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Effect of Substructure on Seismic Performance of Bridges

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ABSTRACT

Bridges are the means of communication between two isolated lands. It connects the nations and remote parts with the urban one. Bridges plays a very important role in transportation network of any country, as in India, fifty percent area of country is susceptible to damaging earthquakes so the seismic performance of bridges is a challenging issue for transportation. As we know some of the bridges have not performed well during past earthquakes because of their construction practices and design philosophies. The performance of bridges under major earthquakes depends on their energy dissipation capacity. For earthquake resistant design damage should not take place in brittle mode and it should be in ductile mode. Behavior of bridge during earthquakes depends upon bridge type and substructure configuration. Single column bent system, multi column bent system and Linked Columns are most common type of substructure configurations.

In a present study, a two span 25.32m R.C.C. T beam bridge existing in major seismic zone near New Delhi is taken for study the performance of bridge substructure by keeping same superstructure. Non-linear pushover analyses have been used to evaluate the seismic behavior of different types of substructure configuration also the displacement of deck, drift of superstructure and finally efficacy of substructure to resist seismic forces.

Keywords: *Bridge Substructure Configuration, Non-Linear static(Pushover)Analysis, CSi Bridge 2016*

1. INTRODUCTION

Bridges are the critical components of a nation's transportation system, as closure of an important bridge in the event of an earthquake can disrupt the total transportation network. These types of life-line structures have to be designed so that they continue to serve during earthquakes Indian Highway have many bridges and most of them are not designed according to modern seismic design codes. And also older structures show insufficient capacity like low deformation capacity. So it is requisite to do seismic assessment of an existing bridges.

In the linear method of analysis, bridge action is within elastic range and results of the method like force and displacement are quite high. So it will make uneconomical bridge design. That's why nowadays non-linear analysis like pushover analysis method can be used to know the non-linear behavior of the structure as well as to draw the failure pattern for different components of the bridges. So the first step of the project is to carry out the Modal Analysis of all three substructure configuration and compare the time period and frequency .Participating mass ratio for higher modes and modes shapes.

The Non-linear static(Pushover)Analysis carried out on all three substructure configuration to find the Maximum base shear and Displacement of respective configuration. Seismic behavior of structure can be evaluate by Pushover analysis.

2. SCOPE AND OBJECTIVE OF STUDY

In this paper attempt is made to study and compare the effects of substructure on seismic performance of bridges having different types of substructure configuration. For this to use CSI (Computers And Structure, INC) Bridge to observed the non-linear behavior in terms of displacement of deck and drift of superstructure.

3. NONLINEAR STATIC (PUSHOVER) ANALYSIS

Pushover analysis is a simplified, static, nonlinear analysis under a predefined pattern of permanent vertical loads and gradually increasing lateral loads. Typically, the first pushover load case is used to apply gravity load and then subsequent lateral pushover load cases are specified to start from the final conditions of the gravity pushover. Typically, a gravity load pushover is force controlled and lateral pushovers are displacement controlled.

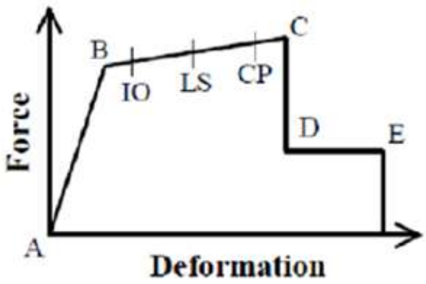

Figure. Non-linear static analysis curve

4. DESCRIPTION AND MODELLING OF THE BRIDGE

For the present study bridge of two lane two span having each span length 25.32m is taken with different types of substructure configuration by keeping same superstructure data. The following figure shows the cross section of the bridge superstructure.

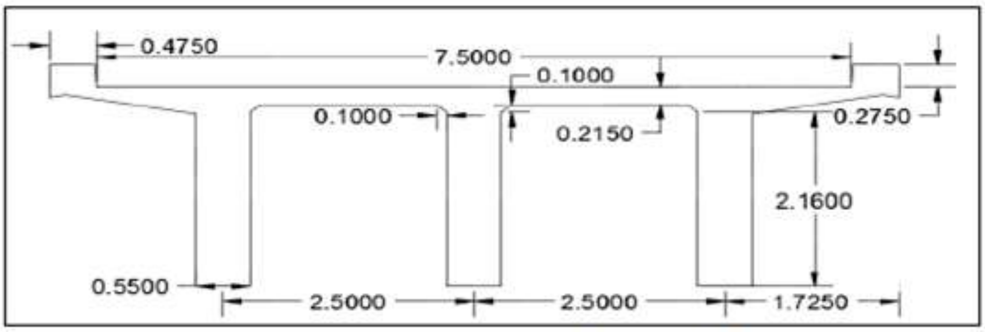

Figure Bridge cross section of span 25.32m

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Sr. No	Bridge Configuration	Data
1.	Overall Span of Bridge	25.32 m
2.	Effective Span of Bridge	24.75 m
3.	Number of Lanes	2
4.	Total Width	8.5 m
5.	Depth of Cross Girder	1.06 m
6.	Depth of Slab	0.215 m
7.	Width of Cross Girder	0.25 m
8.	Depth of Girder	2.16 m
9.	Width of Longitudinal Girder	0.55 m
10.	Materials Concrete M30 Grade and Steel Fe 415 Grade	

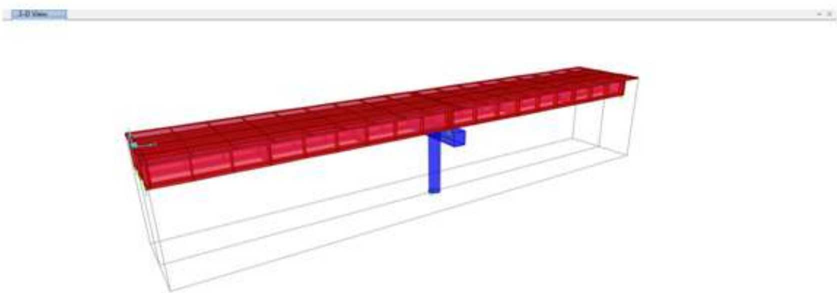

Figure. Single Column substructure configuration Model

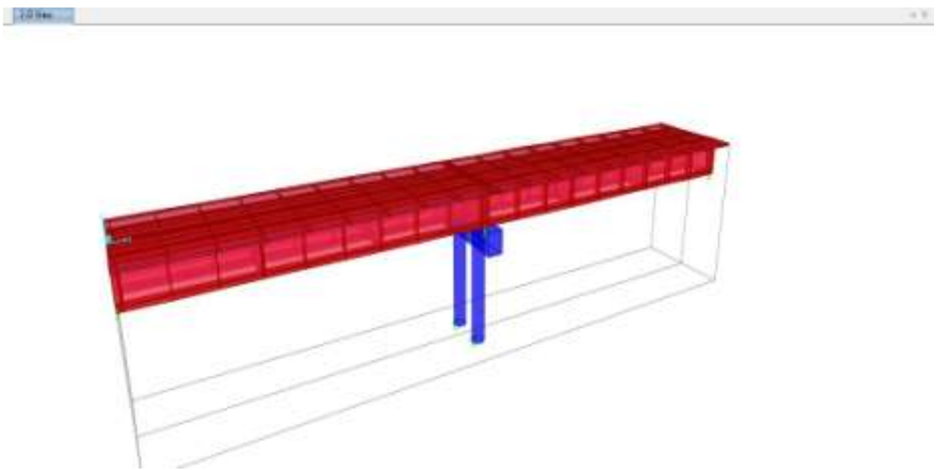

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Figure. Double Column substructure configuration model

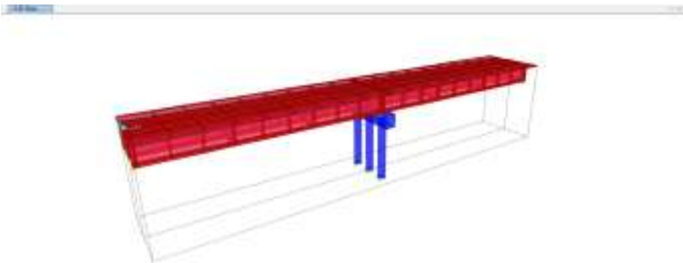

Figure. Triple Column substructure configuration model

5. RESULT AND DISCUSSION

The Following are results we get from Modal analysis of all three types of substructure configuration i.e. Single column, Double column, Triple column

Table 6. Model Analysis Results

	Single Column Substructure Configuration		**Double Column substructure Configuration**		**Triple Column substructure Configuration**	
Mode	Time (sec)	Frequency (cycle/sec)	Time (sec)	Frequency (cycle/sec)	Time (sec)	Frequency (cycle/sec)
Mode 1	0.230	4.343	0.224	4.451	0.225	4.443
Mode 2	0.169	5.889	0.169	5.890	0.169	5.888
Mode 3	0.140	7.095	0.140	7.096	0.140	7.095
Mode 4	0.129	7.698	0.104	9.613	0.101	9.824
Mode 5	0.109	9.166	0.097	10.307	0.092	10.774
Mode 6	0.079	12.601	0.068	14.636	0.068	14.627
Mode 7	0.068	14.626	0.067	14.892	0.060	16.411
Mode 8	0.060	16.431	0.060	16.421	0.060	16.628
Mode 9	0.051	19.259	0.049	20.298	0.049	20.295
Mode 10	0.049	20.299	0.046	21.304	0.044	22.554
Mode 11	0.044	22.534	0.042	23.650	0.040	24.442
Mode 12	0.039	25.169	0.039	25.097	0.040	24.973

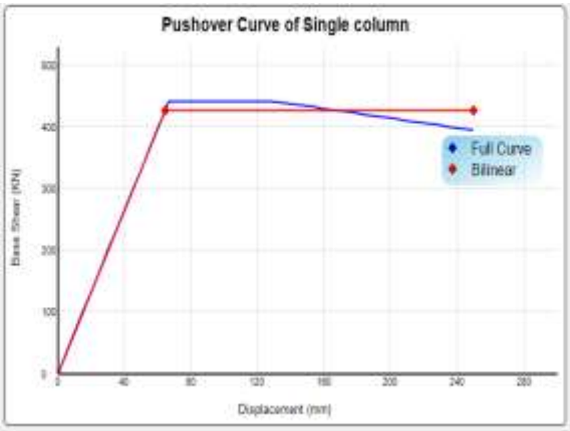

Figure Pushover Curve for Single column substructure configuration bridge

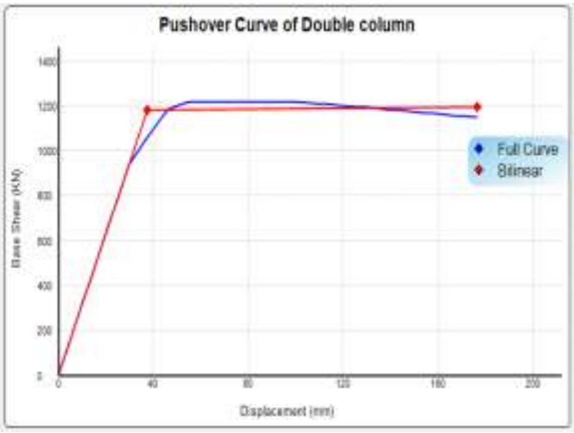

Figure Pushover Curve for Double column substructure configuration bridge

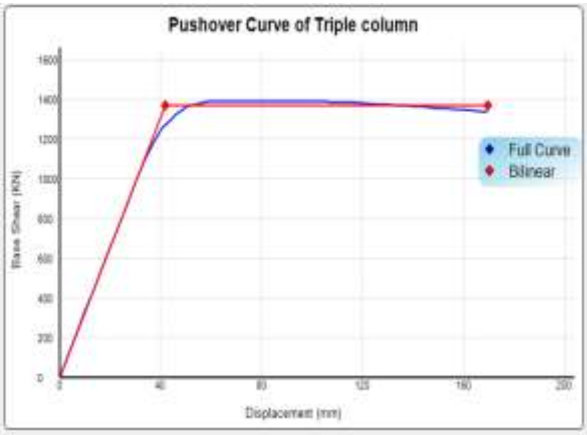

Fig.6.3 Pushover Curve for Triple column Substructure configuration bridge

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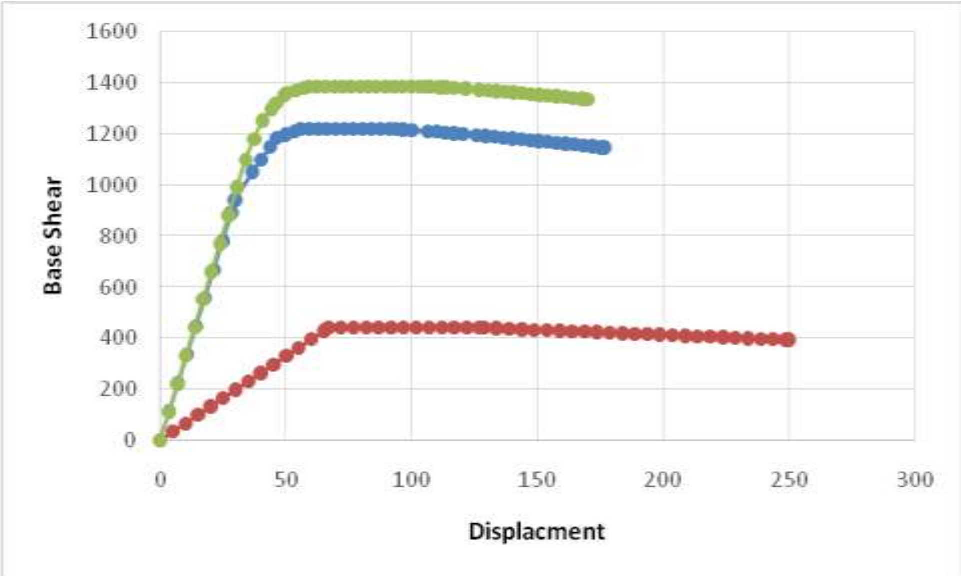

Figure. Comparisons of Base Shear result of all types configurations

6. CONCLUSION

From the above results it is observed that

1 .It is observed that the time period of Double column and Triple Column configuration is comparatively less than single column as these systems are steeper than single column configuration.

2. As the Seismic weight of the structure increase the base shear capacity of the structure increases i.e. Triple column configuration have more base shear capacity compare to the other to configuration.

3. Study also shows that in Non-linear range the performance of Triple column configuration bridge is better than Double column bridge followed by Single column configuration bridge.

4. The Single column configuration is more ductile than Double column configuration followed by Triple column configuration bridge.

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