BASE ISOLATION OF MASS IRREGULAR RC MULTI-STOREY BUILDING

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Abstract - ***The Dynamic reaction of a building to earthquake ground motion is the most critical reason for earthquake actuated damage to structures. The basic concept in seismic isolation is to protect the structure from the damaging effects of an earthquake by introducing a flexible support isolating the building from the shaking ground. Seismic isolation consists of essentially the installation of mechanisms such as isolators which decouple the structure from base. In the present study, the seismic response of multi-storey mass irregular buildings with and without Base isolation system is studied. Mass irregularity is considered to check the effectiveness of base isolation system in irregular buildings. A Time history analysis is carried out for the 10 storey buildings for El Centro earthquake , Using SAP2000 Software.***

Key Words: *Base isolation, Mass irregularity , Time history analysis, El Centro earthquake.*

1. INTRODUCTION

1.1 General

A large proportion of the world's population lives in the regions of seismic hazards. They are at risk from earthquakes of varying severity and frequency of occurrence. Earthquake causes significant loss of life and damage of property every year. The seismic waves first strike the building at foundation level. As the waves travel through the building, deformation happens to oblige the loads. After the earthquake, the building turn out to be non-useful which may be dangerous in a few structures. Especially, irregular buildings are more vulnerable to earthquakes. Structural engineers are attempting to fabricate earthquake safe buildings by ceasing or by lessening the vibrations from the earthquake from coming to the building.

1.2 Base Isolation

To control the effect of earthquake on building the base isolation technique is one of the best solutions. Seismic isolation consists of essentially the installation of mechanisms such as isolators which decouple the structure from base. The seismic isolation system is mounted beneath the structure and is referred as 'Base Isolation'. The idea of separating the superstructure from the substructure has dependably been an elegant thought in principle, yet just as of late has it turn into a suitable solution. The objective is to have flexible material in the horizontal plane that is equipped for anticipating vitality stream into the superstructure. This flexibility expands the superstructure's period, which, thus, lessens the induced acceleration.

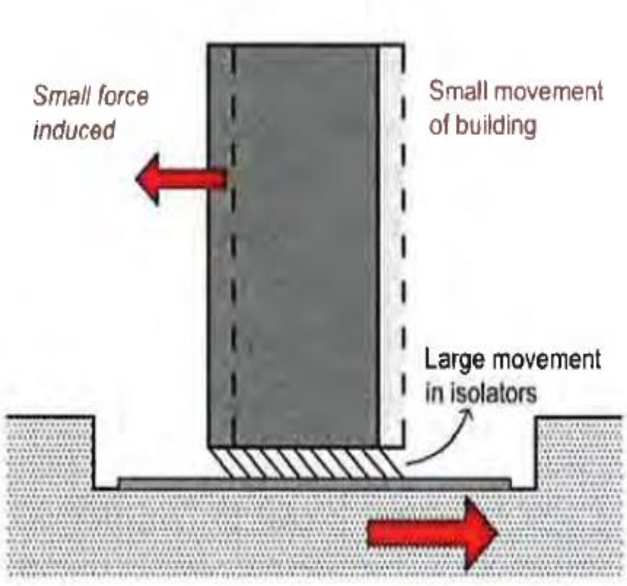

Fig -1: Behavior of the building with base isolators.

2. METHODOLOGY

In the present study reinforced concrete moment resisting frame buildings of ten storied with and without base isolation are considered. In addition, Mass irregularity is also considered by providing the heavy mass at the half portion of the roof. Same properties are used for both the cases i.e with and without base isolation. Dynamic characters of base isolated buildings are investigated using lead rubber bearings (LRB). Analysis is done by using SAP 2000 v14 software. A Time history analysis is carried out for the 1940 El Centro earthquake. The results are tabulated in order to focus the parameters such as lateral displacements and inter-storey drifts in linear analysis. The plan layout and elevated view of the buildings are shown in the below Figures.

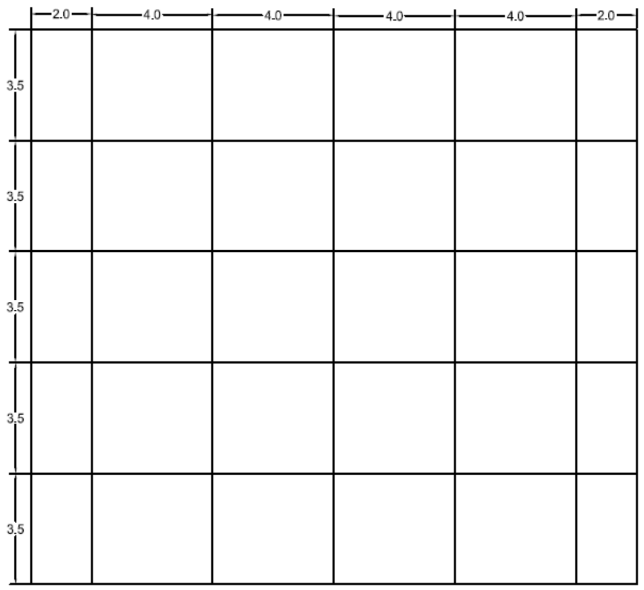

Fig -2: Plan of the building

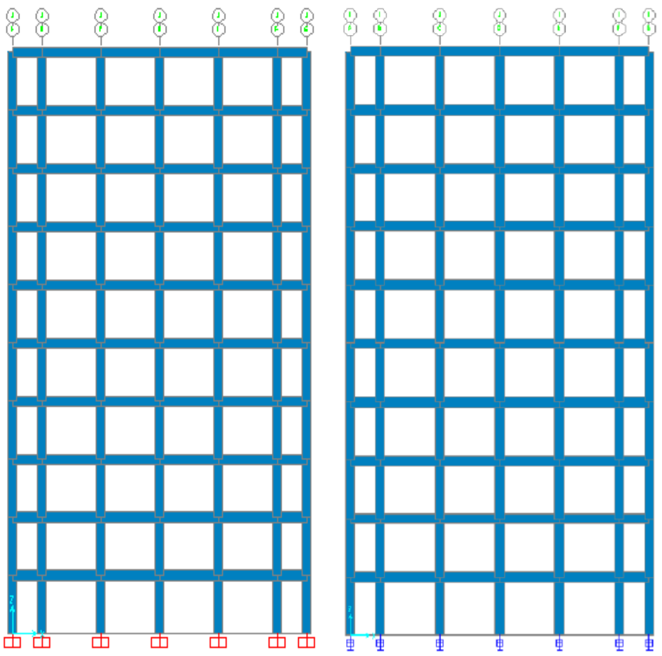

Fig -3: Elevated view of buildings with and without base isolators.

MODEL I – BUILDING WITHOUT BASE ISOLATION

MODEL II – BUILDING WITH BASE ISOLATION

MODEL III – MASS IRREGULAR BUILDING WITHOUT BASE ISOLATION

MODEL IV – MASS IRREGULAR BUILDING WITH BASE ISOLATION

2.1 Material Properties:

The materials used for analysis of building models construction is reinforced concrete with m-25grade of concrete and fe-415 grade of steel. and the stress-strain relationship is used as per is 456:2000.
The basic material properties are in given table 1.

Material Properties	Values
Characteristic strength of concrete, f_{ck}	25 MPa
Yield stress for steel, f_y	415 MPa
Modulus of Elasticity of steel, E_s	20,0000 MPa
Modulus of Elasticity of concrete, E_c	25000 MPa

2.2 Section properties:

The section properties of ten storied building model are given in table 2.

Thickness of slab	0.15 m
Beam size	0.3 x 0.6 m
Column size	0.6 x 0.6 m
Thickness of wall	0.23 m
Assumed dead load intensities	
Roof finishes	1 kN/m^2
Floor finishes	1 kN/m^2
Live load intensities	
Roof	1.5 kN/m^2
Floor	3.0 kN/m^2

2.3 Geometry of the Considered Model:

The geometry of the building of 10 storied model are given in table 3.

No. of Storeys	No. Bays in X direction	No. of Bays in Y direction	Bottom Storey Ht	Storey Ht
10	6	5	3.5 m	3.5m

2.4 Isolator properties

PARAMETER	ISOLATOR PROPERTIES	NOMENCLATURE
W (kN)	1700	Axial load
K_{eff} (kN/m)	5794	Effective stiffness
E_D (Kn-m)	65.7	Energy dissipated
Q (kN)	150	Characteristic strength
K_d (kN/m)	4429	Post-elastic stiffness
K_i (kN/m)	44290	Inelastic stiffness
K_d/K_i	0.1	Stiffness ratio
F_Y (kN)	168	Yield force

3. RESULTS & DISCUSSIONS

3.1 LATERAL DISPLACEMENT

The lateral displacements obtained for time history analysis for 10 storey building models, along both X and Y directions are listed in the tables 4 to 5. In order to account the effect of torsion the displacements are captured in both directions when force is acting in particular direction.

Table 4- Lateral displacement of 10 storey buildings along X direction.

STOREY	THX			
	DISPLACEMENT (mm)			
	MODEL I	MODEL II	MODEL III	MODEL IV
10	56.45	36.62	68.11	43.54
9	52.75	36.62	62.11	43.54
8	47.48	36.62	55.14	43.54
7	40.95	36.62	47.52	43.54
6	34.61	36.62	41.49	43.54
5	29.32	36.62	34.69	43.54
4	24.61	36.62	28.26	43.54
3	18.83	36.62	21.29	43.54
2	11.97	36.62	13.46	43.54
1	4.78	36.62	5.34	43.54
BASE	0	36.62	0	43.54

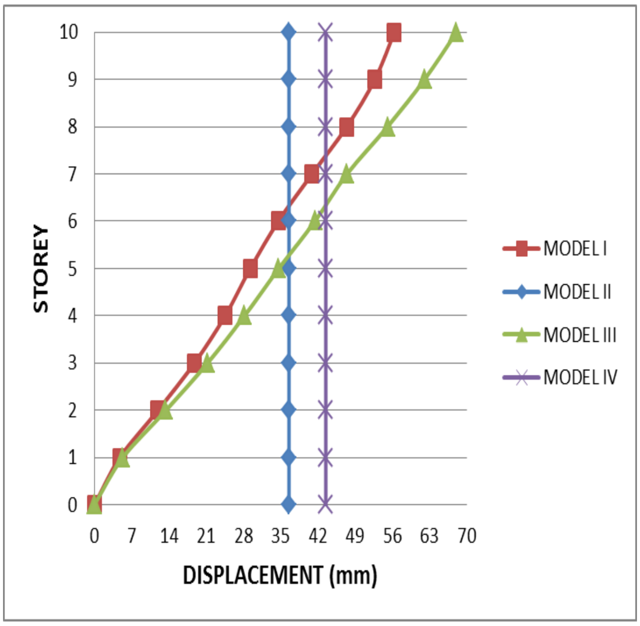

Chart -1: Lateral displacement of buildings – THX

Table 5- Lateral displacement of 10 storey buildings along Y direction

STOREY	THY			
	DISPLACEMENT (mm)			
	MODEL I	MODEL II	MODEL III	MODEL IV
10	54.23	36.62	80.06	56.82
9	51.45	36.62	73.67	56.82
8	46.93	36.62	67.38	56.82
7	40.95	36.62	56.92	56.82
6	34.76	36.62	48.86	56.82
5	30.65	36.62	40.73	56.82
4	25.85	36.62	33.36	56.82
3	19.82	36.62	24.66	56.82
2	12.55	36.62	16.02	56.82
1	4.96	36.62	7.10	56.82
BASE	0	36.62	0	56.82

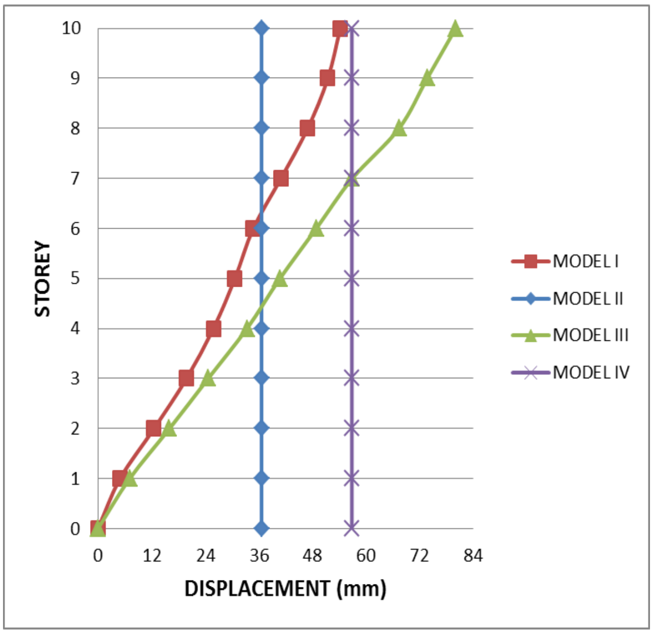

Chart -2: Lateral displacement of buildings – THY

It can be seen that the displacements are varying from base to top storey in fixed base buildings. At the top displacement is more and at the base displacement is zero. Base isolated buildings have same displacements throughout the buildings and it is lesser than the top storey displacement of respective fixed base buildings. Mass irregular building has more lateral displacements than the regular building. Mass irregular building has more lateral displacement in Y direction compared to X direction.

3.2 INTER-STOREY DRIFT

The lateral inter storey drifts obtained for time history analysis for 10 storey building models, along both X and Y directions are listed in the tables 5 to 6.

Table 5- Inter storey drifts of 10 storey buildings along X direction.

STOREY	THX			
	STOREY DRIFT			
	Model I	Model II	Model III	Model IV
10	1.05	0	1.71	0
9	1.50	0	1.99	0
8	1.86	0	2.17	0
7	1.81	0	1.72	0
6	1.51	0	1.94	0
5	1.34	0	1.83	0
4	1.65	0	1.99	0
3	1.96	0	2.23	0
2	2.05	0	2.32	0
1	1.36	0	1.52	0
0	0	0	0	0

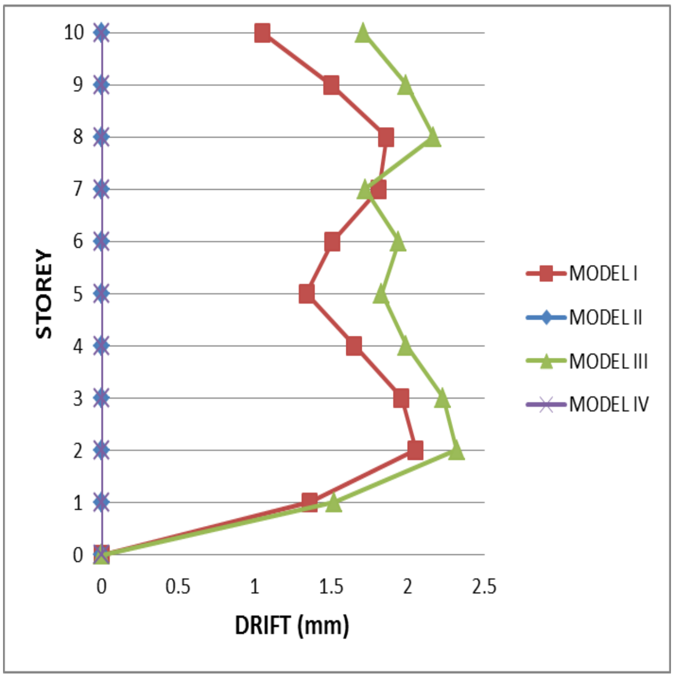

Chart -3: Inter storey drifts of buildings – THX

Table 6- Inter storey drifts of 10 storey buildings along Y direction.

STOREY	THY			
	STOREY DRIFT			
	Model I	Model II	Model III	Model IV
10	0.79	0	1.82	0
9	1.29	0	1.79	0
8	1.70	0	2.98	0
7	1.76	0	2.30	0
6	1.17	0	2.32	0
5	1.37	0	2.10	0
4	1.72	0	2.48	0
3	2.07	0	2.46	0
2	2.16	0	2.56	0
1	1.41	0	2.00	0
0	0	0	0	0

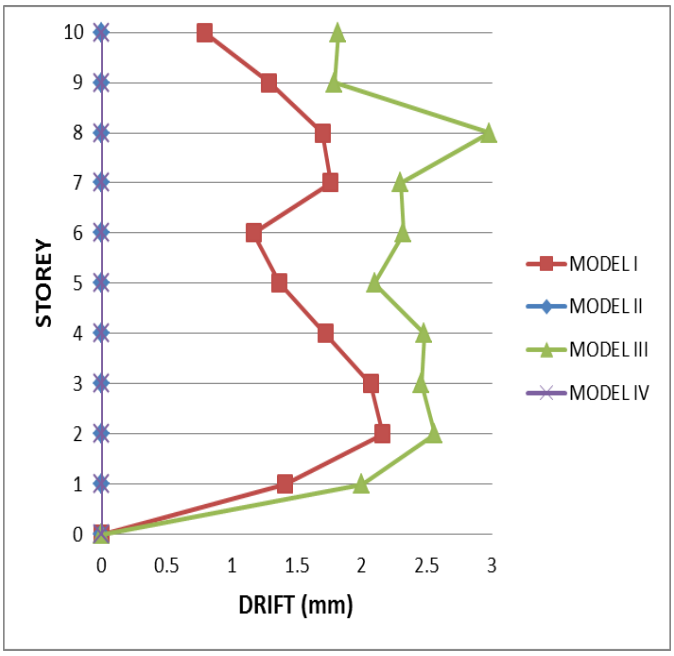

Chart -4: Inter storey drifts of buildings – THY

It can be seen that no inter storey drifts in the base isolated buildings while the buildings without base isolation have some values. It means that there is no transfer of lateral force on the members of the base isolated buildings. So, rigid body movement has been taken in base isolated buildings. Here mass irregular building having more inter storey drifts than the regular building.

4. CONCLUSIONS

The seismic analysis is carried out by time history method for 10 storey buildings with and without base isolation to focus the effectiveness of the base isolation in mass irregular buildings.

The following are the conclusions from the present study on use of base isolation systems in buildings.

- From the Time history analysis for El centro earthquake, it is found that for 10 storied regular buildings the reduction in top storey lateral displacement is 35% whereas in the case of 10 storied mass irregular buildings the reduction in top storey lateral displacement is 36%.
- By analysing the results of lateral displacements in both X and Y directions, it can be seen that mass irregularity in a building causes torsion.
- It is found that there is no inter storey drifts in base isolated buildings. It means that when using base isolators, the building takes rigid body movement. Compared to regular buildings, Inter storey drifts for mass irregular buildings is larger.

REFERENCES

1. **A.N Lin and H.W Shenton,** "Seismic performance of fixed-base and base-isolated steel frames", ASCE, Vol. 118, No.5, ISSN 0733-9399, May, 1992.
2. **A.Sharma and R.S Jangid,** "Behavior of Base Isolated Structure with High Initial Isolator Stiffness", Journal of World Academy of Science Engineering and Technology, No.50, pp. 186-191, (2009).
3. **A.B.M Saiful islam *et al,*** "Simplified design guidelines for seismic base isolation in multi-storey buildings for BNBC", international journal of the physical sciences, Vol. 6 (23), pp.5467-5486, 9 October, 2011.
4. **A.B.M Saiful islam *et al,*** "Seismic isolation for buildings in regions low to moderate seismicity: Practical alternative design", ASCE, Vol. 17, No.1, ISSN 1084-0680, 1 February, 2012.
5. **Desai Amit R, Dr.R.K.Gajjar,** "Structural Control system for mid-rise building", International Journal of Advanced Engineering Technology, E-ISSN 0976-3945.
6. **Dr. Hadi Nasir Ghadhban AL-Maliki,** "Analytical Behavior of Multi-Storied Building with Base Isolation Subjected to Earthquake Loading", Journal of Engineering and Development, Vol. 17, No.2, 2013, ISSN 1813- 7822.
7. **H.W.Shenton and A.N.Lin,** "Relative performance of fixed base and base isolated concrete frames", ASCE, Vol. 119, No.10, ISSN 0733-9445, October, 1993.
8. **Luis Andrade and John Tuxworth,** "Seismic Protection of Structures with Modern Base Isolation Technologies", Concrete solutions 09, Paper 7a-3.
9. **Mehmet A.Komur,** "Soft storey effects on the behavior of fixed base and LRB base-isolated reinforced concrete buildings", Springer, DOI 10.1007/s13369-015-1664-3, 28 April 2015.
10. **Pankaj Agrawal and Manish Shrikhande,** Earthquake and vibration effect on Structure: Basic element of Earthquake Resistant Design, 'Earthquake resistant design of structures, PHI Learning private limited, New Delhi, 200-201, 2012.