Seismic Analysis of Symmetrical and Unsymmetrical Multistory Building with Shear Wall and Hybrid Shear Wall

***Pranjali Padalkar*[1], *S.P. Nirkhe, R. S. Patil*[2]**

[1]P.G. Student (M.Tech- Structures), Department of Civil Engineering, Deogiri Institute of Engineering and Management Studies, Dr. *Babasaheb Ambedkar Technological* University, Aurangabad, Maharashtra, 431005, India

[2]Assistant Professor, Department of Civil Engineering, Deogiri Institute of Engineering and Management Studies, Dr. *Babasaheb Ambedkar Technological* University, Aurangabad, Maharashtra, 431005, India

Abstract

Shear walls are structural systems which provide stability to structures from lateral loads like wind, seismic load. Shear walls are added to the building interior to provide more strength and stiffness to the building when the exterior walls cannot provide enough strength and stiffness. It is necessary to provide these shear walls when the tolerable span width ratio for the floor or roof diaphragm is exceeded. Shear walls are mainly flexural members and usually is provided in high- and low-rise buildings to avoid the total collapse of buildings under seismic forces. In this paper 10 storey symmetrical and unsymmetrical building in zone II is consider and analyzed by comparing result obtain by changing various location of shear wall and hybrid shear wall. Analysis is performed to study effect of shear wall location on story drift, displacement and base shear. Analysis is done using ETABs software.

Keywords: Hybrid Shear Wall, Response Spectrum Analysis, ShearWall, Seismic Forces.

1.1 INTRODUCTION

The design of tall buildings essentially involves a conceptual design, approximate analysis, preliminary design and optimization, to safely carry gravity and lateral loads. The primary purpose of all kinds of structural systems used in the building type of structures is to transfer gravity loads effectively. The most common loads resulting from the effect of gravity are dead load, live load and snow load. Besides these vertical loads, buildings are also subjected to lateral loads caused by wind, earthquake forces. Lateral loads can develop high stresses, produce sway movement or cause vibration. Therefore, it is very important for the structure to have sufficient strength against vertical loads together with adequate stiffness to resist lateral forces. High-rise buildings are constructed everywhere in the world. The structural design of high-rise buildings depends on dynamic analysis for winds and earthquakes. Now a day's performance of computer progresses remarkably, almost structural designers use the software of computer for the structural design of high-rise buildings. Shear walls are especially important in high-rise buildings subjected to lateral wind and seismic forces.Lateral forces caused by wind, earthquake, and uneven settlement loads, in addition to the weight of structure and occupants; create powerful twisting (torsion) forces. These forces can literally tear (shear) a building apart. Reinforcing a frame by attaching or placing a rigid wall inside it maintains the shape of the frame and prevents rotation at the joints.It is provided, when the center of gravity of building area & loads acted on it differs by more than 30%. to bring the C.G. in range of 30% concrete wall is provided lateral forces may not increase much.Shear wall give better response if it is providing at optimum location. The aim of the shear wall is to investigate the different ways in which the tall structures can be stabilized against the effects of strong horizontal wind loading and seismic loading.

The static and dynamic structural responses of high rise buildings are governed by the distributions of transverse shear stiffness and bending stiffness per each storey. “Making changes to the systems inside the building or even the structure itself at some point after its initial construction and occupation.

1.1.1 REQUIREMENTS OF STRUCTURAL ELEMENT IN HIGH RISE BUILDINGS :

The impact of wind and seismic forces acting on High rise buildings becomes an important aspect of the design. Improving the structural system of tall buildings can control their dynamic response with more appropriate structural elements such as shear walls and tube structures, and by improving material properties; the maximum height of concrete buildings has soared in recent decades. Under the large overturning effects caused by horizontal Earthquake forces, edges of shear walls experience high compressive and tensile stresses. To ensure that shear walls behave in a ductile way, concrete in the wall end regions must be reinforced in special manner to sustain these load reversals without losing strength. End regions of wall with increased confinement are called boundary elements. This special confining transverse reinforcement in the boundary elements is similar to that provided in columns of reinforced concrete frames. Sometimes, the thickness of the shear wall in these boundary elements is also increased.

1.1.2 HYBRID SHEAR WALL :

Hybrid systems are commonly used throughout the world and are present in many types of structures with many different types of materials. A hybrid system is any system that combines two or more structural materials. Among the hybrid systems steel and concrete hybridization is most common; these include concrete on metal deck supported on steel beams as a floor system.Fiber reinforced polymers (FRP) materials have been used in civil engineering area for few decades for strengthening reinforced or pressed concrete structures, improving capacity of bridges, dams and tubes. Most common fibers used for strengthening purposes are GFRP and CFRP, as they have numerous advantages like high tensile strength, high strength-to-weight ratio, ease of the application and corrosion resistance.

1.2 AIMS AND OBJECTIVES

In this study R.C.C. building is modelled, analyzed and designed. Design of shear wall by itself is a study of demand Vs capacity ratio adhered to the properties of shear wall sections. This can be generated by the mathematical model created in Etabs by considering the earthquake and wind forces.

1) Behavior study of 15storey high rise RCC structure with shear walls for seismic & wind loads.

2) The variation of storey drifts of the models to be studied.

3) The variation of displacement has to studied

4) Both equivalent static analysis and Response spectrum analysis are to be carried out

5) Optimum location of shear wall.

1.3 LITERATURE REVIEW

C.BRAHAM, T. BOGDAN& H. DEGEE (2012) [1]

In this paper, innovative hybrid coupled shear wall (HCSW) systems are considered, their preliminary design is discussed, their efficiency and limitations evaluated by means of nonlinear static (pushover) analysis as well as nonlinear dynamic (time-history) analysis. Different numbers of storey and different geometries of the HCSW system are examined to give an overview of situations of interest in European seismic prone areas. The results presented in this paper show that promising solutions can be obtained and that some aspects require further research work. This study is part of a larger research project (INNO-HYCO - InnovativeHybrid and Composite steel-concrete structural solutions for building in seismic area) funded by the European Commission and currently under development.

HIMALEE RAHANGDALE (2013) [2]

In this paper Study of G+5 Storey building in Zone IV is presented with some preliminary investigation which is analyzed by changing various position of shear wall with different shapes for determine parameter like axial load and moments. This analysis is done by using Standard package STADD-pro .

D. GOSE PEERA (2014) [3]

In this paper, the multi storey building with 14 storey is analyzed for its displacement, strength and stability using ETABS-2013 software. For the analysis of the building for seismic loading with two different Zones (Zone-II & Zone-V) is considered with a soil I & soil III types. The analysis of the building is done by using equivalent static method and dynamic method. The results from the analysis obtained from both the methods are presented in tabular form and the results are compared using graphical form.

GANGISETTY SRI HARSHA (2015) [4]

In this paper, A 19 floors residential building is analyzed with and without shear walls for wind and earthquake loads. The Building consists of four flats for each floor and comes under zone 2. Shear walls were taken at lift and stair and corners of the building as L shape. Vertical loads, Moments, Lateral forces, Torsional moments were compared for both cases at each floor during analysis part. Optimization techniques are used to solve structural engineering problems where the most complex high-rise structures using design optimization, involving both size and topological optimization is solved by considering stability, safety, response to different type of loadings. Wall-frame structure optimization is the part of project. For this system of wall and cores they were checked for displacement, Internal Stresses and Intensities when subjected to various loadings.

DAVID WERTHEIM (2015) [5]

He presented the strengthening techniques for steel and hybrid steel/FRP shear walls using CFRP and GFRP. Two different types of specimens were developed. First type are three new specimens steel shear wall (SSW-1), hybrid carbon shear wall (HCSW-1) and hybrid glass shear wall (HGSW-1); second type are three strengthened specimens SSW-2, HCSW-2, HGSW-2 created from first three specimens after their testing till destruction. Six medium size shear wall specimens were tested under quasi-static seismic loading. For second type of shear wall specimens, strengthening of boundary elements of shear walls was done with application of FRP fabric and laminates; new infill plates were used. Analysis of the results was done by comparing the behavior and failure modes for new and strengthened specimens after initial testing.

1.4 METHOD OF ANALYSIS :

The most commonly used methods of analysis are based on the approximation that the effects of yielding can be accounted for by linear analysis of the building, using the design spectrum for inelastic system. Forces and displacements due to each horizontal component of ground motion are separately determined by analysis of an idealized building having one lateral degree of freedom per floor in the direction of the ground motion component being considered. Such analysis may be carried out by following method :

1. Linear static analysis

2. Nonlinear-static analysis

i) P-Delta analysis

ii) Pushover analysis

3. Linear dynamic analysis

i) Linear time history analysis

ii) Response spectrum analysis

4. Nonlinear-dynamic analysis

5. Nonlinear time history analysis

1.4.1 RESPONSE SPECTRUM ANALYSIS

According to the Indian code in the response spectrum method, the response of a structure during an earthquake is obtained directly from the earthquake response (or design) spectrum. This procedure gives an approximate peak response, but this is quite accurate for structural design applications. In this approach, the multiple modes of response of a building to an earthquake are taken into account. For each mode, a response is read from the design spectrum, based on the modal frequency and the modal mass. The responses of different modes are combined to provide an estimate of total response of the structure using modal combination methods such as complete quadratic combination (CQC), square root of sum of squares (SRSS), or absolute sum (ABS) method. Response spectrum method of analysis should be performed using the design spectrum specified or by a site – specific design spectrum, which is specifically prepared for a structure at a particular project site. The same may be used for the design at the discretion of the project authorities.

1.5 BUILDING DISCRIPTION :

Detailing of Commercial Building with symmetric and unsymmetric plan of G+10 storey.

1.5.1 GEOMETRICAL PROPERTIES FOR SYMMETRICAL BUILDING :

Sr.No.	Structural Part	Dimension
1.	Length in X-direction	25m
2.	Length in Y-direction	25m
3.	Floor to Floor Height	3m
4.	Total Height of Building	30m
5.	Slab Thickness	150mm
6.	Wall Thickness	230mm
7.	Shear wall Thickness	230mm

8.	Column Size	300X600mm
9.	Beam Size	230X450mm

1.5.2 GEOMETRICAL PROPERTIES FOR UNSYMMETRICAL BUILDING :

Sr.No.	Structural Part	Dimension
1.	Length in X-direction	30
2.	Length in Y-direction	35m
3.	Floor to Floor Height	3m
4.	Total Height of Building	30m
5.	Slab Thickness	150mm
6.	Wall Thickness	230mm
7.	Shear wall Thickness	230mm
8.	Column Size	300X600mm
9.	Beam Size	230X450mm

1.5.3 MATERIAL PROPERTIES:

Sr.No	Material	Grade
1.	Concrete (Beam & Column)	M25
2.	Concrete (Slab)	M25
3.	Grade of Steel	Fe-500

1.5.4 SEISMIC DATA :

1.	Earthquake Zone	III
2.	Damping Ratio	5%
3.	Importance Factor	1.5
4.	Type Of Soil	Medium
5.	Response Reduction Factor	5
6.	Time Period	Program Calculated

1.6 LOADS:

1.6.1 LIVE LOAD :

Live Load = 4 kN/m ^{2}

1.6.2 DEAD LOAD :

Dead load is taken as prescribed by the IS: 875 -1987 (Part-I) [3] Code of Practice Design Loads (other than earthquake) for Buildings and structure

1. Unit weight of R.C.C. = 25 kN/m^3
2. Unit weight of brick masonry = 19 kN/m^3
3. Unit weight of GRP =16.83 kN/m^3
4. Floor finish = 1 kN/m ^{2}
5. Wall load = 13.8 kN/m on all floors

1.6.3 LOAD COMBINATION

The following Load Combinations have been considered for the design :

a) 1.5(DL+LL)

b) 1.5(DL+LL+SIDL)

c) 1.2(DL+LL+SIDL+WL)

d) 1.2(DL+LL+SIDL-WL)

e) 1.5(DL+SIDL+WL)

f) 1.5(DL+SIDL-WL)

g) 0.9(DL+SIDL)+1.5WL

h) 0.9(DL+SIDL)-1.5WL

i) 1.2(DL+LL+SIDL+EQ-X)

j) 1.2(DL+LL+SIDL-EQ-X)

k) 1.2(DL+LL+SIDL+EQ-Y)

l) 1.2(DL+LL+SIDL-EQ-Y)

m) 1.5(DL+SIDL+EQ-X)

n) 1.5(DL+SIDL-EQ-X)

o) 1.5(DL+SIDL+EQ-Y)

p) 1.5(DL+SIDL-EQ-Y)

q) 0.9(DL+SIDL)+1.5EQ-X

r) 0.9(DL+SIDL)-1.5EQ-X

s) 0.9(DL+SIDL)+1.5EQ-Y

t) 0.9(DL+SIDL)-1.5EQ-Y

u) 1.5(DL+SIDL)

1.6.4 PLAN DETAIL :

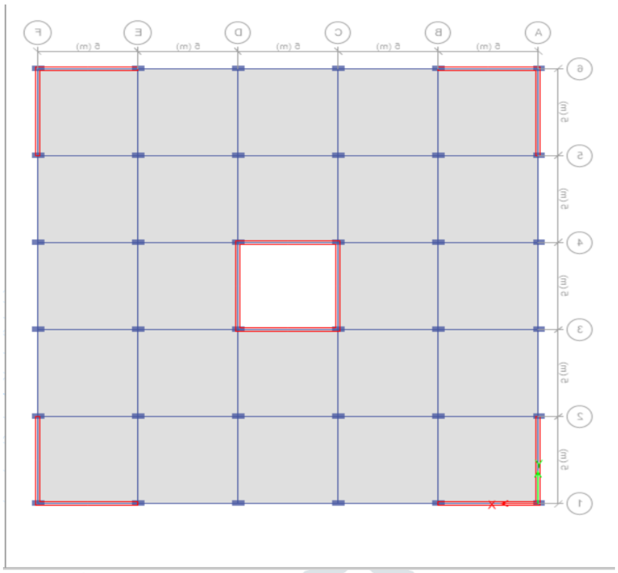


Fig 1 : SYMMETRICAL BUILDING WITH SHEAR WALL

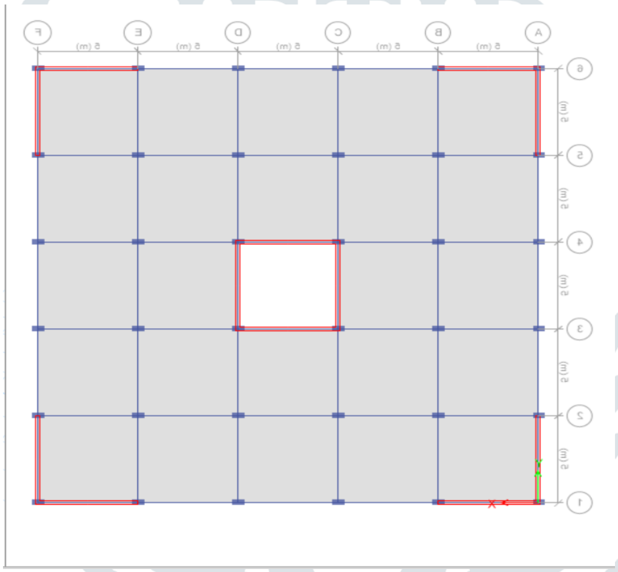


Fig 2 : SYMMETRICAL BUILDING WITH GRP SHEAR WALL

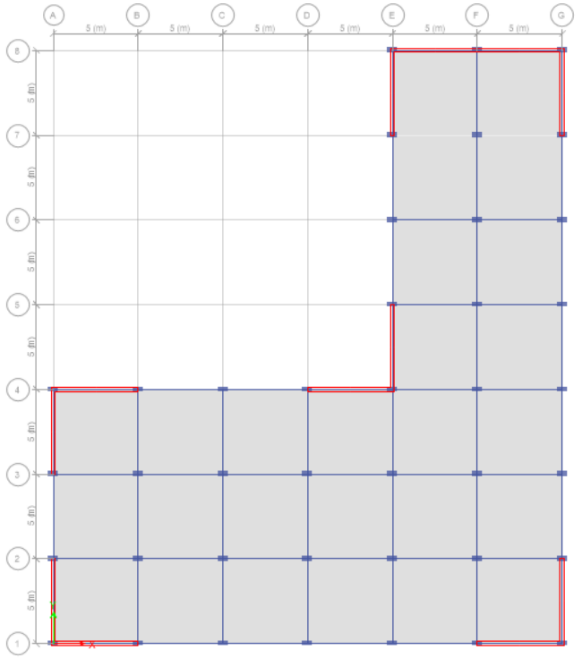


Fig 3 : UNSYMMETRICAL BUILDING WITH SHEAR WALL

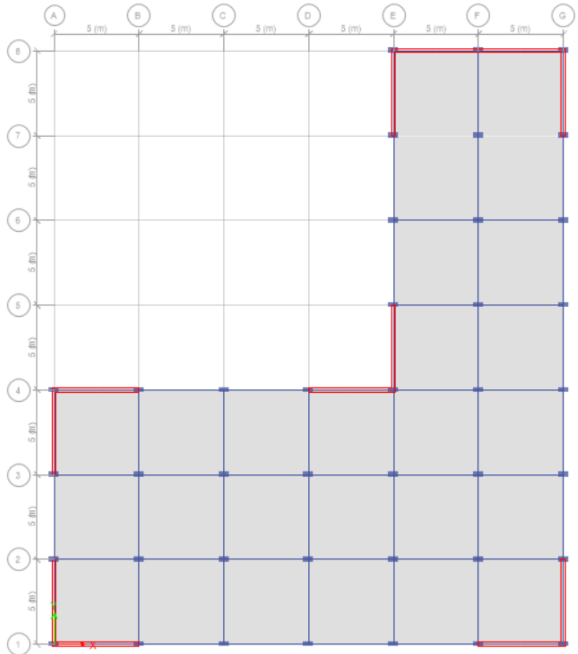
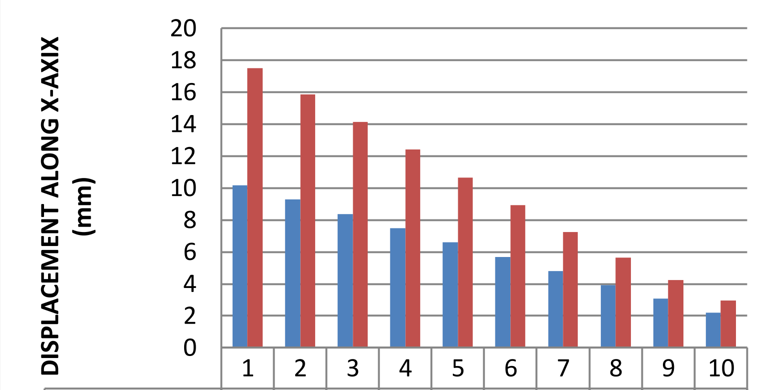


Fig 4 : UNSYMMETRICAL BUILDING WITH GRP SHEAR WALL

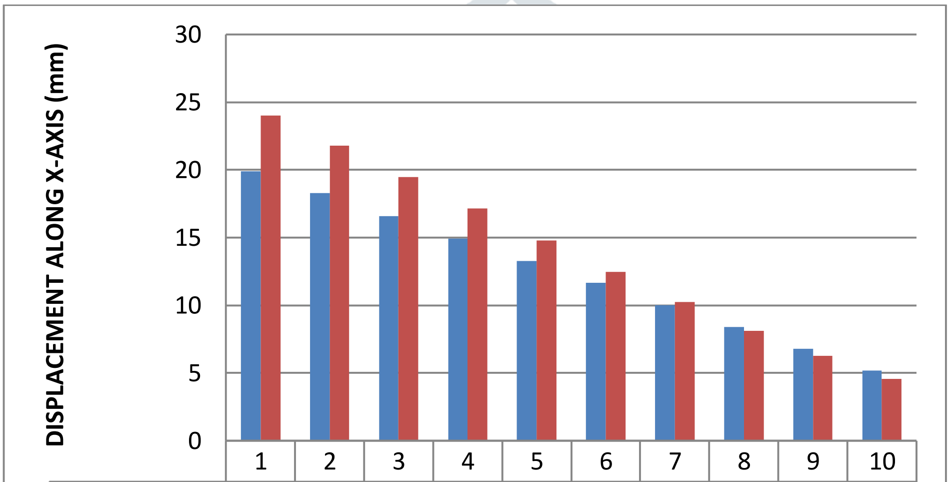
1.7 RESULT AND DISCUSSION :

Following are results obtain from seismic analysis of symmetrical and unsymmetrical building using shear wall and hybrid shear wall in both building :



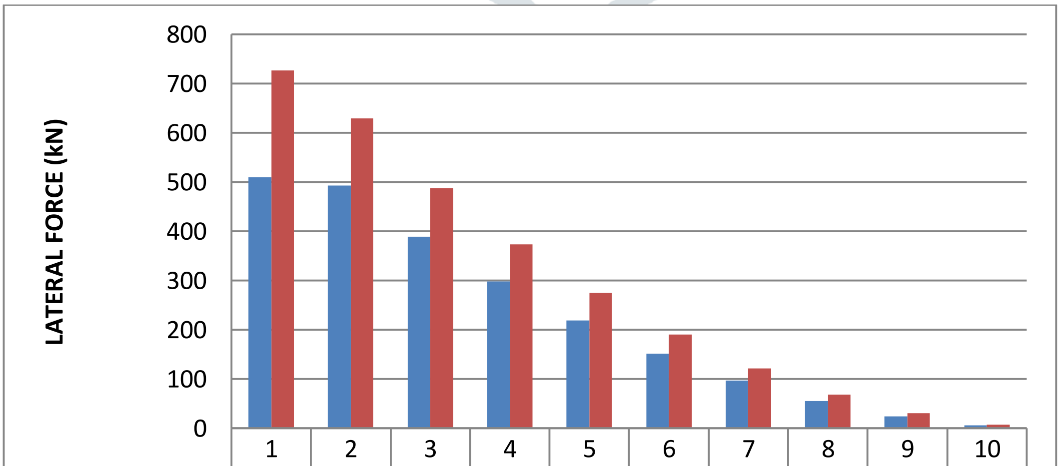
	1	2	3	4	5	6	7	8	9	10
SHEAR WALL	10.2	9.27	8.38	7.48	6.59	5.7	4.82	3.94	3.07	2.2
GRP WALL	17.5	15.9	14.1	12.4	10.7	8.92	7.24	5.65	4.23	2.98

Fig 5 : Comparison for displacement along X-axis for shear wall and GRP shear wall in symmetrical building .



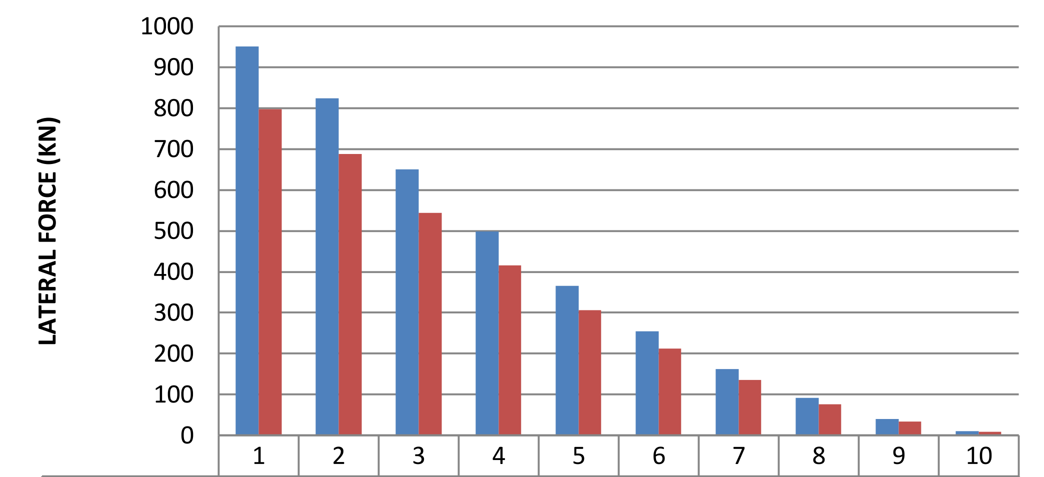
	1	2	3	4	5	6	7	8	9	10
SHEAR WALL	19.88	18.27	16.6	14.95	13.3	11.65	10.02	8.394	6.806	5.2
GRP WALL	24.04	21.81	19.49	17.14	14.79	12.47	10.23	8.125	6.267	4.555

Fig 6 : Comparison for displacement along X-axis for shear wall and hybrid GRP shear wall in unsymmetrical building .



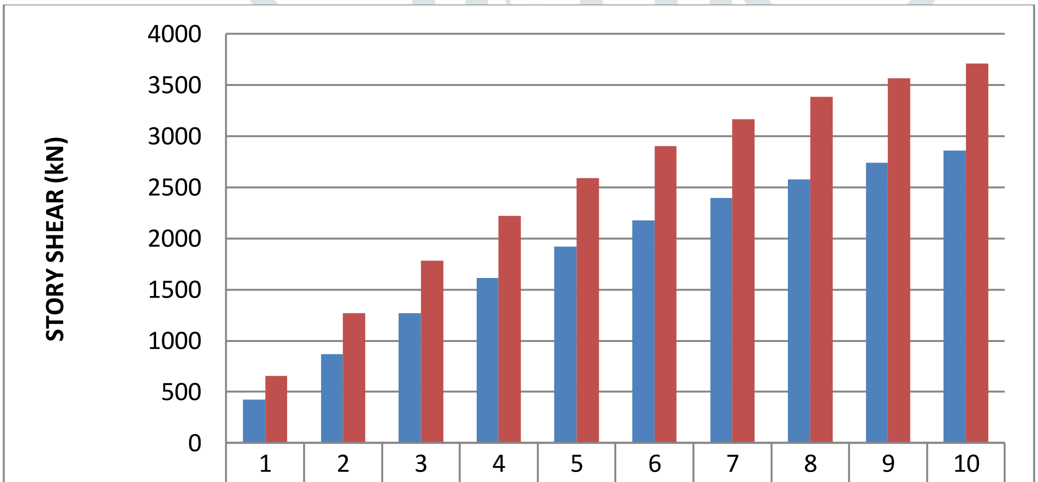
	1	2	3	4	5	6	7	8	9	10
SHEAR WALL	510.19	492.43	389.08	297.89	218.86	151.99	97.271	54.715	24.318	5.4501
GRP WALL	726.24	629.6	487.42	373.18	274.17	190.4	121.85	68.543	30.464	7.3151

Fig 7 : Comparison for displacement along X-axis for shear wall and GRP shear wallin symmetrical building .



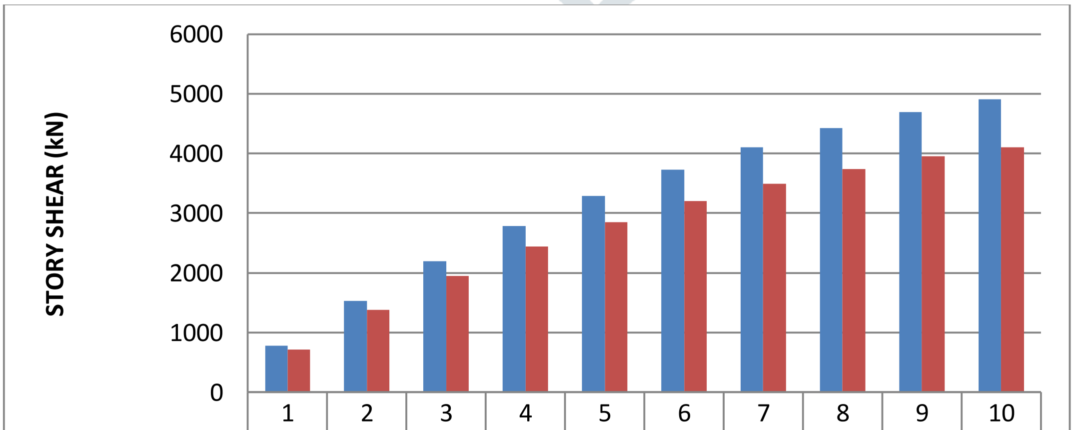
	1	2	3	4	5	6	7	8	9	10
SHEAR WALL	950.95	823.88	650.96	498.39	366.17	254.28	162.74	91.542	40.685	9.7615
GRP WALL	797.92	688.19	543.75	416.31	305.86	212.4	135.94	76.465	33.985	8.2049

Fig 8 : Comparison for displacement along X-axis for shear wall and GRP shear wall in unsymmetrical building .



	1	2	3	4	5	6	7	8	9	10
SHEAR WALL	421.56	870.96	1268.7	1617.1	1918.7	2176.9	2395.9	2580.9	2738.9	2858.8
GRP WALL	655.2	1267.7	1783.3	2221.9	2592.3	2903.7	3165.2	3384.2	3568.5	3709.2

Fig 9 : Comparison for story shear along X-axis for shear wall and GRP shear wall in symmetrical building .



	1	2	3	4	5	6	7	8	9	10
SHEAR WALL-X	782.58	1531.6	2197.1	2782.5	3292	3730.7	4105	4422.7	4694	4908.6
GRP WALL-X	715.48	1379.8	1951	2438.2	2851.7	3201.7	3496.9	3744.7	3952.3	4104.4

Fig 10 : Comparison for story shear along X-axis for shear wall and GRP shear wall in unsymmetrical building .

CONCLUSION :

1. It is observed that for symmetric building , the story shear for the building with hybrid shear wall is greater than story shear of building with shear wall while in case of unsymmetric building story shear for building with normal shear wall is greater tha hybrid shear wall .

2. From comparison of displacement , it is observed that displacement for symmetrical building with shear wall is greater than hybrid shear wall while in case of unsymmetrical building , displacement is less in case of hybrid shear wall than using shear wall .

3. From comparison of lateral forces , it is observed that lateral forces for symmetrical building with shear wall is less than hybrid shear wall while in case of unsymmetrical building , lateral forces is less in case of hybrid shear wall .

4. Storey drift of building is within the limit as clause no 7.11.1 of IS-1893 (Part-1):2002.

5. In this paper due to the presence of shear wall at all possible deflection positions there is possible of controlling the damage that may occur due to wind and earthquake forces.

6. Shear wall increases the stiffness of building and increases the behaviour of building during earthquake. Provision of shear wall in building increases the performance of building by increasing base shear also, it decreases storey displacement and storey drift of a building

REFERANCES:

1. C. Braham, "Behavior and design of innovative hybrid coupled shear walls for steel buildings in seismic areas", 15WCC, LISBOA 2012.
2. HimaleeRahangdale**,**"Designand Analysis of Multistoried Building with Effectof Shear Wall", International Journal of Engineering Research and Applications (IJERA), Vol. 3, Issue 3, May-Jun 2013, pp.223-232
3. D. Peera, "Seismic Analysis of Multi-Storied Building with Shear Walls Using ETABS-2013", International Journal of Science and Research (IJSR) ISSN (Online): 2319-7064, Impact Factor (2014): 5.611
4. Gangisetty SRI Harsha, "Shear Wall Analysis &Design Optimizationin High Rise Building",International Journal of Engineering Sciences and Research Technology, ISSN: 2277-9655(I2OR), Publication Impact Factor: 3.785, August 2015
5. David Wertheim**,** "Strengtheningof Steeland Hybrid Shear Walls",The 12th International Symposium on Fiber Reinforced Polymers for Reinforced Concrete Structures (FRPRCS-12) & The 5th Asia-Pacific Conference on Fiber Reinforced Polymers in Structures (APFIS-2015) Joint Conference, 14-16 December 2015, Nanjing, China

6. PriyankaSoni, "Structural Analysis of Multistory Building of Different shear Walls Location and Heights", International Journal of Engineering Trends and Technology (IJETT) – Volume 32 Number 1- February 2016
7. G. NageshKumar,"Shear Wall Analysis and Design Optimization in Case of High-Rise Buildings Using Etabs (software)",International Journal of Scientific & Engineering Research, Volume 6, Issue 1, January-2015
8. Umamaheshwara.B**,**"Design Optimization and Analysis of Shear Wall in High Rise Buildings Using ETABS", International Journal for Research in Applied Science & Engineering Technology (IJRASET), Volume 4 Issue VIII, August 2016.
9. V.K. Singh, "Optimization of Location of Shear Wall in Irregular Multi Storey Building", International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE), Vol 3, Issue 4, April 2018