Research, 118, pp.145-155.
[2] Barker, M.G. and Barth, K.E., 2013. Improved serviceability criteria for steel girder bridges. Journal of Bridge Engineering, 18(7), pp.673-677.
[3] Batikha, M., Al Ani, O. and Elhag, T., 2017. The effect of span length and girder type on bridge costs. In MATEC Web of Conferences (Vol. 120, p. 08009). EDP Sciences.
[4] Bayat, M., Ahmadi, H.R., Kia, M. and Cao, M., 2019. Probabilistic seismic demand of isolated straight concrete girder highway bridges using fragility functions. Adv. Concrete Construct, 7(3), pp.183-189.
[5] Carden, L.P., Buckle, I.G. and Itani, A.M., 2007. Transverse displacement capacity and stiffness of steel plate girder bridge superstructures for seismic loads. Journal of Constructional Steel Research, 63(11), pp.1546-1559.
[6] Chang, C.J. and White, D.W., 2008. An assessment of modeling strategies for composite curved steel I-girder bridges. Engineering Structures, 30(11), pp.2991-3002.
[7] Chavel, B.W. and Earls, C.J., 2006. Construction of a horizontally curved steel I-girder bridge. Part II: Inconsistent detailing. Journal of Bridge Engineering, 11(1), pp.91-98.
[8] Eröz, M. and DesRoches, R., 2013. A comparative assessment of sliding and elastomeric seismic isolation in a typical multi-span bridge. Journal of Earthquake Engineering, 17(5), pp.637-657.
[9] Gheitasi, A. and Harris, D.K., 2015. Failure characteristics and ultimate load-carrying capacity of redundant composite steel girder bridges: Case study. Journal of Bridge Engineering, 20(3), p.05014012.
[10] Leblouba, M., 2022. Stability analysis of elastomeric bearings in bridge structures. Advances in Bridge Engineering, 3(1), pp.1-21.
[11] Lee, T.H. and Nguyen, D.D., 2018. Seismic vulnerability assessment of a continuous steel box girder bridge considering influence of LRB properties. Sādhanā, 43(1), pp.1-15.
[12] Linzell, D.G. and Nadakuditi, V.P., 2011. Parameters influencing seismic response of horizontally curved, steel, I-girder bridges. Steel and Composite Structures, 11(1), pp.21-38.
[13] Mohseni, I., Ahn, Y. and Kang, J., 2019. Development of improved frequency expressions for composite horizontally curved bridges with high-performance steel girders. Arabian Journal for Science and Engineering, 44, pp.4151-4160.
[14] Sasan, M. and Mohammadsadegh, S., 2011. Seismic evaluation of middle span steel I-girder bridges. Journal of Applied Sciences, 11(1), pp.104-110.
[15] Seo, J., 2013. Statistical determination of significant curved I-girder bridge seismic response parameters. Earthquake Engineering and Engineering Vibration, 12(2), pp.251-260.
[16] Roy, S.S. and Dash, S.R., 2018. Dynamic behavior of the multi span continuous girder bridge with isolation bearings. International Journal of Bridge Engineering (IJBE), 6(2), pp.01-23.
[17] Vatanshenas, A. and Rohanimanesh, M.S., 2020. Investigating the effect of span-length and earthquake directivity on the response of multi-span continuous girder bridges isolated by friction bearings. Bridge Structures, 16(1), pp.27-37.
[18] Vatanshenas, A., Bajestany, D.S. and Aghelfard, A., 2018. The effect of seismic isolation on the response of bridges. International Journal of Bridge Engineering (IJBE), 6(3), pp.61-74.
[19] Wang, W., Deng, L. and Shao, X., 2016. Fatigue design of steel bridges considering the effect of dynamic vehicle loading and overloaded trucks. Journal of Bridge Engineering, 21(9), p.04016048.
[20] MCEER 06-SP16-07: Seismic Isolation of Highway Bridge.
[21] IS 1893 Part-3 Criteria for Earthquake resistant design of structures Bridges and Retaining walls



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