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ANALYZING G+15 BUILDING WITH AND WITHOUT STRUTS AND SHEAR WALLS

Sunil Kumar[1], Dr Hemant Sood[2]

[1]*ME Scholar, Department of Civil Engg., National Instituite of Technical Teachers Training & Research, Chandigarh, jngsunil@gmail.com*

[2]*Professor and Head, Department of Civil Engg., National Instituite of Technical Teachers Training & Research, Chandigarh, sood_hemant@yahoo.co.in*

Abstract— This paper presents the comparison between the building with and without shear wall and struts. Design of high-rise buildings is more complex in general than low-rise buildings and medium-rise buildings. Simple RCC frame structure comprises of only beams and columns which sometimes in high-rise building are not enough to fulfil the strength and durability criteria unless they are provided with large cross-sectional area of columns and beams. But providing large cross-sectional area of beams and columns is not feasible all the time. Therefore, some additional members, like shear walls, struts etc, become essential to support the structure. Therefore, in order to understand this concept, G+15 storey building was analyzed and designed in STAAD.Pro. Dynamic seismic analysis (by Response Spectrum Method in zone-IV as per IS: 1893-2016) was used. Different parameters were recorded from the post-processing of STAAD.Pro and then comparative cost analysis was done. Results of the analysis for G+15 building show that 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 160.82 mm, 67.74 mm and 84.71 mm respectively. Therefore, displacement in Type B 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 276.65 lakhs, Rs 277.90 lakhs and Rs 322.41 lakhs respectively. Therefore, for G+15 building, Type A is the optimum building as it involves minimum total cost of building and it is found economical and safe.

Keywords— Response Spectrum Analysis, Shear walls, Struts, High-Rise Building, Multi-Storey Structure, Staad.Pro.

I. INTRODUCTION

Depending upon the location, type of structure, forces etc structure is being designed with different design methods. Designing is a critical stage and should be done properly by considering all the parameters. There are different software available in market through which a structure is designed. Structural members (beams and columns) of any building should possess enough strength in order to resist all forces acting on it. Stability and durability are the basic requirement of any structure, therefore, in order to achieve to this guidelines through Indian Codes have been provided.
There are mainly four types of structures:

- Brick Masonry
- Reinforced Cement Concrete Structure
- Steel Structure
- Steel sections encased in Concrete called composite structures

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 fulfil 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 behaviour 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 G+15 building with and without struts and shear walls when the building is designed as per IS: 1893-2016.
- To study the structural parameters, like axial force, displacement, bending moment etc, for G+15 building 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 behaviour of G+15 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 models as mentioned below were prepared in STAAD.Pro:

- Type A: G+15 without shear walls or struts
- Type B: G+15 with struts
- Type C: G+15 with shear walls

Height of each storey	3.6m
Total no of bays	5
Each panel size	6 m x 6 m.

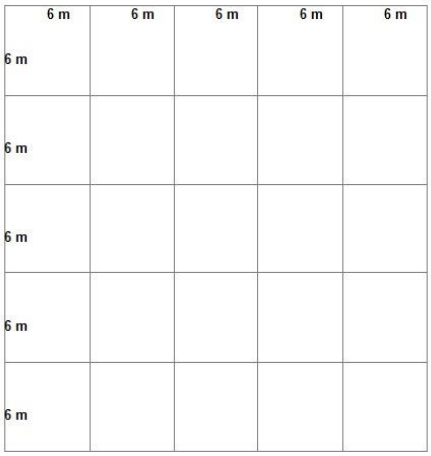

Fig.I General Plan of G+15 Building

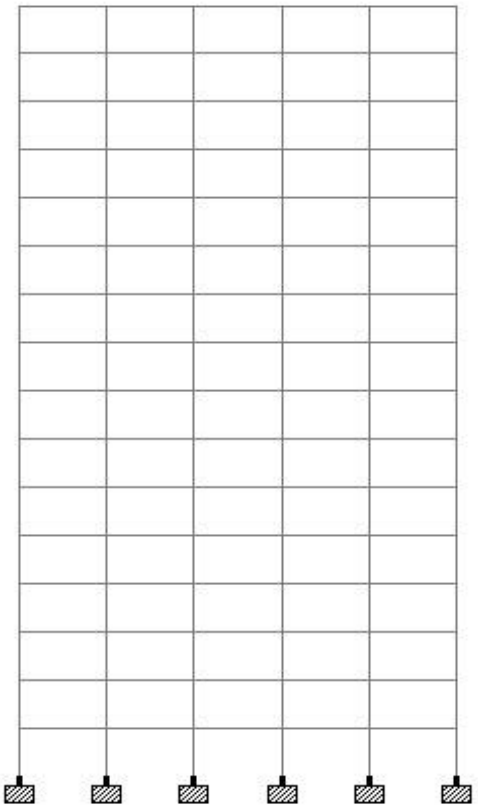

Fig.II Type A- Elevation of G+15 Building.

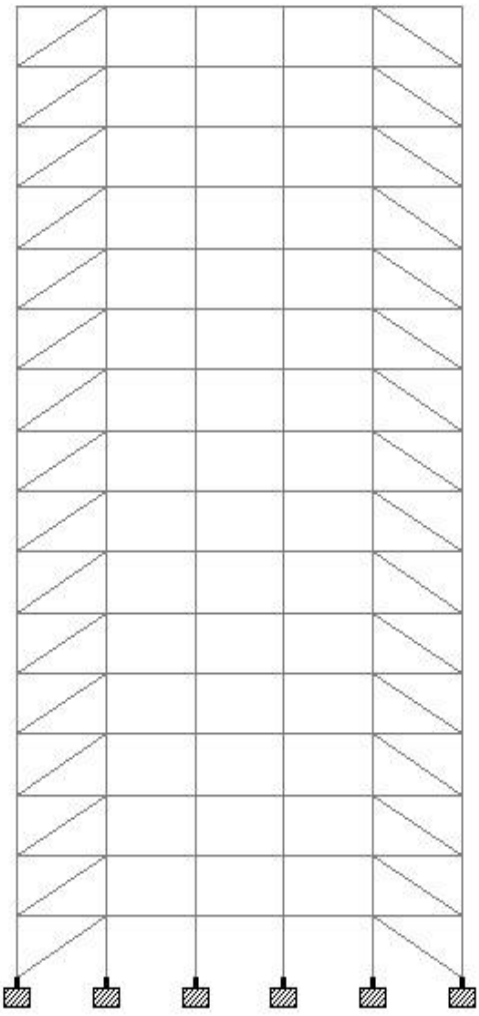

Fig.III Type B- Elevation of G+15 Building With Struts.

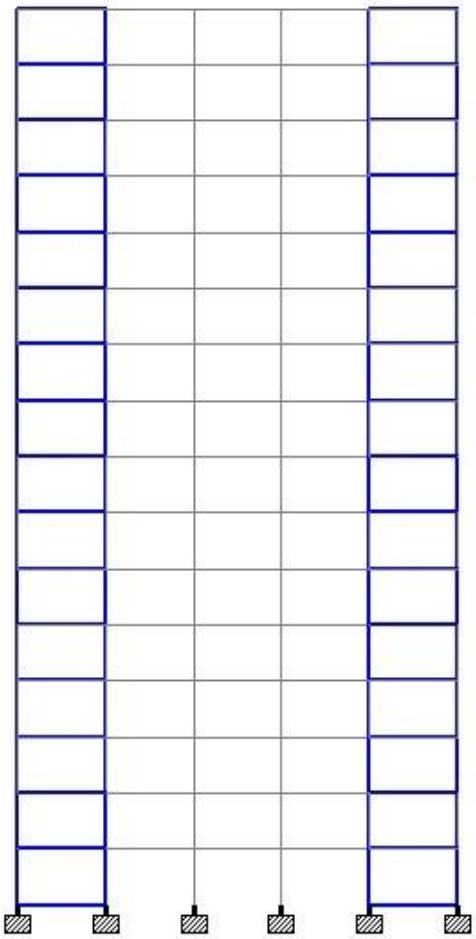

Fig.IV Type C- Elevation of G+15 Building With Shear Wall.

Input Data for preparing RCC frame structures:

a) Grades of Material:

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

b) Earthquake parameters:

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

c) For the purpose of analysing 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+15 storey building are as under:

Floor	**Column Size**	**Beam Size**	**Strut Size**
Upto 5^{th} floor	1350 x 1350 mm	600 x 450 mm	600 x 450 mm
6^{th} to 10^{th} floor	975 x 825 mm	450 x 380 mm	525 x 450 mm
Beyond 10^{th} floor	675 x 525 mm	380 x 380 mm	450 x 380 mm

Thickness of shear wall taken was 230 mm

e) Item Rates for Cost Analysis
- 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 three. Results were obtained from the post-processing of Staad.Pro. The results of the study have been represented in tabular form and comparison was made between these models.

TABLE I AXIAL FORCE

Floor	**Type A**	**Type B**	**Type C**
1	939.86	10836.55	26776.52
2	903.77	9790.80	21789.56
3	843.60	8753.22	18756.94
4	767.19	7808.57	16483.67
5	679.39	6999.46	14439.22
6	582.74	5998.41	10946.92
7	528.63	5118.25	9169.20
8	464.20	4363.54	7850.52
9	395	1188.98	6895.26
10	324.34	1001.52	6003.71
11	258.84	753.65	3905.86
12	201.59	507.38	2962.74
13	147.83	304.34	2187
14	97.72	167.95	1482.26
15	54.95	109.4	985.95
16	22.73	2.59	362.33

TABLE II BENDING MOMENT

Floor	**Type A**	**Type B**	**Type C**
1	1445.66	15.84	1645.35
2	1031.62	53.67	885.43
3	768.76	38.70	580.62
4	617.69	34.41	430.5
5	537.61	33.01	282.70

6	616.68	21.22	384.59
7	413.02	38.52	162.39
8	303.13	32.70	107.54
9	254.18	67.34	93.71
10	218.6	51.77	45.57
11	0.04	59.86	75.46
12	146.46	25.54	12.43
13	115.97	21.06	12.67
14	94.71	14.80	77
15	71.81	9.84	94.45
16	61.74	22.91	32.83

TABLE III PERCENTAGE OF STEEL

Floor	Type A	Type B	Type C
1	0.81	1.79	4.30
2	0.81	1.50	3.35
3	0.81	1.37	3.00
4	0.81	1.18	2.48
5	0.81	1.07	2.20
6	0.80	2.18	3.74
7	0.80	1.87	3.41
8	0.80	1.5	2.92
9	0.80	0.80	2.40
10	0.80	0.80	2.18
11	0.89	0.89	3.19
12	0.89	0.89	2.72
13	0.89	0.89	2.04
14	0.89	0.89	1.36
15	0.89	0.89	1.13
16	0.89	0.89	0.89

TABLE IV DISPLACEMENT IN MM

Floor	Type A	Type B	Type C
1	1.41	0.85	1.1
2	4.93	2.64	3.13
3	9.90	4.99	5.87
4	15.93	7.74	9.13
5	22.79	10.76	12.77
6	32.21	14.57	17.50
7	44.31	19.04	23.14
8	57.71	23.84	29.25
9	71.65	28.84	35.70
10	85.84	33.98	42.31
11	101.93	39.84	49.57
12	118.25	45.89	56.96
13	132.99	51.84	64.33
14	145.20	57.57	71.60
15	154.42	62.93	78.66
16	160.82	67.74	84.71

TABLE V TOTAL QUANTITY OF CONCRETE AND STEEL

Building Type	Concrete (m^3)	Steel (tonnes)
Type A	3083.5	344.72
Type B	3282.7	325.45
Type C	3719.5	387.58

TABLE VI TOTAL COST OF CONCRETE AND STEEL

Building Type	Concrete (Lakhs)	Steel (Lakhs)
Type A	138.76	137.89
Type B	147.72	130.18

Type C	167.38	155.03

TABLE VII TOTAL COST (CONCRETE AND STEEL) OF BUILDING

Building Type	Total Cost (Lakhs)
Type A	276.65
Type B	277.90
Type C	322.41

IV. CONCLUSIONS

Following conclusions have been made for G+15 building from the obtained 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 160.82mm, 67.74mm and 84.71mm respectively. Therefore, displacement in Type B building is minimum.
- Type A (building without shear walls and strut) uses minimum quantity and cost of concrete and Type B (building with strut) 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 276.65 lakhs, Rs 277.90 lakhs and Rs 322.41 lakhs respectively.
- Therefore, for G+15 building, Type A (building without shear walls and strut) is the optimum building as it involves minimum total cost of building and it is found economical and safe.

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