Comparative Study on Seismic performance of Multi Storied Building with and without Shear Wall

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***Abstract*: - As the demand for construction of high rise buildings increased day by day, it is very much necessary to ensure the safety and stability of the structures against lateral forces caused by earthquake. The most predominantly used structural element which resists the lateral forces and imparts the stiffness to the structure is shear wall. Shear walls are specially designed reinforced structural walls to resist all types of lateral forces caused by wind, earthquake. In this thesis our main focus is to compare the seismic performance G+14 storey irregular planned structure with and without shear wall using Response spectrum method. Analysis was carried out by using E-TABS for seismic zone IV in India.**

INTRODUCTION:

Structure analysis involves the determination of the forces and displacements of the structures or components of a structure. Design process involves the selection and detailing of the components that make up the structural system. The main object of reinforced concrete design is to achieve a structure that will result in a safe economical solution. The stiffness property of high rise buildings is to be ensured to resist the lateral forces induced by wind and earthquake. Generally structures experience two types of loads i.e. Static and Dynamic. The most common vertical loads are by gravity, self weight of the structure and due to uniform loads. Beside these vertical static loads, structure will also experience lateral loads which are caused by wind, earthquake. These lateral loads produce vibrations which intern cause the sway moment in the structure and also produce high stresses. The advantages of shear walls in construction of high rise multi-storey buildings have long been recognized. The advantageous position of these walls in buildings is very much efficient in resisting lateral loads, which originated from wind and earthquake. These structural walls take up the horizontal shear coming from these lateral forces. So that's why these walls are called as shear walls. The symmetrical location of these walls will reduce the twisting moment caused by lateral forces. The main objective of this paper is to evaluate the seismic behavior of multi-storey building with and without shear wall using Response spectrum method and to check the storey drifts, storey displacements and storey shears which are obtained from the analysis.

In Bahador Bagheri, Ehsan Salimi Firoozabad, and Mohammadreza Yahyaei [2012] study, he Compared the Study on structural response of the Multi-Storey Irregular shear wall building under Static and Dynamic Analysis with the variation of the building height[VII]. In Axay thapa & Sajal sarkar [2017] study, he compared the dynamic responses of frame structure with and without shear walls with varying structural member dimensions according to height under Static Method and Response Spectrum Method considering seismic zone V[VIII]. In Prakash A N [2018] study, he analysed one buiding without shear wall and other with shear wall at different location[IX]. In Vidyashree [2017] study, A 11 story RCC building with 6 different moders are considered for the seismic analysis in which one is without shear wall and others with shear walls at different locations in zone V under Equivalent static analysis and Response spectrum analysis[X].

OBJECTIVES:

- To develop the model of 14 storied high rise building considering fixed base using ETABS.
- To analyse the structure by both equivalent lateral force method and response spectrum method.
- To find structural responses like storey displacement, storey shear, storey drifts of the structure.
- To compare the storey displacement and storey drift results and base shear results for both linear static and dynamic analysis with and without shear wall.

METHODS OF SEISMIC ANALYSIS:

During an earthquake, ground motions develop in a random manner both horizontally and vertically in all directions radiating from the epicenter. The ground motions develop vibrations in the structure inducing inertial forces on them. Hence structures located in seismic zones should be suitably designed and detailed to ensure strength, serviceability and stability with acceptable levels of safety under seismic forces.
The satisfactory performance of a large number of reinforced concrete structures subject to severe earthquake in various parts of the world has demonstrated that it is possible to design structures to successfully withstand the destructive effects of major earthquakes.
The Indian standard codes IS: 1893-2016 and IS: 13920-2016 have specified the minimum design requirements of earthquake resistant design probability of occurrence of earthquakes, the characteristics of the structure and the foundation and the acceptable magnitude of damage.
Determination of design earthquake forces is computed by the following methods,

1) Equivalent static lateral loading.
2) Dynamic Analysis.

- In the first method, different partial safety factors are applied to dead, live, wind earthquake forces to arrive at the design ultimate load.
- The dynamic analysis involves the rigorous analysis of the structural system by studying the dynamic response of the structure by considering the total response in terms of component modal responses.

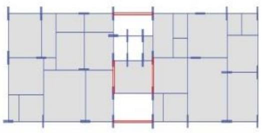
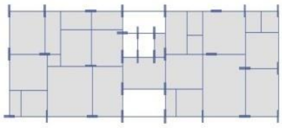
METHODOLOGY

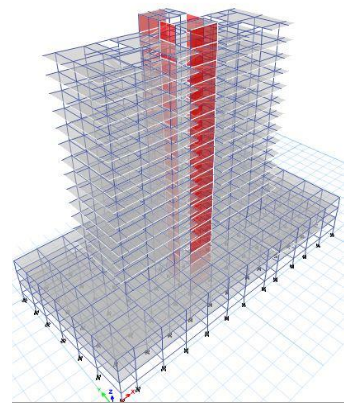
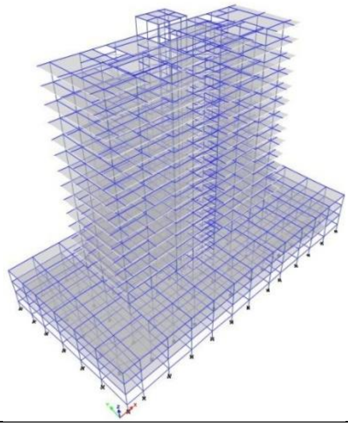
- Modeling and analysis of G+14 storied building with and without shear wall by using Response spectrum method for seismic loads in Zone-IV as per IS code.
- Comparing the analysis results obtained for different parameters like storey shears, storey displacements, storey drifts, storey shears and lateral force to stories.

MODELLING AND ANALYSIS

The present work aims towards analyzing the behavior of a structure which consists of Sub-Cellar, Cellar Floor, Stilt Floor parking, and G+ 14 floors. In this work, a model which is fixed at base is created with slabs, beams, and columns/Shear walls connected to each other with a network of beams and slabs. Slabs act as in-plane rigid diaphragms. Lift machine room and over head tank are provided above terrace floor level. As per IS 1893:2016 (part 1) linear static and dynamic analysis are carried out by equivalent lateral force method and response spectrum method respectively using ETABS. Further study is extended to find out the percentage difference of various response parameters like storey displacement, storey drift, storey shear, etc.

PLANS

 Figure1: Plan Of the building (With Shear Wall)	 Figure2: Plan Of Of the building (Without Shear Wall)
Figure3: 3D View Of the building (With Shear Wall)	Figure4: 3D View Of the building

	(Without Shear Wall) 

Response Spectrum Analysis of the Building with and without Shear Wall

DESIGN CONSIDERATIONS FOR ANALYSIS

The following is the structural data considered for the analysis. Loads are taken according to IS 875(I & II & III). Design of R.C.C. elements is done as per IS 456-2000 from Limit state method. Seismic load calculations have been carried in accordance to IS 1893:2016 and Ductile detailing norms and detailing calculations are done as per IS 13920:2016.

RESULTS AND DISCUSSION

Obtained results from the analysis storey displacement, base Shear, story shear, and story drift and lateral forces which are obtained for all both models along both lateral directions i.e. along X & Y direction. Results and graphs are developed for multistoried building for models of structure with shear wall and without shear wall. Seismic Response of 14 storey building by Response spectrum Method (without shear wall)

Seismic Response of 14 storey building Response spectrum Method without Shear wall:-

THE DESIGN DATA SHALL BE AS FOLLOWS:-

Dead Load of slab 150mm thick +50 thick floor finishes.	:	4.75 kN/m^2
Live load (Rooms)	:	2.0 kN/m^2
Live load (Balcony/corridors/utilities)	:	3.0 kN/m^2
Staircase load (DL) Typical floors	:	8.0 kN/m^2
Staircase load (LL) Typical floors	:	3.0 kN/m^2
Floor finish	:	1.0 kN/m^2
Weight of partitions 9”	:	5.75 kN/m^2
Depth of foundation below ground	:	2.0 m
Safe bearing capacity (SBC) of the soil	:	200kN/m^2
Basement Storey height	:	2.0m
Typical Storey height	:	3.0m
Floors	:	B2 + G + 14 upper floors.
Plinth level	:	0.6 m
Water tank Slab+ finishes(DL) 150 thick	:	7 kN/m^2
Water tank (LL)	:	20 kN/m^2
LIFT Machine room (DL) 150 thick	:	4.75 kN/m^2
LIFT Machine room (LL)	:	10 kN/m^2
Zone factor of the building (Z)	:	0.24 (Zone IV)
Importance of the building (I)	:	1.0
Response reduction factor (R)	:	5(SMRF)
Soil type	:	Medium soil
Width of building in X-direction	:	64m
Width of building in Y-direction	:	31.4m
Height of the building	:	56m

STOREY	FLOOR HEIGHT	FLOOR WEIGHT	LATERAL FORCE (KN)	LATERAL FORCE (KN)	STOREY SHEARS (KN)	STOREY SHEARS (KN)	STOREY DRIFT	STOREY DRIFT
	m	KG	X DIRECTION	Y DIRECTION	X DIRECTION	Y DIRECTION	X DIRECTION	Y DIRECTION
TERRACE	56	78207.7	86.7532	123.8533	86.7532	123.8533	0.004206	0.0124
14F	53	651324.04	629.3708	898.5217	716.124	1022.3723	0.004405	0.016076
13F	50	718037.59	598.2563	854.1011	1314.3803	1876.469	0.005178	0.017177
12F	47	738974.76	524.6208	748.9753	1839.0012	2625.4443	0.005916	0.018533
11F	44	741718.16	442.4638	631.6837	2281.4649	3257.1321	0.006524	0.020007
10F	41	741718.16	365.6725	522.0527	2647.1374	3779.1885	0.007026	0.021368
9F	38	741718.16	296.1947	422.8627	2943.3322	4202.0546	0.007384	0.022408

8F	35	744182.87	234.8081	335.224	3178.1403	4537.2806	0.007526	0.022865
7F	32	747480.04	180.5715	257.793	3358.7117	4795.0754	0.007526	0.022818
6F	29	747480.04	132.6647	189.3989	3491.3765	4984.4758	0.007336	0.022172
5F	26	752025.32	92.6885	132.3268	3584.065	5116.8048	0.006935	0.020914
4F	23	767663.36	60.5542	86.4502	3644.6192	5203.2569	0.006511	0.019463
3F	20	778686.26	34.5508	49.3265	3679.17	5252.5843	0.006055	0.017973
2F	17	778686.26	15.3559	21.9229	3694.5259	5274.5079	0.005225	0.015732
1F	14	662544.09	3.2664	4.6633	3697.7923	5279.1715	0.004222	0.013124
GF	11	2320965.27	0	0	3697.7923	5279.1722	0.00296	0.010623
CELLAR	8	2450164.71	0	0	3697.7923	5279.1721	0.001607	0.007514
SUB CELLAR	5	2489077.88	0	0	3697.7923	5279.1721	0.001295	0.004457
PLINTH	2	420723.86	0	0	3697.7923	5279.1721	0.000659	0.001692
Base	0	66899.12	0	0	0	0	0	0
	MAXIMUM >		629.3708	898.5217	3697.7923	5279.1722	0.007526	0.022865

STOREY	STOREY STIFFNESS(KN/m)	STOREY STIFFNESS(KN/m)
	X-DIRECTION	Y-DIRECTION
TERRACE	7435.406	3523.864
14F	56409.521	28389.481
13F	91243.215	46627.321
12F	113748.806	58406.815
11F	129496.214	66016.556
10F	140385.118	71031.216
9F	149298.204	74840.187
8F	158865.656	78803.053
7F	168358.014	83109.018
6F	178597.616	88497.883
5F	194347.707	95768.682
4F	210776.559	104168.116
3F	228568.187	113552.125
2F	262848.824	127996.78
1F	333687.08	152746.828
GF	505603.274	204040.44
CELLAR	872670.207	282889.34
SUB CELLAR	1252151.114	475770.785
PLINTH	3237731.946	1988055.548
Base	0	0
	3237731.946	1988055.548

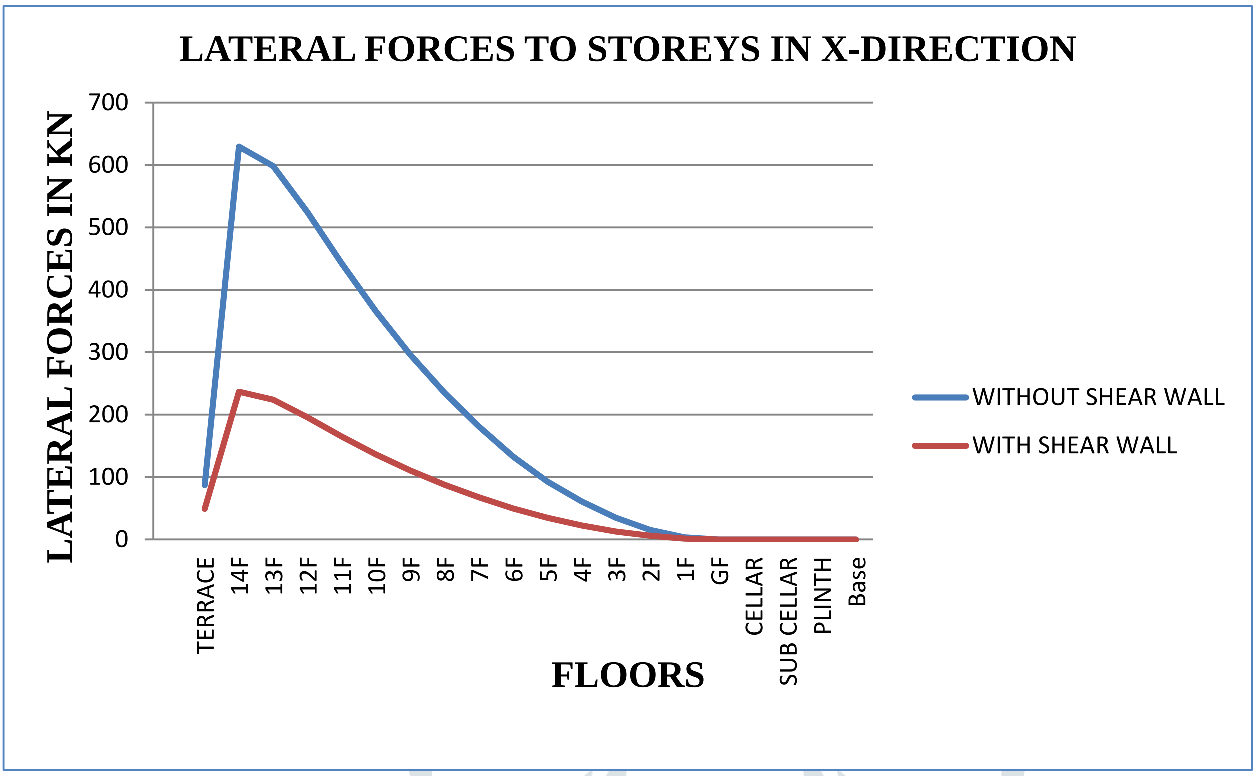
. Seismic Response of 14 storey building Response spectrum Method with Shear wall:-

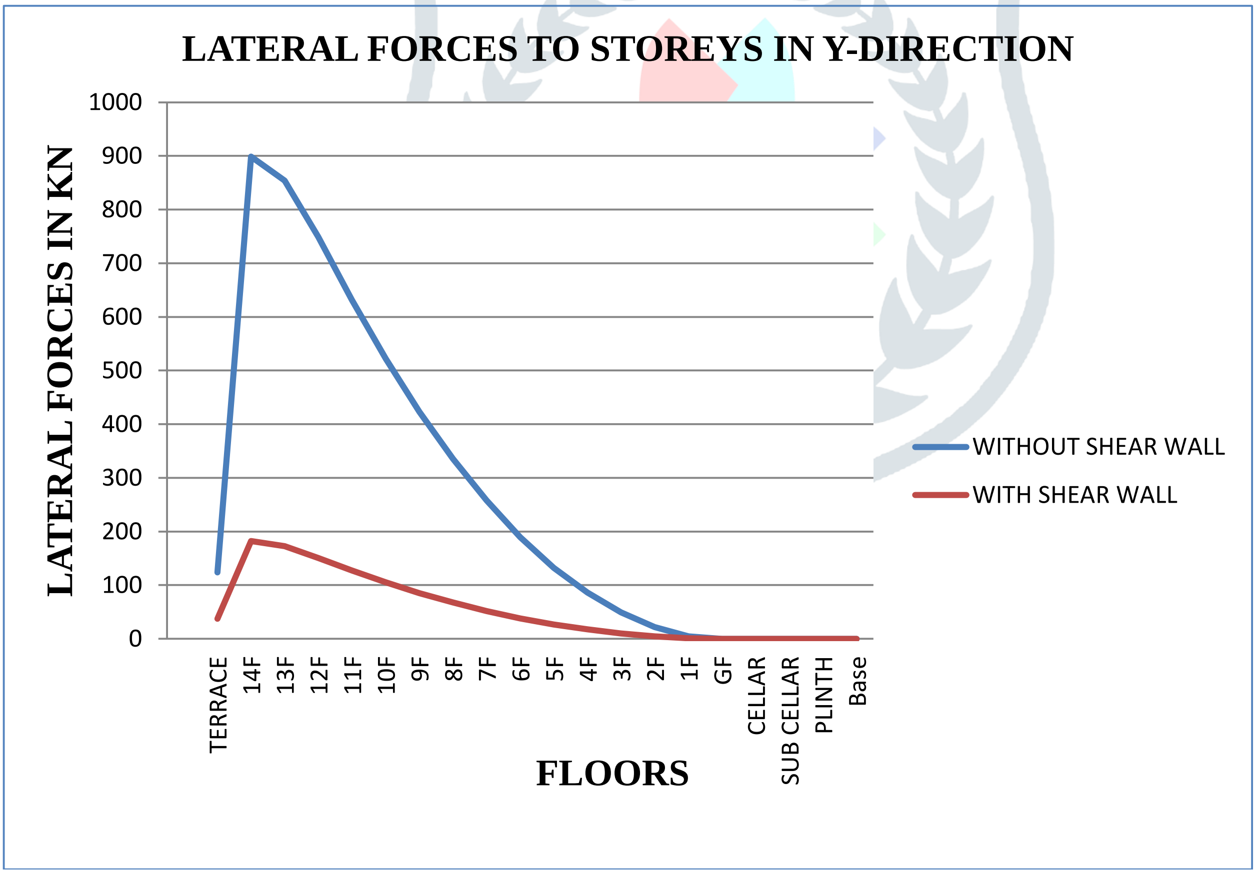
STOREY	FLOOR HEIGHT	FLOOR WEIGHT	LATERAL FORCE (KN)	LATERAL FORCE (KN)	STOREY SHEARS (KN)	STOREY SHEARS (KN)	STOREY DRIFT	STOREY DRIFT
	m	KG	X DIRECTION	Y DIRECTION	X DIRECTION	Y DIRECTION	X DIRECTION	Y DIRECTION
TERRACE	56	127314.08	48.7814	37.6188	48.7814	37.618	0.001173	0.001366
14F	53	708876.81	236.604	182.462	285.3855	240.5685	0.001152	0.001556
13F	50	777271.17	223.6941	172.5063	509.0796	433.0305	0.001166	0.001571
12F	47	798007.29	195.6882	150.9089	704.7678	595.1536	0.001171	0.001604
11F	44	800750.69	164.9977	127.2414	869.7655	738.9218	0.001171	0.001639
10F	41	800750.69	136.3618	105.1581	1006.1273	856.8073	0.001161	0.001664
9F	38	800750.69	110.453	85.1781	1116.5804	955.9245	0.001139	0.001671
8F	35	803237.39	87.5425	67.5102	1204.1229	1034.3305	0.001104	0.001655
7F	32	806837.25	67.3251	51.9192	1271.4481	1097.1763	0.00106	0.001618
6F	29	806837.25	49.4634	38.1447	1320.9114	1143.5841	0.001008	0.001557
5F	26	811835.56	34.5624	26.6535	1355.4738	1177.063	0.000946	0.001466
4F	23	827207.38	22.5387	17.3812	1378.0125	1202.7743	0.000879	0.001364
3F	20	838515.24	12.8513	9.9106	1390.8639	1218.0486	0.000803	0.00126
2F	17	838515.24	5.7117	4.4047	1396.5756	1227.1552	0.000708	0.001117
1F	14	720268.13	1.2266	0.9459	1397.8022	1228.3791	0.000603	0.00096
GF	11	2379775.9	0	0	1397.8022	1228.5488	0.000479	0.000823
CELLAR	8	2511059.08	0	0	1397.8022	1228.5488	0.000328	0.000609
SUB CELLAR	5	2549972.25	0	0	1397.8022	1228.5488	0.000221	0.000369
PLINTH	2	466830.29	0	0	1397.8022	1228.5488	0.000195	0.000141
Base	0	77940.4	0	0	0	0	0	0
	MAXIMUM >		236.604	182.462	1397.8022	1228.5488	0.001173	0.001671

STOREY	STOREY STIFFNESS(KN/m)	STOREY STIFFNESS(KN/m)
	X-DIRECTION	Y-DIRECTION
TERRACE	14115.834	9416.175
14F	83678.533	59309.651
13F	147749.88	103807.405
12F	203516.562	140749.631
11F	250822.944	171851.388
10F	292283.009	197229.97
9F	330868.199	219536.946
8F	367735.636	239709.772
7F	405789.983	259544.249
6F	447442.736	280764.378
5F	495826.186	305956.554
4F	542577.951	334968.186
3F	604225.256	366944.429
2F	693619.646	411745.162
1F	830346.617	478855.026
GF	1078586.445	610006.057
CELLAR	1659928.082	821126.761
SUB CELLAR	2613883.253	1354322.928
PLINTH	5253207.312	5608000.514
Base	0	0
	5253207.312	5608000.514

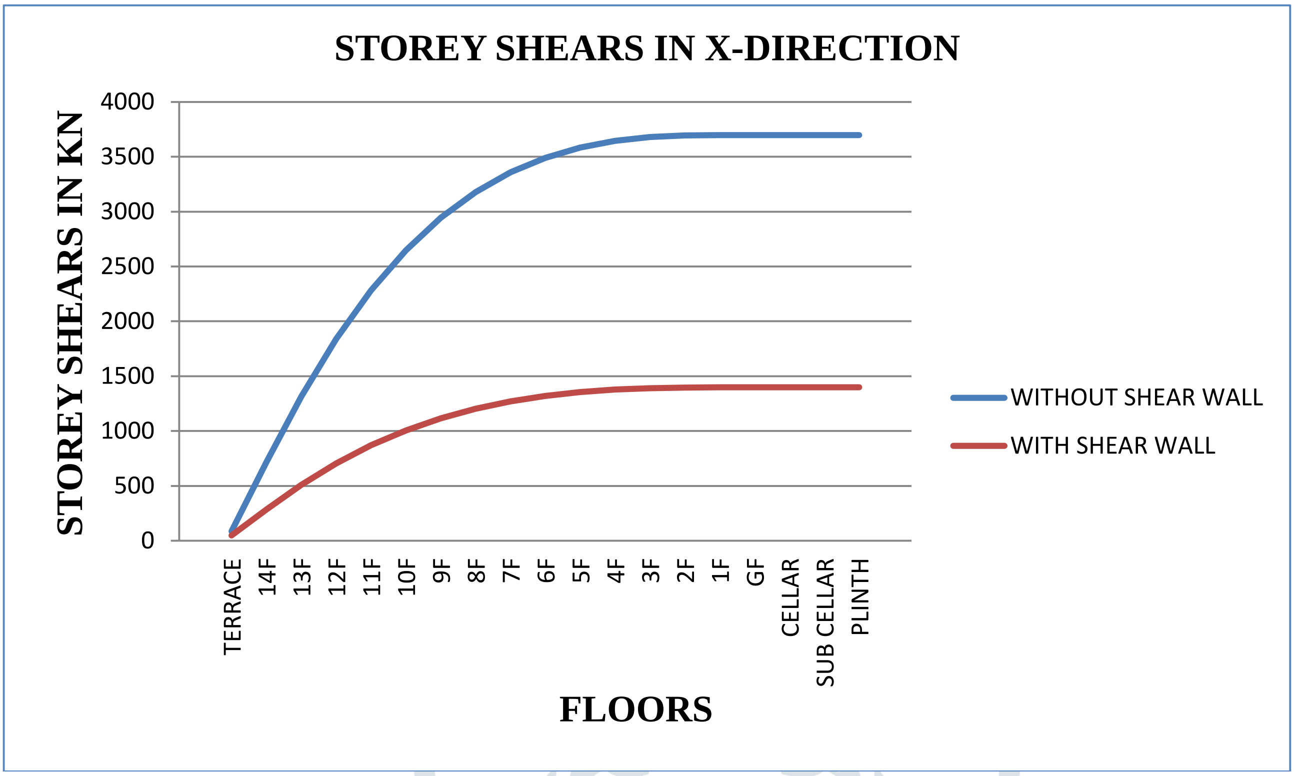
Graphs:-

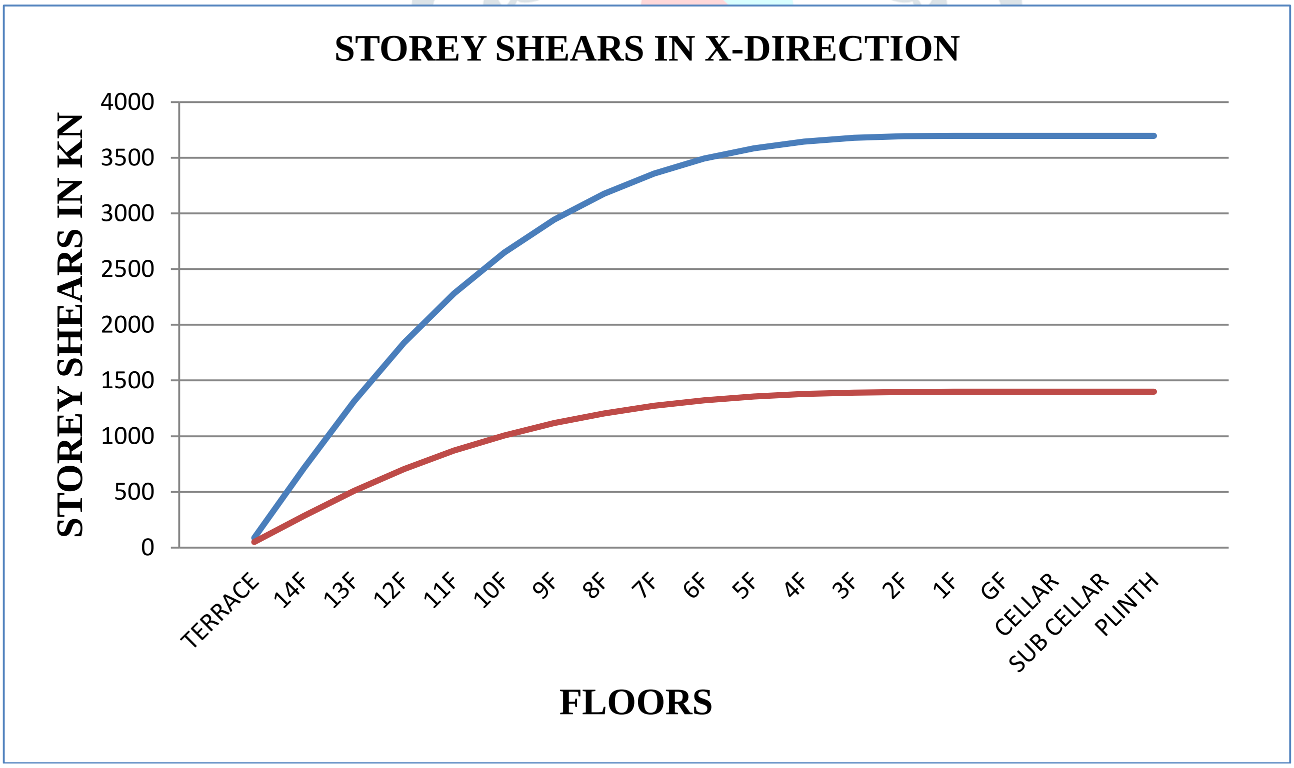
Lateral Forces:



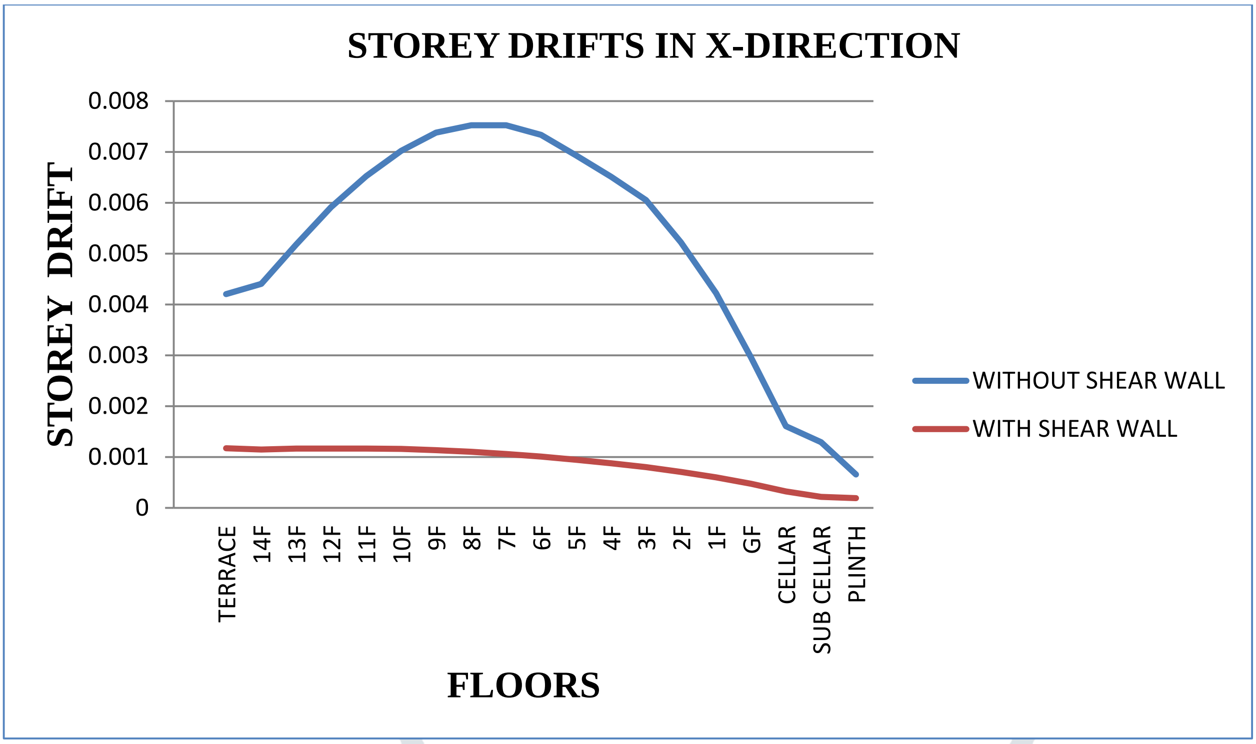


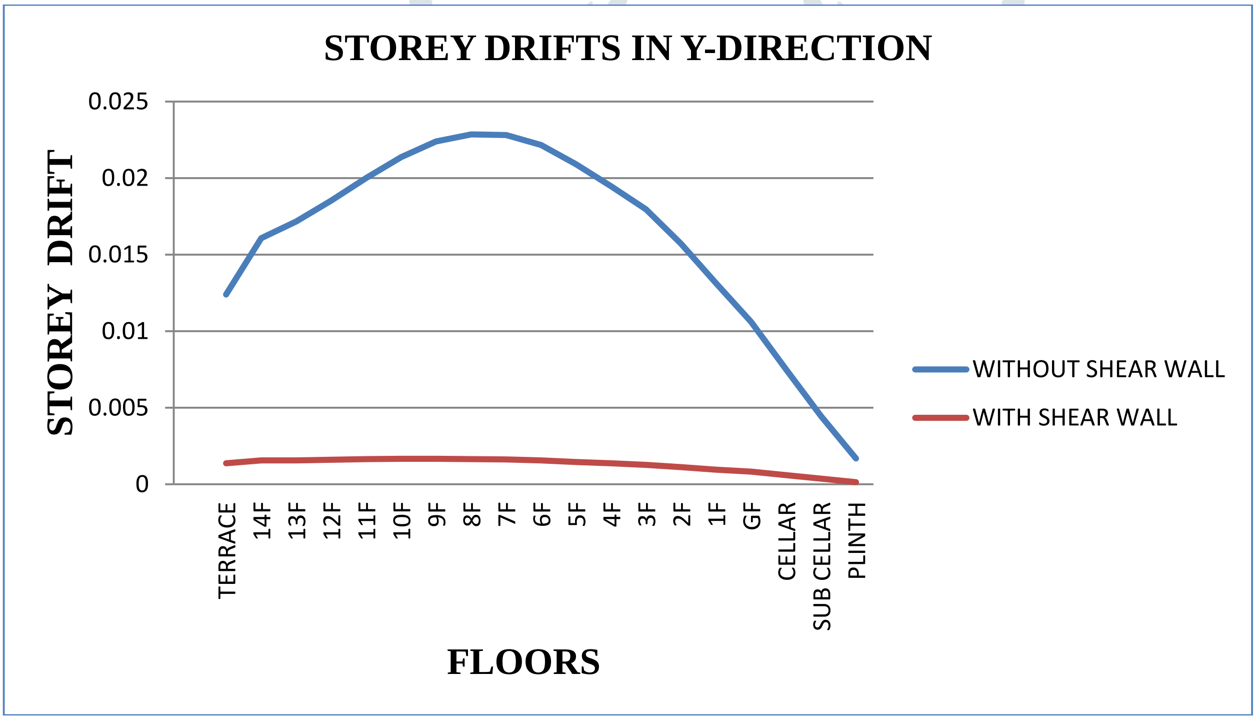
Storey Shears:-



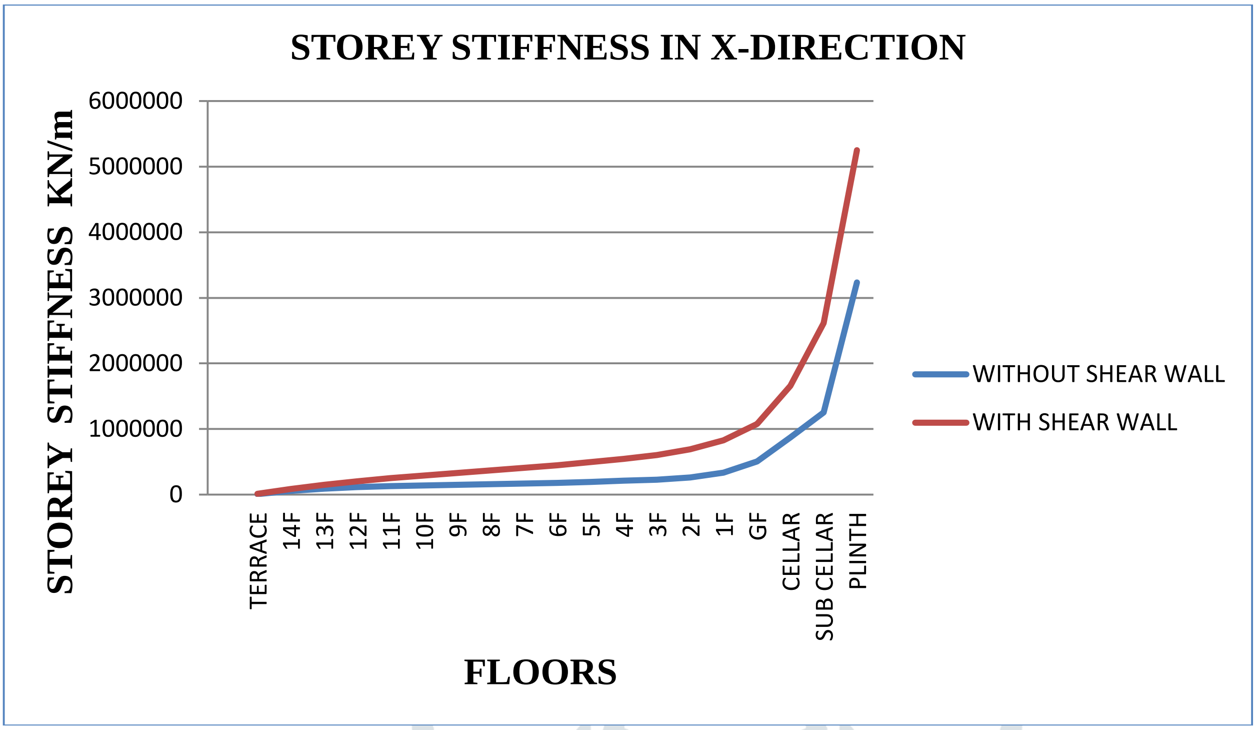


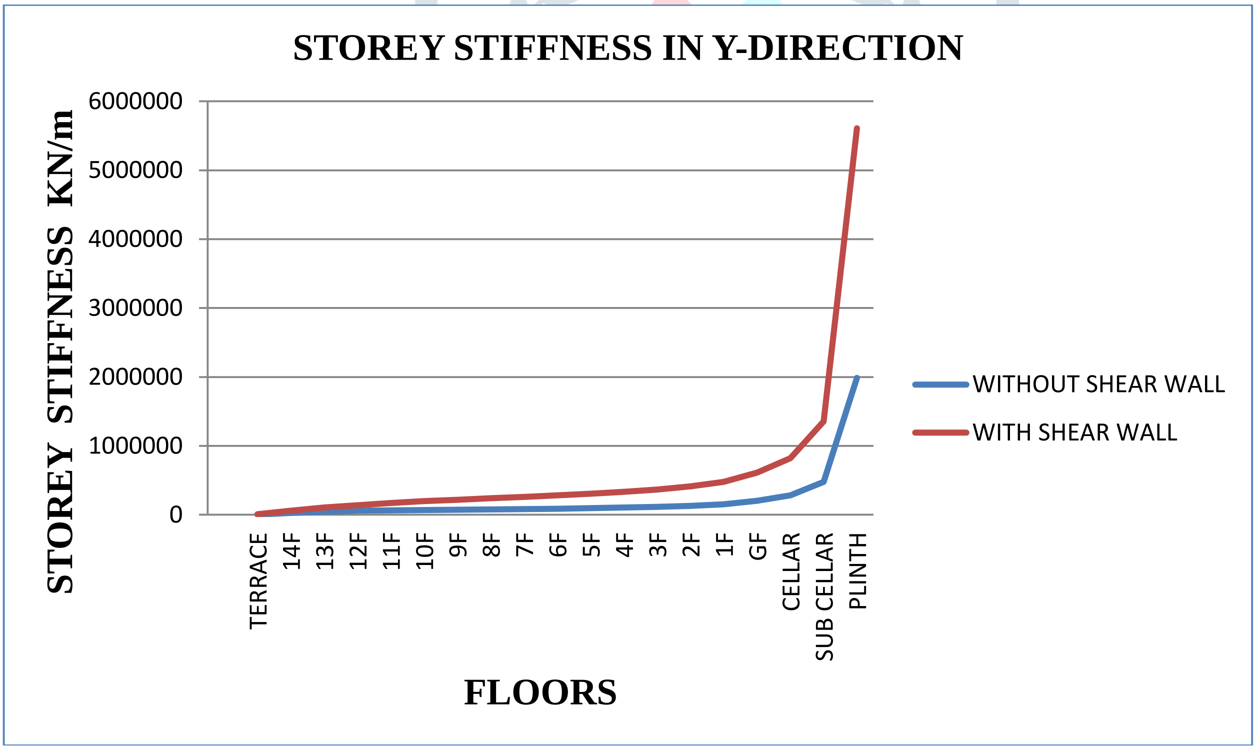
Storey Drifts:-





Storey Stiffness:-





CONCLUSIONS

The present study thesis compares the analysis and design results of building models with and without shear wall. The following were the conclusions which are taken based on the analysis results from both models

1.) After the application of lateral loads on to the building models in both X and Y directions, the building with shear wall shown the less lateral displacements when compared to the regular building model.
2.) The storey drift was observed to be less in shear wall building ,when compared to regular building where the storey drifts are observed to be maximum at the mid storey levels in both the models
3.) The storey stiffness when observed is high in the building with shear wall than the regular building.
4.) It is observed that the presence of shear wall attracts more lateral forces than the regular building.
5.) It is observed that there is increase in lateral displacement, storey drifts and storey shears with increase in building height.
6.) The shear wall acts as a backbone to reduce the lateral forces coming on to a structure, however it is uneconomical
7.) So it is preferable to construct a shear wall structure in high seismic zones where it is very much necessary.

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