STATIC AND DYNAMIC ANALYSIS OF RC BRIDGE

Simulation

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Abstract-While designing any structure, now days the seismic performance of structure is very much important. The basic aim of this dissertation is to analyze the RCC, bridge, statically and dynamically. The performance of bridge is studied with and without application of isolation system. This includes the study of rigid bridge, base isolated bridge, and bridge with bearings between girder and top of pier. The effect of seismic force on these bridge model is carefully studied by applying the seismic force. Depending on behavior of these models the actual seismic demand of bridge is determined and also the importance of isolation system is taken into consideration. The attempts are done to reduce the seismic effect thereby introducing the isolation. The isolations are of various type, here elastomeric bearing and led rubber isolator is used. Also, the comparison of isolated and un isolated bridge structure is carried out. The analysis is mainly consists of response spectrum analysis, time history analysis, eigen value analysis, moving load analysis, and non linear push over analysis etc.

Keyword- Rigid bridge structure , isolated bridge structure , elastomeric bearing and rubber pad.

Introduction- The three span continuous bridge is taken under study. The span of bridge is kept 28m with lane width of 8m. The girder is of rectangular shape having size of 0.53m wide and 0.3m deep along longitudinal direction. The diaphragm is provided only at the ends having size 0.23m wide and 0.4m deep. There are no any intermediate diaphragms. Two types of vehicles i.e. 70R and class A type are run for 8m width of width as per IRC-6-2000. The end pier is solid rectangular type of 0.4m wide and 0.3m depth ant that of mid pier cap is also solid rectangular type of size 0.8m wide by 0.3m deep. The piers are solid octagonal of 1m width. The footing is rigid one. There are two types of isolators are used namely elastomeric bearing and lead rubber bearing. The design of these isolator is based on vertical load coming from sub structure and super structure.

There are three types of model are studied, those are described as follows.

Model No. I In the Model I, the total structure is monolithic. No any isolation or isolator is provided. The model is fixed at the base and also at the foundation.

Model No. II In the model II, the elastomeric bearings are provided between pier and deck slab. The bridge model is fixed at the base (Foundation).

Model No. III In case of model III, the base isolation is provided at the foundation. Base isolation is Lead Rubber Type. The pier and deck slab are kept fixed.

The static and dynamic analysis of these three models is carried out. The results are compared and best performance bridge model are taken into consideration. In all the three models the physical properties like deck, pier, I-girder, span, width, loading, etc are remain same. The results of respective models are as follows. The figure **5.6** shows the three dimensional view of model

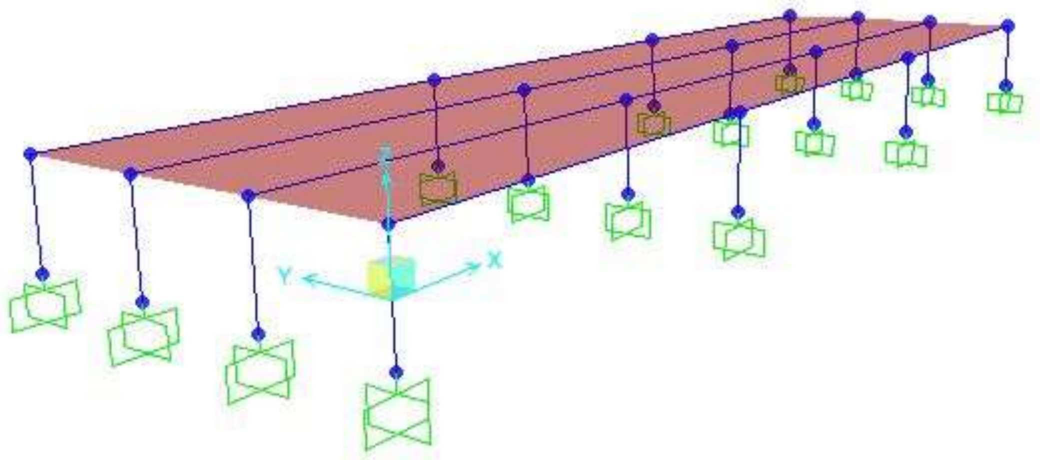


Fig. 8.1 Three-dimensional View of Bridge

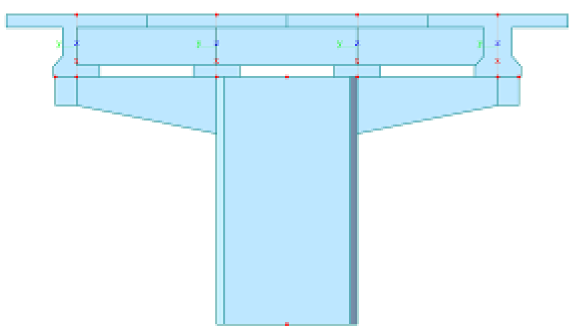


Fig. 8.2 Side View of Bridge Structure

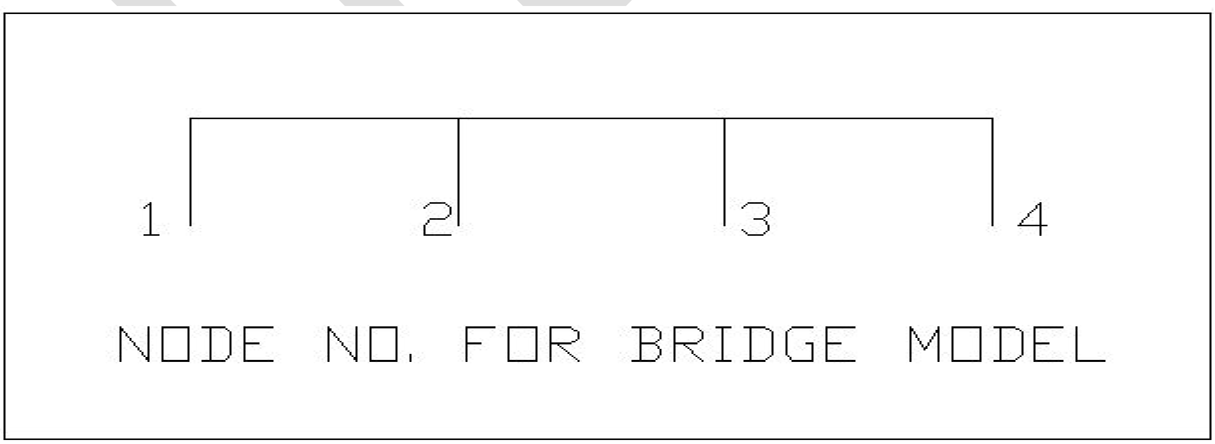


Fig. 8.3 Node No. for Bridge model

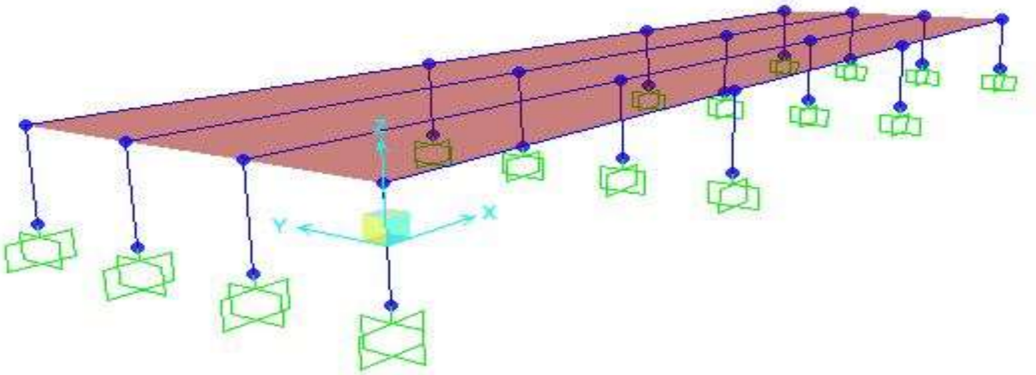
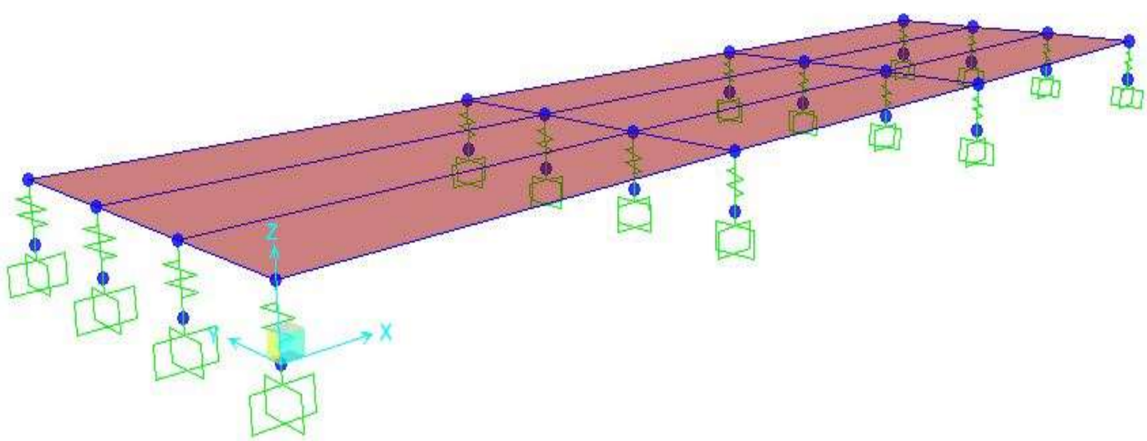


Fig. 8.4 Three-dimensional View of model – I



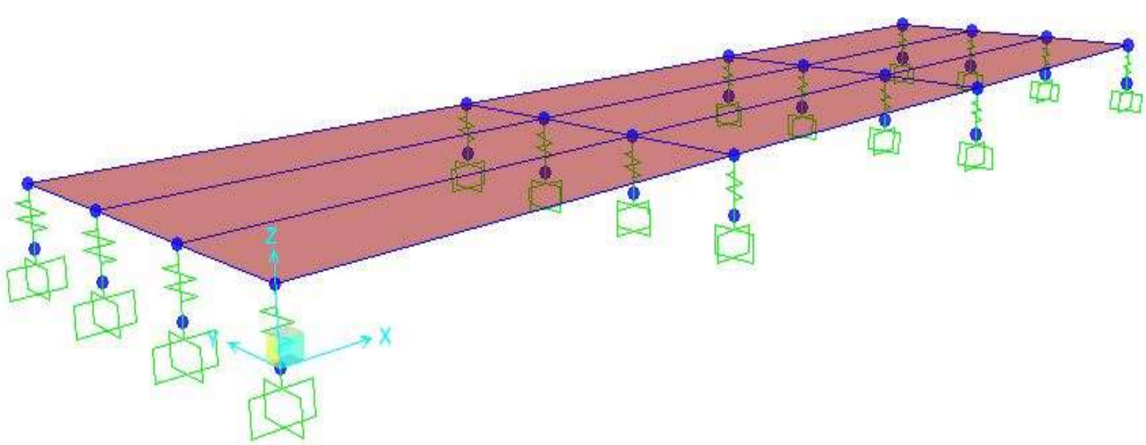


Fig. 8.5 Three-dimensional View of model – II

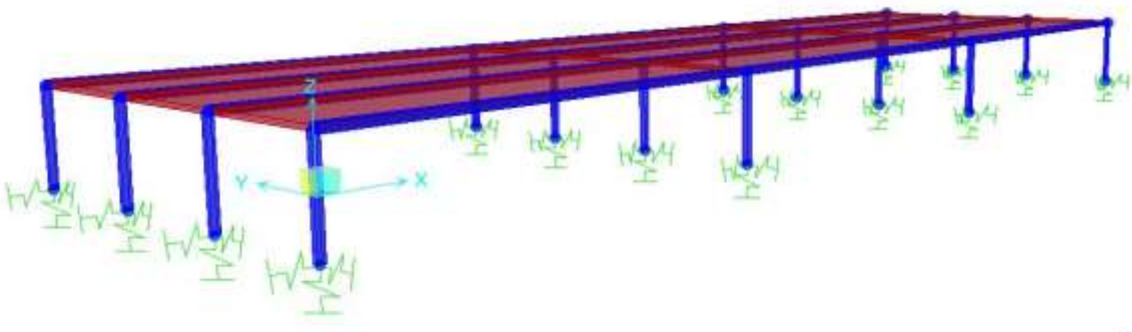


Fig. 8.5 Three-dimensional View of model – III**Results and Discussion**

1. Reactions:

Table 1.1 Support Reaction of Model No. I

Node	**FX (tonf)**	**FY (tonf)**	**FZ (tonf)**	**MX (tonf*m)**	**MY (tonf*m)**	**MZ (tonf*m)**
1	65.91	0.31	205.96	67.52	43.80	0.82
2	34.58	0.44	253.04	69.19	27.95	0.85
3	49.45	0.39	264.61	69.52	44.80	0.84
4	57.68	0.27	273.80	64.12	50.72	0.76

Table 1.2 Support Reaction of Model No. II

Node	**FX (tonf)**	**FY (tonf)**	**FZ (tonf)**	**MX (tonf*m)**	**MY (tonf*m)**	**MZ (tonf*m)**
1	65.91	0.31	205.96	58.48	34.19	0.66
2	34.58	0.44	253.04	61.12	16.20	0.68
3	49.45	0.39	264.61	61.19	27.23	0.70
4	57.68	0.27	273.80	53.11	31.81	0.59

Table 1.3 Support Reaction of Model No. III

Node	**FX (tonf)**	**FY (tonf)**	**FZ (tonf)**	**MX (tonf*m)**	**MY (tonf*m)**	**MZ (tonf*m)**
1	65.91	0.31	205.96	60.61	38.32	0.68
2	34.58	0.44	253.04	65.38	19.18	0.70
3	49.45	0.39	264.61	65.45	30.38	0.72
4	57.68	0.27	273.80	58.30	35.21	0.62

2. Beam stresses

Table 2.1 Beam Member Stresses of Model No. I

Elem	**Axial (tonf/m^2)**	**Shear-y (tonf/m^2)**	**Bending(+y) (tonf/m^2)**	**Bending(-y) (tonf/m^2)**
1	1.21E-08	1.74E-06	2.05E-05	1.51E-05
2	1.01E-06	1.80E-06	2.71E-06	2.93E-05
3	1.38E-07	1.72E-06	2.08E-05	2.79E-05
4	1.43E-07	1.82E-06	2.67E-05	2.78E-05

Table 2.2 Beam Member Stresses of Model No. II

Elem	**Axial (tonf/m^2)**	**Shear-y (tonf/m^2)**	**Bending(+y) (tonf/m^2)**	**Bending(-y) (tonf/m^2)**
1	1.18E-08	1.33E-06	2.01E-05	1.48E-05
2	0.87E-06	1.55E-06	2.53E-05	2.68E-05
3	1.13E-07	1.56E-06	1.97E-05	2.57E-05
4	1.24E-07	1.69E-06	2.35E-05	2.50E-05

Table 2.3 Beam Member Stresses of Model No. III

Elem	Axial (tonf/m^2)	Shear-y (tonf/m^2)	Bending(+y) (tonf/m^2)	Bending(-y) (tonf/m^2)
1	1.20E-08	1.65E-06	2.03E-05	1.50E-05
2	0.93E-06	1.68E-06	2.61E-05	2.87E-05
3	1.23E-07	1.66E-06	2.05E-05	2.61E-05
4	1.35E-06	1.78E-06	2.49E-05	2.63E-05

3. Time period & frequencies

Table 3.1 Modal period & frequencies of Model No.I

Mode No.	Frequency		Period
	(rad/sec)	(cycle/sec)	(sec)
1	21.844511	3.476662	0.287632
2	22.711735	3.614685	0.276649
3	25.86059	4.115841	0.242964
4	27.144447	4.320173	0.231472
5	27.636088	4.39842	0.227354
6	31.064328	4.944041	0.202264

Table 3.2 Modal period & frequencies of Model No.II

Mode No.	Frequency		Period
	(rad/sec)	(cycle/sec)	(sec)
1	12.191533	1.940343	0.515373
2	12.845544	2.044432	0.489133
3	15.24686	2.426613	0412097
4	15.503384	2.46744	0.405278
5	19.194798	3.054947	0.327338
6	21.55689	3.430886	0.29147

Table 3.3 Modal period & frequencies of Model No.III

Mode No.	Frequency		Period
	(rad/sec)	(cycle/sec)	(sec)
1	2.532597	0.24392	4.099697
2	3.9439466	0.627698	1.593122
3	12.120785	1.929083	0518381
4	16.675773	2.654032	0.376785
5	21.276782	3.386305	0.295307
6	21.734488	3.459151	0.289088

4. Nodal Inertia Force

Table 4.1 Inertia Force of Model No.I

Mode No.	Node No.	FX (tonf)	FY (tonf)	FZ (tonf)
1	1	0	0	-0.0094
1	2	0	0	-0.0096
1	3	0	0	-0.0096
1	4	0	0	-0.0094

Table 4.2 Inertia Force of Model No.II

Mode No.	Node No.	FX (tonf)	FY (tonf)	FZ (tonf)
1	1	-0.0013	0.0015	0.0334
1	2	0.0017	0.0015	0.0308
1	3	-0.0003	0.0036	0.1341
1	4	-0.0004	0.0037	0.1324

Table 4.3 Inertia Force of Model No.III

Mode No.	Node No.	FX (tonf)	FY (tonf)	FZ (tonf)
1	1	0	0.1935	0.1327
1	2	0	0.1966	0.045
1	3	0	0.1935	-0.1327
1	4	0	0.1967	-0.045

5. Push Over Analysis:

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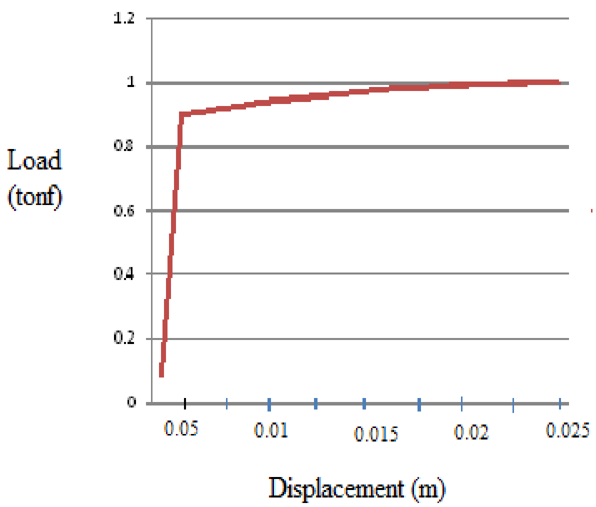
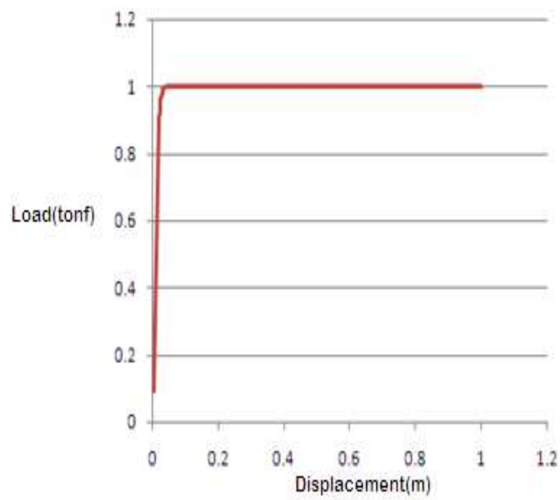
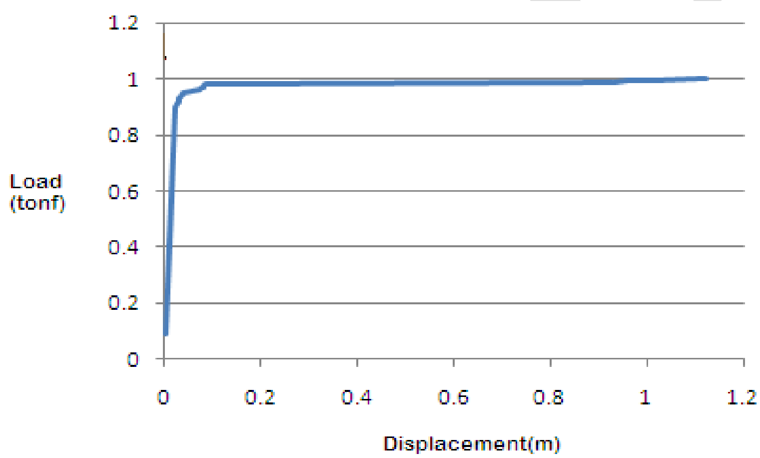




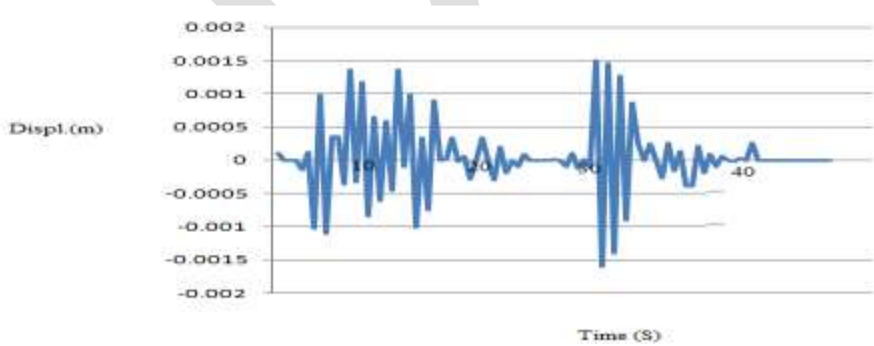
Graph.1 Load vs Displacement of Model I

Graph.2 Load vs Displacement of Model II

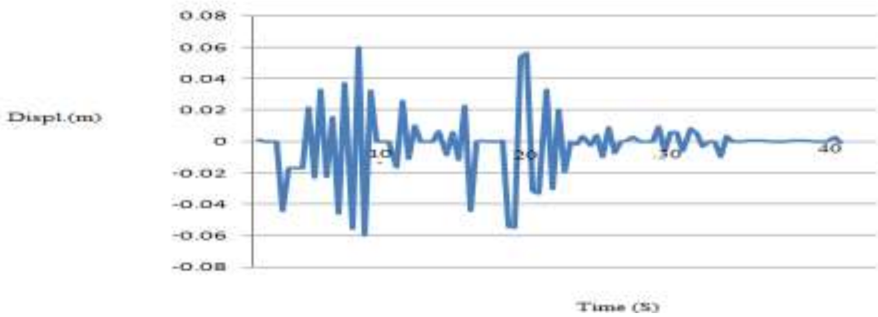


Graph.3 Load vs Displacement of Model III

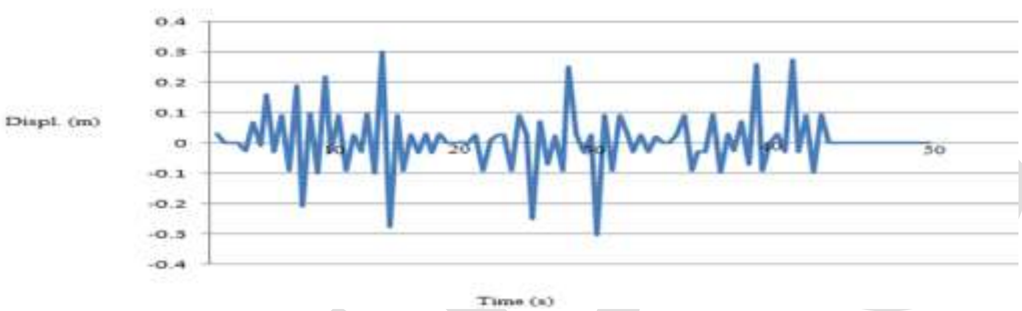
6. Time History Analysis



Graph 4. Time History Analysis of Model No. I



Graph 5. Time History Analysis of Model No. II



Graph 6. Time History Analysis of Model No. III

CONCLUSION

As stated earlier there are three types of model having same physical properties are taken into consideration those models are rigid type (Model No.I), isolated bridge i.e. bearing between girder and pier(Model II), base isolated bridge i.e. isolation at the foundation (Model III) are analyze and their seismic performance are studied. The results are compared and best model are find out for best performance during earthquake. The following conclusions are drawn.

1. Study of virtual model developed in the software gives results such as modal period (table- 3.1, 3.2, 3.3) , frequencies(table- 3.1, 3.2, 3.3) , moments(table- 1.1, 1.2, 1.3); beam stresses (table- 2.1, 2.2, 2.3) were minimum in model II as compared with model I and III.

2. The period of model I is very less. This is because of more rigidity. Though this period is not worst but this amount of period is not enough in moderate or heavy earthquakes in region IV or V. These periods are increased by application of elastomeric bearing. The max period for model 3 is very high which is suitable only during high magnitude of earthquakes. Also the installation of base isolation is very costly hence it is rarely used. Hence model II is best suited. (table- 3.1, 3.2, 3.3)

3. During an Earthquake the inertia force is generated and it is transmitted to the foundation of bridge which leads to its collapse. Thus direct transmition of inertia force to the foundation must be avoided and this can be achieved by the application of isolation system. the result shows that in case of model-I the inertia forces are only in z- direction which is directly transmitted to foundation but in case of model-II this inertia force is contributed by various bridge units in x,y,z direction which not even possible in model-III . Hence model II is feasible. (table- 4.1, 4.2, 4.3)

4. By providing isolation system in the form of elastomeric bearing at the top of pier below the deck of bridge, time period will increase, frequency will decrease, moments will get minimum and the inertia force also will get transferred in three directions. The beam member stresses will also reduces. (table- 3.1, 3.2, 3.3) (table- 3.1, 3.2, 3.3) (table- 1.1, 1.2, 1.3)

5. The period of model III is very high which is best only during high magnitude of earthquake, but the installation of base isolation is very costly. Hence seldom used. In case of model II the time period as compare to that of model III is less, but it is enough for region IV or V and it is not as costly as in case of model III. In case of model II max displacement is about 60 mm which is well enough for bridge structure for its best performance during earthquake. But in case of model-III, the displacement is about 300 mm which is very high and as stated earlier the base isolation system is best only for high intensity of earthquake. (graph 4, 5, 6)

6. In case of unisolated bridge structure,

- Time period is less, frequency is high.
- Beam stresses are high.
- Inertia forces are transmitted only in z-direction.
- Displacement is less but flexibility is also very less which is not required for bridge structure.
- Moments are high.

In case of isolated bridge structure

- Time period is more, frequency is less.
- Beam stresses are low.
- Inertia forces are transmitted in all 3 directions.
- Displacements are more than that in case of unisolated structure but are well within the limits and also the structure is flexible.
- Moments are low.

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