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Anlysis of RCC Building with Multiple Soft Story Using Etabs.

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ABSTRACT:
Earthquake is the most challenging force that affects the buildings and other structures. The most affected type of structure is the building with soft stories. The soft storey located in the lower part of the high rise building especially the ground storey is undesirable as it attracts severely large seismic forces. At the same time, the soft storey located in the upper part of the high-rise building does not significantly affect the stability of the building. The building in which the ground storey consists of open space for parking area is known as stilt building and the parking storey is called as stilt floor or soft-storey. When sudden change of stiffness takes place along the building height, the storey in which the drastic reduction of stiffness is observed is known as soft storey. The building with soft storey is analysed using softwares like E-tabs, Staad-Pro and SAP 2000, and by methods such as time history analysis, response spectrum analysis and pushover analysis. In this proposed paper, we are going to study the literature using the previous researches for further analysis and design of multi-storey building with multiple soft stories

Key words: *soft story analysis, E-tabs, Staad-Pro, SAP2000, time history analysis, response spectrum analysis, pushover analysis.*

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I. INTRODUCTION: -

Stability of earth is always disturbed due to internal forces and as a result of such disturbance, vibrations or jerks in earth's crust takes place, which is known as an earthquake. The fundamental design concept of earthquake resistance design of structures is to make strong column- weak beam construction to ensure safety of user means during earthquake beams yield before columns collapse. Many buildings that collapsed during the past earthquake exhibited exactly the opposite strong beam weak column behaviour means columns failed before the beams yielded mainly due to soft storey effect. A simple understanding of soft storey is sudden change of lateral storey stiffness within the structure. An irregularity in vertical configuration tends to create sudden changes in strength or stiffness that may concentrate earthquake forces or other forces in an undesirable way. These can be very difficult to deal with even in a modern structure although the size of the overall force that building must withstand is determined by the Newton's second law of motion, the way in which this is distributed and concentrated, is determined by the configuration of building in horizontal and vertical direction. The overall forces are concentrated at one or few points of the buildings such as a particular set of beams, columns, or walls. These few members may fail and, by chain reaction, bring down the whole building. The most serious condition of vertical irregularity is that of the soft storey. Such design creates a major stress concentration at that location of discontinuity of lateral storey stiffness and, in extreme circumstance may lead to collapse unless adequate design is provided at such locations.

II. STUDY OBJECTIVES: -

The soft storey irregularity is the most hazardous irregularities. The main objectives of the study are given below:

1. To study the behaviour of structure with multiple soft stories during earthquake.
2. To find out the displacement and storey drifts at each storey level using Time history analysis and Response Spectrum analysis.
3. To study the parameters such as storey drift, storey displacement, story shear in multi-story building.
4. To check the results with software ETABS with different models.

Following factors or parameters affect the weak-story irregularity formation in structures:
1. Height of the weak-story.
2. Existence of mezzanine floor
3. Rigidity and distribution of columns in weak-story.
4. Overhang and cantilever projection existence in weak-story.
5. Infill wall material properties.
6. Soil class and properties.
7. Floor number.
8. Seismic conditions.

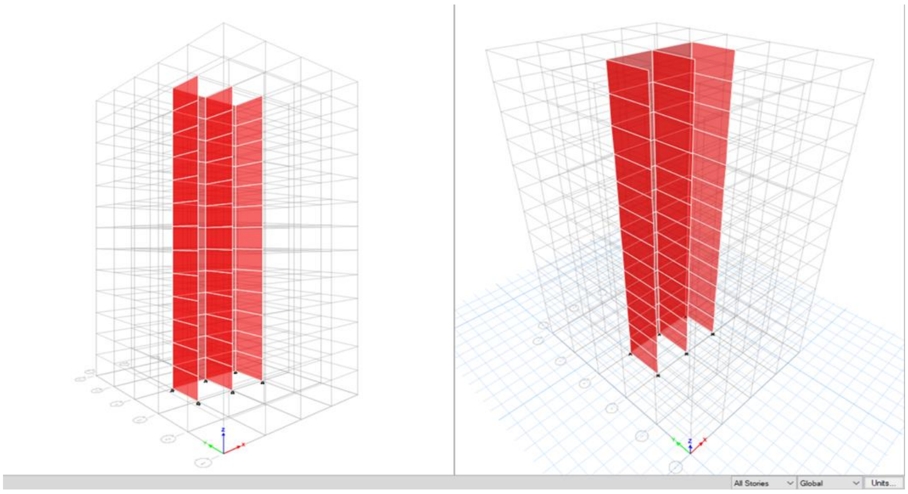
These factors must be considered for eliminating the destructive effects of the weak-story irregularity.
If weak story present in buildings, measures must be taken for preventing the adverse effects of this irregularity.

MODEL DESCRIPTION:

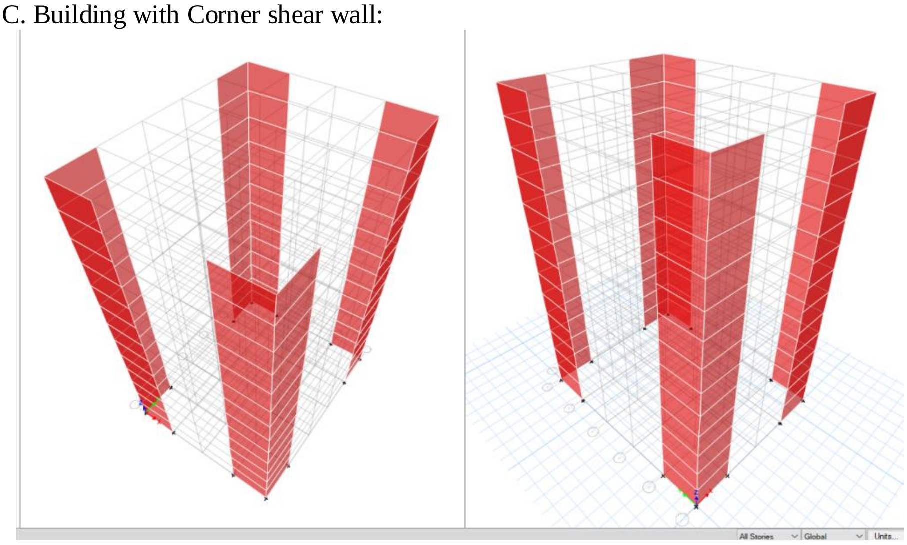
Utility of building	Residential building
No. of stories	13 stories (3parking+10 residential)
Grade of concrete	M40
Grade of reinforcing steel	HYSD Fe 415
Type of construction	RCC Framed structure
Dimension of beam	300*400, 500*300, 550*350, 600*400 (Auto Select)
Dimension of column	500*500, 550*550, 600*600, 750*750 (Auto Select)
Thickness of slab	150mm
Thickness of wall (masonry)	230 mm
Thickness of wall (shear wall)	250 mm
Height of bottom story	3.0m
Height of remaining story	3.0m
Total building height	40.5m
Live load	5 kn/m
Dead load	2 kn/m
Load considered in building	Dead load, live Load, Earthquake load
Method of analysis	Response spectrum method, time history analysis
RCC design code	IS 456:2000
Steel design code	IS 800:2007
Earthquake design code	IS 1893:2002 (PART 1)
Software used	Etabs v.17

Models used for Analysis:

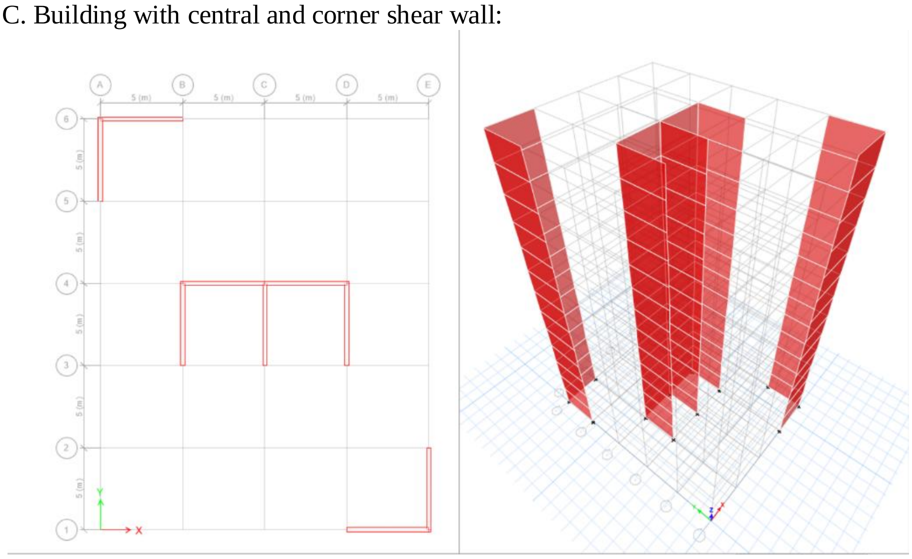
1. R.C.C. Building with central shear wall:



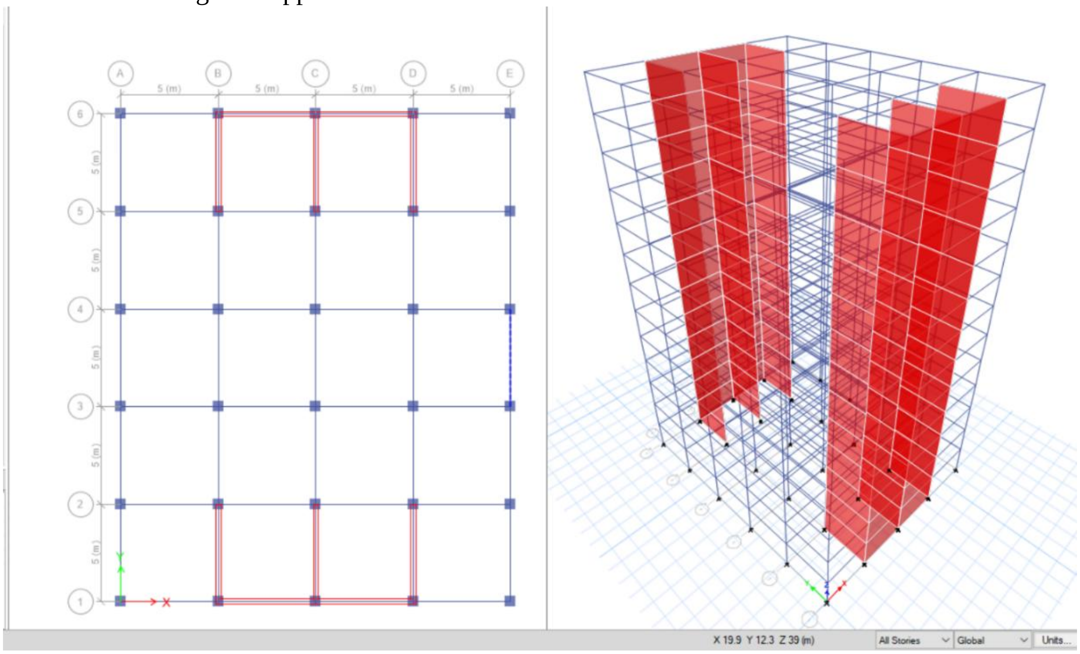
2. R.C.C. Building with Corner shear wall:



3. R.C.C. Building with central and corner shear wall:



4. R.C.C. Building with opposite shear wall:



III. Methodology:

For the study of the various methods of the linear and nonlinear analysis following steps should be followed.

1. Select the building for the study of the building which is open ground story building (3 OGS+10 Residential).
2. Review and detail study of the previous researches, study and literature of the effect of OGS building and infill wall as per code recommended.
3. The model was developed with infill masonry and different shear wall condition.
4. The models are analysed based on linear and nonlinear methods

Different analysis done on model and different considerations for analysis:

➢ Response Spectrum Analysis: The linear dynamic method of analysis has been proved to be the efficient ever design methods and almost mostly used and suggested by the structural designers for the purpose of analysis and design of the RC framed structure and their respective components.

When we carry out the dynamic analysis, the inelastic response is empirically purely reviewed, As the non-linear behavioural properties of the buildings which purely govern the designing under the strong ground motion. Due to these reasons the designers suggests and they too prefer the simplex methodology to carry out the analysis with the help of the elastic dynamic analysis methods. The consideration of the modal contributions of each mode is the very important parameter in case of the multi-storeyed buildings. A unique deformation possesses at each single mode. The several important factors of the building structures are purely depending on the contributions from these vibration modes. The modal contributions resulting from the higher modes is smaller for the seismic response of a short to medium rise buildings because of the influencing property of the fundamental mode is very larger that is in the range of about 70-90%.

Here in this method, it is mostly important to consider the vibrations at the initial stages so that we get the results in an almost nearer exactly conditions.

Seismic zone factor (Z)	0.16
Seismic zone	3
Importance factor (I)	1.2
Soil type	1
Response reduction factor®	3
Function damping ratio	0.05

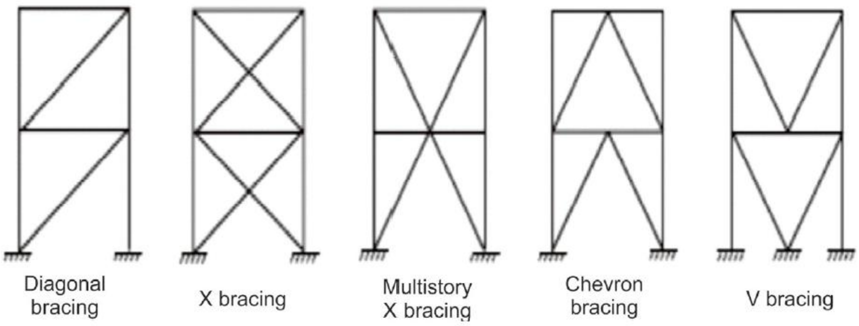
➢ Time history analysis: Time-history analysis is the behavioral study of a structure under a past earthquake or wind acceleration data. Structure need not be SDOF system. Time-history is a plot of amplitude or acceleration vs time. In time history analyses the structural response is computed at a number of subsequent time instants.

✓ Time history data: Bhuj earthquake Data is used.

➢ Seismic analysis: It is a subset of structural analysis and is the calculation of the response of a building structure to earthquakes. It is part of the process of structural design, earthquake engineering or structural assessment and retrofit in regions where earthquakes are prevalent.

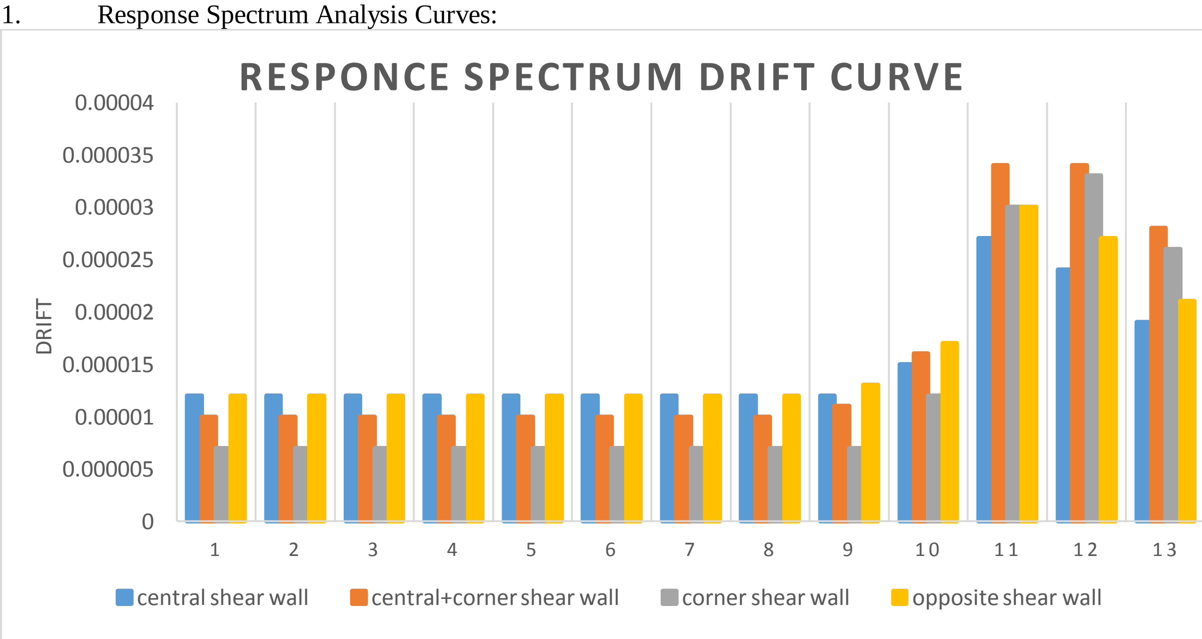
Direction and Eccentricity	X-direction
Seismic Zone Factor (Z)	0.16 (As per code)
Importance Factor (I)	1.2
Site type	1

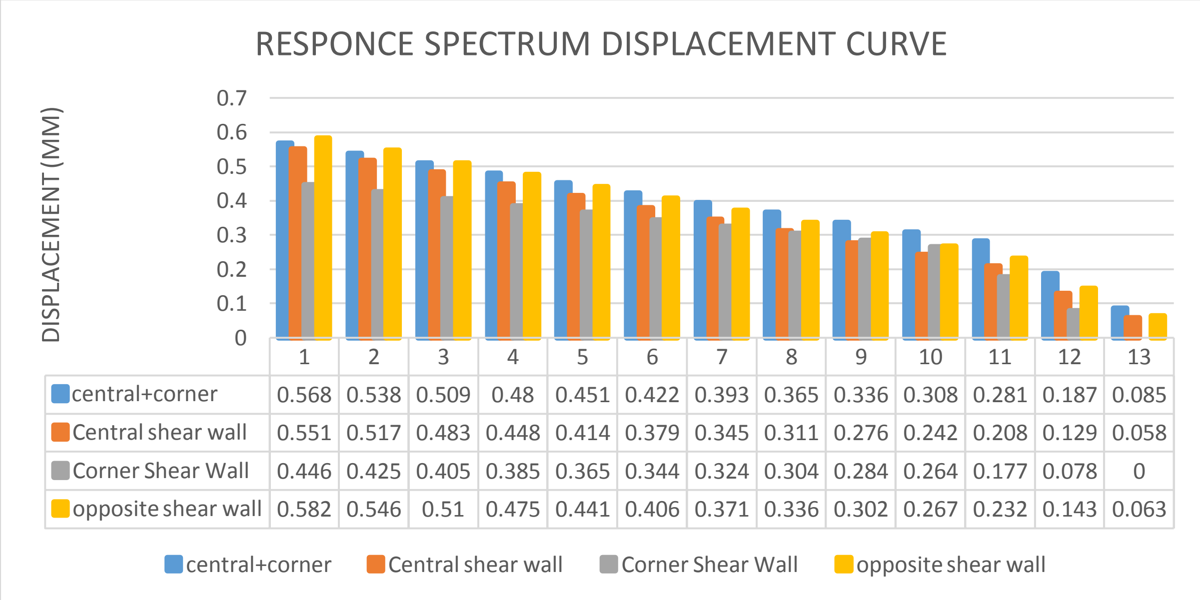
❖ Provisions of Bracings: Braced frames are used for trussing to resist sideway forces on structure. Trussing or triangulation, is formed by inserting corner to corner (diagonal) structural members into rectangular zones of a structural frame. It helps to stabilize the frame against sideway forces from earthquakes and strong winds. In a braced frame, bracing is usually provided in each storey of the structure to resist the forces. Beams, columns and braces arranged in such a way to form a truss. It resists lateral seismic forces by truss action and develops flexibility through inelastic action in braces.



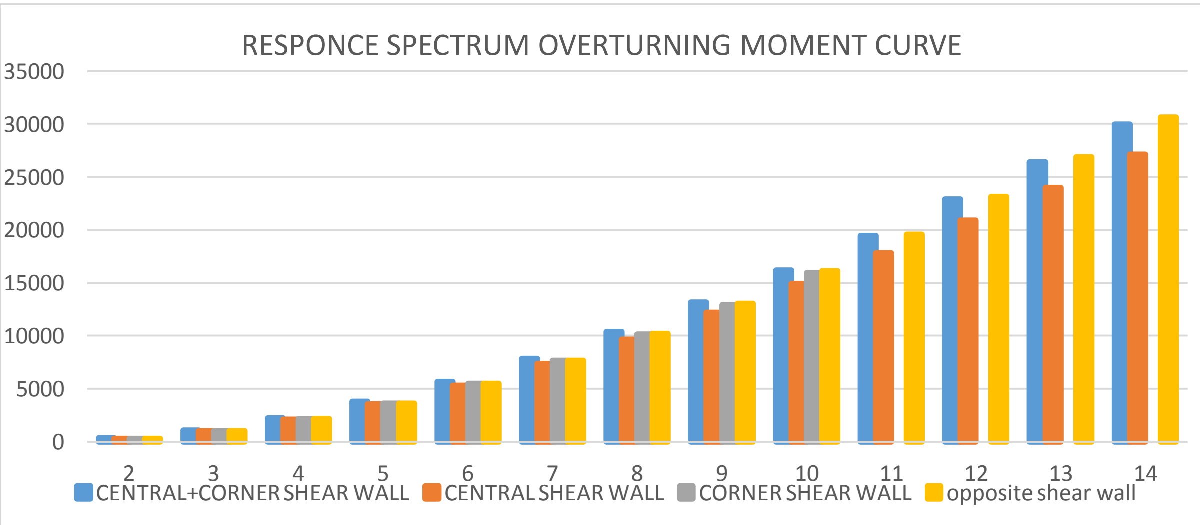
IV. Results:

1. Response Spectrum Analysis Curves:



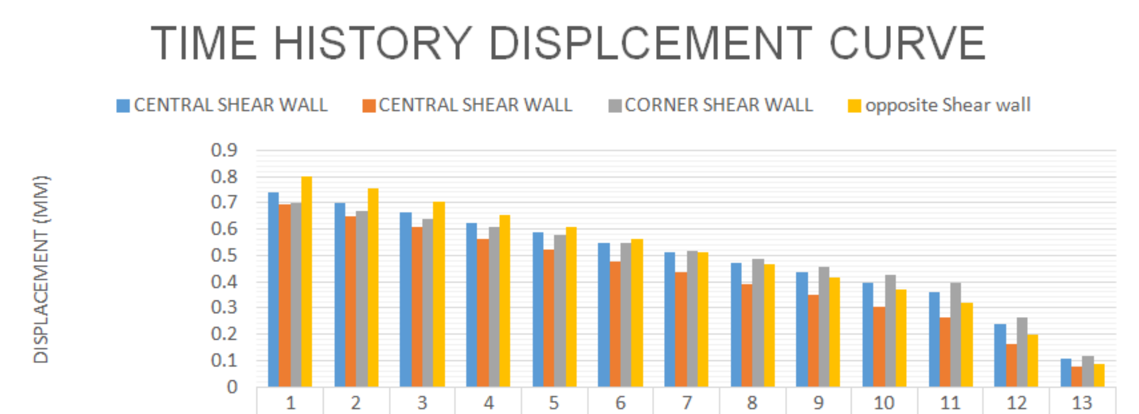


Story3	9	Top	0.000027	0.000029	Story3	9	Top	0.000034	0.000024
Story2	6	Top	0.000024	0.000031	Story2	6	Top	0.000034	0.000026
Story1	3	Top	0.000019	0.000027	Story1	3	Top	0.000028	0.000021
Base	0	Top	0	0	Base	0	Top	0	0
		CENTRAL SHEAR WALL					CENTRAL + CORNER SHEAR WALL		
Story3	9	Top	0.00003	0.000029	Story3	9	Top	0.00003	0.000018
Story2	6	Top	0.000033	0.000032	Story2	6	Top	0.000027	0.000019
Story1	3	Top	0.000026	0.000026	Story1	3	Top	0.000021	0.000015
Base	0	Top	0	0	Base	0	Top	0	0
		CORNER SHEAR WALLS					OPPOSITE SHEAR WALL		

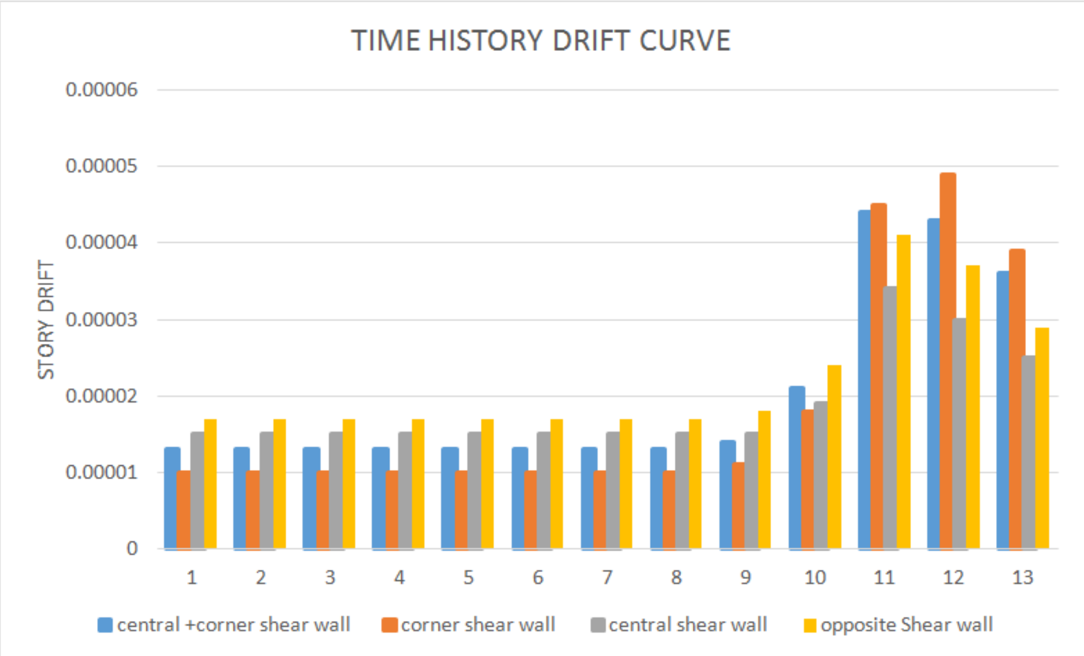


Story3	9	Top	19617.19	19451.58		Story3	9	Top	17809.7	17839.62
Story2	6	Top	23127.74	22877.79		Story2	6	Top	20963.35	20884.86
Story1	3	Top	26730.46	26388.84		Story1	3	Top	24188.56	23986.21
Base	0	Top	30376.65	29942.57		Base	0	Top	27449.17	27116.6
CENTRAL + CORNER SHEAR WALL						CENTRAL SHEAR WALL				
Story3	9	Top	17809.7	17839.62		Story3	9	Top	19541.04	19849.85
Story2	6	Top	20963.35	20884.86		Story2	6	Top	23141.86	23256.3
Story1	3	Top	24188.56	23986.21		Story1	3	Top	26846.85	26734.85
Base	0	Top	27449.17	27116.6		Base	0	Top	30599.3	30250.01
CENTRAL SHEAR WALL						OPPOSITE SHEAR WALL				

2. Time History Analysis Curves:



	1	2	3	4	5	6	7	8	9	10	11	12	13
CENTRAL SHEAR WALL	0.739	0.701	0.663	0.625	0.587	0.549	0.51	0.472	0.434	0.396	0.358	0.236	0.108
CENTRAL SHEAR WALL	0.694	0.651	0.608	0.564	0.521	0.478	0.435	0.392	0.348	0.305	0.262	0.164	0.074
CORNER SHEAR WALL	0.699	0.669	0.638	0.608	0.577	0.547	0.517	0.486	0.456	0.426	0.395	0.265	0.117
opposite Shear wall	0.803	0.753	0.704	0.656	0.608	0.56	0.512	0.464	0.416	0.368	0.32	0.197	0.086

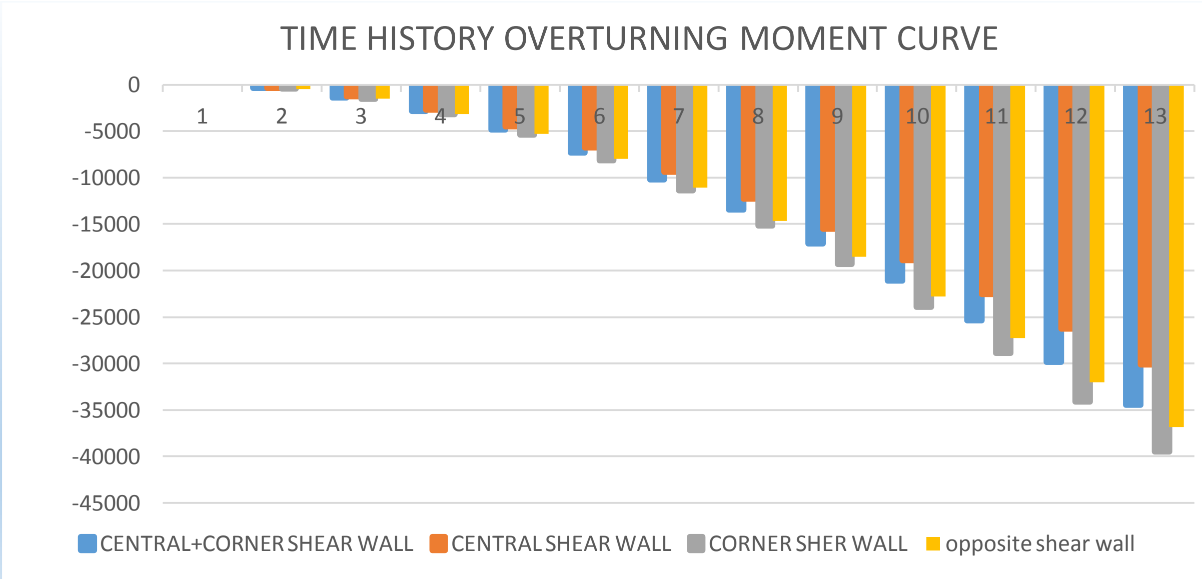


Story3	9	Top	0.000044	0.000021	Story3	9	Top	0.000045	0.000002
Story2	6	Top	0.000043	0.00002	Story2	6	Top	0.000049	0.000003
Story1	3	Top	0.000036	0.000016	Story1	3	Top	0.000039	0.000002
Base	0	Top	0	0	Base	0	Top	0	0

CENTRAL + CORNER SHEAR WALL — CORNER SHEAR WALLS

Story3	9	Top	0.000034	0.000001	Story3	9	Top	0.000041	0.000002
Story2	6	Top	0.00003	0.000001	Story2	6	Top	0.000037	0.000002
Story1	3	Top	0.000025	0.000001	Story1	3	Top	0.000029	0.000001
Base	0	Top	0	0	Base	0	Top	0	0

CENTRAL SHEAR WALL — OPPOSITE SHEAR WALL



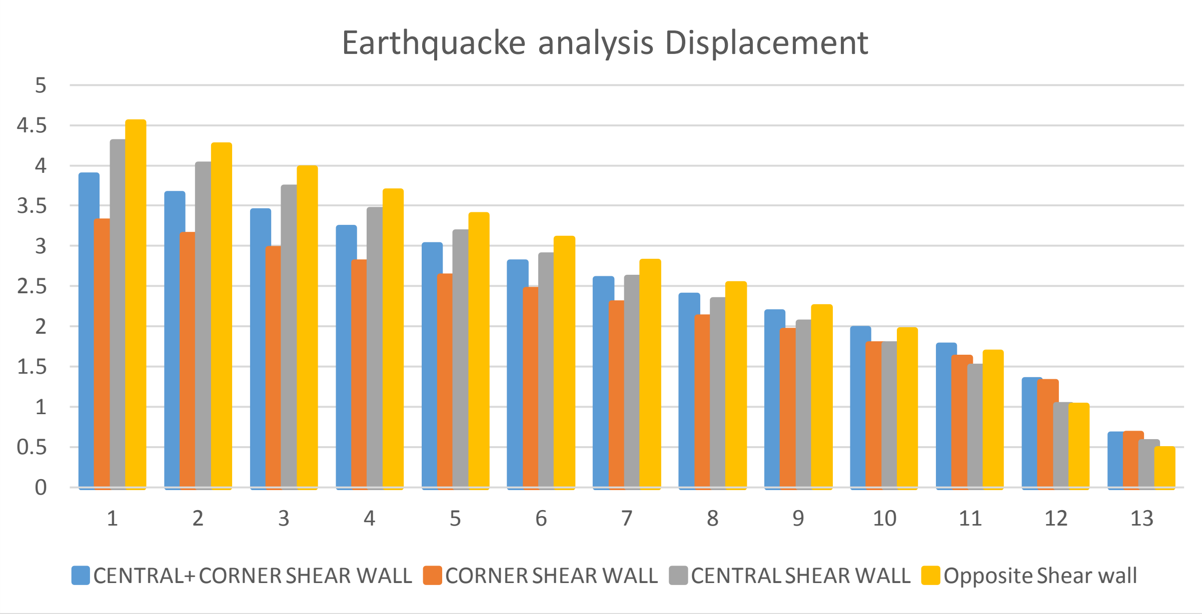
Story3	9	Top	-13651.9844	-25397.9	Story3	9	Top	-0.0001	-22539.3
Story2	6	Top	-16084.2821	-29884.3	Story2	6	Top	-2.65E-05	-26251.6
Story1	3	Top	-18572.2271	-34477.8	Story1	3	Top	-0.0001	-30099.4
Base	0	Top	23014.4345	38077.45	Base	0	Top	0.0001	36622.36

CENTRAL + CORNER SHEAR WALL — CENTRAL SHEAR WALL - COPY - COPY -

Story3	9	Top	-9.83E-06	-28889.8	Story3	9	Top	-1.18E-05	-27303.9
Story2	6	Top	-1.51E-05	-34136.3	Story2	6	Top	-0.0001	-32028.8
Story1	3	Top	-8.78E-06	-39526.7	Story1	3	Top	-0.0001	-36847.8
Base	0	Top	2.63E-05	44147.87	Base	0	Top	9.21E-06	41213.89

CORNER SHEAR WALLS. — OPPOSITE SHEAR WALL.

3. Seismic Analysis Curves:



Story3	9	Top	1.761	1.359
Story2	6	Top	1.331	1.063
Story1	3	Top	0.657	0.537
Base	0	Top	0	0

CENTRAL + CORNER SHEAR WALL

Story3	9	Top	1.61	1.492
Story2	6	Top	1.31	1.243
Story1	3	Top	0.67	0.644
Base	0	Top	0	0

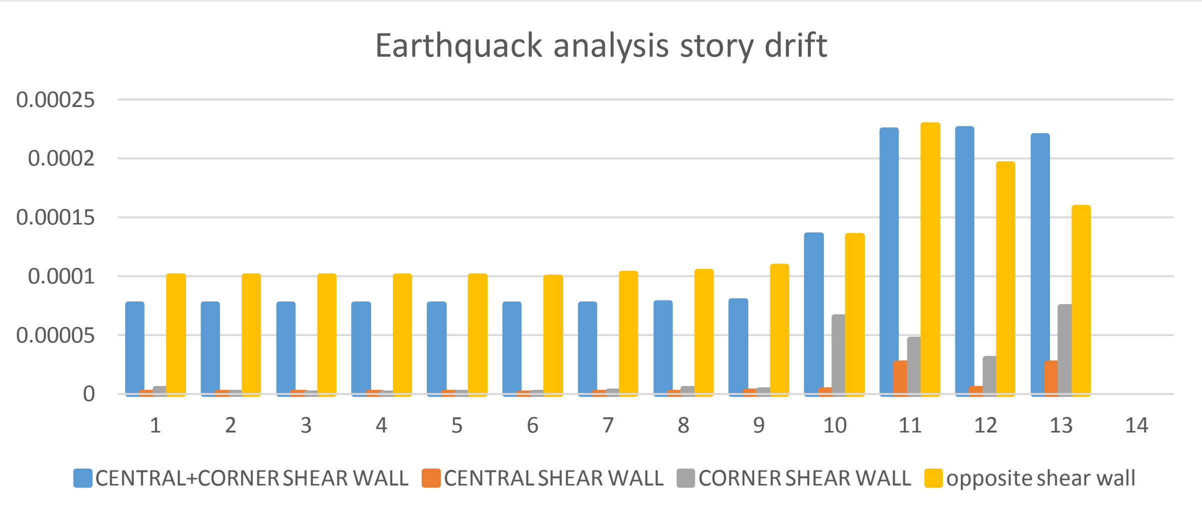
CORNER SHEAR WALLS

Story3	9	Top	1.502	0.095
Story2	6	Top	1.026	0.126
Story1	3	Top	0.561	0.142
Base	0	Top	0	0

CENTRAL SHEAR WALL

Story3	9	Top	1.67	0.055
Story2	6	Top	1.02	0.12
Story1	3	Top	0.47	0.099
Base	0	Top	0	0

OPPOSITE SHEAR WALL.



Story3	9	Top	0.000224	0.000169
Story2	6	Top	0.000225	0.000176
Story1	3	Top	0.000219	0.000179
Base	0	Top	0	0

CENTRAL + CORNER SHEAR WALL

Story3	9	Top	0.000026	0.000025
Story2	6	Top	0.000004	0.000006
Story1	3	Top	0.000026	0.000023
Base	0	Top	0	0

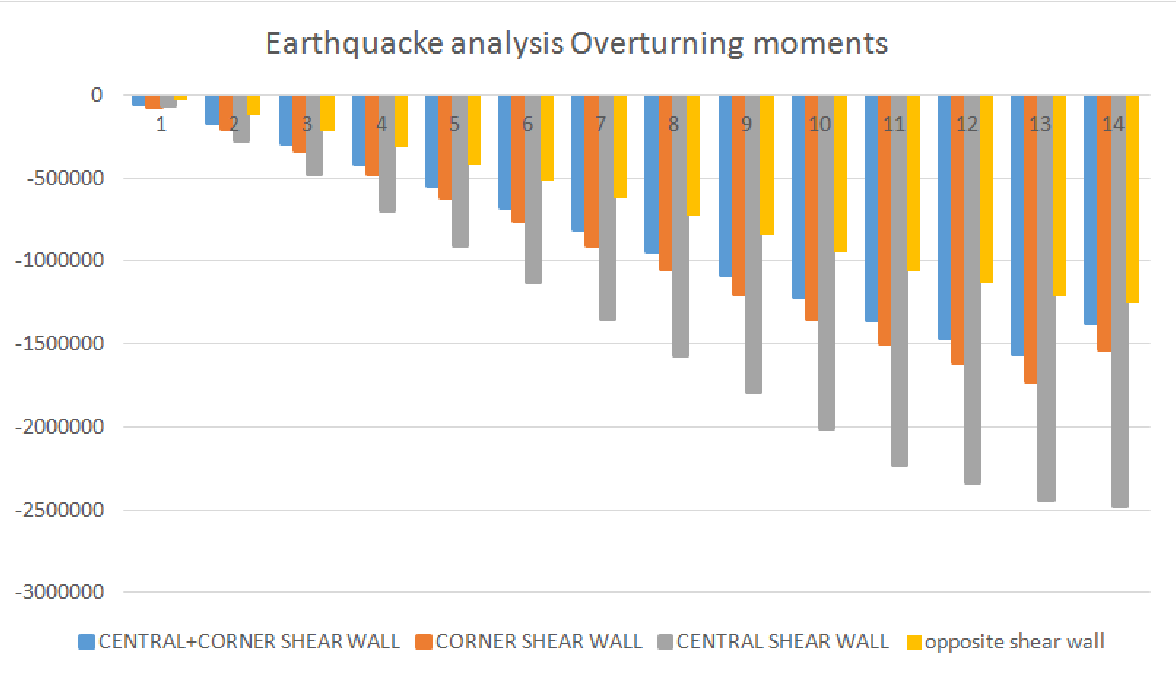
CENTRAL SHEAR WALL

Story3	9	Top	0.000046	0.000049
Story2	6	Top	0.00003	0.000032
Story1	3	Top	0.000074	0.00008
Base	0	Top	0	0

CORNER SHEAR WALLS

Story3	9	Top	0.000228	0.000022
Story2	6	Top	0.000195	0.000009
Story1	3	Top	0.000158	0.000033
Base	0	Top	0	0

OPPOSITE SHEAR WALL



Story3	9	Top	1490440.45	-1358256
Story2	6	Top	1589415.05	-1460886
Story1	3	Top	1688389.64	-1563590
Base	0	Top	1960018.7	-1374672

CENTRAL + CORNER SHEAR WALL

Story3	9	Top	1671313.055	-1500669
Story2	6	Top	1784160.974	-1614370
Story1	3	Top	1897008.893	-1728140
Base	0	Top	2151022.06	-1533583

CORNER SHEAR WALLS

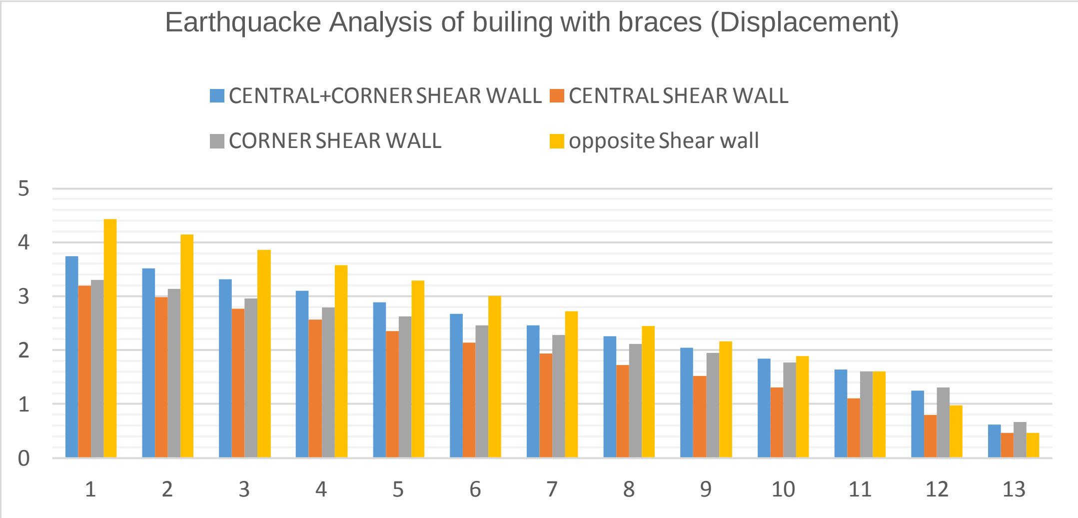
Story3	9	Top	2607920.56	-2235426
Story2	6	Top	2711774	-2339909
Story1	3	Top	2815627.43	-2444452
Base	0	Top	2835674.63	-2481965

CENTRAL SHEAR WALL

Story3	9	Top	1114815.749	-1059917
Story2	6	Top	1180494.497	-1136533
Story1	3	Top	1246173.245	-1213226
Base	0	Top	1271473.607	-1257635

OPPOSITE SHEAR WALL

4. Seismic Analysis with provision of cross Bracings:



Story3	9	Top	1.64	1.305
Story2	6	Top	1.249	1.03
Story1	3	Top	0.623	0.523
Base	0	Top	0	0

CENTRAL + CORNER SHEAR WALL

Story3	9	Top	1.108	0.095
Story2	6	Top	0.796	0.124
Story1	3	Top	0.458	0.137
Base	0	Top	0	0

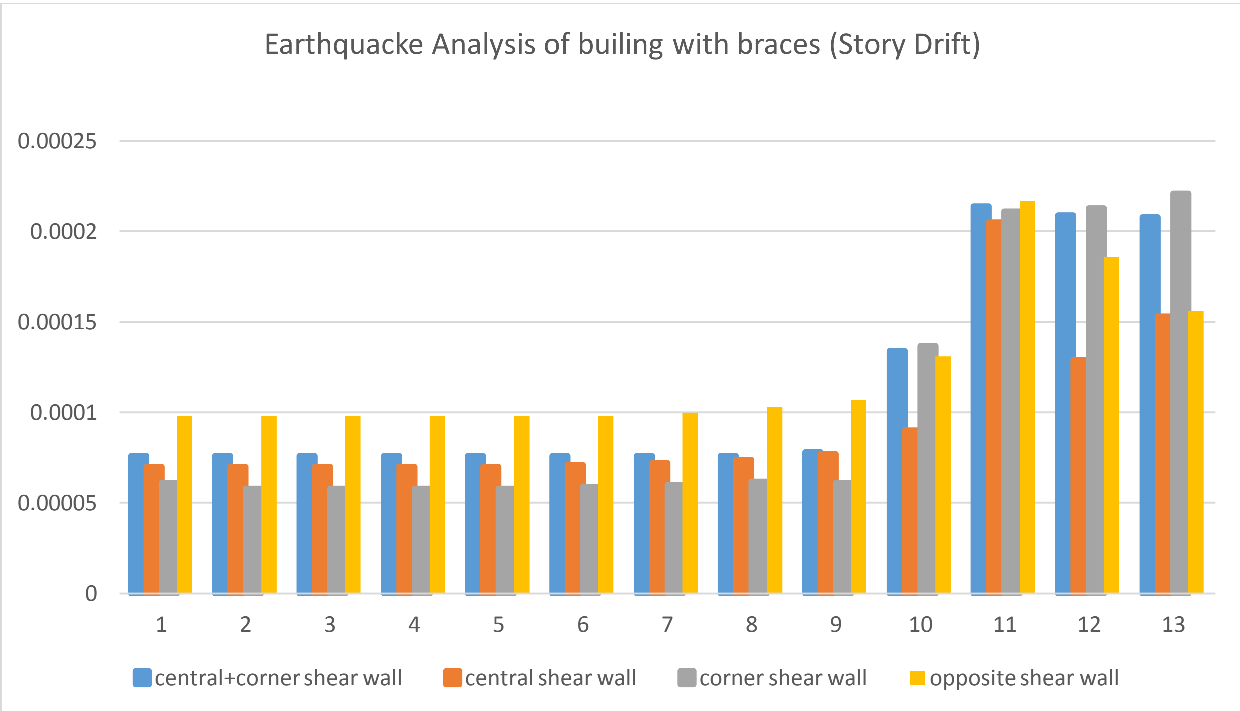
BRACES CENTRAL SHERE WALL

Story3	9	Top	1.606	1.492
Story2	6	Top	1.304	1.245
Story1	3	Top	0.663	0.645
Base	0	Top	0	0

CORNER SHEAR WALLS

Story3	9	Top	1.606	0.055
Story2	6	Top	0.975	0.12
Story1	3	Top	0.468	0.106
Base	0	Top	0	0

OPPOSITE SHEAR WALL



Story3	9	Top	0.000214	0.000165
Story2	6	Top	0.000209	0.000169
Story1	3	Top	0.000208	0.000174
Base	0	Top	0	0

CENTRAL + CORNER SHEAR WALL

Story3	9	Top	0.000205	0.000067
Story2	6	Top	0.000129	0.00001
Story1	3	Top	0.000153	0.000046
Base	0	Top	0	0

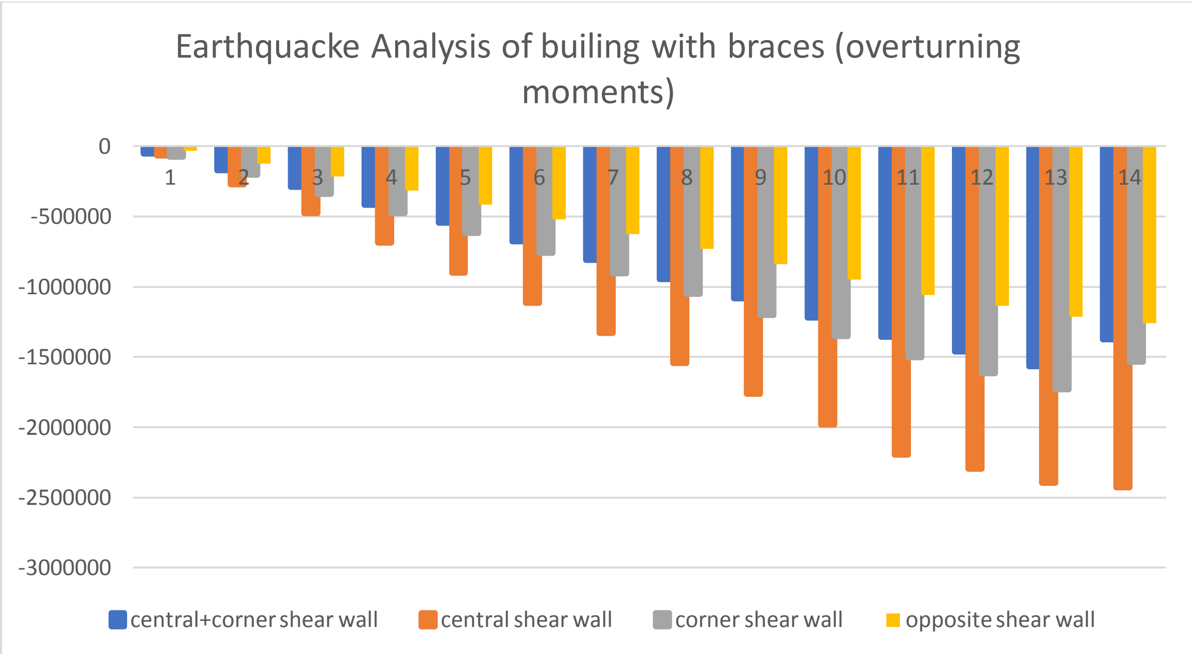
BRACES CENTRAL SHERE WALL

Story3	9	Top	0.000211	0.000197
Story2	6	Top	0.000213	0.0002
Story1	3	Top	0.000221	0.000215
Base	0	Top	0	0

CORNER SHEAR WALLS

Story3	9	Top	0.000217	0.000023
Story2	6	Top	0.000186	0.000008
Story1	3	Top	0.000156	0.000035
Base	0	Top	0	0

OPPOSITE SHEAR WALL



Story3	9	Top	1490440	-1358442
Story2	6	Top	1590007	-1461573
Story1	3	Top	1689573	-1564779
Base	0	Top	1962064	-1376093

CENTRAL + CORNER SHEAR WALL

Story3	9	Top	2607921	-2198231
Story2	6	Top	2712102	-2297638
Story1	3	Top	2816284	-2397091
Base	0	Top	2836659	-2429509

BRACES CENTRAL SHERE WALL

Story3	9	Top	1671313	-1500908
Story2	6	Top	1784919	-1615249
Story1	3	Top	1898524	-1729662
Base	0	Top	2153641	-1535401

CORNER SHEAR WALLS

Story3	9	Top	1114816	-1059917
Story2	6	Top	1180494	-1136533
Story1	3	Top	1246173	-1213226
Base	0	Top	1271474	-1257635

OPPOSITE SHEAR WALL

V. Results Discussions:

The presence of walls in upper storeys makes them much stiffer than open ground storey. Hence the upper storey moves almost together as a single block and most of the horizontal displacement of the building occurs in the soft ground storey itself. Such building swing back and forth like inverted pendulums during earthquake shaking and columns in the open ground storey are severely stressed. It is clear that building with soft storey will exhibit poor performance during a strong shaking. But the open first storey is an important functional requirement of almost all the urban multistorey buildings and hence cannot be eliminated. Alternative measures need to be adopted for this specific situation. The under-lying principle of any solution to this problem is in (a) increasing the stiffness of the first storey (b) provide adequate lateral strength in the first storey.

In the comparison of results of three models i.e.; Building with central shear wall, building with corner shear wall and building with central and corner shear wall in different conditions like response spectrum analysis, time history analysis and seismic analysis and seismic analysis with the provisions of steel bracings; it is found that the two models i.e.; corner shear wall model and, central and corner shear wall model shows better performance the model with central shear wall.

Now, it is only two models we have compare, model with corner shear wall and model with central and corner shear wall, we can compare the two models in all the parameters of the analysis the we can see that the model with central and corner shear wall proves to better than the other two.

VI. Conclusion:

1. It is found that the steel bracing system at open bottom storey significantly contributes to the structural stiffness and reduces the maximum inter story drift, lateral displacement of R.C.C building.
2. It is found that the X type of steel bracing system at bottom storey has less torsion effect.
3. Presence of soft story at the ground floor causes concentration of forces at the ground story columns causing the columns to be stressed severely, leading to the failure of the building.
4. There is reduction in displacement of shear wall which may increase in building stiffness.
5. It shows that use of shear wall is a good way to provide more level of ductility and getting more stable behaviour and appear to be a novel approach to reduce effect of soft story in seismic response .in the other hand, vulnerability level of existing high-rise building can be increased by adding different arrangement of shear wall on building and it will help for retrofitting of structure to resist the major portion of lateral load induced by an earthquake.
6. ETABS is the robust software which is utilized for analysing any kind of multi building structures. it can easily analyse 13 floors building structures by its fast and accuracy.

Future Scope:

1. The study can also be applied for the analysis of the structures located on the sloping grounds in hilly regions/ terrains, with different locations.
2. The study can be extendable by using the provisions of damping and also the base isolation systems which isolates the building from its foundation during the ground motion.
3. The study can consider different size and shapes of models with different shear wall positions.
4. The study can be further extended to design process.
5. Columns can be designed according to the axial forces and moments.

References:

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