

A COMPARITIVE ANALYSIS OF INNER AND OUTER SHEAR WALL ON MULTISTORY STRUCTURE BY STAAD APPLICATION

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Abstract: This project work focuses on comparison of seismic analysis of G+10 building stiffened with bracings and shear wall. The performance of the building is analyzed in different zones. The study includes understanding the main consideration factor that leads the structure to perform poorly during earthquake in order to achieve their appropriate behavior under future earthquakes. The analyzed structure is symmetrical, G+10, Ordinary RC moment-resting frame (OMRF). Modelling of the structure is done as per staad pro. V8i software. Time period of the structure in both the direction is retrieve from the software and as per IS 1893(part 1):2002 seismic analysis has undergone. The Lateral seismic forces of RC frame is carried out using linear static method as per IS 1893(part 1): 2002 for different earthquake zones.

Shear walls have high in-plane quality and firmness, which can be utilized at the same time for opposing substantial flat and gravity loads. In tall structures, it is vital to guarantee satisfactory lateral solidness to oppose parallel load. As in tall structures it is essential, it is to be taken for low ascent structures also. The point of this research is to decide the arrangement whether the structure with or without shear wall is appropriate and area of the shear wall as per the suitability. For this reason three unique models ten storied building each has been considered i.e. one model without shear wall and other with shear wall with various areas (i.e., inward and external part). The results of the performance and the analysis of the models are then graphically represented and also in tabular form and is compared for determining the best performance of building against lateral stiffness by arrangement of three different types of bracings with three different orientation of bracings and shear wall.

Key Notes: Shear wall, lateral loads, Seismic analysis, High Rise Building, torsional irregularity, Displacement.

I. INTRODUCTION

In many respects concrete is an ideal building material, combining economy, versatility of form and function, and noteworthy resistance to fire and the ravages of time. The raw materials are available in practically every country, and the manufacturing of cement is relatively simple. It is little wonder that in this century it has become a universal building material. Tall buildings are the most complex built structures since there are many conflicting requirements and complex building systems to integrate. Today's tall buildings are becoming more and more slender, leading to the possibility of more sway in comparison with earlier high-rise

buildings. RC Buildings are adequate for resisting both the vertical and horizontal load. When such building is designed without shear wall, the beam and column sizes are quite heavy, steel quantity is also required in large amount thus there is lot of congestion at these joint and it is difficult to place and vibrate concrete at these places and displacement is quite heavy which induces heavy forces in member. Shear wall may become imperative from the point of view of economy and control of lateral deflection. In RC multi-storey building R.C.C. lift well or shear wall are usual requirement. Centre of mass and stiffness of the building must coincide. However, on many occasions the design has to be based on the off center position of lift and stair case wall with respect to center of mass which results into an excessive forces in most of the structural members, unwanted torsion moment and deflection.

Reinforced concrete walls, which include lift wells or shear walls, are the usual requirements of Multi Storey Buildings. Design by coinciding center of mass and stiffness of the building is the ideal for a Structure. Providing of shear wall represents a structurally efficient solution to stiffen a building structural system because the main function of a shear wall is to increase the rigidity for lateral load resistance. The use of shear wall structure has gained popularity in high rise building structure, especially in the construction of service apartment or office, commercial tower. It is very important to note that shear walls meant to resist earthquake should be designed for ductility. The construction technique of a building has a great concern in the field of civil engineering. Many concepts were taken into account for the structures like their strength, durability, life cycle, stiffness, compression, tension, moment, displacement, shear and etc.; Shear wall systems are most effective means to adopt to add more stiffness in frames. At present, in many high rise building constructions, shear wall has been provided as lift core in case of core type shear wall or constructed as load bearing walls.

Generally shear wall can be defined as structural vertical member that is able to resist combination of shear, moment and axial load induced by lateral load and gravity load transfer to the wall from other structural member. As per assumptions, it is considerably regarded that less self-weight causes less story shears. Previously, the findings of researches had almost identical outcomes to determine the effectiveness of strengthening systems. Discussions on comparison between with shear walls and without shear wall system based on performance levels were made. Reinforced concrete walls, which include shear walls, are the usual

requirements of Multi Storey Buildings. Design by coinciding centroid and mass center of the building is the ideal for a Structure. An introduction of shear wall represents a structurally efficient solution to stiffen a building structural system because the main function of a shear wall is to increase the rigidity for lateral load resistance. In modern tall buildings, shear walls are commonly used as a vertical structural element for resisting the lateral loads that may be induced by the effect of wind and earthquakes which cause the failure of structure. Provision of walls helps to divide an enclose space, whereas of cores to contain and convey services such as elevator. Wall openings are inevitably required for windows in external walls and for doors or corridors in inner walls or in lift cores. The size and location of openings may vary from architectural and functional point of view. The use of shear wall structure has gained popularity in high rise building structure, especially in the construction of service apartment or office/ commercial tower.

Reinforced concrete (RC) buildings often have vertical plate-like RC walls called Shear Walls in addition to slabs, beams and columns. These walls generally start at foundation level and are continuous throughout the building height. Their thickness can be as low as 150mm, or as high as 400mm in high rise buildings. RC shear walls provide large strength and stiffness to buildings in the direction of their orientation, which significantly reduces lateral sway of the building and thereby reduces damage to structure and its contents. Since shear walls carry large horizontal earthquake forces, the overturning effects on them are large. Shear walls in buildings must be symmetrically located in plan to reduce ill-effects of twist in buildings. They could be placed symmetrically along one or both directions in plan. Shear walls are more effective when located along exterior perimeter of the building such a layout increases resistance of the building to twisting.

The most probable structure which is suitable for resist the building from all the classified causes like Wind, seismic transformation, torsional forces, displacement of the body and etc. is expectably RC Building with braced system (Shear wall). Mostly in structured part it is usually going to be difficult to follow the examined part. Hence some of the methods were used to analyze it. If analyzed it according to the economic purpose, the structure without support of shear wall is much more economical than without providing shear wall.

FUNCTION OF SHEAR WALL: Shear walls must provide the necessary lateral strength to resist horizontal earthquake forces. When shear walls are strong enough, they will transfer these horizontal forces to the next element in the load path below them. These other components in the load path may be other shear walls, floors, foundation walls, slabs or footings. Shear walls also provide lateral stiffness to prevent the roof or floor above from excessive side's way. When shear walls are stiff enough, they will prevent floor and roof framing members from moving off their supports. Also, buildings that are sufficiently stiff will usually suffer less non-structural damage.

II. ADVANTAGES OF SHEAR WALL

(1) Sound reducing: Land for home building is becoming scarce and homes are being built closer together and near noise sources like highways, railways and airports. Concrete homes have attractive sound-reducing qualities to provide the kind of quiet comfort buyers look for in a home.

(2) Cost saving: Purchasers and developers will reap the benefits of concrete construction, including good acoustic performance, excellent fire resistance, high thermal mass and low maintenance, all achieved within budget. Conventional structural design emphasizes rebar component with minimum concrete frame. This type of reinforce concrete structure emphasizes very heavy rebar design. Conventional design remains infilling with brick walls of which require a lot of skill workers for brick lying and plastering. That gives cost savings in material, time and money and eliminating waste etc. Mortar, Timber form, Steel reinforcement, Bricks, Plastering, Sand, Cement.

(3) Greater control of accuracy and workmanship: With the durable, each successive home built is as high quality as the first. When you build a house using pre-engineering, it offers greater control of accuracy and workmanship during construction. This result in a higher quality structure compared to the conventional method using a lot of timber formwork. The quality of timber formwork very much depends on the individual skills of workers of which made the quality of each home built different. With the shortage of available skill labours in today construction market, selecting the right forming equipment becomes even more important.

(4) Superb concrete finish, quality improvement: Have all the value and benefit of concrete. Quality is enhanced despite the speed of construction. The precise, even steel face of PCG SYSTEMS creates a smooth, high quality finish capable of receiving direct decoration with the minimum of preparation (a level of 1 to 10mm thick skim coat is required). This reduces the requirement for finishing trades, thus providing additional cost savings and speeding the entire process.

(5) Lesser water seepage problem: Water seepage through external walls was found to be a common defect faced by homeowners. The survey findings also showed that the use of single layer brick wall is the most common cause of water seepage through external walls. Almost 90% of the water seepage occurred through cracks in the plastered brick walls. In general, water seepage through external walls occurred within the first five years of building completion. Water seepage through the external walls is unacceptable to the occupants.

(6) Fire resistance: Fire can endanger the lives of everyone in the family and destroy those things that cannot be replaced. Insurance companies recognize concrete as being safer than any other method of construction when fire threatens a home. Living in a concrete home can ultimately bring peace of mind for homeowners concerned about fire.

(7) Strong, solid, rigid, durable and low maintenance: One of the key benefits of building with concrete is that it is durable and easy to maintain. Concrete and cement based products

form a solid, durable that resists rot, pests and wild fires. Buying a home is typically the biggest investment we will ever make. If that home is constructed with concrete walls, our investment is naturally protected from the structural damage that can be caused by the effects of nature. As the owner of a concrete home, we will benefit from lowest annual maintenance and energy costs while living in a home that provides a secure haven for our family.

Following are the applications of Shear wall:-

- Shear wall is a structural member used to resist lateral forces i.e. parallel to the plane of the wall. In other words, Shear walls are vertical elements of the horizontal force resisting system.
- In building construction, a rigid vertical diaphragm applicable for transferring lateral forces from exterior walls, floors, and roofs to the ground foundation in a direction parallel to their planes.
- Shear walls are especially applicable in high-rise buildings subject to lateral wind and seismic forces. They provide adequate strength and stiffness to control lateral displacements.
- Structurally, the best position for the shear walls is in the center of each half of the building. This is rarely practical, since it also utilizes the space a lot, so they are positioned at the ends.

III. METHODOLOGY

In this study comparison of conventional building under seismic forces is done with and without shear wall and also consideration of location to be determined. Here G+ 9 storey is taken and same live load is applied in the structure for its behavior and comparison. The framed buildings are subjected to vibrations because of earthquake and therefore seismic analysis is essential for these building frames. The fixed base system is analyzed by employing in building frames in seismic zone III by means of STAAD software. The response of the building frames with and without shear wall and the structure with shear wall in different location as in inner and outer portion of the structure is studied for useful interpretation of results. Selection of appropriate damage parameters is very important for performance evaluation. Overall lateral deflection and inter-Storey drift are most commonly used damage parameters. Overall deflection is not always a good indicator of damage, but inter-Storey drift is quite useful because it is representative of the damage to the lateral load resisting system. Maximum values of member or joint rotations, curvature and ductility factors are also good indicators of damage because they can be directly related to the element deformation capacities. However, the maximum value alone of any of these parameters may not be salient to quantify the overall damage caused by cyclic reversal of deformation.

STRUCTURAL DISPLACEMENT

The lateral displacements for 10 storey building with and without shear wall for zone III were determined from the analysis on STAAD Software. The lateral displacement of 10 Storey building with shear walls was then compared to the

lateral displacement of 10 storey building without shear wall in Zone III and corresponding graphs were plotted. As per IS 1893 (Part 1):2002, clause 7.11.1, the displacement shall not exceed 0.004 times the storey height. The maximum limits for 10 storey building are as follow, For 10 Storey Building, $0.004 \times 45 = 0.180\text{m}$.

TORSIONAL IRREGULARITY

Earthquake field investigations repeatedly confirm that irregular structures suffer more damage than their regular counterparts. Torsional irregularity is one of the most important factors, which causes severe damage (even collapse) for the structures. A large number of studies exist which investigate various aspects of torsional irregularity including geometric asymmetry. Regarding the torsional irregularities, most of the codes have similar provisions essentially based on principles of the well-known standards of IBC06 (2006), UBC97 (1997), and ASCE7-10 (2010). A certain number of studies are devoted to the discussion and interpretation of the provisions in UBC97, IBC06 (2006), and other seismic codes.

Torsional irregularity which is recognized in most of the seismic design codes varies depending on a number of factors including plan geometry, dimensions and positions of structural elements, and story numbers. The purpose of this study is first to determine the conditions for excessive torsional irregularity. In order to achieve this aim, an investigation is performed for four groups of typical structures by considering without shear wall and shear wall with different positions.

MODELLING: For this study, G+9 story building with a 4-meters height for each story, regular in plan is modeled. These buildings were designed in compliance to the Indian Code of Practice for Seismic Resistant Design of Buildings. The buildings are assumed to be fixed at the base. The sections of structural elements are square and rectangular. Storey heights of buildings are assumed to be constant including the ground storey. The buildings are modeled using software STAAD. Four different models were studied in which Structure with and without Shear wall, structure with different positioning of shear wall in building i.e., Inner and Outer Portion of the Structure. Models are studied in zone-3 comparing lateral displacement for all models.

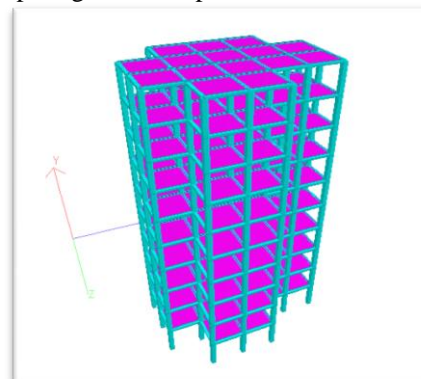


FIG.1: STRUCTURE WITHOUT SHEAR WALL

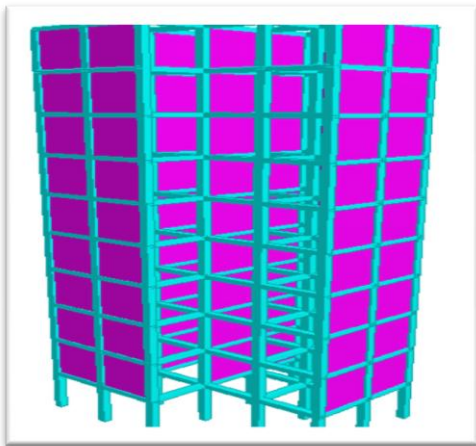


FIG.2: STRUCTURE WITH SHEAR WALL

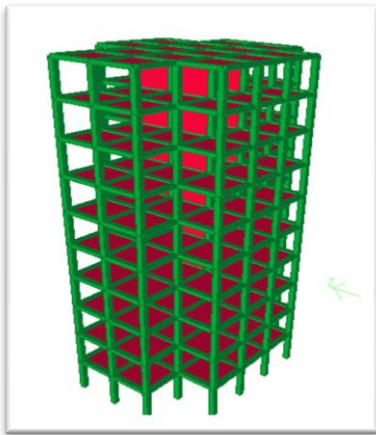


FIG.3: STRUCTURE WITH INNER SHEAR WALL

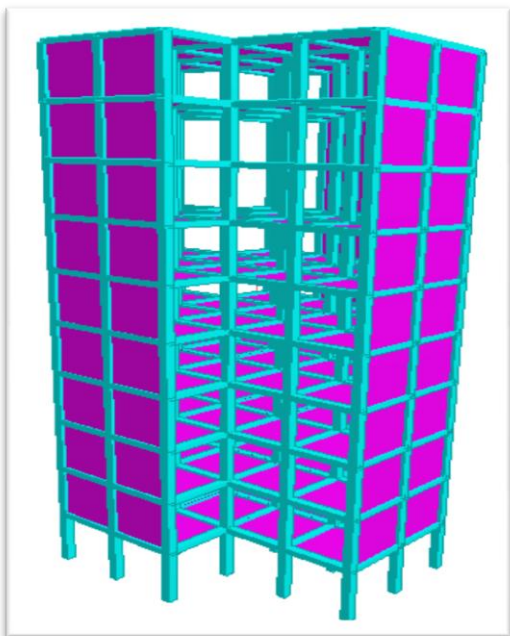


FIG.4: STRUCTURE WITH OUTER SHEAR WALL

MATERIALS:

The modulus of elasticity of reinforced concrete as per IS 456:2000 is given by $E_c = 5000 \sqrt{f_{ck}}$. For the steel rebar, the

necessary information is yield stress, modulus of elasticity and ultimate strength. High yield strength deformed bars (HYSD) having yield strength 415 N/mm^2 is widely used in design practice and is adopted for the present study.

- Type of frame: Special RC moment resisting frame fixed at the base
- Seismic zone: III
- Number of storey: 10
- Floor height: 4.0 m
- Depth of Slab: 130 mm
- Size of beam: $(450 \times 600) \text{ mm}$
- Size of column (exterior): $(400 \times 800) \text{ mm}$
- Size of column (interior): $(600 \times 600) \text{ mm}$
- Live load on floor: 2 kN/m^2
- Floor finish: 1.0 kN/m^2
- Wall load: 9.936 kN/m
- Materials: M-30 concrete, Fe-500 steel Material
- Thickness of wall: 230 mm
- Thickness of shear wall: 230 mm
- Density of concrete: 25 kN/m^3
- Type of soil: Hard
- Damping of structure: 5 percent

STRUCTURAL ELEMENTS: In this section, the details of the modeling adopted for various elements of the frame are given below.

Beams and Columns: Beams and columns were modeled as frame elements. The elements represent the strength, stiffness and deformation capacity of the members. While modeling the beams and columns, the properties to be assigned are cross sectional dimensions, reinforcement details and the type of material used.

Beam-Column Joints: The beam-column joints are assumed to be rigid.

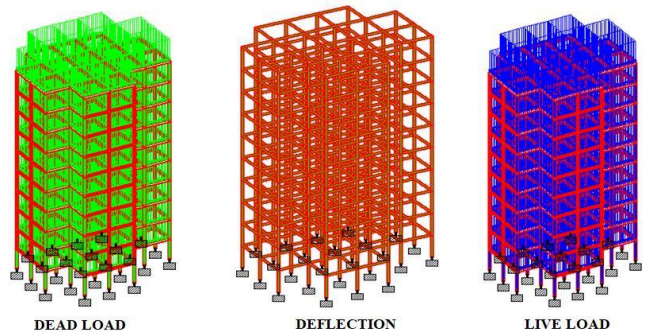
Foundation Modeling: Fixed supports were provided at the ends of supporting columns.

LOADS: All loads acting on the building except wind load were considered. These are

1. Dead Load
2. Live Load
3. Lateral Load due to Earthquake

LOAD COMBINATIONS: The load combinations considered in the analysis according to IS 1893:2002 are given below. $\text{COMB1} = 1.5(\text{DL} + \text{LL})$

IV. RESULT



MAXIMUM TORSIONAL IRREGULARITY:

Number of stories	Structure type			
	A	B	C	D
1	1.918	2.076	2.551	2.487
2	1.891	2.024	2.420	2.262
4	1.855	1.962	2.279	2.073
6	1.824	1.917	2.163	1.963
8	1.790	1.873	2.056	1.875
10	1.756	1.830	1.955	1.804

A- STRUCTURE WITHOUT SHEAR WALL
B- STRUCTURE WITH SHEAR WALL
C-STRUCTURE WITH INNER SHEAR WALL
D- STRUCTURE WITH OUTER SHEAR WALL

STORY DRIFT

Number of stories	Structure type			
	A	B	C	D
1	0.519	.340	.338	.18
2	.95	.69	.634	.398
3	1.078	.85	.776	.543
4	1.125	.955	.864	.648
5	1.148	1.019	.922	.728
6	1.163	1.06	.959	.788
7	1.172	1.087	.984	.763
8	.937	.886	.787	.724
9	.876	.83	.734	.681
10	.808	.767	.676	.636

LATERAL DISPLACEMENT

Number of stories	Structure type
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	A	B	C	D
1	1.56	0.99	0.99	0.55
2	7.64	5.43	5.5	3.30
3	14.46	11.24	10.41	7.35
4	21.47	17.61	16.14	12.13
5	28.53	24.21	22.05	17.30
6	35.55	30.83	27.96	22.63
7	42.40	37.30	33.72	27.93
8	48.94	43.47	39.21	33.07
9	55.02	49.20	44.27	37.90
10	57.83	54.33	48.79	42.31

COMPARISON OF INNER AND OUTER SHEAR WALL STRUCTURE

STRUCTURE	Structure type		
	DISPLACEMENT	TORSIONAL IRREGULARITY	STORY DRIFT
MODEL C	166.4 mm	1.752	0.788
MODEL D	151.88 mm	1.756	0.728

WITH SHEAR WALL REINFORCEMENT DETAILS

SR NO	SHEAR WALL TYPE	(W) (M M)	(L) (M M)	VERTICAL REINFORCEMENT	LATERAL TIES (NOMINAL)	LATERAL TIES (CONFINING)
1	SW ₁	230	1200	12-12mm \emptyset ,12-16mm \emptyset	8mm \emptyset @150mm c/c	100mm c/c
2	SW ₂	230	2400	16-16mm \emptyset	8mm \emptyset @150mm c/c	100mm c/c
3	SW ₃	230	2060	10-12mm \emptyset ,10-16mm \emptyset	8mm \emptyset @150mm c/c	100mm c/c
4	SW ₄	230	2000	12-16mm \emptyset ,12-16mm \emptyset	8mm \emptyset @150mm c/c	100mm c/c
5	SW ₅	230	1500	12-20mm \emptyset ,12-16mm \emptyset	8mm \emptyset @150mm c/c	100mm c/c
6	SW ₆	230	1400	12-20mm \emptyset ,12-16mm \emptyset	8mm \emptyset @150mm c/c	100mm c/c

WITH COLUMN REINFORCEMENT DETAILS

SR NO	COLUMN TYPE	WIDTH (W)(MM)	LENGTH (L)(MM)	VERTICAL REINFORCEMENT	LATERAL TIES
1	C ₁	300	800	12 No.s-12mmØ	8mmØ@100 c/c
2	C ₂	300	800	12 No.s-16mmØ	8mmØ@150 c/c
3	C ₃	300	800	12 No.s-20mmØ	8mmØ@150 c/c
4	C ₄	300	400	8 No.s-12mmØ	8mmØ@100 c/c
5	C ₅	300	600	8 No.s-12mmØ	8mmØ@100 c/c
6	C ₆	300	600	8 No.s-16mmØ	8mmØ@100 c/c

V. CONCLUSION

In this examination a research is carried on five types of average structures by considering miscellaneous shear wall positions and story numbers and on the inferred structure groups with differing axis number. the following conclusions were outlined:

- The location of shear-wall and brace member has significant effect on the seismic response than the plane frame.
- Floor revolutions increment in extent to the story numbers, i.e., most extreme floor rotation happen for most elevated story numbers.
- The concept of using steel bracing is one of the advantageous concepts which can be used to strengthen or retrofit the existing structures.
- Floor turns accomplish their most extreme values for the structures where the walls are in most remote positions from the center of mass. It is seen that the outcomes got for torsional abnormality coefficients and floor turns are very opposing.
- The lateral displacements of the building studied are reduced by the use of X type of bracing systems.
- Using steel bracings the total weight on the existing building will not change significantly.
- It has been discovered that model-D demonstrates lesser inter story drift when contrasted with different models longitudinal way.
- The lateral displacement of the building is reduced by 35% to 45 % by the use of X Type steel bracing system, and X bracing type reduced maximum displacement.

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