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ANALYZING RCC FRAME STRUCTURE WITH AND WITHOUT STRUTS AND SHEAR WALLS

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Abstract— This paper presents the comparison between the building with and without shear wall and struts. High-rise buildings are more complex in design and differ from low-rise buildings. Lateral stiffness is critical in the mechanism of resistance of multi-storey frames. Simple RCC frame structure comprises of only beams and columns which sometimes in high-rise building are not enough to fulfill the strength criteria unless they are provided with large cross-sections. But providing large cross-section of beams and columns is also not feasible. Therefore, additional members (shear walls, struts etc) to support the structure become essential. Therefore, in order to rectify this concept, G+19 storey building was designed in STAAD.Pro. Response spectrum method (zone-IV as per IS: 1893-2016) was used for seismic analysis. Different structural parameters were recorded from the results of STAAD.Pro and then comparative cost analysis was done. Results for G+19 building show that the maximum displacement in Type A, Type B and Type C is 209.80 mm, 93.73 mm and 81.68 mm respectively. Therefore, displacement in Type C building is minimum.Total cost of Type A, Type B and Type C works out to be Rs 413.28 lakhs, Rs 362.40 lakhs and Rs 421.42 lakhs respectively. Therefore, for G+19 building, Type B is the optimum building as it involves minimum total cost of building and it is found economical and safe.

Keywords— Seismic Analysis, Shear walls, Struts, High-Rise Building, Multi-Storey Structure, Structural analysis, Staad.Pro.

I. INTRODUCTION

Depending upon the location, type of structure, forces etc there are many design methods through which a structure is designed. Designing should be done in such a manner that structural members (beams and columns) should possess enough strength in order to resist all horizontal and vertical forces acting on it. As stability and durability are the basic requirement of any structure, therefore, designers while designing refer to the Indian Codes for guidelines and design criteria.

There are mainly four types of structures:

- Brick Masonry
- RCC Structure
- Steel Structure
- Composite Structure (steel sections encased in Concrete)

High-rise buildings are more complex in design and differ from low-rise buildings. Lateral stiffness is critical in the mechanism of resistance of multi-storey frames. As simple RCC frame structure comprises of only beams and columns which sometimes in high-rise building are not enough to fulfill the strength criteria unless they are provided with large cross-sections. But providing large cross-section of beams and columns is also not feasible. Therefore, additional members (shear walls, struts etc) to support the structure become essential from the design and economy point of view. Considering the earthquake forces, the seismic behavior of building is strongly affected by the arrangement of additional members like shear walls, struts and the rigidity of these additional members. They are generally arranged in such a manner that they can easily resist the lateral forces of the building effectively. The efficiency of this system is seriously affected by the location of these members in building. Therefore, it is of prime importance to know the best optimum location of these additional members.

Previously, many projects were done using STAAD.Pro for analyzing different types of building, such as Seismic Behavior Of Shear Wall Framed Buildings, Seismic Analysis And Design Of R.C.C Tall Building With Shear Wall, Analysis and Strengthing of Soft Storey Building with Equivalent Diagonal Strut at Center under Earthquake and Wind Load, A Review on Analysis and Design of Shear Walls in High Rise Irregular Building had been done, but no research work has been carried out with respect to the comparison of building with and without strut and shear wall.

II. RESEARCH PROGRAM

The orientation for research program mainly focuses on:

- To study the high-rise buildings with and without struts and shear walls when the building is designed as per the new seismic code IS: 1893-2016.
- To study different parameters, like axial force, displacement, bending moment etc, for RCC framed structure with shear walls and struts and compare the results.
- To study the effect of variable percentage of reinforcement for these structure.
- To draw conclusions towards behavior of RCC buildings built with and without struts and shear walls.

In order to perform the research work, following codes had been used:

- BIS:875-1987 (part-1) for Dead Load
- BIS:875:1987 (part-2) for Live Load
- BIS:1893-2016, for Earthquake Loads
- BIS:456-2000, for RCC Structures

Total 3 number of models as mentioned below were prepared in STAAD.Pro:

- Type A: G+19 without shear walls or struts
- Type B: G+19 with struts
- Type C: G+19 with shear walls

The height of each storey is taken as 3.6m with total no of bays as 5 in both the directions and the panel size as 6 x 6m.

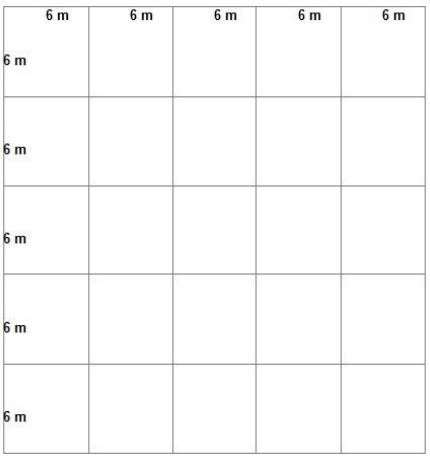

Fig. 1 General Plan of G+19 Building

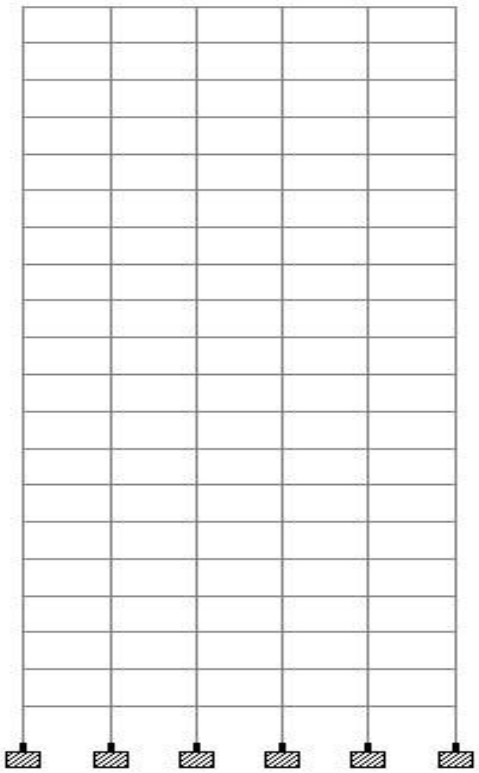

Fig.II Type A- Elevation of G+19 Building.

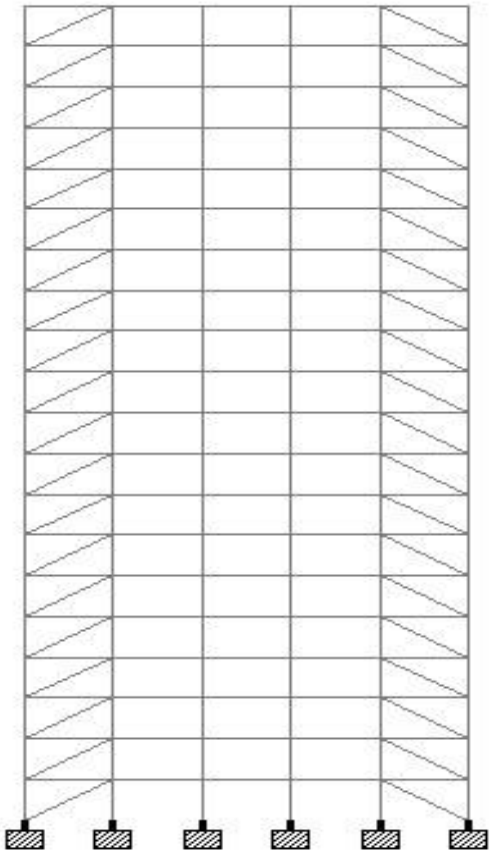

Fig.III Type B- Elevation of G+19 Building With Struts.

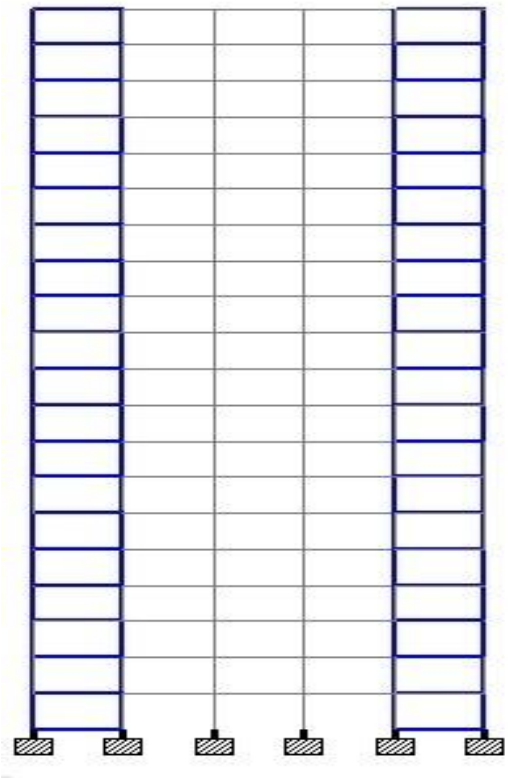

Fig.IV Type C- Elevation of G+19 Building With Shear Wall.

Input Data for preparing RCC frame structures:

a) Grades of Material:

- Grade of Concrete was M-25.
- Grade of Steel reinforcement was Fe-500.

b) Earthquake parameters:

- Seismic Zone IV
- Response reduction factor 5 (SMRF)
- Importance factor 1.2

c) For the purpose of analyzing the structure, following variable loads had been taken into consideration:

Dead Load:

- Load of outer walls: 13.8 kN/m
- Load of inner walls: 6.9 kN/m
- Load of parapet: 2.6 kN/m
- Load of slab: 6 kN/sqm

Live Load:

- Floor Load: 3 kN/sqm
- Roof Load: 1.5 kN/sqm

d) Load Combinations:

As per IS: 1893-2016, different load combinations applied for determining the loads and forces are given as under:

- 1.5(DL+LL)
- 1.2(DL+LL)
- 1.2DL+1.2LL+1.2EQ (x direction)
- 1.2DL+1.2LL+1.2EQ (-x direction)
- 1.2DL+1.2LL+1.2EQ (z direction)
- 1.2DL+1.2LL+1.2EQ (-z direction)
- 1.2DL+1.2LL+1.2EQ (y direction)
- 1.2DL+1.2LL+1.2EQ (-y direction)
- 1.5DL
- 1.5DL+1.5EQ (x direction)
- 1.5DL+1.5EQ (-x direction)
- 1.5DL+1.5EQ (z direction)
- 1.5DL+1.5EQ (-z direction)
- 1.5DL+1.5EQ (y direction)
- 1.5DL+1.5EQ (-y direction)
- 0.9DL+1.5EQ (x direction)
- 0.9DL+1.5EQ (-x direction)
- 0.9DL+1.5EQ (z direction)
- 0.9DL+1.5EQ (-z direction)
- 0.9DL+1.5EQ (y direction)
- 0.9DL+1.5EQ (-y direction)

d) Member Properties:

The cross-sectional properties which were assigned to the structural members of G+19 storey building are as under:

Floor	**Column Size**	**Beam Size**
Upto 5th floor	1500 x 1200 mm	675 x 525 mm
6th to 10th floor	975 x 750 mm	600 x 525 mm
11th to 15th floor	825 x 675 mm	525 x 525 mm
Beyond 15th floor	675 x 525 mm	380 x 380 mm

Floor	**Strut Size**
Upto 5th floor	600 x 525 mm
6th to 10th floor	525 x 450 mm
11th to 15th floor	450 x 380 mm
16th to 17th floor	380 x 380 mm
Beyond 17th floor	230 x 230 mm

Thickness of shear wall taken was 230 mm

e) Item Rates for Cost Analysis

For the purpose of cost analysis following rates of material was used:

- Rate of Concrete has been taken as Rs. 4500 per cumec.
- Rate of Steel has been taken as Rs. 40 per Kg.

III. RESULTS

Total number of models made for analyzing cost analysis was 3. Results were obtained from the post-processing of Staad.Pro. The results of the study have been presented in tabular form and comparison was made between these models.

TABLE I AXIAL FORCE

Floor	Type A	Type B	Type C
1	2174.5	4262.9	25706.5
2	2107.4	3811.8	20514.2
3	2000	3348.5	17374.6
4	1869.1	2935.7	14978
5	1725.3	2600.8	12671.7
6	1546.9	10423	8976
7	1438.1	9242.2	7332.4
8	1293.9	1691.5	6395.1
9	1150.2	1542	5870.9
10	1008.4	1454.6	5516.5
11	844.8	1330.8	4781.8
12	749.1	1198.8	4366.1
13	630.9	1086.2	4060.7
14	514.9	986.9	3825.1
15	399.5	2602.5	3492.5
16	964.9	2010.7	2603.5
17	772.8	416.4	1779.8
18	941.1	185.3	1055.9
19	552	89.8	703.5
20	31.9	4.7	263.3

TABLE II BENDING MOMENT

Floor	Type A	Type B	Type C
1	2092.8	1006.2	1562.5
2	1411.1	558.1	812.8
3	988.3	356.5	503
4	728.5	257.7	339
5	552	182.4	180.8
6	0.16	32.5	249.6
7	342.7	49.4	28.4
8	268.3	72.6	20.1
9	263.8	62.7	9.7
10	257.9	46.5	16.6
11	0.52	88.9	47
12	254.89	51.8	8.4
13	212.65	43.9	13.7
14	206.33	44.4	8.2
15	215.1	75.1	167.2
16	72.3	72.9	35.5
17	75.3	31	80
18	76.9	18.4	71.7
19	70.5	33.6	87.2
20	89.7	45.4	27

TABLE III PERCENTAGE OF STEEL

Floor	Type A	Type B	Type C
1	0.80	0.80	3.92
2	0.80	0.80	3.35
3	0.80	0.80	2.68
4	0.80	0.80	2.32
5	0.80	0.80	1.95
6	1.05	1.43	3.43
7	0.80	0.99	2.95
8	0.80	0.80	2.41
9	0.80	0.80	2.23
10	0.80	0.80	2.14
11	0.89	0.81	2.46
12	0.81	0.81	2.25
13	0.81	0.81	2.02
14	0.81	0.81	2.02
15	0.81	1.41	1.87
16	2.04	1.77	2.21
17	1.02	0.89	1.66
18	1.02	0.89	1.06
19	1.02	0.89	0.89
20	0.89	0.89	0.89

TABLE IV DISPLACEMENT IN MM

Floor	Type A	Type B	Type C
1	1.66	0.86	0.87
2	5.64	2.60	2.43
3	11.07	4.87	4.50
4	14.41	7.50	6.82
5	24.33	10.35	9.37
6	33.2	14.02	12.66
7	43.25	18.21	16.34
8	53.548	22.64	20.26
9	63.76	27.25	24.34
10	73.97	32.01	25.53
11	85.43	37.40	33.15
12	97.541	43.07	38.01
13	109.44	48.81	42.93
14	120.93	54.58	47.95
15	132.41	60.35	52.93
16	148.27	67.06	55.66
17	167.44	74.20	64.69
18	185.32	81.17	70.62
19	199.59	87.94	76.40
20	209.80	93.73	81.68

TABLE V TOTAL QUANTITY OF CONCRETE AND STEEL

Building Type	Concrete (m^3)	Steel (tonnes)
Type A	4191.7	561.63
Type B	4424	408.31
Type C	4986.7	492.55

TABLE VI TOTAL COST OF CONCRETE AND STEEL

Building Type	Concrete (Lakhs)	Steel (Lakhs)
Type A	188.63	224.65
Type B	199.08	163.32
Type C	224.40	197.02

TABLE VII TOTAL COST (CONCRETE AND STEEL) OF BUILDING

Building Type	Total Cost (Lakhs)
Type A	413.28
Type B	362.40
Type C	421.42

IV. CONCLUSIONS

Following inferences have been made for G+19 building from the results of the study:

- The maximum displacement in Type A (building without shear walls and strut), Type B (building with strut) and Type C (building with shear walls) is 209.80 mm, 93.73 mm and 81.68 mm respectively. Therefore, displacement in Type C building is minimum.
- Type A uses minimum quantity and cost of concrete and Type B uses minimum quantity and cost of steel.
- Total cost (concrete and steel) of Type A, Type B and Type C works out to be Rs 413.28 lakhs, Rs 362.40 lakhs and Rs 421.42 lakhs respectively.
- Therefore, for G+19 building, Type B is the optimum building as it involves minimum total cost of building and it is found economical and safe.

V. LIMITATIONS

Following are the limitations of the study:

- The above study is performed only for the buildings in seismic Zone-IV and if the zone is changed then the results of the study may vary.
- The above study is performed only in STAAD.Pro but with the change of the software, results may vary.
- The study was conducted on assumed structure. No actual constructed building was taken for this study.

REFERENCES

[1] Bureau of Indian Standard, "Code of Practice for plain and reinforced concrete", fourth edition, IS-456:2000, New Delhi.

[2] Bureau of Indian Standard, "Criteria for Earthquake Resistant Design of Structures (part-1)", fifth edition, IS-1893:2016, New Delhi.

[3] Bureau of Indian Standard, "Code of Practice for design loads(other than earthquake) for buildings and structures", second edition, IS-875:1987, New Delhi.

[4] Sigmund A. Freeman (2007). "Response Spectra As A Useful Design And Analysis Tool For Practicing Structural Engineers", ISET Journal of Earthquake Technology, Vol. 44, pp. 25–37.

[5] M. I. Adiyanto, T. A. Majid, S. S. Zaini (2008). "Analysis and Design Of 3 Storey Hospital Structure Subjected To Seismic Load Using STAAD PRO", ICCBT 2008, pp. 337–388.

[6] Sumit Pawah, Vivek Tiwari, Madhavi Prajapati (2014) "Analytical Approach to Study Effect of Shear Wall on Flat Slab & Two Way Slab", International Journal of Emerging Technology and Advanced Engineering, Vol. 4, Issue-7, pp. 244–252.

[7] M Adi Lakshmi , Ch Surendra Reddy (2014) "Effect Of Diaphragm Discontinuity In The Seismic Response Of Multy Storied Building", International Journal of Research Sciences and Advanced Engineering, Vol. 2, Issue-8, pp. 182-192.

[8] Venkatesh S.V., Sharada Bai H (2014) "Effect of Different Lateral Load Resisting Systems on 2 X 7 Bays Building Frame Subjected to Lateral (Seismic) Load", International Conference on Infrastructure Management, Assessment and Rehabilitation Techniques, pp. 01-06.

[9] Er. Raman Kumar, Er. Shagunveer Singh Sidhu, Er. Shweta Sidhu, Er. Harjot Singh Gill (2014) "Seismic Behavior Of Shear Wall Framed Buildings", International Journal of Engineering Technology, Management and Applied Sciences,Vol. 2, Issue-1, pp. 28-38.

[10] M.E. Ephraim, T.C. Nwofor (2015) "Composite Behaviour of Unbraced Multi-Storey Reinforced Concrete Infilled Frames Based on Modified One-Strut Model", Int. Journal of Engineering Research and Applications, Vol. 5, Issue-4, pp. 47-51.

[11] M.Rajivgandhi, S.Akila (2015) "Seismic Analysis And Design Of R.C.C Tall Building With Shear Wall", International Journal of Emerging Researches in Engineering Science and Technology, Vol. 2, Issue-4, pp. 7-15.

[12] Abdul Juned Siddiqui , Prabhat Soni , Aslam Hussain (2015) "Analysis and Strengthing of Soft Storey Building with Equivalent Diagonal Strut at Center under Earthquake and Wind Load", International Journal of Engineering Research, Vol. 5, Issue-2, pp. 162-171.