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"SEISMIC ANALYSIS OF BRIDGE WITH ELASTOMERIC BEARING"

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Abstract — Seismic isolators have been used to protect buildings, bridges and mission-critical infrastructure from the damaging effects of earthquake shaking. In past earthquakes, most of the damages of the bridges occurred due to the failure of the bearings and substructure. 3 models are going to use in this Project. One is non-isolated bridge modal and two models of base isolated bridges with different elastomeric bearings. Elastic time-history analyses were carried out using comprehensive finite element structural analysis software package SAP2000.Time history analysis was conducted for the Bhujj Earthquake. Isolators are to be designed by considering suitable soil type and site conditions.

The properties of isolators are to be introduced between super structure and sub structure. Influence of the base isolator is to be studied. The influence of the elastomeric bearing in the dynamic behavior of the bridge shows an extended time period, increase in deck displacement and decrease in base shear in both isolated bridge models.

Keywords-: Bridges, Base isolation, bearings, Time History Analysis, SAP2000.

I. INTRODUCTION

A bridge is made up of two major parts namely, superstructure and substructure. Superstructure consists of track structure, girder/ truss and bearing. Substructure consists of bed block, pier or abutment and foundation as shown in Fig.1

Bridges are vulnerable when subjected to severe earthquakes. Although considerable progress has been made in earthquake engineering, catastrophic bridge failure examples are found wherever large-scale earthquakes attack. Damage of the bridge structures occur primarily in the piers, which may in turn result in collapse of the bridge spans. Although the ductility design concept has been widely accepted for seismic design of structures in engineering practice, this may not be appropriate for bridges since they are short of structural redundancy in nature.

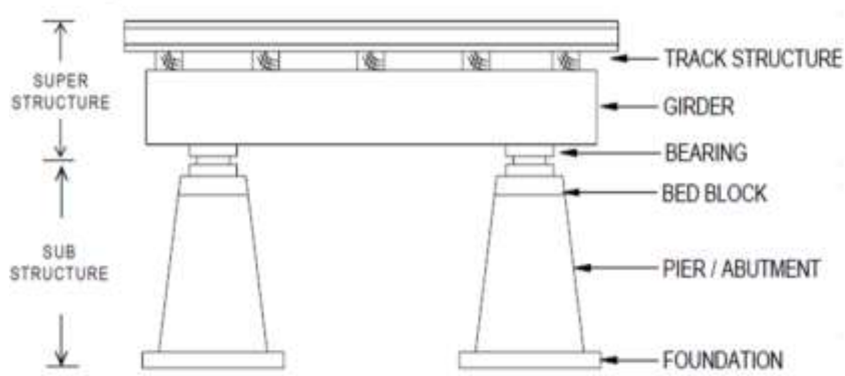

Fig 1: Parts of bridge

A. TYPES OF BASE ISOLATORS

1. Elastomeric (rubber) bearings.
2. Lead rubber bearing.
3. High damping rubber bearing (HDRB)
4. Friction pendulum system bearing.

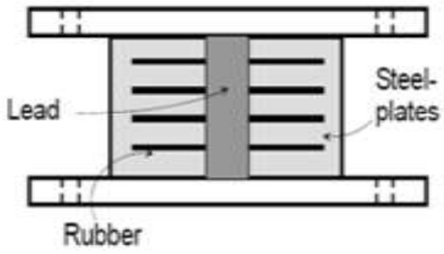

Fig 2: Lead Rubber Bearing

Recent investigations are turning out to be most vital in safe outline, which requires more data about the floats, relocations and inelastic disfigurements of a structure than conventional configuration systems. SAP2000 V14.2 is a standout amongst the most refined and easy to understand programming.

For the present Project an existing bridge located at hagarebommanahalli seismic zone III Davanagere, Karnataka SH-120 is adopted. Three bridges of 149.29m total length and width of 12 m is analyzed by nonlinear modal method. One is non-isolated and other two are isolated. All three models are analyzed by TIME HISTORY METHOD in SAP2000. Base isolation system of elastomeric bearing for isolated bridge is designed as per IRC and IBC code practice. Dynamic responses of models are compared and studied.

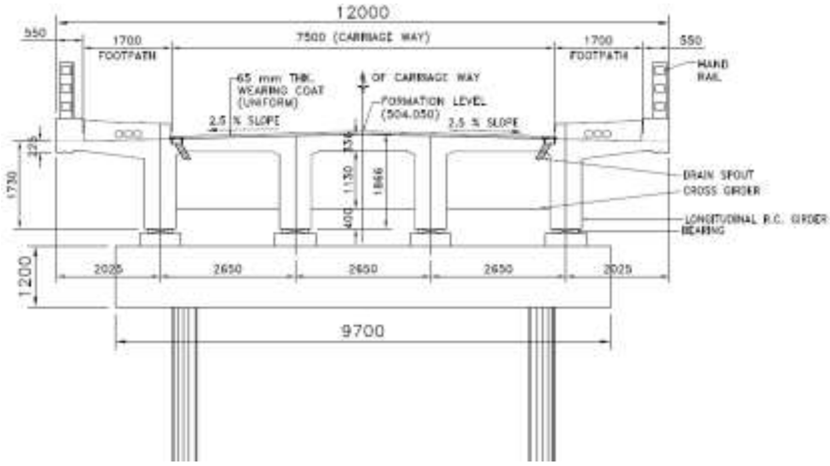

Fig 3:Details of bridge at hagarebommanahalli

A. METHOD OF ANALYSIS

In this study the performance of a Rc bridge subjected to severe earth tremor loads was evaluated using Non Linear analyses. Based on the findings from the analysis, a base isolation system was designed for the bridge. The parameters of base isolation system were chosen using the theory of multi degree of freedom dynamic systems. Then base isolation parameters were included into the initial mode and the performance of the isolated structure subjected to the same seismic loads was evaluated. The two sets of results were compared and the structural effectiveness of base isolation system for that particular bridge was discussed. In addition, economic and practical aspects of base isolation systems were discussed and the conclusion with regard to feasibility of the system was drawn based on both structural and economic arguments.

Recent investigations are turning out to be most vital in safe outline, which requires more data about the floats, relocations and inelastic disfigurements of a structure than conventional configuration systems. SAP2000 V14.2 is a standout amongst the most refined and easy to understand programming (Shatarat, 2009).

B. TIME HISTORY ANALYSIS

The earth tremor ground motions used in this study are the actual ground motions recorded at the base of the building during 2001 January 26, 08:46:42.9 I.S.T. Mag.: 7.0 mb, 7.6 Ms. Station: Ahmadabad, (**Bhuj Earth tremor**).

These motions include components in the x (North-South) and y (East-West) directions shown The acceleration time history in the z direction was not included in the analysis as the study by **John A Martin Associates [1999]** showed that the effects of vertical excitation were insignificant.

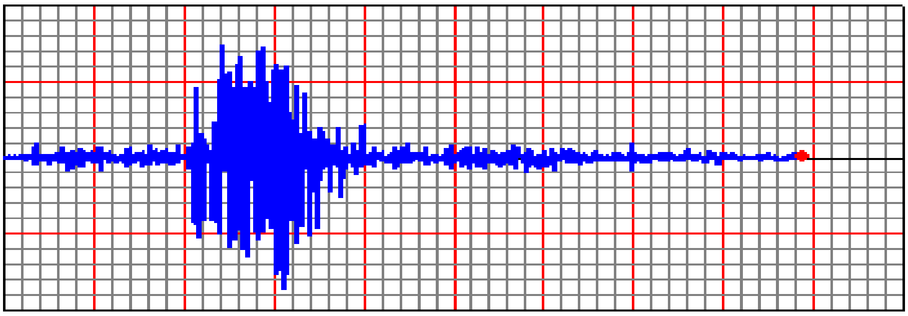

Fig 4:Time history of Bhuj. Earth tremor. (2001)

C. MODELLING
The bridge modelling is carried out by using SAP (2000) software.

Finite element model:
Total span = 149.29m (8 span bridge)
Bridge type = T beam bridge
Material = Concrete (M35)
Poisson's ratio = 0.2
Pier cross section = Rectangular (7.5mx1m)
Material properties =As per IS: 456

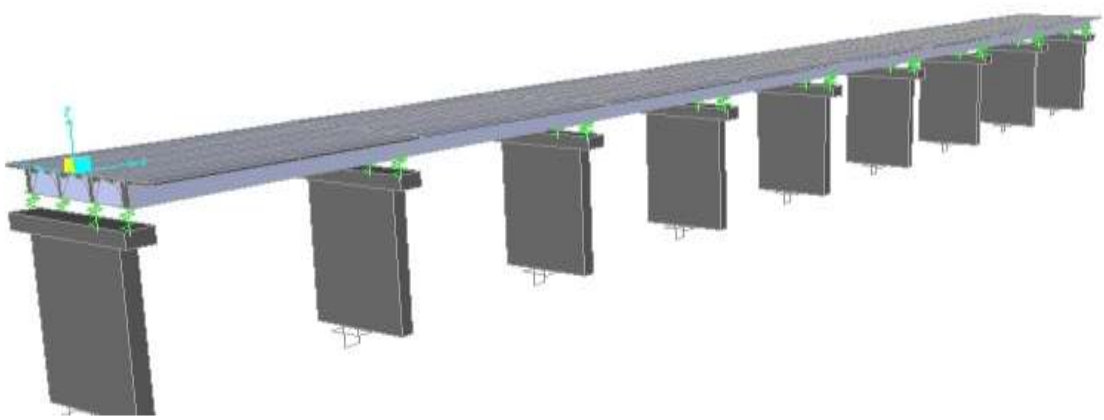

Fig 5: 3D view of bridge

D. Computation of Gravity load

a) **Dead load**
The dead load acting on the bridge is assigned as the self-weight with a self-weight multiplier of 1.

b) **Super dead load**
Load on deck slab

i. **Carriage way**
Thickness of wearing coat = 65 mm

Load on carriage way = (65*24)/1000=1.5kN

ii. **Footpath and curb**

Width of footpath = 12-7.5 =4.5m

Width of footpath each side = 4.5/2 = 2.25m
Height of the curb = 0.3 m
Load on footpath = 0.3*2.25*18=12.5kN

c) **Vehicle load (bridge live)**

The vehicle load on the bridge is assigned by choosing standard moving load case that is "**IRC CLASS A TR"** and the vehicle class 1.

d) **Earthquake Data (IS 1893 2002)**

Seismic zone = zone III
Zone factor = 0.16
Soil type = II
Importance factor = 1.5 (I)
RR factor = 3 (R)

E. Load assignment to the bridge model

Table 1: Load Pattern Definitions

Load Pat	Design Type	SelfWt Mult	Auto Load
DEAD	DEAD	1.0	
SDL	SUPER DEAD	0	
EQX	QUAKE	0	IS1893 2002
EQY	QUAKE	0	IS1893 2002
VEHI CLE	BRIDGE LIVE	0	

II. RESULTS AND DISCUSSION

This chapter presents the results and discussion of behaviour of RC Bridge under seismal load with different base conditions. The R.C. Bridge is analysed for bhuj earthquake by non-linear time history method.The study has been carried out for following different cases.

1) Fixed base RC Bridge
2) RC Bridge with LRB isolator
3) RC Bridge with HDRB isolator

The result has been discussed by considering following parameters

1) Modal Time period
2) Base shear
3) Joint displacement

1.Modal Time Period

Table 2: Modal Time Period Of Bridge

Mode	Non Isolated Bridge	Lead Rubber Bearing	High Damping Rubber Bearing
1	0.84	1.58	1.61
2	0.58	1.37	1.43
3	0.44	1.2	1.24
4	0.15	1.03	1.07
5	0.12	0.97	1
6	0.11	0.92	0.96
7	0.1	0.59	0.6
8	0.09	0.57	0.58
9	0.09	0.36	0.36
10	0.08	0.35	0.36
11	0.08	0.35	0.35
12	0.08	0.33	0.33

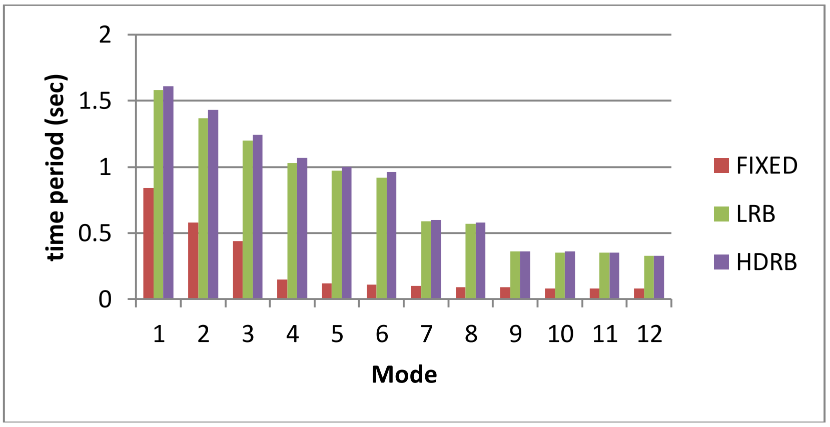

Fig 6 : Modal Time Periods of the bridge

The modal time period of both isolated and non isolated bridge is shown in Table 2 .It is clearly observed that the isolation technique shifts the time period as well as frequency of the structure significantly. However the mode characteristics under both of these situation remains unchanged. It is mainly the first mode that is mainly affected by the isolation technique, higher the mode, lesser is the alteration of modal time period

From the above Fig 6 the variation of the modal time period is shown. The modal time period of the structure being 0.84sec in non isolated condition is increased to 1.61sec after using isolator i.e the time period of the structure increases by 47% after providing isolators. Hence increase in time period increases the flexibility of structure. Under isolated condition the LRB isolator has a time period of 1.58sec which is increased to 1.61sec in HDRB isolator i.e the time period of the structure is increased to 2% for HDRB isolator. Hence under isolated technique the HDRB isolator holds good in increasing the time period and flexibility of structure.

2.Base Shear

After time history analysis we can compare the base shear of all the three models. Base shear both in X & Y direction can be obtained in plot function in SAP2000.

Table 3: Maximum Base Shear For Bridge Along X And Y Direction

BASE SHEAR (KN)	FIXED	LRB	HDRB
X	50000	13000	5000
Y	14000	4000	3000

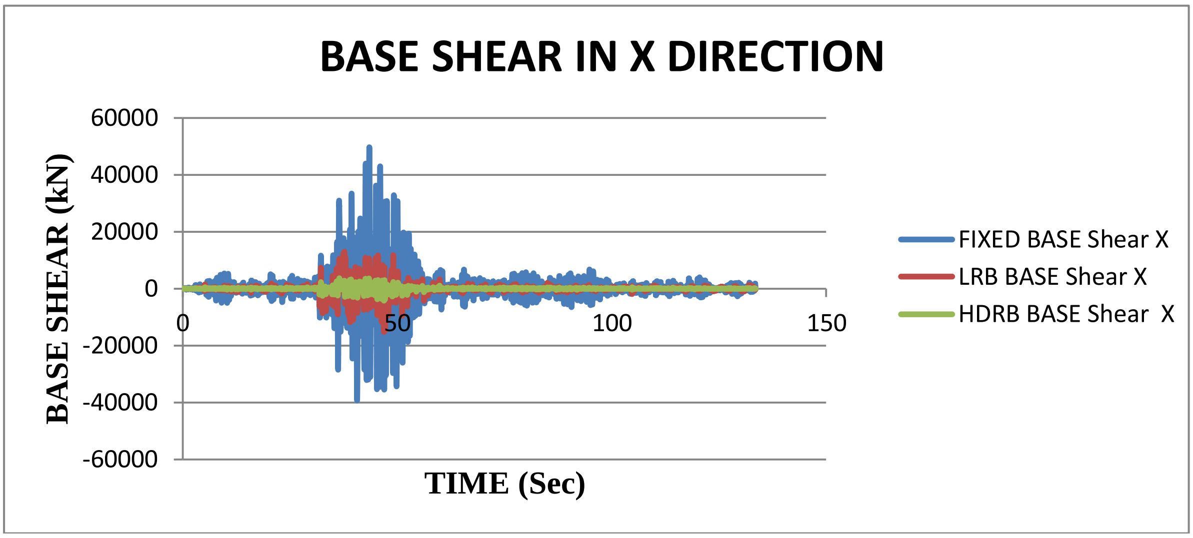

Fig 7 : Base shear in X direction of the bridge for Bhuj earthquake

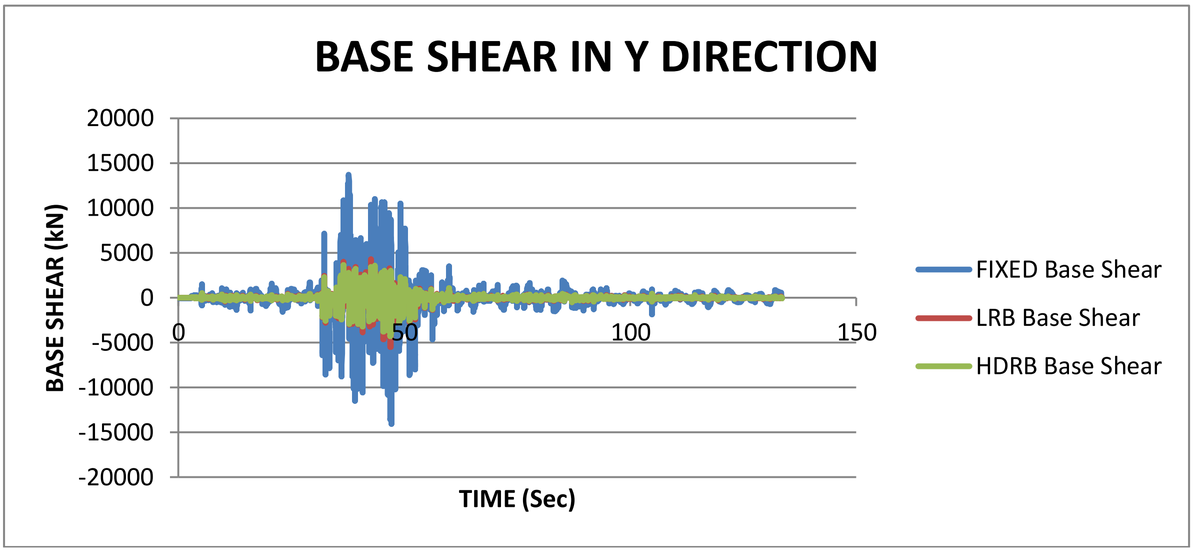

Fig 8 : Base Shear in Y direction of the bridge for Bhuj earthquake

The above Table 3 gives the maximum value of base shears for both isolated and non isolated conditions. The base shear for isolated and non isolated technique in X and Y direction has reduced to 90% and 79% respectively by using isolators. Under isolated condition the base shear for LRB isolator and HDRB has reduced to 62% in X direction and 25% in Y derection for HDRB isolator.

From the above Fig 7 and 8 we compare that the base shear value for fixed base bridge is comparatively more than LRB and HDRB base bridges hence it concludes that the isolated bridge reduces the base shear significantly. While in the isolated bridges the HDRB base bridge gives significantly less base shear. It concludes that HDRB isolator is more effective in reducing the base shear both in X & Y direction.

3 Joint Displacement

Time Joint displacement is one of the parameter considered under current analysis process. Joint displacement is obtained by running modal analysis of both non isolated and isolated bridges. The isolated period and the elastic base stiffness characterize a base isolated structure.

Table 4:Joint Displacement for deck slab

Node no	Displacement (mm)		
	Fixed	LRB	HDRB
1115	13.8624	49.2364	54.5683
1155	14.0246	49.8465	55.2643
1195	14.2689	50.0256	57.5168
1235	15.2978	49.8498	56.3154
1275	14.9685	50.2356	55.5651

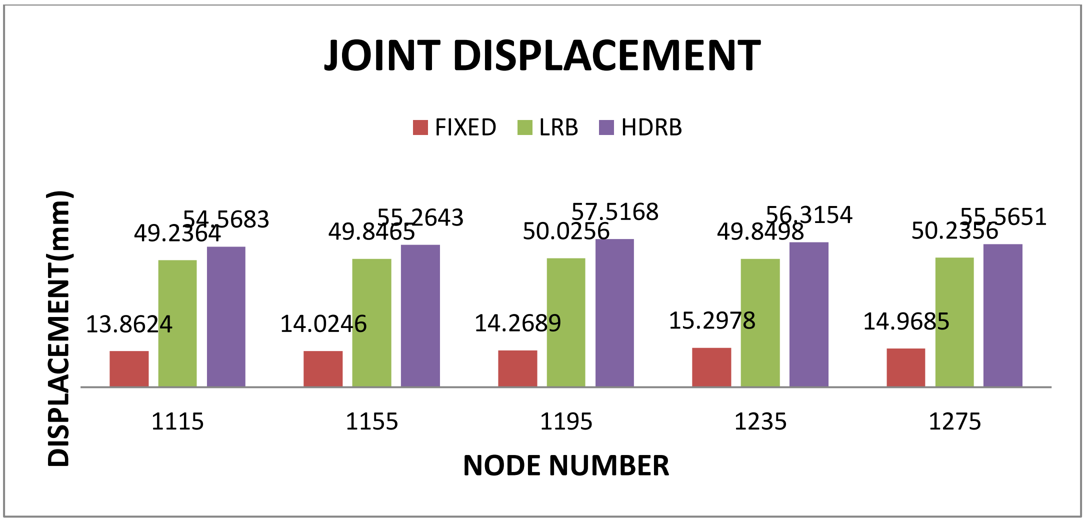

Fig 9: Maximum Displacement at centre of bridge span for Bhuj earthquake

The above Table 4 shows the joint displacement of deck slab for five different nodes at the centre of span. The displacement value of isolated and non isolated structure is 14mm and 57mm respectively i.e in isolated structure 75% of displacement has increased which concludes that using isolators the displacement of structure is increased. Under isolated condition the displacement value of LRB isolator is 50mm and HDRB isolator is 57mm which shows that there is an increase of 12% displacement by using HDRB isolator . The variation of joint displacement for isolated and non isolated technique is shown in Fig 9.

The displacement at the level of bearing in base isolated bridge in the direction of earthquake increases compared to non isolated bridge, hence the base isolation reduces the seismic energy transferred from foundation to deck slab of the bridge by allowing displacement in the direction of earthquake

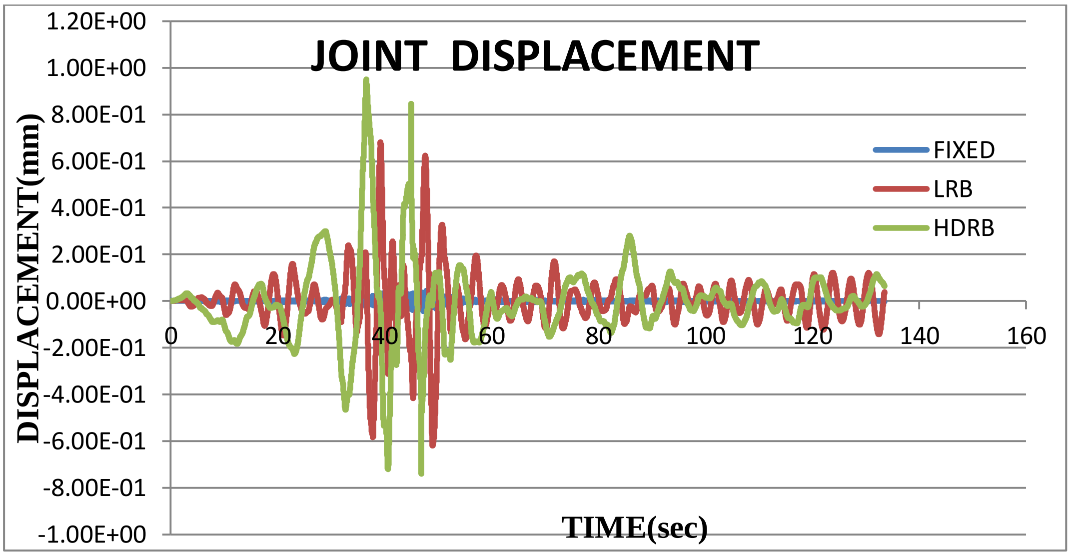

Fig 10: Maximum Displacement vs Time of the bridge for Bhuj earthquake

A Variation of displacement vs time is shown in Fig 10 which shows that under isolated and non isolated technique the isolated structure significantly increases the displacement than non isolated structure .under isolated condition the HDRB isolator shows increase in displacement than LRB isolator .Hence it concludes that for the present case study the HDRB isolator is well suited for improving the earthquake resistance of structure.

Summary

The isolated period and the elastic base stiffness characterize a base isolated structure. The period of these structures has increased from a fixed-base value of 0.84 seconds to 1.61 seconds for the fundamental mode. According to the results of Time History analyses of both bridges, such period shift reduces accelerations .

By comparing results in Fig 9 and 10,one can observe that the maximum displacement has increased in isolated bridges compared to fixed bridge. Thus, having conducted a series of analyses with a fixed-base and isolated structures, we can conclude that base isolation is an effective measure for substantially improving earthquake resistance of bridges.

Among the isolators used in the present work i.e., LRB and HDRB systems, High Damping Rubber Bearing (HDRB) gives the better results in the applied time history analysis (Bhuj earthquake data). The HDRB system reduces the base shear to the maximum extent than the LRB system and also HDRB system increases the joint displacement relatively more than LRB systems.

All these results concludes that, for the proposed RC Bridge HDRB isolator suits better to avoid the future earthquake losses if any occurred in the proposed location of the bridge.

III. CONCLUSION

Seismic analysis of the bridge is carried out by time history method in which non-linear modal analysis is used. Performance of the Non isolated bridge, LRB isolator bridge and HDRB isolators bridge is studied based on Time period, displacement and base shear .

The following conclusions are made from the numerical investigation carried out:

- The modal Time period of the structure is 0.84sec in non isolated bridge which increases to 1.61sec by using isolators, hence the use of base isolators increases the time period of the structure and makes the structure more flexible.

  Base isolation has displayed significant positive effect by increasing the bridge natural period and hence reducing inertia force on the bridge structure.
- The bearings have been designed to maximize the seismic performance of the bridge.
- The displacement at the level of bearing in base isolated bridge in the direction of earthquake increases compared to non isolated bridge,hence the base isolation reduces the seismic energy transferred from foundation to deck slab of the bridge by allowing displacement in the direction of earthquake.
- The HDRB is more effective in increasing the joint displacement than LRB and fixed bearing.
- The base shear in non isolated bridge is comparatively more than the isolated bridge ,hence the isolated bridge reduces the base shear significantly..

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