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DYNAMIC RESPONSE OF HIGH RISE BUILDINGS UNDER THE CONFIGURATION OF SHEAR WALL BY USING STAAD PRO.

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ABSTRACT

It is well-established fact that shear walls are quite effective in lateral load resistance of low-rise to medium-rise reinforced concrete buildings. Restriction in the architectural design by the presence of the shear walls may contribute to discourage the engineers from adopting the shear walls. Due to this a new concept of providing storey deep and bay wide discrete staggered shear wall panels have been introduced. In this study, the effect of various configurations of shear walls on high-rise structure is analyzed. The drift and inter-storey drift of the structure in the following configurations of shear wall panels is studied and is compared with that of bare frame: (1) Conventional shear walls. (2) Alternate arrangement of shear walls. (3) Diagonal arrangement of shear walls. (4) Zigzag arrangement of shear walls. (5) Influence of lift core walls. Of the configurations studied, the zigzag shear wall configuration is found to be better than the other systems studied in controlling the response to earthquake loading. The diagonal configuration is found to be having significant role in controlling the response of structures to earthquake.

Keywords: High Rise Structures, Shear Wall Panels, Configuration of Shear Wall, Drift, Dynamic Response, Software Analysis.

1. INTRODUCTION

1.1 General

The Republic Day earthquake of January 26, 2001 in Gujarat clearly demonstrated the earthquake vulnerability profile of our country. It created a considerable interest amongst the professionals associated with construction activities in any form, as well as the non-professionals regarding the earthquake safety issues. The subject of earthquake engineering has its own sophistication and a lot of new research is being conducted in this subject. The analysis of a structure can be done using any one of the methods namely linear static analysis, nonlinear static analysis, linear dynamic analysis and nonlinear dynamic analysis. Bureau of Indian standards (BIS) has published the IS 1893 – 2000 "Criteria for Earthquake Resistant Design of Structures". In this code, the equivalent static analysis and response spectrum methods are dealt with. It also says the dynamic analysis can be done using the time history analysis [4]. In this work, the analysis is conducted. It is well-established fact that shear walls are quite effective in lateral load resistance of reinforced concrete buildings.

The performance of shear walls in high-rise buildings would be different from low-rise buildings. Restriction in the architectural design by the presence of the shear walls may contribute to discourage the engineers from adopting the shear walls. Due to this reasons a new concept of providing storey deep and bay wide discrete staggered shear wall panels have been introduced and nonlinear analysis were conducted on the models.

1.2 Objectives of the study

The objectives of the study are (1) To study the effect of various configurations of shear wall panels. (2) To study the variation in storey drift due to the presence of shears walls. (3) To study the variations in inter-storey drift due to the presence of shear walls. (4) To obtain the best configuration of shear walls from those under consideration.

2. LITERATURE REVIEW

BozdoganK.B.,Deierlein et.al.,(2010) The examination discussed in inconspicuous components the showing issues, nonlinear lead and examination of the packaging – shear divider essential system. An expected system which relies upon the continuum approach and one dimensional restricted part methodology to be used for parallel static and dynamic examinations of divider layout structures is presented

Shaik Kamal Mohammed Azam et. al.,(2013) the present examination on seismic execution appraisal of multistoried rc encompassed structures with shear divider. An examination of essential direct similar to quality, strength and damping properties is done. The plan of shear divider has vital impact on sidelong quality in taller structures while it has less effect on even robustness in taller structures. The plan of shear divider has significant impact on flat immovability in structures of shorter stature while it has less effect on parallel quality. The effect of shear dividers is basic to the extent the damping properties and period at the execution point for tall structures. Game plan of shear dividers symmetrically in the fringe minute contradicting edges and in a perfect world interconnected regularly inverse way surrounding the inside will have better seismic execution to the extent quality and strength.

Shahabodin1,Zaregarizi2 et al., (2013) The present examination on Comparative examination on using shear divider and concrete infill to improve seismic execution of existing structures in zones with high seismic potential. Results exhibits that strong fills have amazing quality than square in fills. while the migration affirmation of square infill's is higher than cement infill's. Workmanship infill's as sidelong contradicting segments have broad quality which can keep away from even fall in direct tremors. Execution of bond in fills is dependent on adjacent segments especially segments, so less than ideal dissatisfaction in portions due to strong center forces must be considered.

K. PRIYANKA: This examine gives the procedure to seismic generally speaking execution estimation of over the top ascent homes principally dependent on an idea of technique in the limit range.

3. STRUCTURAL MODELING ON STADD PRO

3.1 About STAAD Pro Software

STAAD Pro complete shape represents Structural Analysis and Designing Program. STAAD Pro is a primary exam and plan PC software that became being created by way of Research Engineers International (REL) at Yorba Linda, California in 1997. Today, STAAD Pro is one of the widely recognized and widely concerned programming for number one investigation and plan across the globe by way of Civil professionals.

It upholds a wide variety of various steel, cement, and lumber configuration codes. Utilizing STAAD Pro, affable specialists can configuration any type of creation, and later provide the synchronized model statistics among the entire plan organization. It guarantees on-time and financial plan agreeable consummation of designs and plans linked with metal, concrete, lumber, aluminum, and cold-framed metallic tasks, unimportant to the intricacies. STAAD Pro assists number one designers with computerizing their undertakings through disposing of the dreary and long strategies of the guide strategies. It lets in structural professionals to observe and plan different types of designs on digital tiers. Primary designing firms, consultancies, distinctive divisions of development corporations, and government companies use STAAD genius broadly.

4. STUDY ON THE BEHAVIOR OF HIGH RISE BUILDINGS

4.1 General

The following configurations of shear wall panels are studied and are compared with that of bare frame. (1)Conventional shear walls. (2)Alternate arrangement of shear walls. (3)Diagonal arrangement of shear walls. (4)Zigzag arrangement of shear walls. (5)Influence of lift core walls. Each of these configurations is analysed providing shear walls of thickness 0.10m along the longer plan direction and shorter plan direction of the building. The primary objective is to achieve a configuration where the drift and inter-storey drift is the minimum.

4.2 Nomenclature

The models prepared were designated as follows. Shear wall panels oriented along the longer plan dimension and shorter plan dimension are represented by ALD and ASD respectively. Models with and without shear wall panels in ground storey are represented by WSW and WOSW respectively.

4.3 Bare Frame (BF)

For the analysis, a typical frame of plan dimensions 30m × 20m and of height 91m is considered (Fig. 1). The longer plan dimension is taken as the X direction, the shorter one as Z direction and Y direction is taken in the vertical direction. The aspect ratio is taken as 1.5 so as to study the effect due to the orientation of shear walls along the both plan dimensions. Along the longer dimension in the plan, six frames are considered. Along the shorter direction, four bays are considered. The ground storey height is taken as 4m and the rest of the storeys are taken to be 3m high. The plan of the structure considered is given in Fig. 1.

The isometric view of the structure is shown in Fig.2(a). Up to the 20th storey, the column cross section is taken as 1.20m × 0.50m. For the rest 10

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storeys, the column cross section is taken as 1.10m × 0.50m. Up to the 3rd storey, the beam cross section is taken as 0.30m × 0.60m. From 3rd storey to the 20th storey, the beam cross section is taken as 0.30m × 0.50m. For the remaining top ten storeys the cross section of beams are taken as 0.30m × 0.40m.

The floor slabs are modelled as plates of 0.15m thickness. All the supports are modelled as fixed supports. Non-linear analysis is conducted on each of these models. The loads considered for the analysis are given below.

4.4 Dead Load

The dead load of the structure is obtained from Table 1, Page 8, of IS 875 – Part 1 – 1987. The permissible value for unit weight of reinforced concrete varies from 24.80kN/m3 to 26.50kN/m3 . From the table, the unit weight of concrete is taken as 25kN/m3 , assuming 5% steel in the reinforced concrete.

4.5 Imposed Load

The imposed load on the floor is obtained from Table 1 of IS 875 (Part 2) – 1987. The uniformly distributed load on the floor of the building is assumed to be 4kN/m2 (for assembly areas, corridors, passages, restaurants, business and office buildings, retail shops etc).

4.6 Earth Quake Load

The structure is assumed to be in Kerala (Zone 3 as per IS 1893 – 2002). So the zone factor is taken as 0.16 as per Table 2 of IS 1893 – 2002. The damping is assumed to be 5%, for concrete as per Table 3 of IS 1893 – 2002. Importance factor is taken as 1.5 as per Table 6 of IS 1893 – 2002.

4.7 Wind Load

Basic wind speed is taken as 39 m/s. Form appendix A, a risk factor, k1 is taken as 1.0 as per Table 1 and k2 is taken as 1.20 as per Table 2 of IS 875 – Part 3.

PROBLEM STATEMENT

In the present examination, examination of G+20 multi-story working in numerous isolates zone for wind and earth shake powers is passed on out.3D demonstrate is set up for G+20 multi-story building is in ETABS. Building has a typical size of fundamental parameters consider for the study are

1. Utility of building — Residential building
2. Number of stories — G+20
3. Shape of building — Rectangular
4. Type of walls — Brick wall
5. Geometric details
    a. Ground floor — 3.3m
    b. Floor to floor height — 3.0 m
6. Material details
    a. Concrete Grade : M30 (COLUMNS AND BEAMS)
    b. All Steel Grades : HYSD reinforcement of Grade Fe415
    c. Bearing Capacity of Soil : 200 KN/m^2
7. Type of Construction: R.C.C FRAMED structure
8. Column : 0.6m X 0.6m
9. Beams : 0.4m X 0.6m
10. Slab : 0.150m
11. Special considerations
12. Shear wall: Thickness 150mm

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5. ANALYTICAL MODELLING

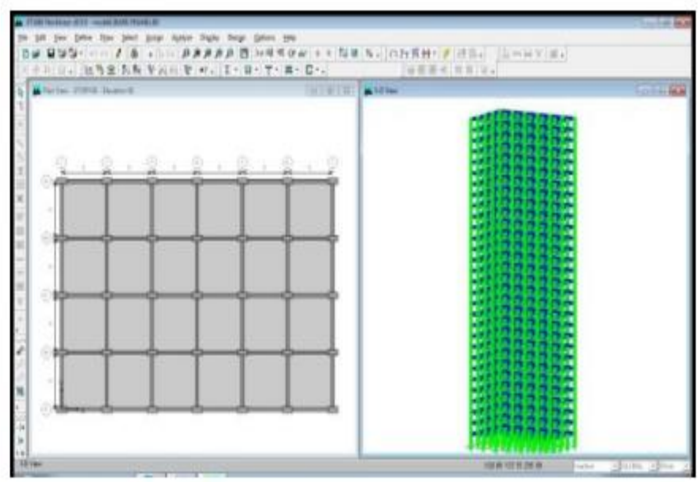
Model 1: Bare frame:- Building is modeled as bare frame. For the Analysis, a typical frame plan dimensions 30mx20m and height 91m is considered. The longer plan dimension is taken on X-direction, the shorter one as Y-direction and Z-direction is taken in the vertical direction.

The aspect ratio is taken as 1.5 so as to study the effect due to the orientation of shear walls along longer plan dimension. Along the longer dimension in the plan, six frames are considered. Along the shorter direction, four bays are considered. The ground storey height is taken as 4m and the rest of the storeys are taken to be 3m high. Upton to the 20th storey, the column cross section is taken as 1.20mx0.50m. for the rest 10 storeys, the column cross section is taken as 1.10mx0.50m.Up to 3rd storey, the beam cross section is taken as 0.3mx0.6m.From 3rd storey to the 20th storey, the beam cross section is taken as 0.30mx0.525m.For the remaining top ten storeys the cross section of beams are taken as 0.30mx0.45m.The floor slabs are modeled as membrane element of 0.15m thickness. All the supports are modeled as fixed supports. Linear and Non-Linear analysis is conducted on each these models. The loads are considered for the analysis are given below.

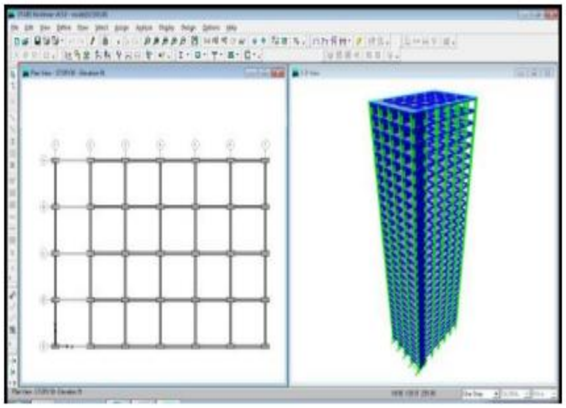
Dead Load:-The dead load of structure is obtained from Table 1,Page 8,of IS 875-Part 1-1987.The permissible value for unit weight of reinforced concrete varies from 24.80kN/m 3 to 26.50kN/m3 .From the table, the unit weight of concrete is taken as 25kN/m 3 , assuming 5% steel in the reinforced concrete.

Imposed Load:- The imposed load on the floor is obtained from Table 1 of IS 875 (Part 2) – 1987. The uniformly distributed load on the floor of the building is assumed to be 4kN/m2 (for assembly areas, corridors, passages, restaurants, business and office buildings, retail shops etc).

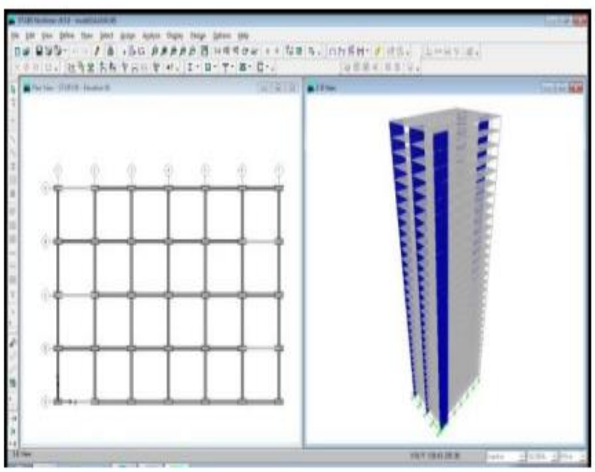
Earth Quake Load:- The structure is assumed to be in Hyderabad (Zone 2 as per IS 1893 – 2002). So the zone factor is taken as 0.10 as per Table 2 of IS 1893 – 2002. The damping is assumed to be 5%, for concrete as per Table 3 of IS 1893 –2002. Importance factor is taken as 1.5 as per Table 6 of IS 1893 – 2002.



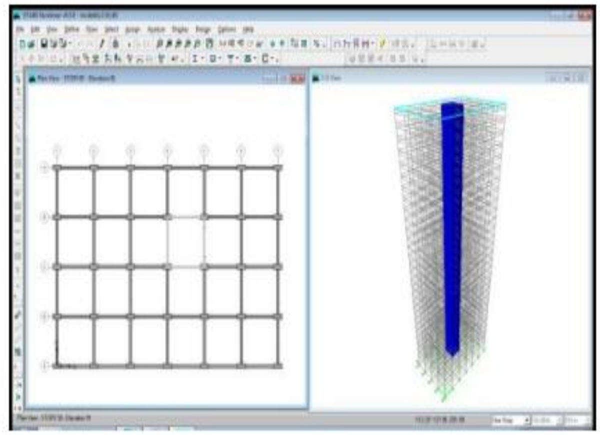
Model 2: Bare frame with conventional shear walls (CSW):-The second model is obtained by added conventional shear walls to the bare frame the arrangement of conventional shear walls along X direction



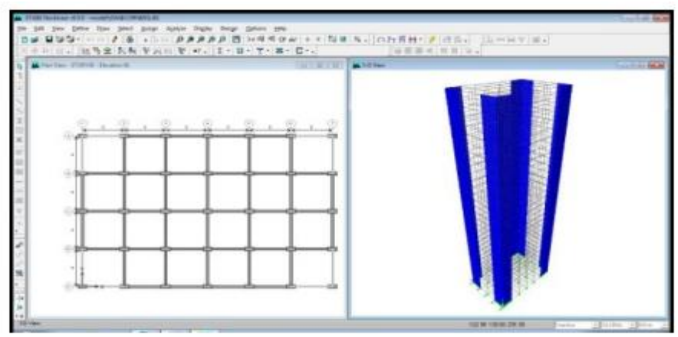
Model 3: Bear frame with alternate arrangement of conventional shear wall system (AASW):-In the conventional shear wall system all the shear wall in a frame are provide one above the other.



Model 4: Bare frame with lift-core walls (LCW):- The high rise structure will be having lifts. The corewalls (shear walls) around the lift core will add up to the stiffness of the structure, there by reducing the deflection.



Model 5: Bare frame with conventional shear wall (L-section) at exterior corners:- In this case the conventional shear wall are placed at exterior corners (L-section) in the structure. However masses of floor finish and imposed live load is added at each storey.



Model 6: Bare frame with conventional shear wall at centre of exterior panel:-In this case conventional shear wall is provided at center in both x and y-direction. However masses of floor finish and imposed live load is added at each storey.

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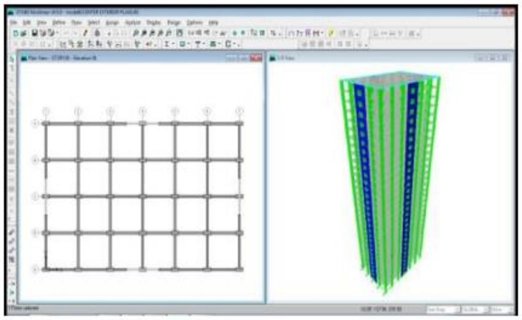


Model 7: Bare frame with LCW and SW at Corners:- In this case model is prepared by adding shear wall at corner and lift core wall to the bare frame. However masses of floor finish and imposed live load is added at each storey.

6. RESULTS AND DISCUSSION

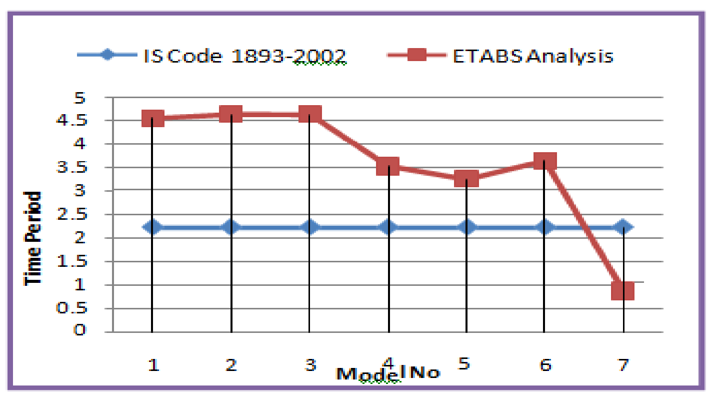
The results of the selected building studied are presented and discussed in detail. The results are included for building models and the response results are computed using the response spectrum and pushover analysis. The analysis and design of the different building models is performed by using STADD PRO analysis package.

6.1 NATURAL PERIODS:-

From the Table 1 and Graph 1, it is observed that the time period obtained by the IS code and by the STADD PRO analysis possess a huge difference. The table shows that the natural time period of bare frame model from STADD PRO is almost twice more than that of the value obtained from code. For models2,3,4,5 & 6 the time period obtained from STADD PRO is higher as compared to the corresponding values from the IS code. Out of all the models the time period is maximum for model-2 and minimum for model-7. From STADD PRO analysis it can be observed that from the below table 1 vertical period of bare frame (model 1) is greater than four (model-4,5,6,7) cases of building models and while comparing model to each other, the model 4,5,6 and 7, time periods are 22.25%, 28.42%, 28.41%, 20.07%, 80.92% less compared to as model-1.

Table 1:-Comparison of time period between IS Code method and analysis using STADD PRO software for various models.

Model No.	IS Code 1893-2002		STADD PRO Analysis	
	longitudinal	transverse	longitudinal	transverse
1	2.2097	2.2097	4.5383	4.5383
2	2.2097	2.2097	4.6267	4.6267
3	2.2097	2.2097	4.6206	4.6206
4	2.2097	2.2097	3.5186	3.5186
5	2.2097	2.2097	3.2449	3.2449
6	2.2097	2.2097	3.6345	3.6345
7	2.2097	2.2097	0.8666	0.8666



Graph 1:-Model Vs Time period for different models along longitudinal and transverse direction

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TABLE 2:-Comparison of Base Shear by IS code method,

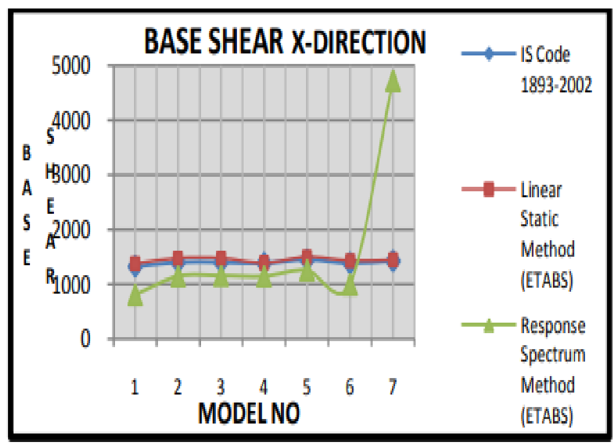
Base shear (KN)						
Model No.	IS Code 1893-2002		Linear Static Method (STADD PRO)		Response Spectrum Method (STADD PRO)	
	longitudinal	transverse	longitudinal	transverse	Longitudinal	transverse
1	1325	1325	1374	1374	805.1	723.1
2	1399	1399	1476	1476	1145.1	825
3	1399	1399	1476	1476	1155.6	815.5
4	1384	1384	1387	1387	1144.3	1017
5	1444	1444	1499	1499	1255.1	1189
6	1384	1384	1431	1431	990.3	906.1
7	1423	1423	1444	1444	4719.1	3145

Design seismic base shear:-

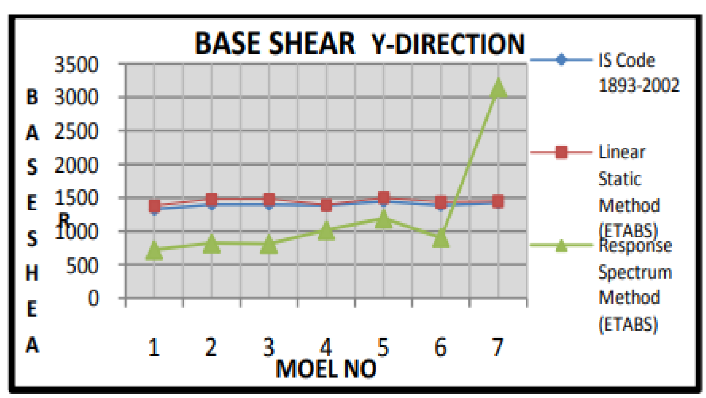
From the below Table 2 Represents The Seismic Base Shear For Various Models. From the Table it can be Observed that the seismic base shear for all the models except model 1 has smaller values compared to others models. The reduced percentages from model 2 to model 7 are 6.91%, 6.91%, 0.92%, 8.30%, 3.95% and 4.80% respectively.

It can be observed that the Response Spectrum Analysis Yields Lesser Values Of Base Shear as compared to that of equivalent static analysis as the higher modes are given due consideration. Table 2 represents the comparison of base shear obtained from IS Code method, ESM and RSM .From the above table, it is clearly identified that the values obtained from the IS Code method are the least as compared to the ESM. Whereas ESM yields the largest values and further the curves for IS Code lies in between that of ESM and RSM method. Apart from the bare frame model the values for the rest of the models lies almost in a straight horizontal line obtained from IS Code and ESM where as in case of RSM the base shear for each model fluctuates very significantly as shown in the below Graph 2 and 3. It has been found that calculation of earthquake forces by treating the buildings as ordinary frames results in an underestimation of base shear

Graph 2:-Comparison of Base Shear by IS code method, ESM and RSM for various models a long longitudinal direction



Graphs 3:-Comparison of base shear by IS Code method, ESM and RSM for various models along transverse direction



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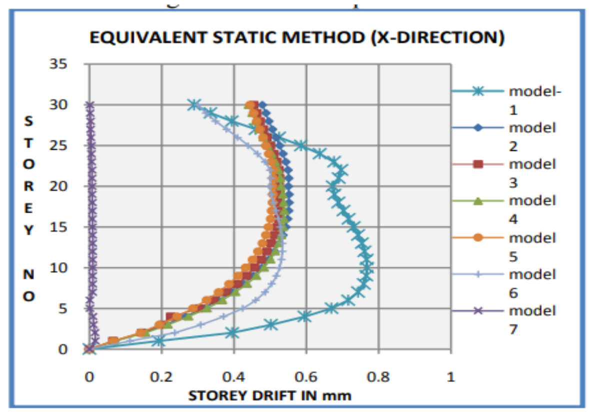
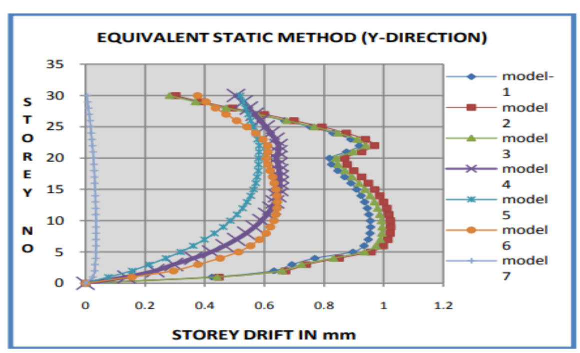
LATERAL DISPLACEMENTS:-The maximum displacements at each floor level with respect to ground for equivalent static response spectrum and pushover analysis. For better comparability the displacement for each model along the two directions of ground motion are plotted in as shown in Graphs from 4 to 9. In the three dimensional model, however, there are six degrees of freedom with the two translational degree of freedom along X, Y-axes and rotation degree of freedom about Z (vertical)-axis playing significant role in the deformation of the structure. Apart from the translation motion in a particular direction, there is always an additional displacement due to the rotation of floor. Due to this the maximum displacement at floor levels obtained by three-dimensional analysis are always greater than the corresponding values obtained by one-dimensional analysis

Moreover, the floor rotation is maximum at the top floor, gradually reducing down the height of the building to an almost negligible rotation at the lowest basement floor. In equivalent static analysis it has been found that model -2, model-3, model-4, model-5, model-6 and model-7 has 26.71%, 29.93%, 28.44%, 32.66%, 28.55% and 28.72% respectively less displacement as compared to the model-1 in longitudinal direction and in transverse direction model-4, model-4, model-6, and model-7, has 31.14%, 39.89%, 31.95%, and 99.94% respectively less displacement compared to model-1. In response spectrum analysis it has been found that model -2, model-3, model-4, model-5, model-6 and model-7 has 35.18%, 37.44%, 46.15%, 66.74%, 14.38% and 94.77% respectively less displacement as compared to the model-1 in longitudinal direction and in transverse direction model-3, model-4, model-5, model-6, and model-7 has 3.75%, 45.03%, 75.11%, 26.42% and 94.11% respectively less displacement compared to model-1. **STOREY DRIFTS**:-The permissible inter-storey drift is limited to 0.004 times the storey height, so that minimum damage would take place during earthquake and pose less psychological fear in the minds of people. The storey drifts for all models of descending building along longitudinal and transverse directions are shown in Graph from 10 to 15. From the below Graph it can be seen that, all storey drifts are within the permissible limit (0.004*h=12mm) and the storey drifts in lower stories are larger than that in top stories.



Graph 10:-Equivalent Static method X-direction



Graph 11:-Equivalent Static method Y-direction

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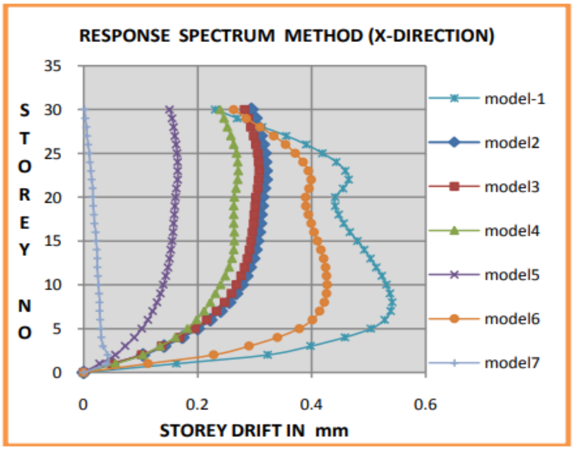
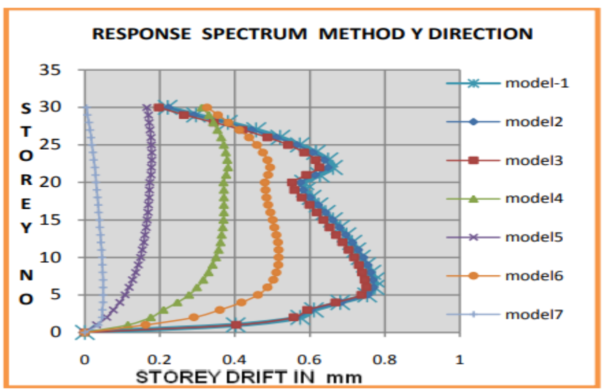
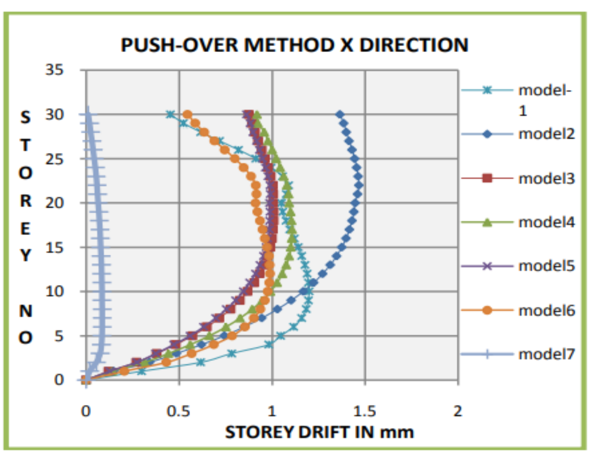


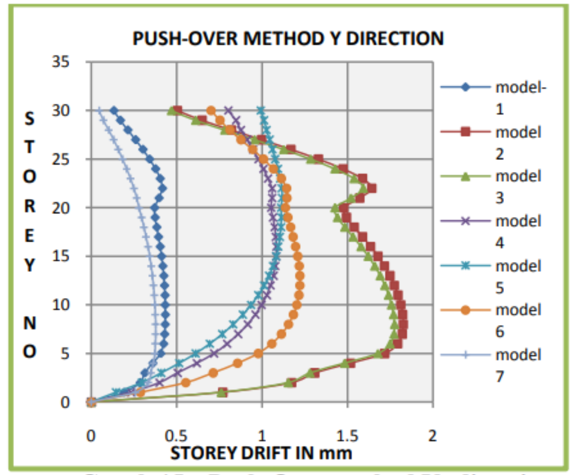
Graph 12:-Response Spectrum method Xdirection



Graph 13:-Response Spectrum method Ydirection



Graph 14:- Push-Over method X- direction



Graph 15:- Push-Over method Y- direction

Table-3: Response reduction factor and ductility ratio along longitudinal direction

	M-1	M-2	M-3	M-4	M-5	M-6	M-7
Yield displacement (UYield) (mm)	87.40	106.2	74.9	82.6	73.5	73.7	21.4
Ultimate displacement Uultimate (mm)	1039	805.4	659	790	716	556	135
Ductility ratio	11.89	7.60	8.80	9.56	9.74	7.55	6.34
R	4.77	3.76	4.08	4.26	4.30	3.76	3.42

Table-4: Response reduction factor and ductility ratio along transverse direction

	M-1	M-2	M-3	M-4	M-5	M-6	M-7
Yield displacement (UYield) (mm)	32.4	132	128	81.7	82.5	91.9	25.8
Ultimate displacement Uultimate (mm)	100	163	535	838	742	664	385
Ductility ratio	30.95	1.241	4.18	10.2	8.99	7.23	14.9
R	7.805	1.22	2.71	4.42	4.12	3.67	5.37

PERFORMANCE POINT:- The values of performance point parameters such as structural acceleration (Sa), structural displacement (Sd), base shear (V) and roof displacement (D) are shown in Table 3 and 4 along longitudinal and transverse direction for all the building models. It can be noted that the structural displacement (Sd) and roof displacement (D) has smaller value for model 7 as compared to other models, it can also be seen that for structural acceleration (Sa) is maximum for model-7 and base shear (v) is almost max. for model 7 as compared to other models.

CONCLUSION

1. Fundamental natural period decreases when effect concrete core wall is considered.

2. Storey drifts are found within the limit as specified by code (IS 1893-2002 Part-1) in both linear and dynamic and non-linear static analysis.

3. Bay wide and storey height shear wall can be effectively used in reducing the dynamic response of a structure.

4. The addition of shear walls for lateral strength increases the structural stiffness which in turn increases the spectral acceleration sa/g value in models of building.

5. The behaviour of properly detailed reinforced concrete frame building is adequate of demand and capacity curves and the distribution of hinges in the beams and the columns. Most of hinges developed in the beams and few in the columns but with limited damage.

6. The result obtained in terms of performance point and plastic hinges gave on insight into the real behaviour of structures.

7. Base shear at first hinge is less and displacement at first hinge is more for bare frame model and vice versa for other models.

8. Ductility ratio is maximum bare frame structure and it get reduced when the effect of shear wall is considered. It indicates that this structure will show adequate warning before collapse.

9. Bare frame structure are having highest response reduction factor as compared to other models. It indicates that bare frame structure are capable of resisting the forces still after first hinges.

10. In case of core-wall structure it can be seen that almost all hinges are formed in link beams. To function properly under severe earthquake loading, the core-wall requires ductile link beams that can undergo large inelastic deformation.

For the above study we conclude that model 7 i.e., bare frame with shear wall at corner plus lift core wall shows better performance among the

SCOPE FOR FURTHER STUDY

Further studies can be conducted that on sky scrappers, composite structures, Studies can be conducted by providing dual system, which consists of shear wall (or braced frame) and moment resisting frame such that the two systems are designed to resist the total design force in proportion to their lateral stiffness considering the interaction of dual system at all floor levels. The moment resisting frames may be designed to independently resist at least 25% of design seismic base shear. For better ductility beam column junction study can also be made. Various damping mechanisms and its applications on structures can also be studied. Studies also on existing building can be considered for evaluation. Where, a preliminary investigation using FEMA-273 can be done before evaluation of the existing building using mathematical modeling with the help of FEA package and further it can be evaluated using NonLinear Dynamic Analysis. Conventional approach to earthquake resistant design of buildings depends upon providing the building with strength, stiffness and inelastic deformation capacity. But the new techniques like Energy Dissipation and Active Control Devices are a lot more efficient and better.

REFERENCES

[1.] IS: 1893 (Part-I) 2002 (2002): "Criteria for Earthquake Resistant Design of Structures", Part-I General Provisions and Buildings, Fifth Revision, Bureau of Indian Standards, New Delhi.

[2.] Pankaj Agrawal, Manish Shrikhande, "Earthquake Resistant Design of Structures", Prentice Hall India Publication.

[3.] Bangle S. Taranath, Textbook of McGraw Hill International Editions, "Structural Analysis and Design of Tall Building", 1988, pp. 563-569.

[4.] IS : 875 (Part I) – 1987, "Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures – Dead Loads" Bureau of Indian Standards, New Delhi.

[5.] IS : 875 (Part II) – 1987, "Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures – Imposed Load" Bureau of Indian Standards, New Delhi.

[6.] Federal Emergency Federal Agency, FEMA-356, "Pre-standard and Commentary for Seismic Rehabilitation of Buildings", Washington DC, 2000.

[7.] Applied Technology Council, ATC-40, "Seismic evaluation and retrofit of concrete buildings", Vol. 1 and 2, California 1996.

[8.] Chpopra AK, Goel RK. "A modal pushover analysis procedure to estimate seismic demands for buildings: Theory and preliminary evaluation, Report. No. PEER 2001/03, Pacific Earthquake Engineering Research Center, University of California, Berkeley, California., 2001.

[9.] Kabeyasawa, 1993; Eberhard and Sozen 1993. "The Effect of Concrete Core Wall".

[10.] Rutenberg A and Nsieri, E. (2006). "The seismic shear demand in ductile cantilever wall systems and the EC8 provision", Bulletin of Earthquake Engineering, 4, 1-21