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Comparison of Different Parameters of Base Isolated and Inter-Storey Isolated Irregular Buildings

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Abstract:

In civil engineering when there is a talk of strength of the structure, the major problem which affects the strength of the structure is earthquake. Many researches and experiments have been done in the field of earthquake or seismic resistant design of the structure. Base isolation technique is one in the row in designing earthquake resistant structures. Isolation at the base of the building or isolation at any storey or mid storey can be done while design the structure. This technique found to be very helpful in this field. In this paper, base isolation as well as inter-storey isolation technique has been used in irregular building for designing the seismic resistant building. Mass irregularity has been taken into consideration. G+10, G+20 and G+30 irregular structures have been used and all analysis is done on ETABS software. Different parameters like story drifts and stiffness are taken for comparisons.

Keywords — **Base isolation, Irregularities, Inter-storey isolation, seismic resistant design, earthquake.**

I. INTRODUCTION

Base isolation and Inter-storey isolation (IIS) is a technique developed to prevent or minimize damage to buildings during an earthquake. It is a method in which the superstructure is separated from the foundation or substructure by introducing a suspension system between the base and the main structure. IIS is obtained by shifting the position of the isolation system from the base of the building to a level closer to the midpoint along the elevation. This system can vastly decreases seismic intensity and losses from earthquake. It is a passive energy dissipation technique for earthquake resistance design of structures as it absorbs and deflects the energy released from the earthquake before it is transferred to the super structure. Base isolation technique decreases base reactions, displacements and member forces in structure. The fundamental principle behind the base isolated system is that the super structure is decoupled from the ground motion. It has been done by introducing a flexible interface between the structure and its foundation. This result in drastically reducing the transmission of ground motion into upper storey and prevent the super structure from the earthquake.

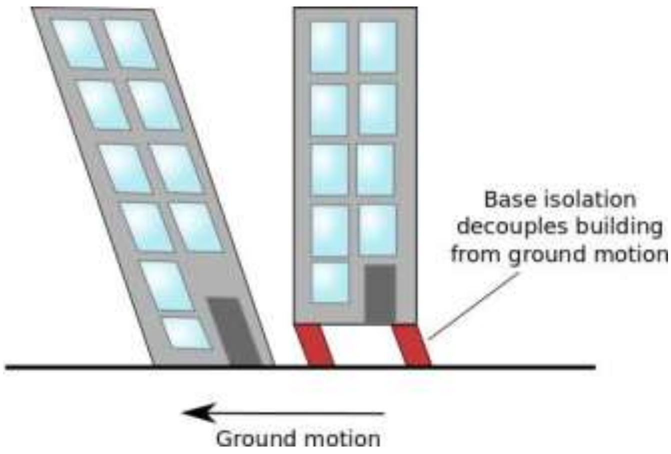

Fig. 1: Building with and without base isolation

II. ADVANTAGES OF ISOLATION SYSTEM

Base isolation and inter-storey isolation system drastically improves the function of building during any seismic activity. This system allows the maximum amount of safety in comparison to any other system of earthquake resist design of structure. There are lot of advantages of base and inter-storey isolation system. Some of the main advantages of isolation system in building are listed below:

- The base isolation system is helpful in strategically improving the performance during earthquake of important structures that needs to remain functional right after the earthquake for emergency response operation such as hospitals, schools, power plants, bridges, police stations etc.
- This system helps in reducing deformation in structural and non structural component during and after earthquake.
- Isolation of base of the structure prevents plastic deformation of structural elements.
- It gives protection of life safety of occupants, Improvement for safety of building.
- Reduced floor acceleration and inter-storey drift.
- It provides less damage to structural members, better protection of secondary systems.
- This system helps in the prediction of response is more reliable and economical.
- Base isolation system not only is used for residential or commercial buildings but also for bridges, tanks, storage containers, hospitals etc.
- Peak acceleration transmitted to the superstructure is reduced effectively by using base isolation system. Thus, stresses and deflection generated in the base isolated structure is significantly low as compared to fixed base structures.
- Existing structures can also be retrofitted with base isolation to enhance the strength of the structure further. During construction (retrofitting), building remains serviceable.
- This system can also protect the structure from GSA blast load apart from earthquake, as the ability to movement reduces the overall impact on the structure from blast load.

III. TYPES IF BASE ISOLATION SYSTEM:

Base isolation system is classified as following:

1. Elastomeric bearing system; and
2. Sliding system.

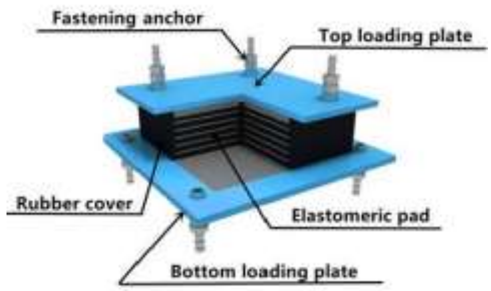

Fig.2: Elatomeric Bearing system

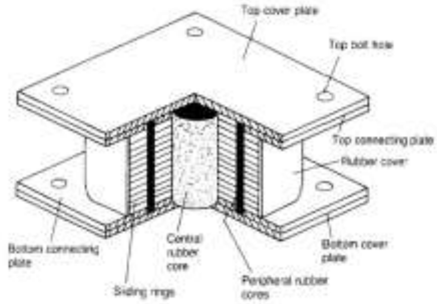

Fig3: schematic Diagram of sliding system

Resilient friction system and Friction pendulum system are the types of sliding system whereas Natural rubber bearings, Low damping rubber bearings, Lead plug bearings, High damping rubber bearings.

In this paper lead rubber bearings are taken for the design purpose. Lead rubber bearing is an important types of elastomeric bearings. Lead rubber bearing is most widely used bearings in the world. Lead cores are provided to increase damping capacity as plain elastomeric bearings does not provide significant damping. Lead rubber bearing is formed of a lead plug force- fitted into a preformed hole in an elastomeric bearing. The lead core provides rigidity under service loads and energy dissipation under high service loads. When subjected to low lateral loads (such as minor earthquakes) the lead rubber bearing is stiff both laterally and vertically.

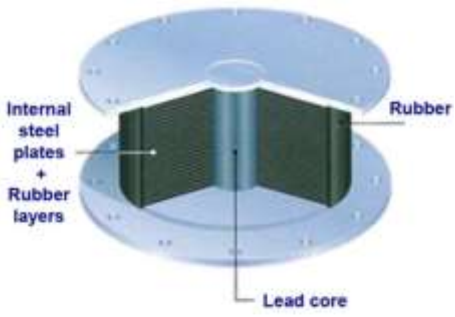

Fig.4: Schematic Diagram of Lead Rubber Bearing

IV. OBJECTIVE

I.1. To study different types of base isolation technique and to model 3 buildings in ETABS as G+10, G+20, G+30.

I.2. Every model has contains 3 type of structure: fixed base irregular model, isolated base irregular model and base+ inter-storey isolated model.

I.3. Each and every model will be analysed by static method and response spectrum method.

I.4. To study and compare different parameters like story stiffness, story drift, time period etc.

V. MODELLING

a) To model buildings with different height and specification in ETABS, first choose the Indian standard codes as IS 800: 2007 for steel specifications, IS 456:2000 for concrete.
b) After that, specify grid and put the value of number of story (10, 20 and 30), typical story height (3.3 m) and bottom story height (1.5 m).
c) In the present case, number of grid lines in X and Y- directions are 7 and spacing between grids are 5.
d) After that, provide material properties, frame properties, slab properties, property of wall and its thickness from IS 456: 2000.
e) Fixed the base of structure i.e., restraints the translation and rotation in x, y and z- directions.
f) For base and inter-storey isolated buildings, instead fixing the base, provide linear link and choose lead rubber bearing.
g) Define load cases as dead load, live load, floor finishes and earthquake loads in x, y and z- directions as per IS 1893: 2016 and different load combinations.
h) Analyse different models and display the results.

VI. LOAD COMBINATIONS

- 1.2[DL+LL+(EQx+0.3EQy)]
- 1.2[DL+LL-(EQx-0.3EQy)]
- 1.2[DL+LL+(EQy+0.3EQx)]
- 1.2[DL+LL-(EQy-0.3EQx)]
- 1.5[DL+(EQx+0.3EQy)]
- 1.5[DL-(EQx-0.3EQy)]
- 1.5[DL+(EQy+0.3EQx)]
- 1.5[DL-(EQy-0.3EQx)]
- 0.9DL+1.5(EQx+0.3EQy+0.3EQz)
- 0.9DL-1.5(EQx-0.3EQy-0.3EQz)
- 0.9DL+1.5(EQy+0.3EQx+0.3EQz)
- 0.9DL+1.5(EQy-0.3EQx-0.3EQz)
- 1.5[DL+(EQx+0.3EQy+0.3EQz)]
- 1.5[DL-(EQx-0.3EQy-0.3EQz)]
- 1.5[DL+(EQy+0.3EQx+0.3EQz)]
- 1.5[DL-(Eqy-0.3EQx-0.3EQz)]

This load combinations are according to IS 1893: 2016.

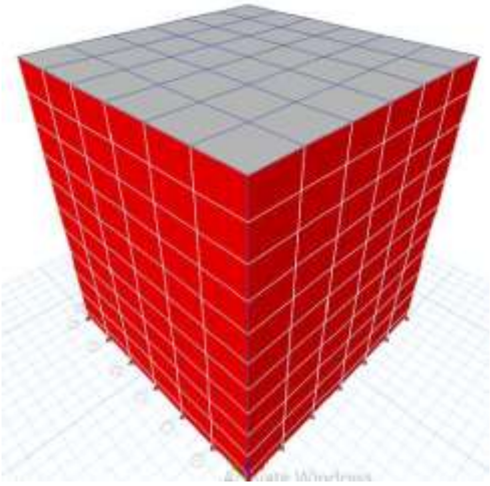

Fig.5: G+10 building model

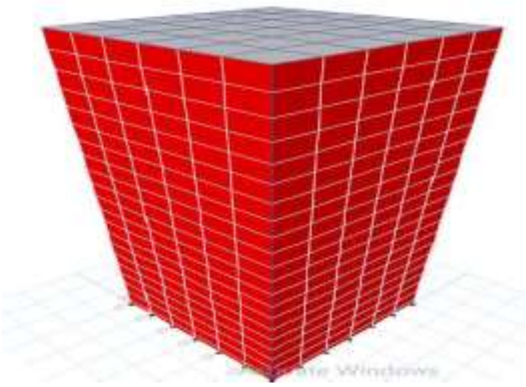

Fig.6: G+20 building model

Fig.7: G+30 building model

Fig.8: G+10 base isolated structure

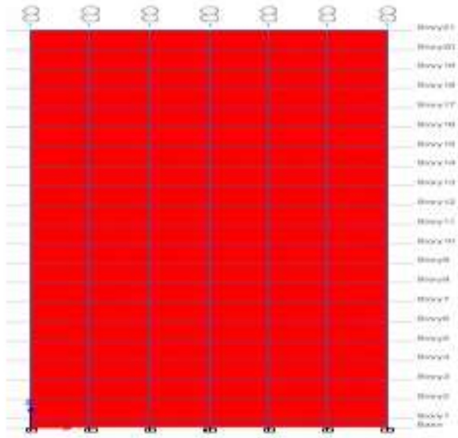

Fig.9: G+20 base isolated structure

Fig.10: G+30 base + inter-storey isolated model

VII. ANALYSIS

In order to understand the behaviour of fixed base, base isolated and base+inter-storey isolated structure, static and response spectrum analysis has been performed in ETABS.

A linear static load case is automatically created for each load pattern that is defined. The results of different load cases can be combined with each other and with other linear load cases, such as response spectrum analyses. Static analysis can be done by running only dead, live and earthquake loads. Modal case is not required to run for static analysis.

Response spectrum analysis is the statistical type of analysis for the determination of likely response of the structure to seismic loading. For response spectrum analyses, earthquake ground acceleration in each direction is given as a digitized response spectrum curve of pseudo spectral acceleration response versus period of the structure. This approach seeks to determine the likely maximum response rather than the full time history.

Mass irregularity has been taken in account for the designing purposes. Every building is made irregular by increasing the weight of floors with respect to upper and lower floors. A building is said to be irregular in mass if a floors weights 150% more than weight of floor below.

VIII. RESULTS

Different buildings model has been analysed in ETABS software and many results has been concluded. Comparison of different parameters like story forces, base shears etc are done and graphs of these parameters are plotted along with tables.

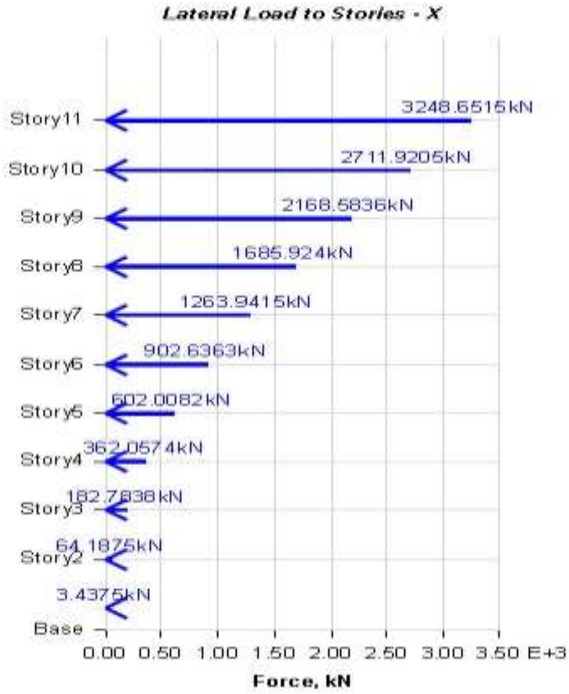

Fig. 11: lateral loads to storey of G+10 irregular building

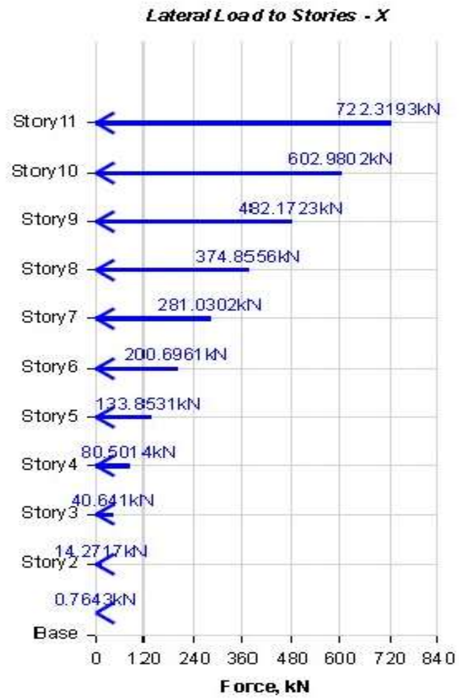

Fig. 12: Lateral loads to storey of G+10 base+inter-storey irregular building.

Fig. 14: Lateral loads to storey of G+20 base+inter-storey irregular building.

Fig. 13: Lateral loads to storey of G+20 irregular building.

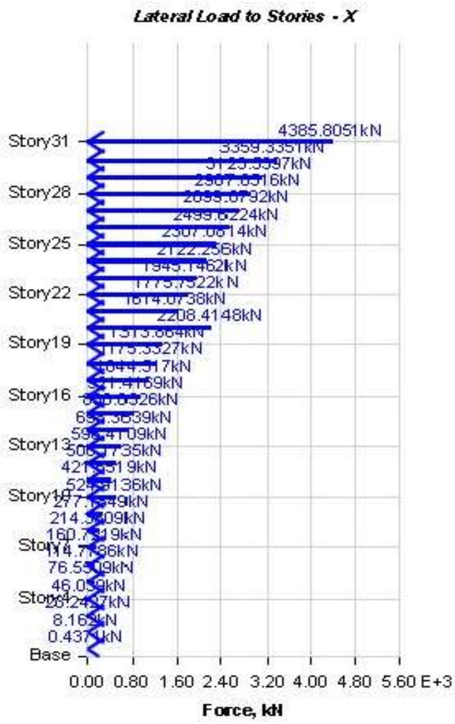

Fig. 15: Lateral loads to storey of G+30 irregular building.

Fig. 16: Lateral loads to storey of G+30 base+inter-storey irregular building.

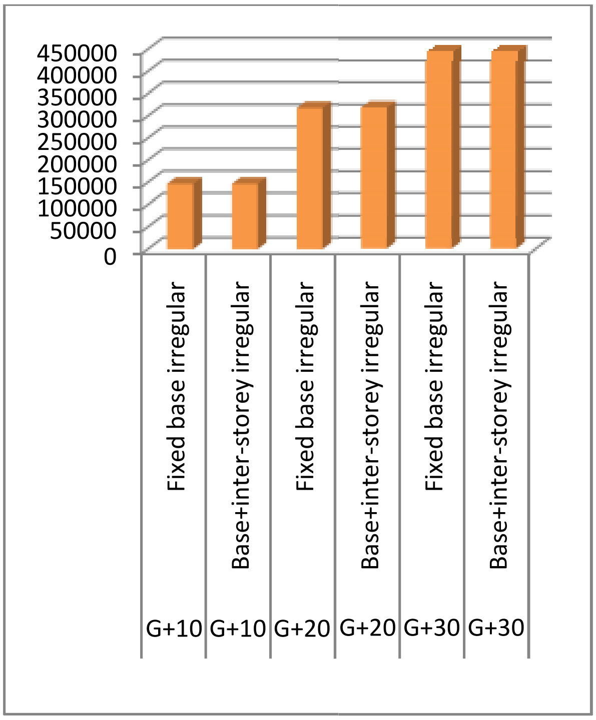

Fig.17: Graphs Showing Weights of Different Buildings

TABLE 1: WEIGHT OF DIFFERENT BUILDINGS

Structure	Types	Weight (kN)
G+10	Fixed base irregular	146623.6868
G+10	Base+inter-storey irregular	146623.6868
G+20	Fixed base irregular	318123.04
G+20	Base+inter-storey irregular	318123.04
G+30	Fixed base irregular	443121.4714
G+30	Base+inter-storey irregular	443121.4714

TABLE 2: TIME PERIOD OF G+10 BUILDING.

Mode	Fixed Base Irregular Model Period	Base+ Inter-storey Isolation Period
	sec	Sec
1	0.015	2.447
2	0.014	2.447
3	0.014	2.252
4	0.011	0.074
5	0.011	0.074
6	0.011	0.039
7	0.009	0.033
8	0.009	0.026
9	0.008	0.026
10	0.008	0.018

TABLE 3: TIME PERIOD OF G+20 BUILDING.

Mode	Fixed Base Irregular Model	Base+Inter-Storey Irregular Model
	Sec	Sec
1	0.433	3.69
2	0.433	3.69
3	0.241	3.385
4	0.117	0.266
5	0.117	0.266
6	0.081	0.12
7	0.058	0.082
8	0.058	0.082
9	0.048	0.061
10	0.047	0.052

TABLE 4: TIME PERIOD OF G+30 BUILDING.

Mode	Fixed Base Irregular Building	Base+Inter-Storey Isolated Irregular Building
	sec	Sec
1	0.078	4.349
2	0.078	4.349
3	0.035	3.971
4	0.031	0.362
5	0.02	0.362
6	0.02	0.039
7	0.018	0.036
8	0.018	0.026
9	0.018	0.026
10	0.016	0.018

IX. CONCLUSIONS

Overall conclusion of the entire work of this paper has been summarized below:

- Lateral loads decreases on the application of base isolation system with inter storey isolation system.
- Lateral loads of top floor of G+10 buildings decreases 25% on the application of base+inter-storey isolation system.
- Lateral loads of top floor of G+20 buildings decreases 14% on the application of base+inter-storey isolation system.
- Lateral loads of top floor of G+30 buildings decreases 13% on the application of base+inter-storey isolation system.
- Total weight of the building increases as increase in the number of floors.
- Total time period of the structure increases on application of base isolation system.

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