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An Analysis and Comparative Study of Replacement of Shear Wall with Intermediate Beams

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***Keywords*— Shear walls, Storey drift, Base shear, Shear force, Bending Moment, Node displacement.**

***Abstract*— Shear wall systems are one of the most commonly used lateral load resisting systems in high-rise buildings. Shear wall has very high in-plane stiffness and strength, which could be used to simultaneously resist large horizontal loads, and supports vertical or gravity loads. In multi-storey buildings to resist lateral forces incorporation of shear walls has become inevitable. It is very necessary to determine the effective, efficient, and ideal location of the shear wall. This paper's study of G+5 storey building in zone-III is presented with some preliminary investigation which is analyzed by changing various position of shear wall and replacement of shear with an intermediate beam. In this paper determine the node displacement, maximum shear force, maximum moment storey drift and base shear with the help of STAAD-pro software. The building is modelled with floor area of (28m*18m) with 7 bays along 28m span each 4m and 6 bays along the 18m span each 3m and each storey height is 3m. The analysis is carried out using STAAD-pro software. A comparative study has been done placing of shear wall at different position of building and shear walls replace with the intermediate beams in the building.*

I. INTRODUCTION

Shear walls are vertical elements of the structure i.e. the horizontal force resisting system [2]. Shear walls are a type of structural system that provides lateral resistance to the building. Shear walls are designed to resist in-plane lateral forces, typically wind and seismic loads. Reinforced shear wall has high in plane stiffness. Positioning of shear wall has influence on the overall behavior of the building [1]. In many jurisdictions the international building code and international residential code govern the design of shear walls. A shear wall resists loads parallel to the plane of the wall. Shear walls are typically light framed or braced wooden walls with shear panels, reinforced concrete walls, reinforced masonry walls, or steel plates. Shear walls generally start at foundation level and are continuous throughout the building height. In absence of shear wall axial load and bending moments are maximum on column [6]. The constructing of shear wall in building damages due to effect of lateral forces due to earthquake and high wind can be minimize [8]. The thickness of the reinforced concrete wall can be as low as 150mm or as high as 400mm in high rise buildings. Shear walls are usually provided along both length and width of buildings. All of the load combinations in the STAAD Pro software. Load like dead load, live load, earthquake load and other load. The load combination is 1.5 (dead load + earthquake load) is to be more critical. [11].

In residential building construction, shear walls are straight external walls that typically from a box which provides all of the lateral support for the building. When shear walls are designed and constructed properly and they will have the strength and stiffness to resists the horizontal forces [9]. In building construction, a rigid vertical diaphragm capable to transferring lateral forces from exterior walls, floors, and roofs to the ground foundation in a direction parallel to their planes. Examples are the reinforced concrete wall or vertical truss. Lateral forces caused by wind, earthquake, and uneven settlement loads, in addition to the weight of structure and occupants create powerful twisting (torsion) forces. A structure with shear wall offer significant reduction in lateral sway [10]. A study has been carried out to determine the strength of Reinforced shear wall of a multi-storey building by changing shear wall location and replace the shear wall by an intermediate beam. Parameters like maximum shear, maximum moment, node displacement, maximum reaction and storey drift are observed and compared. The different types of models are as follows (Table 2).

1. Type 1 Building without a shear wall.
2. Type 2 Building with shear walls at sides.
3. Type 3 Replacement of shear walls at sides by the intermediate beam.
4. Type 4 Building with shear walls at corners.
5. Type 5 Replacement of shear walls at corner by the intermediate beam.
6. Type 6 Building with shear walls at the center.
7. Type 7 Replacement of shear walls at center by the intermediate beam.

II. OBJECTIVE

1. To analyze and compare the buildings with shear walls and replacement of shear walls by intermediate beams and without shear walls with the help of STAAD pro software.
2. To calculate maximum node displacement and storey drift values in x-direction and z-direction and compare all types of buildings.
3. To calculate maximum bending moment in columns in y-direction and z-direction in different directions in all types of buildings.
4. To calculate the maximum shear force in columns in y-direction and z-direction in a different direction in all types of buildings.
5. To calculate maximum bending moment in beams of all types of buildings.
6. To calculate the maximum shear force in beams of all types of buildings.
7. To calculate base shear in x-direction and z-direction in all types of buildings.

III. METHODOLOGY

There are many ways to test the performance of various arrangements described above. The STAAD.PRO software simulate various loading conditions and show results about how the structure will perform in actual scenarios. The software offers various types of analysis techniques such as p-delta analysis, static analysis, geometric non-linear analysis, buckling analysis, dynamic analysis, Time-history analysis etc. In our paper study of multistoried frame under seismic loads have been investigated for various locations of shear walls & replacement of various location of shear wall by intermediate beams. An analysis of multistoried frame of G+5 stories has been carried out. The building were assumed to be located in seismic zone III. The shear walls were provided at different locations of building and replacement of shear walls at different locations by an intermediate beams. The analysis of the building has been carried out by static method approach using STAAD Pro V8i SELECT series 4.

A G+5 multistory frame with three different locations of shear walls situated in seismic zone III have been taken for the purpose of the study. The size of building in plan is 28m x18m. Height of each storey= 3m, Size of column= 300mm x 300mm, Size of beam= 230mm x 230mm, Shear wall thickness= 200mm, Slab thickness= 150mm, Concrete mix used= M30, Grade of steel= Fe415. Dead loads and Live loads have taken as per IS 875 (Part 1) 1987 and IS 875 (Part 2) (1987), respectively Seismic load calculation has been done based on the IS 1893 (part 1) 2002. The loads combinations considered in the analysis are 1.5(DL+LL), 1.5(DL+EQ), 1.2(DL+LL+EQ) and 0.9DL+1.5EQ. Table (1) shows various features which are given as input to the software to simulate the loading conditions. After successfully performing the analysis the results are compared Results and Discussion section.

IV. RESULTS & DISCUSSION

In this paper, an attempt has been made to test & find the best location to provide shear wall in multi-storey buildings. In total, 7 different configurations were made and results were analyzed. When considering maximum shear force and maximum bending moment Type 4 configured showed least values of maximum shear force and bending moment in beams and columns.

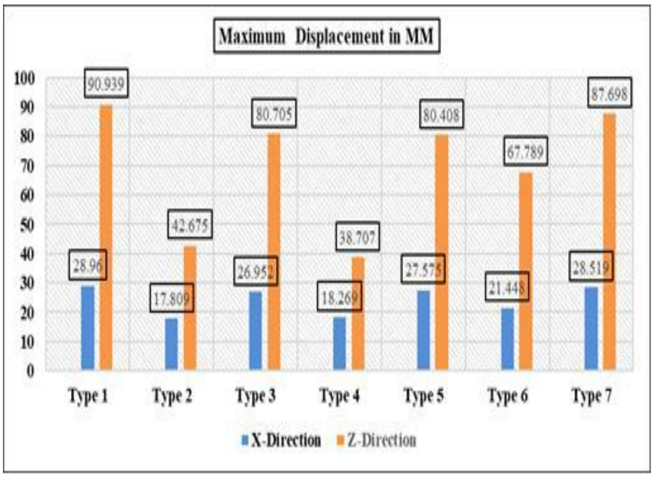


Fig.1: - Maximum displacement in X-direction and Z-direction

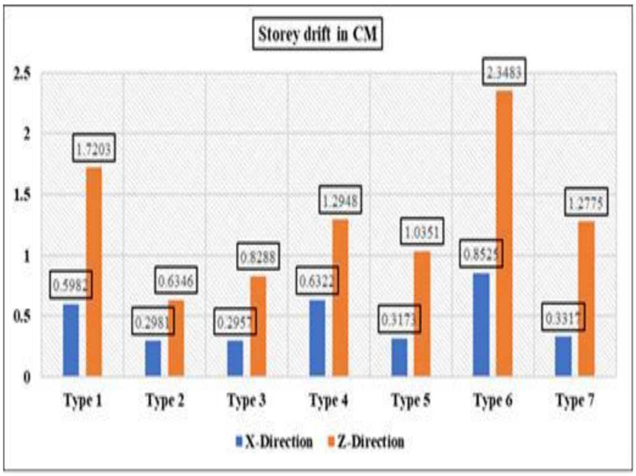


Fig. 2:- Maximum storey drift in X-direction and Z-direction

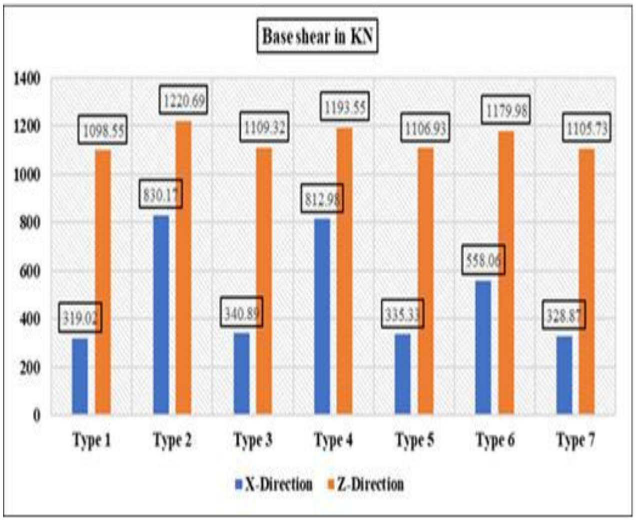


Fig. 3:- Maximum base shear in X-direction and Z-direction

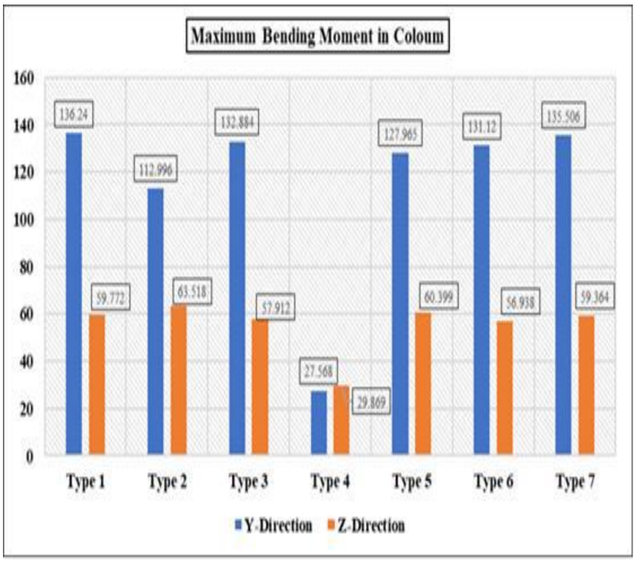


Fig. 4:- Maximum bending moment in column in Y-direction and Z-direction

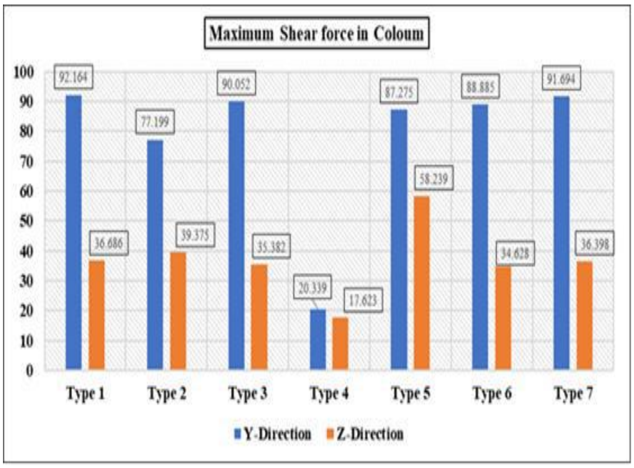


Fig. 5:- Maximum shear force in column in Y-direction and Z-direction

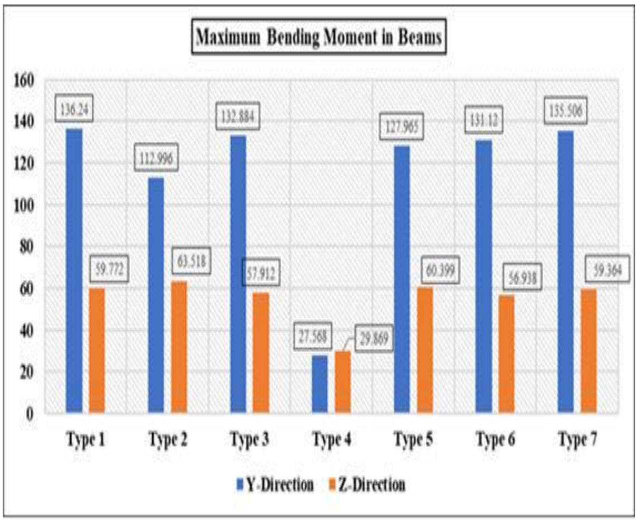


Fig. 6: - Maximum Bending Moment in Beams

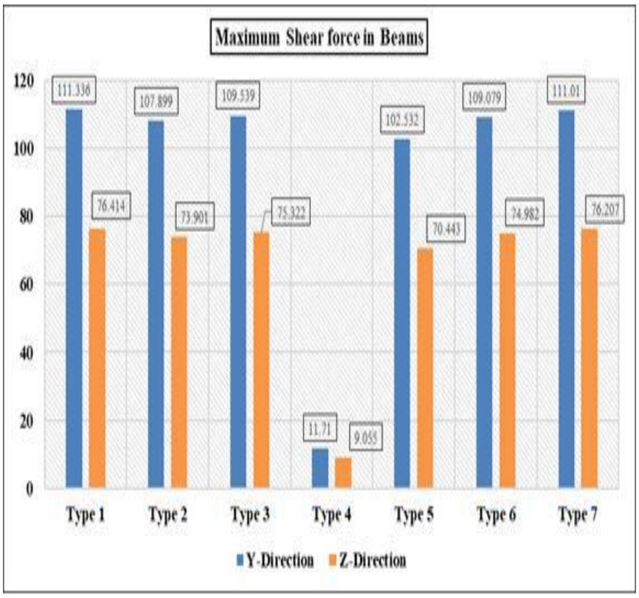
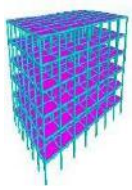
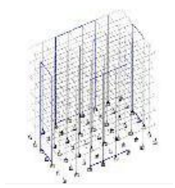
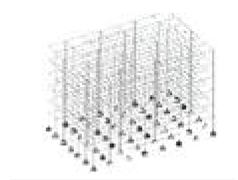
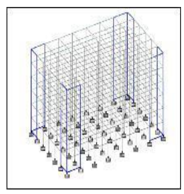


Fig.7:- Maximum shear force in beams

Table 1: - Structural Properties of RC Buildings

Properties	**Details**
Type of building	Residential
Stories	G+5
Storey height	3m
Beam dimension	0.23m x0.23m
Column dimension	0.3mx0.3m
Shear wall thickness	200mm
Depth of slab	150mm
Grade of concrete	M30
Grade of steel	Fe415
Support condition	Fixed
Earthquake Zone	III
Live load	3 KN/m2
Floor finish	1 KN/m2
Calculation of dead load- Self weight of slab	0.15x25= 3.75KN/m2
Zone factor	0.16
Response reduction factor	5.0
Importance factor	1.0
Soil type	medium soil
Rock and soil site factor	2
Damping ratio	5%
Period in Z-direction	0.50 sec

Table 2: Different Types of Models made.

Type of Model	**Types - 1**	**Types - 2**	**Types - 3**	**Types – 4**
Description	Building without shear wall	Building with shear wall with sides.	Replacement of Shear walls at sides with Intermediate beam	Building with shear walls at corner
Illustration				

Type of Model	**Types - 5**	**Types - 6**	**Types - 7**
Description	Replacement of Shear walls at corner by Intermediate beams	Building with shear walls at centre	Replacement of Shear walls at centre by Intermediate beams

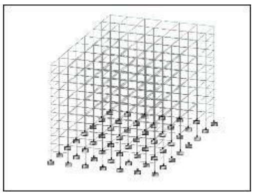
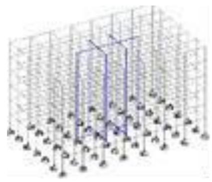
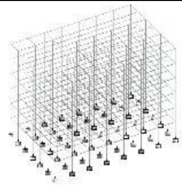
Illustration			

Table 3:- Value of base shear for all types of structure in X-direction and Z-direction

Type	**Base shear in X-direction**	**% increase↑ and decrease↓**
Type 1	319.02	-
Type 2	830.17	160.23 % ↑
Type 3	340.89	**6.86 % ↑**
Type 4	812.98	154.84 % ↑
Type 5	335.33	**5.11 % ↑**
Type 6	558.06	74.93 % ↑
Type 7	328.87	**3.09 % ↑**

Type	**Base shear in Z-direction**	**% Increase↑ and decrease↓**
Type 1	1098.55	-
Type 2	1220.69	11.12 % ↑
Type 3	1109.32	**0.98 % ↑**
Type 4	1193.55	8.65 % ↑
Type 5	1106.93	**0.76 % ↑**
Type 6	1179.98	7.41 % ↑
Type 7	1105.73	**0.65 % ↑**

Table 4:- Value of Bending moment in column in Y-direction and Z-direction in KN-m

Type	**Bending moment in column in Y-direction**	**% Increase↑ and decrease↓**
Type 1	136.240	-
Type 2	112.996	17.06 % ↓
Type 3	132.884	**2.46 % ↓**
Type 4	27.568	79.76 % ↓
Type 5	127.965	**6.07 % ↓**
Type 6	131.120	3.76 % ↓
Type 7	135.506	**0.54 % ↓**

Type	**Bending moment in column in Z-direction**	**% increase and decrease↓**
Type 1	59.772	-
Type 2	63.518	6.27 % ↑
Type 3	57.912	**3.11 % ↓**
Type 4	29.869	50.03 % ↓
Type 5	60.399	**1.05 % ↑**
Type 6	56.938	4.74 % ↓
Type 7	59.364	**0.68 % ↓**

Table 5:- Value of Shear force in column in Y-direction and Z-direction

Type	**Shear force in column in Y-direction**	**% Increase↑ and decrease↓**
Type 1	92.164	-
Type 2	77.199	16.24 % ↓
Type 3	90.052	**2.29 % ↓**
Type 4	20.339	77.93 % ↓
Type 5	87.275	**5.30 % ↓**
Type 6	88.885	3.56 % ↓
Type 7	91.694	**0.51 % ↓**

Type	**Shear force in column in Z-direction**	**%Increase ↑and decrease↓**
Type 1	36.686	-
Type 2	39.375	7.33 % ↑
Type 3	35.382	**3.55 % ↓**
Type 4	17.623	51.96 % ↓
Type 5	58.239	**58.75 % ↑**
Type 6	34.628	5.61 % ↓
Type 7	36.398	**0.78 % ↓**

Table 6:- Value of Bending moment in beam in KN-m

Type	Bending moment in beam	%Increase↑ and decrease↓
Type 1	111.336	-
Type 2	107.899	3.09 % ↓
Type 3	109.539	**1.61 % ↓**
Type 4	11.710	89.48 % ↓
Type 5	102.532	**7.91 % ↓**
Type 6	109.079	2.03 % ↓
Type 7	111.010	**0.30 % ↓**

Table 7:- Value of Shear force in beam in KN

Type	Shear force in beam	% Increase↑ and decrease↓
Type 1	76.414	-
Type 2	73.901	3.29 % ↓
Type 3	75.322	**1.43 % ↓**
Type 4	9.055	88.15 % ↓
Type 5	70.443	**7.81 % ↓**
Type 6	74.982	1.87 % ↓
Type 7	76.207	**0.27 % ↓**

IV. CONCLUSION

In this paper main aim was to compare and analyzed effect of shear walls at different Location of multistory. Building and replacement of shear wall by intermediate beams. The parameter of comparison like Maximum Node displacement, Base shear, Storey drift, maximum Bending moment and maximum shear force at different directions.

On analysis based on designed structure with various positional configuration of shear walls and of shear wall by intermediate beam with respect to seismic load acting as calculated from STAAD Pro software shows that at sides position of shear wall and replacement of shear wall by intermediate beam structure with respect to node displacement is best suited.

Base shear is an estimate of the maximum expected lateral force that will occur due to seismic ground motion at the base of structure. Value of base shear is observed minimum for the case in which no shear walls are provided in the structure. The value of base shear increases with the provision of shear wall and replacement of shear wall by intermediate beams. In this paper the maximum base shear is observed in the type 2, it means that it provides maximum safety against the earthquake load.

The proportionate material requirement for the applied load, in the construction of building is type 4 structure will be more economical than other type structure.

Provision of shear wall results in reduction of average displacements it means if shear wall is provided in structure the displacement should be minimum and replacement of shear wall by intermediate beams will also displacement should be minimum with respect to without shear wall structure. In this paper type 2 structure is shows that the minimum nodal displacement.

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