International Journal For Technological Research In Engineering
Volume 4, Issue 11, July-2017 *ISSN (Online): 2347 - 4718*

A COMPARATIVE ANALYSIS OF STRUCTURE WITH INNER AND OUTER EDGE SHEAR WALL BY STAAD-PRO

Ms. Jiji Thomas[1], Dr. Rakesh Patel[2]
[1]Scholar M.Tech (Structure), [2]Head
Department of Civil Engineering, SIRT-Science, Bhopal (M.P).

ABSTRACT: Shear wall system is one of the most commonly used lateral-load resisting technique for construction of buildings and to analyze its torsional irregularity. Shearwalls have very high in-plane strength and stiffness, which can be usedsimultaneously for resisting large horizontal and gravity loads. In tall buildings,it is very important to ensure adequate lateral stiffness to resist lateral load. As in tall buildings it is important, it is to be taken for low rise buildings as well. The aim of this project is to determine the solution whether the structure with or without shear wall is suitable and location of the shear wall according to the suitability. For this purpose three different models ten storied building each has been considered i.e. one model without shear wall and other with shear walls with different locations (i.e., inner and outer part). Models are studied comparing lateral displacement and load transfer to various structural elements with different positioning of shear wall. The buildings are modeled using software STAAD Pro. Providing shear walls at adequate locations substantially reduce the displacements due to earthquake as well as wind load is taken into consideration. Hence accounting shear wall in a building will form an efficient lateral force resisting system.

Key Notes:- With/Without Shear wall, lateral loads, Location of Shear wall, Low 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.

II. 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.

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 successivehome built is as high quality as the first. When youbuild a house using pre-engineering, it offers greatercontrol of accuracy and workmanship duringconstruction. This result in a higher quality structurecompared to the conventional method using a lot oftimber formwork. The quality of timber formworkvery much depends on the individual skills ofworkers of which made the quality of each homebuilt different. With the shortage of available skilllabours in today construction market, selecting theright forming equipment becomes even moreimportant.

(4) Superb concrete finish, quality improvement: Have all the value and benefit of concrete. Quality isenhanced despite the speed of construction. Theprecise, even steel face of PCG SYSTEMS creates asmooth, high quality finish capable of receivingdirect decoration with the minimum of preparation (alevel of 1 to 10mm thick skim coat is required). Thisreduces the requirement for finishing trades, thusproviding additional cost savings and speeding theentire 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. LITERATURE REVIEW

O. Esmaili, Epackachi et al (2008): In this paper study the structural aspects of one of the tallest RC buildings, located in the high seismic zone. Some especial aspects of the tower and the assessment of its seismic load bearing system with considering some important factors will be discussed.
Author concludes that the concrete structural element with different longitudinal stiffness makes the tower to be more sensitive to differential displacements due to concrete time dependency. A level of ductility for seismic bracing systems, conceptually, should be provided for energy absorption but axial loads have an adverse effect on their acceptable performance. Using shear walls for both gravity and bracing system is unacceptable neither conceptually nor economically. By considering both time dependency of concrete and construction sequence loading simultaneously in analyses, the critical demands occur in the middle height of the structure.
Dr. S.K. Dubey et al (2011):The main objective of this study was to understand different irregularity and torsional response due to plan and vertical irregularity, and to analyse shaped building while earthquake forces acts and to calculate additional shear due to torsion in the columns. Additional shear due to torsional moments needs to be considered because; this increase in shear forces causes columns to collapse. Irregularity lead to building structures with irregular distributions in their mass, stiffness and strength along the height of building. The main purpose of taking this type of building is to understand basic behavior of soft storey structure.
It was concluded that necessary to develop a simple analytical procedure based on rigorous computations and experiments on the seismic response of irregular structures. Necessary that irregular buildings should be carefully analyzed for torsion. Soft storey-For all new RC frame buildings, the best option is to avoid such sudden and large decrease in stiffness and/or strength in any storey; it would be ideal to build walls in the ground storey also.
Mahesh N. Patil et al (2015): In this paper, the earthquake response of symmetric multistoried building is studied by manual calculation and with the help of ETABS 9.7.1 software (IS 1893:2002). The responses obtained by manual analysis as well as by soft computing are compared. This paper provides complete guide line for manual as well s software analysis of seismic coefficient method. As per IS 1893:2002, Analysed base shear for the structure. Seismic analysis was done by using ETABS software and successfully verified manually as per IS 1893-2002. There is a gradual increase in the value of lateral forces from bottom floor to top floor in both manual as well as software analysis. Calculation of seismic weight by both manual analysis as well as software analysis gives exactly same result.
Results as compared and approximately same mathematical values are obtained for 8-story building. To conclude a complete design involving several parameters so as to result the earthquake has been done and 3D prospective is shown for easy understanding and use.
SUMMARY: Using shear walls for both gravity and bracing system is unacceptable neither conceptually nor economically. The presence of shear wall in the building influence the overall behavior of the structure and it increases the strength and stiffness of the structure.The selection of especially the location and amount of shear walls is of the highest importance in strengthening. Strengthening shear wall may vary in various positions according to their positions in the plan. shear wall directly obstruct this end oscillation, hence reduce overall bending moment of building. Shear wall with different opening sizes and locations considering coupling beam actions may be considered for future research.

IV. 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 x 45 = 0.180m.

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.

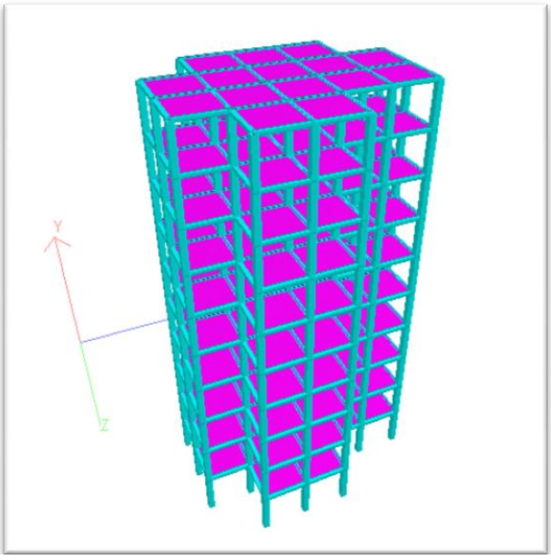


FIG.1: STRUCTURE WITHOUT SHEAR WALL

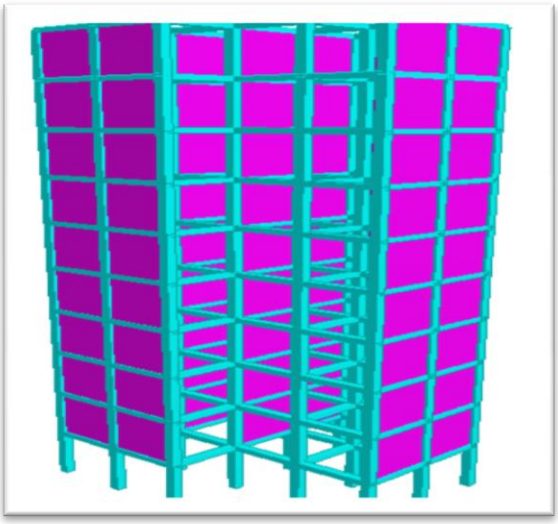


FIG.2: STRUCTURE WITH SHEAR WALL

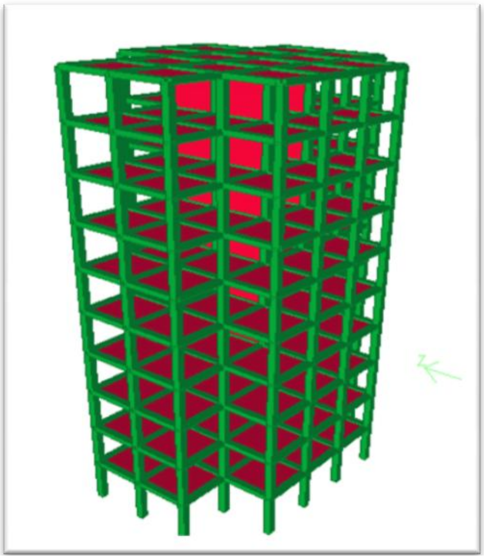


FIG.3: STRUCTURE WITH INNER SHEAR WALL

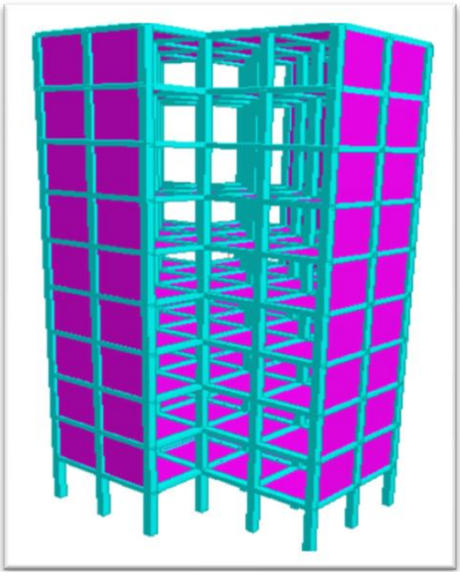
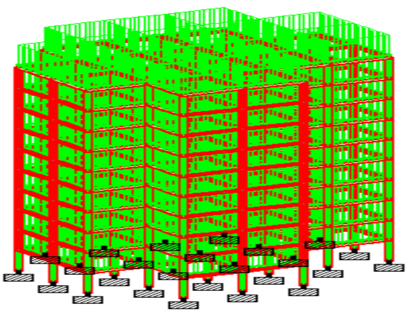


FIG.4: STRUCTURE WITH OUTER SHEAR WALL

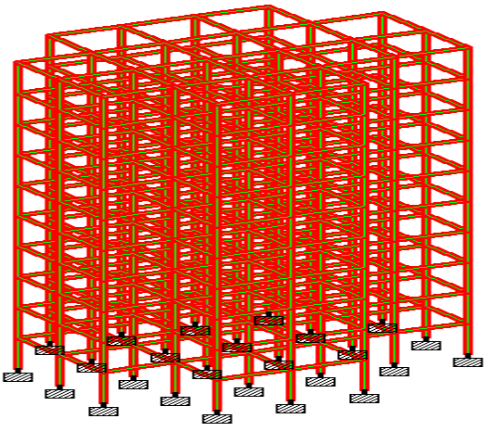
MATERIALS:
The modulus of elasticity of reinforced concrete as per IS 456:2000 is given by E_c=5000√f_{ck}.For the steel rebar, the necessary information is yield stress, modulus ofelasticity and ultimate strength. High yield strength deformed bars (HYSD)having yield strength 415 N/mm2is widely used in design practice and isadopted 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 × 600) mm
- Size of column (exterior): (400 × 800) mm
- Size of column (interior): (600× 600) 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: 230mm
- Density of concrete: 25 kN/m^3
- Type of soil: Hard
- Damping of structure: 5 percent

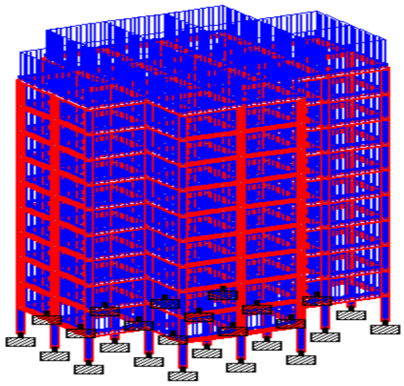
STRUCTURAL ELEMENTS: In this section, the details of the modeling adopted for various elements of the frame are given below.
Beams and Columns: Beams and columns were modeled as frame elements. The elements represent the strength, stiffness and deformation capacity of the members. While modeling the 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.COMB1 = 1.5 (DL+LL)
RESULT:



DEAD LOAD



DEFLECTION



LIVE LOAD

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

COMPARISION 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) (MM)	(L) (MM)	VERTICAL REINFORCEMENT	LATERAL TIES (NOMINAL)	LATERAL TIES (CONFINING)
1	SW_1	230	1200	12-12mmØ,12-16mmØ	8mmØ@150mm c/c	100mm c/c
2	SW_2	230	2400	16-16mmØ	8mmØ@150 mm c/c	100mm c/c
3	SW_3	230	2060	10-12mmØ,10-16mmØ	8mmØ@150 mm c/c	100mm c/c
4	SW_4	230	2000	12-16mmØ,12-16mmØ	8mmØ@150 mm c/c	100mm c/c
5	SW_5	230	1500	12-20mmØ,12-16mmØ	8mmØ@150 mm c/c	100mm c/c
6	SW_6	230	1400	12-20mmØ,12-16mmØ	8mmØ@150 mm c/c	100mm c/c

WITH COLUMN REINFORCEMENT DETAILS

SR NO	COLUMNT YPE	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 study a parametric investigation is performed on six types of typical structures by considering different shear wall positions and story numbers and on the derived structure groups with varying axis number. Findings on lateral load analyses are evaluated and the following conclusions are summarized:

- For all the investigated structures, torsional irregularity coefficients increase as the story numbers decrease.
- Floor rotations increase in proportion to the story numbers, i.e., maximum floor rotations occur for highest story numbers.
- Torsional irregularity coefficients reach maximum values when the shear walls are placed as close as possible to the centres of mass without coinciding them.
- It has been found that model- D shows lesser displacement as compared to other models in longitudinal direction.
- It has been found that model-D shows lesser inter storey drift as compared to other models in longitudinal direction.

REFERENCES

[1] FEMA. NEHRP Guidelines For The Seismic Rehabilitation Of Buildings (FEMA 273). Washington (DC): Building Seismic Safety Council; 1997.

[2] FEMA 356 NEHRP Pre Standard And Commentary For The Seismic Rehabilitation Of Buildings. (2000).

[3] K.V.G.D BALAJI PUSHOVER ANALYSIS OF UNSYMMETRICAL FRAMED STRUCTURES ON SLOPING GROUND. International Journal Of Civil, Structural Environmental And Infrastructure Engineering, Research And Development (IJCSEIERD), ISSN 2249- 6866,Vol. 2 Issue 4 Dec - 2012 45-54.

[4] Mrugesh D. Shah NONLINEAR STATIC ANALYSIS OF R.C.C. FRAMES (Software Implementation ETABS 9.7) National Conference On Recent Trends In Engineering & Technology.

[5] S. V. Venkatesh EFFECT OF INTERNAL & EXTERNAL SHEAR WALL ON PERFORMANCE OF BUILDING FRAME SUBJECTED TO LATERAL LOAD. International Journal Of Earth Sciences And Engineering, ISSN 0974-5904, Volume 04, No 06 SPL, October 2011.

[6] Anshuman.S. SOLUTION OF SHEAR WALL LOCATION IN MULTI-STOREY BUILDING. International Journal Of Civil And Structural Engineering, ISSN 0976 – 4399, Volume 2, No 2, 2011.

[7] Mangulkar Madhuri N. REVIEW ON SHEAR WALL FOR SOFT STORY HIGH-RISE BUILDINGS. International Journal Of Engineering And Advanced Technology (IJEAT), ISSN: 2249 – 8958, Volume-1, Issue-6, August 2012

[8] Anuj Chandiwala EARTHQUAKE ANALYSIS OF BUILDING CONFIGURATION WITH DIFFERENT POSITION OF SHEAR WALL. International Journal Of Emerging Technology And Advanced Engineering, ISSN 2250-2459, Volume 2, Issue 12, December 2012.

[9] O. Esmaili S STUDY OF STRUCTURAL RC SHEAR WALL SYSTEM IN A 56-STORY RC TALL BUILDING. The 14th World Conference On Earthquake Engineering, Oct 2008, Beijing, China.

[10] Y.M. Fahjan. NONLINEAR ANALYSIS METHODS FOR REINFORCED CONCRETE

BUILDINGS WITH SHEAR WALLS. Gebze Institute Of Technology, 41400 Gebze, Kocaeli, Turke

[11] A. Kadid, PUSHOVER ANALYSIS OF REINFORCED CONCRETE FRAME STRUCTURES. Asian Journal Of Civil Engineering (Building And Housing) Vol. 9, No. 1 (2008) Pages 75-83

[12] BAI Jiulin SEISMIC FAILURE MODE IMPROVEMENT OF RC FRAME STRUCTURE BASED ON MULTIPLE LATERAL LOAD PATTERNS OF PUSHOVER ANALYSES. School Of Civil Engineering, Harbin Institute Of Technology, Harbin 150090, China, Published Online June 24, 2011.

[13] Abhilash R. EFFECT OF LATERAL LOAD PATTERNS IN PUSHOVER ANALYSIS, 10th National Conference On Technological Trends (NCTT09) 6-7 Nov 2009.

[14] F. Khoshnoudian, PROPOSAL OF LATERAL LOAD PATTERN FOR PUSHOVER ANALYSIS OF RC BUILDINGS. Comp. Meth. Civil Eng., Vol. 2, 2 (2011) 169-183.

[15] Anil K. Chopra A MODAL PUSHOVER ANALYSIS PROCEDURE FOR ESTIMATING SEISMIC DEMANDS FOR BUILDINGS. EARTHQUAKE ENGINEERING AND STRUCTURAL DYNAMICS Earthquake Engng Struct. Dyn. 2002; 31:561–582.

[16] M.K. Rahmn, NONLINEAR STATIC PUSHOVER ANALYSIS OF AN EIGHT STOREY RCFRAME-SHEAR WALL BUILDING IN SAUDI ARABIA

[17] Rahul RANA, Limin JIN And Atila ZEKIOGLU, “PUSHOVER ANALYSIS OF A 19 STOREY CONCRETE SHEAR WALL BUILDING” 13th World Conference On Earthquake Engineering, Vancouver, B.C., Canada. August 1-6, 2004 Paper No. 133.

[18] Chan CM, Zou XK. OPTIMAL INELASTIC DRIFT DESIGN OF REINFORCE CONCRETE STRUCTURES UNDER PUSHOVER LOADING. In: The Second China–Japan–Korea Joint Symposium On Optimization Of Structural And Mechanical Systems, (2002).

