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Comparative Seismic Analysis of Conventional and RC Wall Building With and Without Base Isolation

[1]Madhu B N, [2]Dr.M Keshava Murthy,
[1]Post Graduate Student, [2]Professor,
[1]Department of Civil Engineering,
[1]University of Visvesvaraya College of Engineering, Bangaluru, India

Abstract: The main principle of this project is to protect the building by constructing them as earthquake-resistant structure. In multi-storey buildings earthquake forces will have a very high impact on any form of the structure. In recent years the construction industry had developed many new technologies. RC wall (MIVAN) construction technology is also one of the best method. It has been adopted all over the world because the construction is speedy. This work is conducted to come up with the realistic conventional and RC wall building models to study the seismic analysis under fixed base and base isolated. The main objective of the work is to study the comparative seismic analysis of conventional and RC wall building and to study the performance of both the building under earthquake generated forces. In this work a G+15 storey conventional building and RC wall building (mivan construction) of same plan is considered. To study the seismic analysis of the both conventional and RC wall building the response spectrum analysis was performed on both models as per the Indian standard code IS 1893:2016 Part 1. From the analysis results it was found that RC wall building performs better compared to conventional building. Consider the maximum vertical reaction obtained from fixed base is used to design base isolators the obtained stiffness is used in modeling by replacing the fixed base joint to base isolators in the buildings. Story displacement, story drift and story shear are compared for both cases. In this case, we are using rubber base isolators for analyzing the structure using ETABS Software.

Keywords: Mivan Construction, RC Wall Building, Conventional Building, Base Isolation, Lead Rubber Bearing (LRB), ETABS Software, Response Spectrum Method, Base Shear, Story Displacement and Story Drifts.

I. INTRODUCTION

One of the most commonly used and recognized systems for seismic protection is base isolation. This technique mitigates earthquake effects by separating the structure and its contents from potentially damaging ground motion, particularly within the frequency range that most affects the building. In India many of building are currently constructed on fixed bases, meaning they are built directly on the ground. During on the earthquake as the ground shakes, these building sway in response. A severe earthquake can cause critical parts of the buildings infrastructure, such as wall, columns and beams, to collapse, potentially leading to the entire building falling. A base isolation system however, involves placing bearings known as base isolators. It is in between the super-structure and sub-structure (foundation) of the building. It absorb the shocking of an earthquake and significantly reduce the shaking impact on the building.

A. Base Isolation

The base isolation system in general consists of bearing allowing horizontal movement which provides the member under the horizontal loads and controls the displacement. The members are provided have the behavior of rigid to pass vertical load as well as horizontal load. This helps in changing the period of the base isolation system along the structure above the ground level. It helps in decreasing the inertia forces. When the seismic isolation system is compared with fixed base the displacement of the base isolation system causes big displacements in the super-structure. There are different types of base isolators are used in the base isolation system.

B. Lead Rubber Bearing

The lead rubber bearing (LRB) invented in New Zealand at 1975. Lead rubber bearings (LRB) represent a significant advancement in seismic isolation technology, serving an essential function in enhancing the structural resilience against seismic forces. By incorporating a flexible layer and dampening material between a building's foundation and superstructure, these devices reduce the impact of seismic events. The parts of LRB comprises a lead plug, end plates, steel shims and rubber layers. The steel stims are crucial for providing vertical stiffness and while the rubber layers allow for lateral horizontal stiffness. The lead core enhances the isolators stiffness and imparts damping to the system.

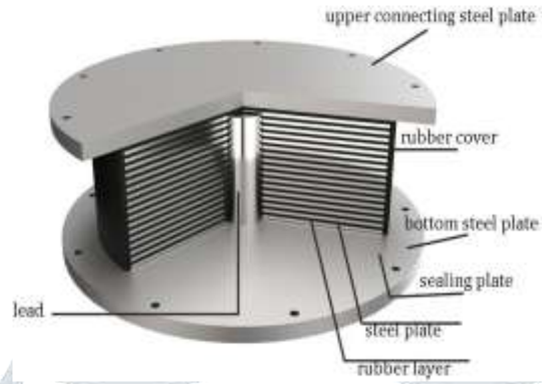

Fig 1: Lead Plug Rubber Bearing (LRB)

(LRBs) are typically constructed from alternating layers of steel plates and natural rubber, with a central hole designed to accommodate a press-fitted lead core. The rubber layers within LRBs function as flexible components, enabling movement and managing displacements induced by seismic activity. These layers effectively absorb and distribute the energy created during an earthquake, thus reducing the detrimental forces transmitted to the structure above. Furthermore, the natural elasticity of the rubber enhances the overall adaptability of the bearing.

II OBJECTIVES

This study to investigate the impact of base isolators on the structural performance of reinforced concrete (RC) wall buildings compared to conventional beam, column, and slab buildings when exposed to various loads, including seismic loads. it seeks to analyse the influence of base isolation on both building types constructed on different soil conditions.

The primary goals of this study are outlined below:

1. To examine how RC wall buildings perform in terms of seismic response relative to conventional buildings.
2. To analyse the seismic responses of both building types under varying zone conditions.
3. To investigate the impact of base isolation on both types of structures subjected to seismic forces and to assess how this effect varies across different zone types.

III METHODOLOGY

- Detailed literature review is carried out on seismic response of conventional and RC wall building with and without base isolation.
- Structures with G+15 is modelled for both conventional and RC wall building. Both structures are having fixed and base isolation condition.
- All the loads applied are as per Indian Standard code IS1893:2016 part 1.
- The study was conducted on four earthquake zones as per code. Both types of the building are studied in earthquake zones (zone II, zone III, zone IV, zone V) and considering the medium soil that is soil type II.
- FE analysis involves Model, Equivalent Static and Response Spectrum Analysis to be and the combination of both structures to obtain Time period, Base shear, Storey Displacement and Storey drifts.
- All results are tabulated, compared discussed and conclusions are draw.

IV PRESENT STUDY

The present study uses a conventional and RC wall building model of fixed support and base isolation condition and also combination for different types of earthquake zones and medium soil (soil type II). Conventional and RC wall building having the same dimensions. Base plan size 35m x 35m has been considered in both the horizontal and vertical direction. The model contains 7 x 7 bays. It considers the seismic design code as per (IS 1893:2016).

V PROJECT DESCRIPTION

Table 1: Section properties for structure considered

Model	G+15 (16 floors)	G+15 (16 floors)
Type of structure	Conventional	RC Wall (mivan)
Number of stories	(G+15)	(G+15)
Height of each story	3m	3m
Height of bottom story	3.2m	3.2m
Height of the building	45.2m	45.2m
Column size	450mm x 300mm	-
Beam size	400mm x 400mm	Wall size - 200mm
Thickness of slab	150mm	150mm
Floor finish load	1.5KN/m^2	1.5 KN/m^2
Live load	3KN/m^2	3KN/m^2
Grade of concrete (f_{ck})	M25	M25
Grade of steel (f_y)	Fe 500	Fe 500
Density of steel	77KN/m^3	77KN/m^3

Density of concrete	25KN/m^3	25KN/m^3
Type of structure	Conventional	RC Wall (mivan)

Table 2: Material properties for structure considered

Parameter	Values
Grade of concrete	M_{30} (30 N/mm^2)
Grade of rebar	HYSD500 (500 N/mm^2)
Density of concrete	25 KN/m^3
Density of concrete block	17.65 KN/m^3

Table 3: load combination

Combination name	Load combination
Comb EQX	1.2 (DL+LL+EQX+SDL)
Comb EQY	1.2 (DL+LL+EQY+SDL)
Comb RSX	1.2 (DL+LL+RSX+SDL)
Comb RSY	1.2 (DL+LL+RSY+SDL)

Table 4: Nomenclature and description of the models

Sl/no	Description	Nomenclature
		G+15
1.	Conventional + fixed support	G+1 5CF
2.	Conventional + base isolation	G+15 CB
3.	RC wall + fixed support	G+15 RCF
4.	RC wall + base isolation	G+15 RCB

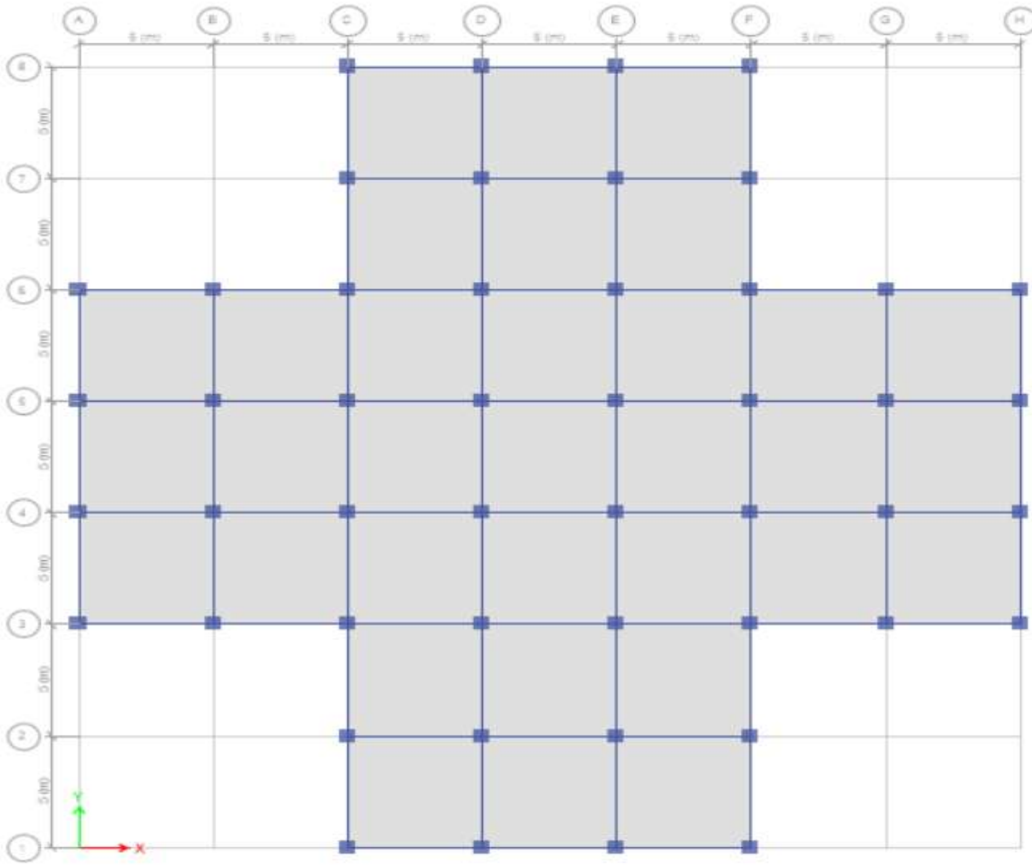

Fig 2: Plan of the Building`

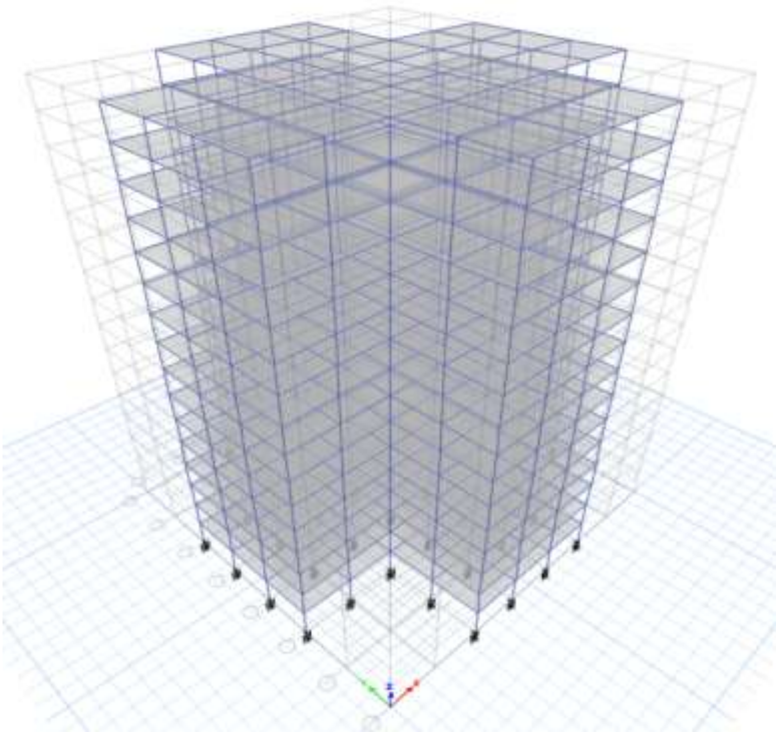

Fig 3: Conventional Building

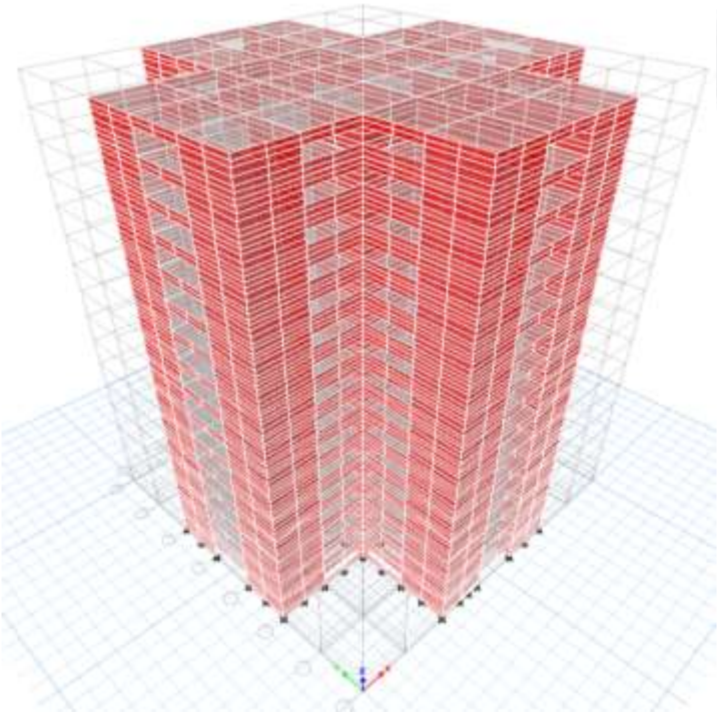

Fig 4: RC Wall Building

VI RESPONSE SPECTRUM METHOD

Response spectrum method may be performed for any building using the design acceleration. The response spectrum proves to be valuable in earthquake engineering as it aims in the analysis of a buildings and equipment performance during seismic events.

Response Spectrum Analysis for design of LRB

Table 5: Seismic parameters (IS: 1893-2016, Part-I)

Parameter	Values adopted	Reference in code
Zone	II, III,IV,V	Table-3
Soil	2 (medium soil)	Table-2
Importance factor	1.5 (commercial building)	Table-8
Response reduction factor	5 (conventional building) 4 (mivan building system)	Table-9

Table 6: Response Spectrum Analysis

Sl/no	Property type	Response spectrum analysis
1.	Effective stiffness K_{eff}	4179.024 KN/m
2.	Horizontal stiffness K_H	4179.104 KN/m
3.	Vertical stiffness K_V	1486328.35 KN/m
4.	Yield strength Q_R	496.15 KN/m
5.	Post yield stiffness ratio	0.1

VII RESULTS

From the analysis results some of the parameters such as Displacements, Drifts, and Base Shear are compared for the Conventional building and RC wall building. The analysis results, tabulated and represented in the form of plots are given below.

A. Time Period

The primary time period for all models is derived from the model analysis, which is based on the mass and stiffness of the structure. The fundamental time period according to IS1893:2016 part 1 is expressed by the following formula,

G+15 Storey = $T_a = \frac{0.09\ x\ 48}{\sqrt{35}}$ = 0.73 sec

B. Maximum Displacement

Table 7: Maximum displacement in Zone II (Conventional Building and RC wall Building)

Height of the story	Conventional building		RC wall building	
	Fixed support	Base isolation	Fixed support	Base isolation
Story16	45.534	83.257	3.896	27.153
Story15	44.686	82.425	3.606	26.992
Story14	43.492	81.306	3.461	26.825
Story13	41.929	79.853	3.271	26.648
Story12	40.016	78.057	3.074	26.46
Story11	37.786	75.929	2.862	26.261
Story10	35.266	73.484	2.64	26.05
Story9	32.478	70.735	2.409	25.827
Story8	29.436	67.693	2.173	25.593
Story7	26.146	64.371	1.935	25.349
Story6	22.615	60.779	1.699	25.096
Story5	18.849	56.923	1.47	24.834
Story4	14.856	52.806	1.253	24.568
Story3	10.666	48.404	1.056	24.297
Story2	6.377	43.616	0.876	24.03
Story1	2.354	37.824	0.779	23.745
Base	0	29.276	0	23.527

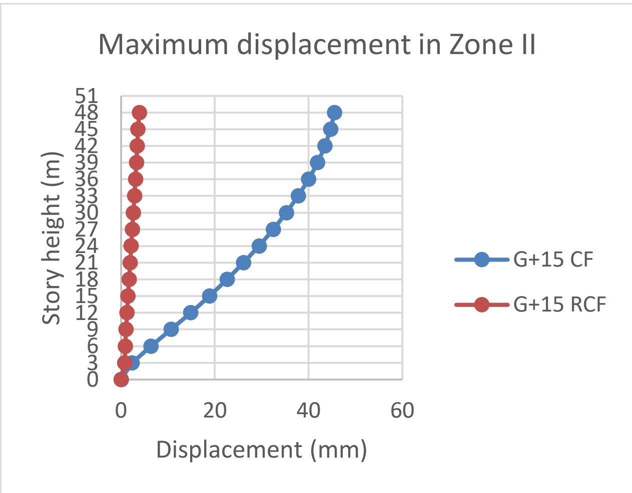

Fig 5: Maximum displacement in Zone II (Conventional Building and RC wall Building) Fixed Support

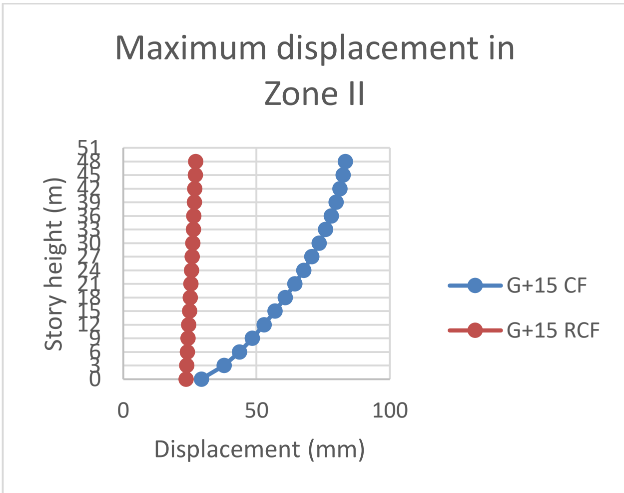

Fig 6: Maximum displacement in Zone II (Conventional Building and RC wall Building) Base Isolation

Table 8: Maximum displacement in Zone III (Conventional Building and RC wall Building)

Height of the story	Conventional building		RC wall building	
	Fixed support	Base isolation	Fixed support	Base isolation
Story16	72.801	133.169	5.77	43.419
Story15	71.471	131.866	5.386	43.163
Story14	69.569	130.086	5.138	42.896

Story13	67.069	127.761	4.837	42.614
Story12	64.009	124.888	4.52	42.315
Story11	60.441	121.484	4.181	41.998
Story10	56.41	117.571	3.825	41.662
Story9	51.951	113.172	3.455	41.307
Story8	47.084	108.305	3.077	40.934
Story7	41.822	102.99	2.696	40.544
Story6	36.174	97.242	2.318	40.14
Story5	30.149	91.074	1.951	39.724
Story4	23.762	84.487	1.604	39.298
Story3	17.059	77.444	1.288	38.867
Story2	10.2	69.783	1.004	38.441
Story1	3.764	60.511	0.824	37.989
Base	0	46.757	0	37.563

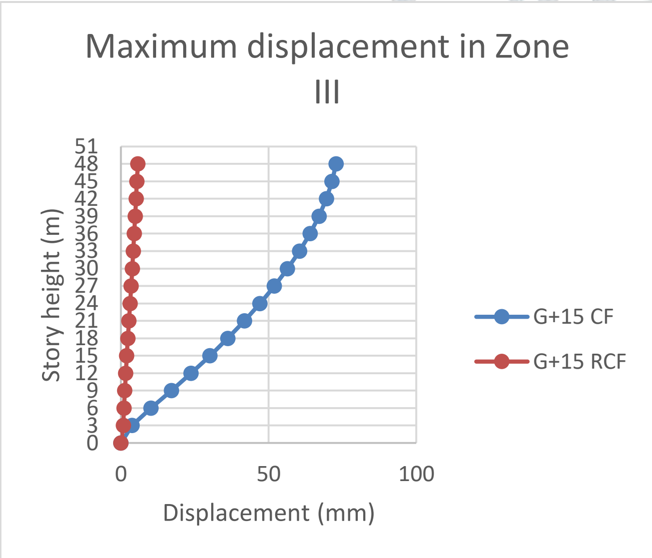

Fig 7: Maximum displacement in Zone III (Conventional Building and RC wall Building) Fixed Support

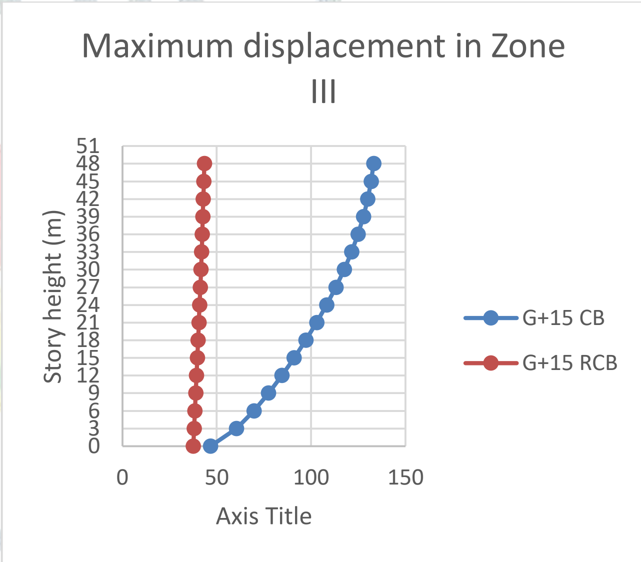

Fig 8: Maximum displacement in Zone III (Conventional Building and RC wall Building) Base Isolation

Table 9: Maximum displacement in Zone IV (Conventional Building and RC wall Building)

Height of the story	Conventional building		RC wall building	
	Fixed support	Base isolation	Fixed support	Base isolation
Story16	109.172	199.726	8.268	65.106
Story15	107.198	197.796	7.76	64.724
Story14	104.354	195.133	7.374	64.325
Story13	100.604	191.646	6.925	63.903
Story12	96.013	187.335	6.448	63.456
Story11	90.661	182.229	5.939	62.981
Story10	84.615	176.36	5.405	62.478
Story9	77.925	169.761	4.85	61.946
Story8	70.625	162.461	4.282	61.388
Story7	62.732	154.488	3.71	60.805
Story6	54.26	145.866	3.143	60.199
Story5	45.222	136.613	2.592	59.576
Story4	35.641	126.732	2.071	58.939
Story3	25.587	116.169	1.596	58.294
Story2	15.299	104.675	1.176	57.657
Story1	5.646	90.767	0.884	56.981
Base	0	70.067	0	56.303

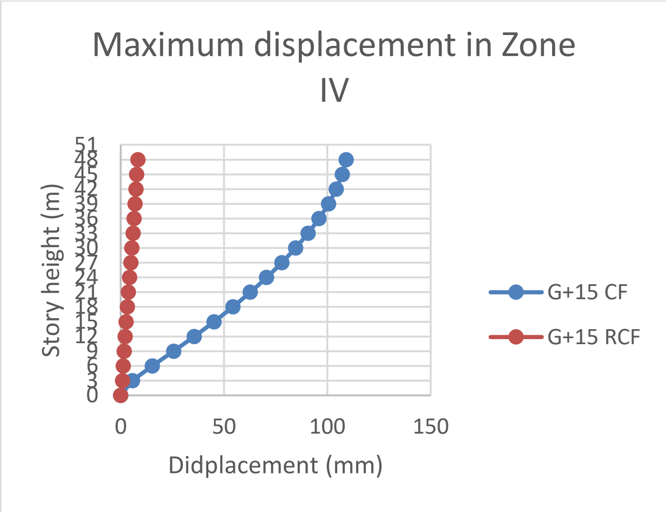

Fig 9: Maximum displacement in Zone IV (Conventional Building and RC wall Building) Fixed Support

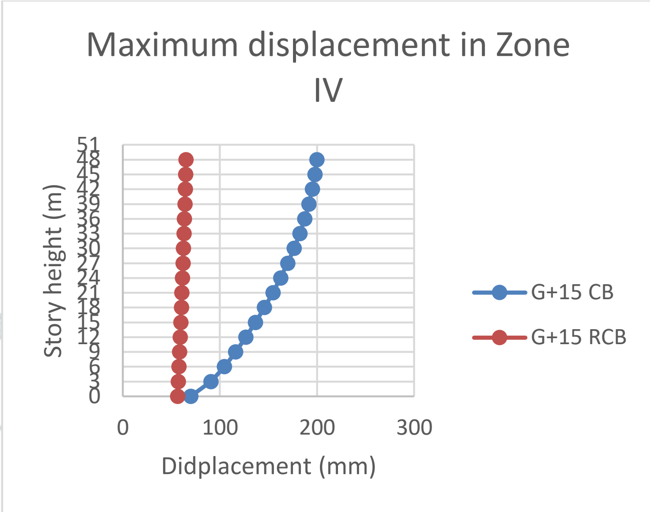

Fig 10: Maximum displacement in Zone IV (Conventional Building and RC wall Building) Base Isolation

Table 10: Maximum displacement in Zone V (Conventional Building and RC wall Building)

Height of the story	Conventional building		RC wall building	
	Fixed support	Base isolation	Fixed support	Base isolation
Story16	163.77	299.559	12.015	97.599
Story15	160.83	296.688	11.321	97.027
Story14	156.569	292.701	10.729	96.429
Story13	150.942	287.471	10.056	95.798
Story12	144.055	281.005	9.34	95.128
Story11	136.024	273.346	8.577	94.417
Story10	126.953	264.542	7.775	93.664
Story9	116.916	254.643	6.943	92.868
Story8	105.963	243.693	6.09	92.032
Story7	94.121	231.733	5.231	91.159
Story6	81.409	218.8	4.38	90.252
Story5	67.848	204.92	3.554	89.318
Story4	53.474	190.099	2.772	88.365
Story3	38.389	174.254	2.059	87.399
Story2	22.954	157.012	1.433	86.446
Story1	8.47	136.15	0.975	85.435
Base	0	105.033	0	84.39

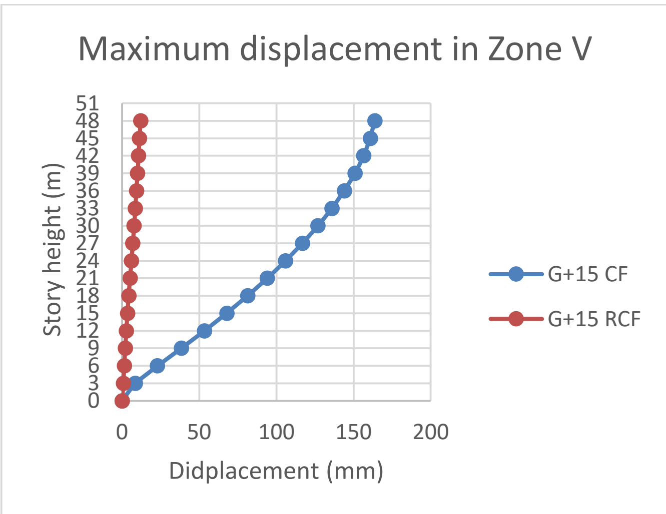

Fig 11: Maximum displacement in Zone V (Conventional Building and RC wall Building) Fixed Support

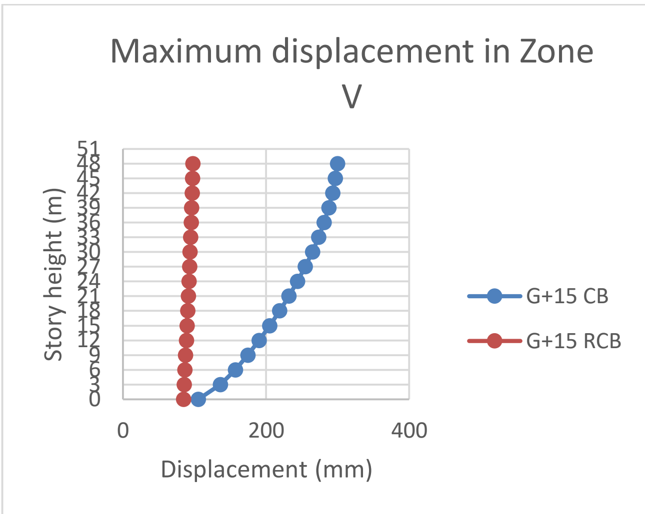

Fig 12: Maximum displacement in Zone V (Conventional Building and RC wall Building) Base Isolation

From the above tables and graphs, it can be seen that the RC wall building has produced much lesser displacements than the conventional building. This shows that the RC wall building (mivan building) offers more resistance to the seismic forces (lateral forces) than the conventional building.

C. Maximum storey drifts

Table 11: Maximum story drift in Zone II (Conventional Building and RC wall Building)

Height of the story	Conventional building		RC wall building	
	Fixed support	Base isolation	Fixed support	Base isolation
Story16	0.000362	0.00032	5.30E-05	5.50E-05
Story15	0.000515	0.000426	5.70E-05	5.70E-05
Story14	0.00067	0.000557	6.20E-05	6.10E-05
Story13	0.0008	0.000683	6.70E-05	6.50E-05
Story12	0.000905	0.000799	7.10E-05	6.90E-05
Story11	0.000992	0.000905	7.50E-05	7.30E-05
Story10	0.001065	0.001002	7.80E-05	7.70E-05
Story9	0.001128	0.001092	8.00E-05	8.00E-05
Story8	0.001186	0.001176	8.10E-05	8.40E-05
Story7	0.001244	0.001255	8.00E-05	8.60E-05
Story6	0.001301	0.001331	7.90E-05	8.90E-05
Story5	0.001357	0.001405	7.50E-05	9.00E-05
Story4	0.001408	0.001489	6.90E-05	9.10E-05
Story3	0.001434	0.001617	6.10E-05	9.00E-05
Story2	0.001348	0.001984	5.00E-05	9.30E-05
Story1	0.000785	0.003605	3.40E-05	0.002791
Base	0	0	0	0

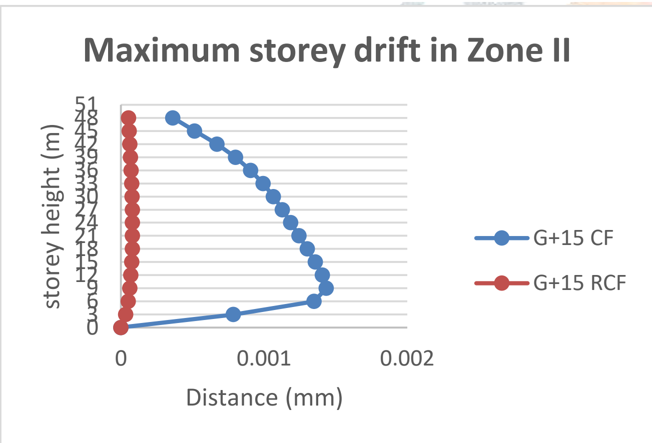

Fig 13: Maximum storey drift in Zone II (Conventional Building and RC wall Building) Fixed Support

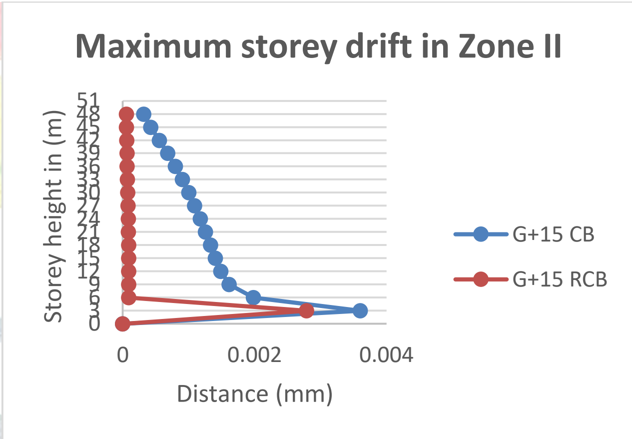

Fig 14: Maximum storey drift in Zone II (Conventional Building and RC wall Building) Base Isolation

Table 12: Maximum storey drift in Zone III (Conventional Building and RC wall Building)

Height of the story	Conventional building		RC wall building	
	Fixed support	Base isolation	Fixed support	Base isolation
Story16	0.000564	0.000496	8.40E-05	8.70E-05
Story15	0.00082	0.000679	9.10E-05	9.20E-05
Story14	0.001071	0.00089	9.90E-05	9.70E-05
Story13	0.001279	0.001092	0.000107	0.000103
Story12	0.001447	0.001278	0.000114	0.000109
Story11	0.001586	0.001448	0.00012	0.000116
Story10	0.001703	0.001603	0.000125	0.000122
Story9	0.001804	0.001748	0.000128	0.000128
Story8	0.001898	0.001882	0.000129	0.000133
Story7	0.00199	0.002008	0.000129	0.000138
Story6	0.002081	0.002129	0.000126	0.000141
Story5	0.00217	0.002248	0.00012	0.000144
Story4	0.002252	0.002382	0.000111	0.000145
Story3	0.002294	0.002588	9.80E-05	0.000143
Story2	0.002156	0.003171	8.00E-05	0.000148
Story1	0.001255	0.005704	5.40E-05	0.004313
Base	0	0	0	0

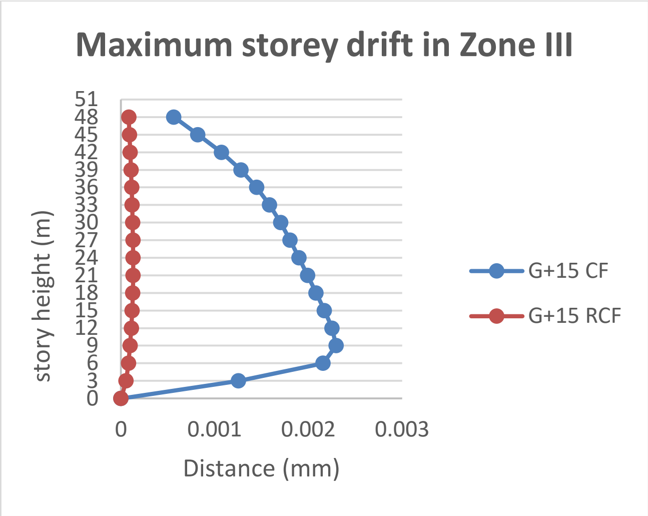

Fig 15: Maximum storey drift in Zone III (Conventional Building and RC wall Building) Fixed Support

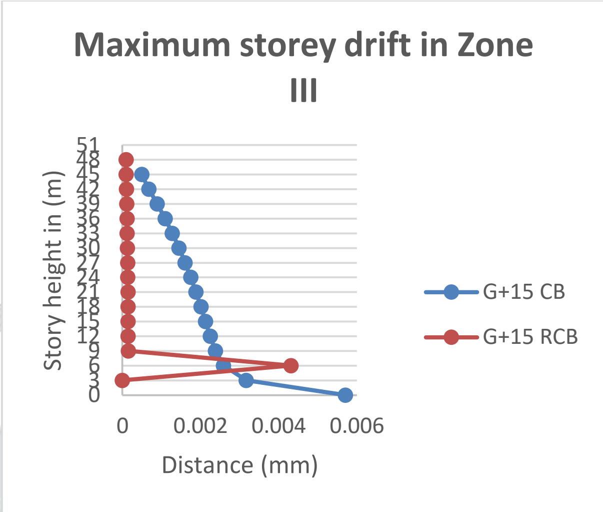

Fig 16: Maximum storey drift in Zone III (Conventional Building and RC wall Building) Base Isolation

Table 13: Maximum story drift in Zone IV (Conventional Building and RC wall Building)

Height of the story	Conventional building		RC wall building	
	Fixed support	Base isolation	Fixed support	Base isolation
Story16	0.000835	0.00073	0.000127	0.00013
Story15	0.001227	0.001015	0.000137	0.000137
Story14	0.001607	0.001335	0.000149	0.000145
Story13	0.001919	0.001639	0.00016	0.000154
Story12	0.002171	0.001917	0.000171	0.000164
Story11	0.00238	0.002171	0.00018	0.000173
Story10	0.002555	0.002405	0.000187	0.000183
Story9	0.002706	0.002621	0.000192	0.000191
Story8	0.002847	0.002823	0.000194	0.000199
Story7	0.002985	0.003012	0.000193	0.000206
Story6	0.003122	0.003193	0.000189	0.000212
Story5	0.003255	0.003372	0.00018	0.000215
Story4	0.003378	0.003573	0.000167	0.000217
Story3	0.003441	0.003881	0.000147	0.000214
Story2	0.003234	0.004754	0.00012	0.000222
Story1	0.001882	0.008501	8.10E-05	0.006343
Base	0	0	0	0

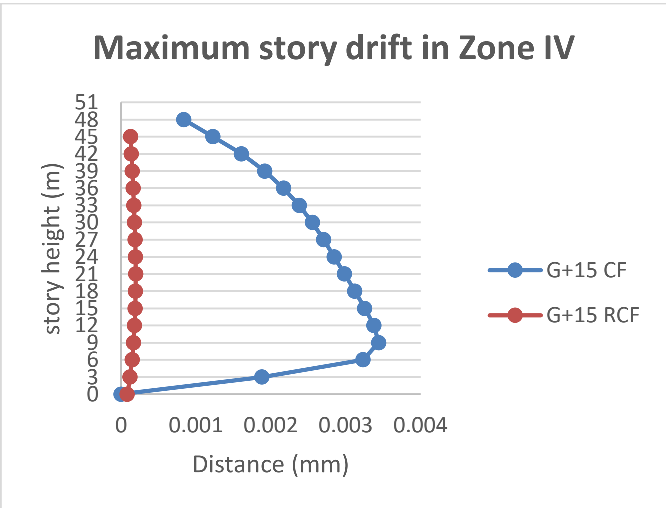

Fig 17: Maximum storey drift in Zone IV (Conventional Building and RC wall Building) Fixed Support

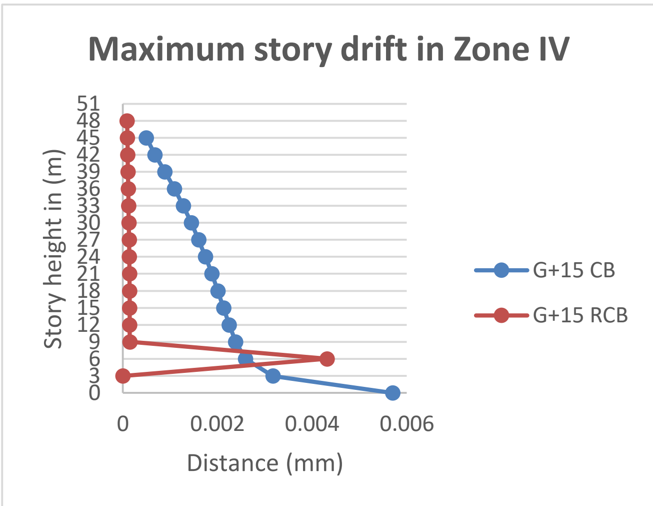

Fig 18: Maximum storey drift in Zone IV (Conventional Building and RC wall Building) Base Isolation

Table 14: Maximum story drift in Zone V (Conventional Building and RC wall Building)

Height of the story	Conventional building		RC wall building	
	Fixed support	Base isolation	Fixed support	Base isolation
Story16	0.00124	0.001082	0.00019	0.000195
Story15	0.001839	0.00152	0.000206	0.000205

Story14	0.002411	0.002002	0.000223	0.000217
Story13	0.002879	0.002458	0.00024	0.000231
Story12	0.003257	0.002875	0.000256	0.000245
Story11	0.00357	0.003257	0.00027	0.000259
Story10	0.003833	0.003608	0.000281	0.000273
Story9	0.00406	0.003932	0.000288	0.000287
Story8	0.004271	0.004234	0.000292	0.000299
Story7	0.004478	0.004518	0.00029	0.000309
Story6	0.004683	0.00479	0.000284	0.000317
Story5	0.004884	0.005058	0.000271	0.000322
Story4	0.005069	0.00536	0.00025	0.000324
Story3	0.005163	0.005822	0.000221	0.00032
Story2	0.004851	0.007128	0.000181	0.000332
Story1	0.002823	0.012698	0.000121	0.009385
Base	0	0	0	0

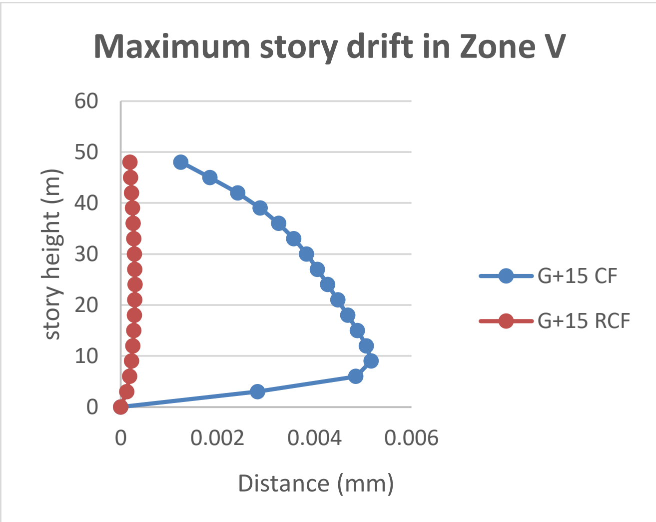

Fig 19: Maximum storey drift in Zone V (Conventional Building and RC wall Building) Fixed Support

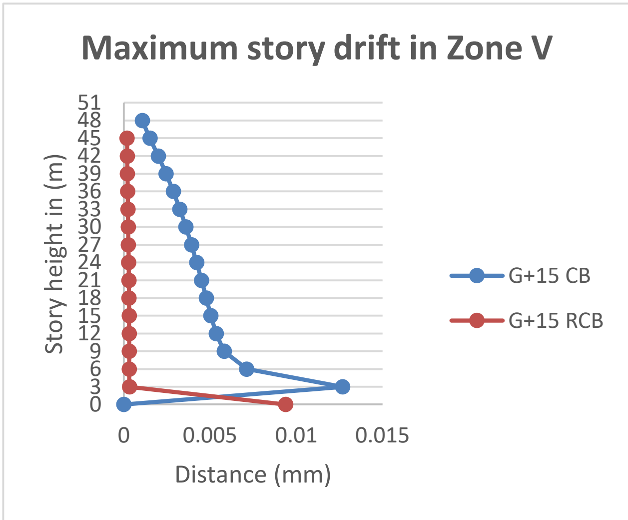

Fig 20: Maximum storey drift in Zone V (Conventional Building and RC wall Building) Base Isolation

As seen in the previous section of displacements, here it can be seen from the tables and graphs that the storey drifts in the RC wall building is very much less to the conventional building. This result shows that the RC wall building is safer against drift caused by the lateral forces (seismic forces) as it produces less storey drift compared to the conventional building in the same seismic zone.

D. Base shear

The base shears of the conventional and RC wall fixed and isolated buildings are compared and tabulated below.

Table 15: Base Shear Fixed for Conventional Building and RC wall building.

Zones	Fixed base	Isolated base
Zone II	5038.976	3344.254
Zone III	8062.355	5350.807
Zone IV	12093.53	8105.468
Zone V	18140.3	12158.2

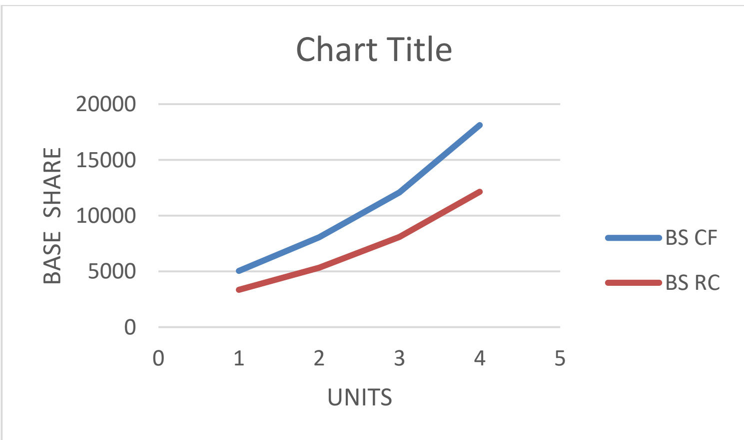

Fig 21: Base Shear Fixed for Conventional Building and RC wall building.

From the table and graph shows that, the base shear in the RC wall building is lesser than the conventional building. This result shows that the RC wall building increase the overall stiffness of the building and also the lateral forces of the building compared to the conventional building.

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