[Anwar, 4(7): July 2017] ISSN 2348 – 8034
DOI- 10.5281/zenodo.830199 Impact Factor- 4.022

GLOBAL JOURNAL OF ENGINEERING SCIENCE AND RESEARCHES

ANALYTICAL STUDY ON STRENGTH CHARACTERISTICS OF BUILDING USING SHEAR WALL WITH AND WITHOUT OPENINGS UNDER LATERAL LOADS

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ABSTRACT

Finite Element Modeling now a day is an essential approach in analysis and simulating civil engineering problem numerically. In this thesis ANALYTICAL STUDY ON STRENGTH CHARACTERISTICS OF BUILDING USING SHEAR WALL WITH AND WITHOUT OPENINGS UNDER LATERAL LOADS to apply the finite element modeling in analyzing and exploring the behavior of shear wall with & without opening under seismic load actions and wind load actions.

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. Shear walls are generally located at the sides of buildings or arranged in the form of core that houses stairs and lifts. Due to functional requirements such as doors, windows, and other openings, a shear wall in a building contains many openings. The size and location of openings may vary from architectural and functional point of view. In most of the apartment building, size and location of openings in shear wall are made without considering its effect on structural behavior of the building.

This study is carried out on G+20 story frame-shear wall buildings, using linear elastic analysis with the help of finite element software, ETABS under earthquake loads in equivalent static analysis. The results reveal that stiffness as well as seismic responses of structures is affected by the size of the openings as well as their locations in shear wall. It is also explored that top lateral drift of the system can also be reduced thickening the element in the model around the opening of shear wall.

I. INTRODUCTION

The achievement of structural system for tall buildings is not an easy task. Where, as building height increases the importance of lateral loads action rises in an accelerating rate. There are two types of lateral loads, wind and seismic loads. Wind load presents the most critical lateral loading for modern tall buildings, which have lightweight skeletons that cause uncomfortable horizontal movements for occupants. Also, wind is not constant either with height or with time and is not uniform over the sides of a building. So, windy weather creates a variety of problems in tall buildings, causing concern for buildings owner and engineers alike. Where, excessive vibration due to this load is a major obstacle in design and construction of a modern tall building. it should be limited to prevent both structural and nonstructural damage.

The case-study is a regular-shaped un-symmetrical plan with dimensions 50x19 m. In structural modeling building arranged in 8 bays in X direction and 3bays in Y direction as shownin Fig. 1.The storey height is assumed to be 3 m. The analysis used is a three-dimensional analysis of detailed finite element models. The columns and beams were represented by frame type element,while shear walls and core components were represented byshell-type element.
Building analyzed is a 21 storey (20 storey + Ground story), 64.50 meters tall concrete tower located in india with a gross area of 950 . Unique features of the slender concrete tower presented parmetric study on with and without opening shearwall for seismic design and wind design. Typically, a 64.5 meters tall concrete building in seismic zone 4 would have a lateral system that combines shear walls and moment frames.

Thus lateral system of the building consists of shear walls with arrangement as shown in a typical floor plan in Fig. 1.1

Shear Walls

Without opening

W300 mm thick at the 11th story and above,
W 400mm thick at the 10th story and below,

With opening 5% ,10%, 15%, 20%

W300 mm thick at the 11th story and above,
W 400mm thick at the 10th story and below

Columns	:	C 700x700 mm of M40 grade concrete at 11th story and above ,
		C 900x900 mm of M40 grade concrete at 10th story and below,
Beams	:	B400x700 mm of M40 grade concrete at 11th story and above
		B450x800 mm of M40grade concrete at 10th story and below
Slab	:	S 200 mm of M40 grade concrete for all story
		S150 mm of M30 grade concrete on roof
Staircase	:	S150 mm of M 30 grade concrete for all story
Wall	:	Brickwall 230 mm upto 20th story
		Brickwall 115mm thick at roof

II. SHEAR WALLS

Reinforced concrete framed buildings are adequate for resisting both the vertical and the horizontal loads acting on them. However, when the buildings are tall, say, more than twelve storey's or so, beam and column sizes work out large and reinforcement at the beam-column junctions works out quite heavy.

So that, there is a lot of congestion at these joints and it is difficult to place and vibrate concrete at these places, which fact, does not contribute to the safety of buildings. These practical difficulties call for introduction of shear walls in tall buildings.

Shear walls in plan, may be deep straight walls or angular, u- shaped or box-shaped in plan, around stairs or lifts or toilets, where there will be no architectural difficulty in extending them thought the height of the building, care shall be taken to have symmetrical configuration of walls in plan so that torsional effect in plan could be avoided.

Further, shear walls should get enough vertical load from floors, for which reason, nearby columns should be omitted and load taken to the shear walls by means of long span beams if required

Purpose Of Constructing Shear Walls

Shear walls are not only designed to resist gravity / vertical loads (due to its self-weight and other living / moving loads), but they are also designed for lateral loads of earthquakes / wind. The walls are structurally integrated with roofs / floors (diaphragms) and other lateral walls running across at right angles, thereby giving the three dimensional stability for the building structures.

Shear wall structural systems are more stable. Because, their supporting area (total cross-sectional area of all shear walls) with reference to total plans area of building, is comparatively more, unlike in the case of RCC framed structures.

Walls have to resist the uplift forces caused by the pull of the wind. Walls have to resist the shear forces that try to push the walls over. Walls have to resist the lateral force of the wind that tries to push the walls in and pull them away from the building.

Forces On Shear Wall

Shear walls resist two types of forces: shear forces and uplift forces. Shear forces are generated in stationary buildings by accelerations resulting from ground movement and by external forces like wind and waves. This action creates shear forces throughout the height of the wall between the top and bottom shear wall connections.

Uplift forces exist on shear walls because the horizontal forces are applied to the top of the wall. These uplift forces try to lift up one end of the wall and push the other end down. In some cases, the uplift force is large enough to tip the wall over. Uplift forces are greater on tall short walls and less on low long walls. Bearing walls have less uplift than non-bearing walls because gravity loads on shear walls help them resist uplift. Shear walls need hold down devices at each end when the gravity loads cannot resist all of the uplift. The hold down device then provides the necessary uplift resistance.

Shear walls should be located on each level of the structure including the crawl space. To form an effective box structure, equal length shear walls should be placed symmetrically on all four exterior walls of the building. Shear walls should be added to the building interior when the exterior walls cannot provide sufficient strength and stiffness.

Shear walls are most efficient when they are aligned vertically and are supported on foundation walls or footings. When exterior shear walls do not provide sufficient strength, other parts of the building will need additional strengthening. Consider the common case of an interior wall supported by a sub floor over a crawl space and there is no continuous footing beneath the wall.

For this wall to be used as shear wall, the sub floor and its connections will have to be strengthened near the wall. For Retrofit work, existing floor construction is not easily changed. That's the reason why most retrofit work uses walls with continuous footings underneath them as shear walls.

Classification Of Shear Walls

i. Simple rectangular types and flanged walls (bar bell type)
ii. Coupled shear walls
iii. Rigid frame shear walls
iv. Framed walls with in filled frames
v. Column supported shear walls
vi. Core type shear walls

Methods Of Design Of Shear Wall

There are three types of design methods

1) Segmented shear wall method
2) Force transfer –ground openings method
3) Perforated shear wall method

The segmented shear wall method uses full height shear wall segments that comply with ratio requirements and are usually restrained against overturning by hold down devices at the ends of each segment.

The second method force transfer-ground openings method considers the entire shear wall with openings and the wall piers adjacent to openings are segments. The method requires the forces around the perimeter of the openings to be analyzed, designed, and detailed. With this method, the hold-down devices generally occur at the ends of the shear wall, not at each wall pier, and special reinforcement around the opening is often required. .

The third and newest method is the perforated shear wall method which is an empirical approach that does not require special detailing for force transfer adjacent to the openings. The perforated shear wall method, however, specifically requires hold-down devices at each end of the perforated shear wall.

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Types Of Shear Walls

a) RC Shear Wall
b) Plywood Shear Wall
c) Midply Shear Wall
d) RC Hollow Concrete Block Masonry Wall
e) Steel Plate Shear Wall

The role of floor diaphragm is as important as it is in the case of framed buildings. The

The Architectural Aspects Of Shear Walls

Most RC buildings with shear walls also have columns; these columns primarily carry gravity loads (i.e., those due to self-weight and contents of building). 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. Thus, design of their foundations requires special attention. Shear walls should be provided along preferably both length and width. However, if they are provided along only one direction, a proper grid of beams and columns in the vertical plane (called a moment-resistant frame) must be provided along the other direction to resist strong earthquake effects.

Door or window openings can be provided in shear walls, but their size must be small to ensure least interruption to force flow through walls. Moreover, openings should be symmetrically located. Special design checks are required to ensure that the net cross-sectional area of a wall at an opening is sufficient to carry the horizontal earthquake force.

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.

Advantages Of Shear Walls In Buildings

Properly designed and detailed buildings with shear walls have shown very good performance in past earthquakes. Shear walls in high seismic regions require special detailing. However, in past earthquakes, even buildings with sufficient amount of walls that were not specially detailed for seismic performance (but had enough well-distributed reinforcement) were saved from collapse. Shear wall buildings are a popular choice in many earthquake prone countries, like Chile, New Zealand and USA.

Shear walls are easy to construct, because reinforcement detailing of walls is relatively straight forward and therefore easily implemented at site. Shear walls are efficient, both interims of construction cost and effectiveness in minimizing earthquake damage in structural and nonstructural elements like glass windows and building contents.

The Role Of Floor Diaphragm In Framed Buildings

The role of floor diaphragm is as important as it is in the case of framed buildings. The floor diaphragm forces all the vertical elements like frames and shear walls to share the incumbent horizontal shear in the ratio of their rigidities or stiffness. To calculate the share of the total horizontal shear of each shear wall element is a major task and it may be called ‘allocation analysis’, while each shear wall under the assigned horizontal shears at floor levels acts as a vertical cantilever beam fixed at base4 and its analysis and design will be given later under the head’ shear wall analysis and design’.

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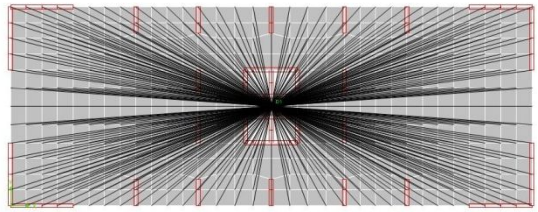


Figure Diapram

Effect Of Earthquakes On High Rise Buildings

When a building experiences earthquake vibrations, its foundation will move back and forth with the ground. These vibrations can be quite intense, creating stresses and deformation throughout the structure making the upper edges of the building swing from a few mm to many inches dependent on their height size and mass. This is uniformly applicable for buildings of all heights, whether single storied or multi-storied in high-risk earthquake zones. A building needs to be slightly flexible and also have components, which can withstand or counter the stresses caused in various parts of the building due to horizontal movements caused by earthquakes. It was observed that buildings of different sizes and heights vibrated with different frequencies. Where these were made next to each other they created stresses in both the structures and thus weakened each other and in many cases caused the failure of both the structures. Bureau of Indian Standards clearly gives in its code IS 4326 that a Separation Section is to be provided between buildings. Separation Section is defined as "A gap of specified width between adjacent buildings or parts of the same building, either left uncovered or covered suitably to permit movement in order to avoid hammering due to earthquake ". Further it states that “for buildings of height greater than 40 meters, it will be desirable to carry out model or dynamic analysis of the structures in order to compute the drift at each storey, and the gap width between the adjoining structures shall not be less than the sum of their dynamic deflections at any level."

Thus it is advised to provide adequate gap between two buildings greater than the sum of the expected bending of both the buildings at their top, so that they have enough space to vibrate. This situation is further compounded when the slab level of one building is near the mid level of the walls and columns of the neighboring building, the walls and columns are normally not designed for taking this additional shear force caused by the horizontal force coming from the neighboring slab. This causes buckling of the columns and walls at times of excessive stresses at the mid points (courtesy your neighboring building) and thus the collapse of the buildings onto each other starting a chain reaction. Since one cannot predict how one's neighbor is going to build his house at the time of design it is better to take other precautions such as maintaining gap. In areas where high intensity earthquakes are expected the precautions are to be taken: Expansion joints proper gap as required due to bending/movement of the two parts of the building due to earthquake be provided in all buildings. It should be made compulsory to submit structural design, drawings along with certificate from structural engineer at the time of sanction of building plans. These should give details of

a) Soil condition and bearing capacity.
b) Earthquake zone for which the building has been designed.
c) I.S. Codes used for design.

All relaxations in building byelaws generally given at the time of completion should be incorporated at the time of sanction only in the new byelaws and no relaxation should be permitted afterwards to ensure that no changes are made in structural design after sanction.

Submission of Structural certificate from the designer to the governing municipal body after casting of foundations and at each floor level should be made compulsory. This should state that the reinforcement and R.C.C caste have been verified and are as per his structural design submitted to the body at time of sanction. Common wall system between adjoining buildings should be totally abolished.

III. LITERATURE REVIEW

General

Influence of building configuration on seismic response

Generally, the building configuration, which is conceived by architects and then accepted by developer or owner may provide a narrow range of options for lateral-load resistant systems that can be utilized by structural engineers. By observing the following fundamental principles relevant to seismic responses, more suitable structural systems may be adopted (Paulay and Priestley, 1992):

1. To perform well in an earthquake, a building should possess simple and regular configurations. Buildings with articulated plans such as T and L shapes should be avoided.
2. Symmetry in plans should be provided, wherever possible. Lack of symmetry in plan may lead to significant torsional response, the reliable prediction of which is often difficult.
3. An integrated foundation system should tie together all vertical structural elements in both principal directions. Foundation resting on different soil condition should preferably be avoided.
4. Lateral force resisting systems with significantly different stiffness such as shear walls and frames within one building should be arranged in such a way that at every level of the building, symmetry in lateral stiffness is not grossly violated. Thus, undesirable torsional effects will be minimized.
5. Regularity in elevation should prevail in both the geometry and the variation of story stiffness.

Smith And Coull (1991)

Beam elements (**Fig 2.10a**) can be used to represent the beams and columns while the membrane elements (**Fig 2.10b**) can be used to represent the shear walls. Since the membrane elements do not have a degree of freedom to represent in plane rotation of their corners, a beam element connected to a node of the membrane element is effectively connected only by a hinge. The remedy for this deficiency can be maintained by adding a fictitious flexural rigid auxiliary beam to the edge of the wall element. Also the truss elements (**Fig 2.10c**), quadrilateral plate elements, (**Fig 2.10d**) and combined membrane-plate elements can be used to better represent, respectively the truss members, slabs in bending and shear walls subjected to out of plane bending.

4. Past studies on frame-shear-wall structures and shear walls with openings Sharma (1998) studied on various structural systems i.e. moment resisting frames, frame-shear wall and frame-coupled shear wall, concentrically braced frame under seismic excitation, eccentrically braced frame and hybrid structures, using structural analysis software Sap90. From the results it was concluded that design based on drift control criteria generally results into same levels of stiffness whatever may be the structural system and it is advantageous to use correct combination of frame and shear wall to get uniform inter story drift.

Atimtay and Kanit (2006) said that earthquake itself is a great professor to learn the seismic design of buildings and it tells the engineer what to do and what not. From numerous and careful examinations of the wide spread earthquake damage due to Marmara earthquake on August 17, 1999 of 7.4 Richter scale in north western region of Turkey, it was found that no buildings had collapsed which contain shear walls as part of the structural system. It was concluded that successfully designed and constructed building should contain adequate number of shear wall with well detailed reinforcement.

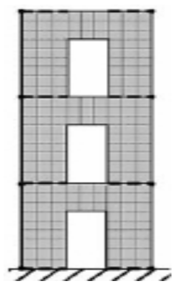
Singh (2000) studied on effect of curtailment of shear walls at different levels on seismic response of 12-story frame-shear wall building. It was suggested that it is better to keep uniform column dimension throughout the building than to proportion the column sizes at intermediate levels. In the first case, the walls can be reduced to 10th floor, thereby saving 8.77% of the gross concrete volume with no amendment in material property and size of the full wall structure. However, for same concrete volume, it can be reduced only up to 11th floor in the 2nd case.

Lin and Kuo (1988) had conducted finite element analysis and experimental work to study the ultimate strength of shear wall with openings under lateral load. The test program demonstrated the shear behavior of reinforced concrete walls with different sizes of opening and reinforcing patterns around the opening. In the test program, the

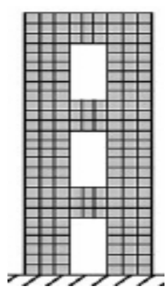
ISSN 2348 – 8034
Impact Factor- 4.022

different amount and pattern of reinforcement were arranged around the openings so that, overall dimension of boundary element and reinforcement were same for all wall units. The test results indicated that the shear strength contributed by diagonal reinforcement around opening reached 40% of its yield strength, while the shear strength contributed by rectangular arrangement reached 20% of its yield strength. It was also concluded that shear capacity of section is not only affected by width of opening but also affected by depth of opening as well.

Kim and Lee (2003) proposed a method for the analysis of shear wall with openings using super elements (**Fig 2.11a**) to model the shear wall. Matrix condensation technique was used to eliminate the degrees of freedom (DOFs) in the shear wall except at end nodes of fictitious beams, added to enforce the compatibility conditions at the boundaries of the super elements. Static and dynamic analyses of shear walls with various sizes of door and window openings were performed to verify the efficiency and accuracy of the proposed method. Fine mesh (**Fig 2.11b**) with large number of finite elements to model the shear wall was assumed to be most accurate for verification of the proposed method. The results (top displacements, natural period) of the method were found very close to those obtained from the fine mesh model regardless of the number, size and location of the openings.



a) Super element used for wall model



b) Fine mesh model using FEM

Qaqish and Daqqaq (2000) studied on effect of small openings on behavior of shear walls and the effect of opening size on behavior of coupled shear walls. It was concluded that opening area approximately less than 0.11 times the wall area surrounded by centerlines of columns and beams can be categorized as small openings. Comparing vertical stresses at the base of shear wall for each size of opening, it was found that the effects of small opening can be neglected on overall state of stress due to opening. It was also concluded that the wall with opening area less than 0.11 times the wall area acts as single cantilever while the wall with that greater than 0.11 times and less than 0.29 times the wall area acts as couple shear walls.

Lateral Load Bearing Member

In framed buildings, horizontal forces due to wind or earthquake are resisted by frames in proportion to their rigidities. In tall buildings of moderate heights (say, up to 20 story), where both frames and shear walls must be provided, horizontal forces are assumed to be fully resisted by shear walls alone, with frames being designed being designed for at least 25% of the total horizontal load. For taller buildings, the rigidity of shear walls in the upper storey gets reduced due to the accumulation of deflection of the storey's below, necessitating joint participation of frames and shear walls to resist shear walls alone, is hen no more valid and more accurate methods must be adopted to apportion the horizontal shear between frames and shear walls.

ISSN 2348 – 8034
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Problems involved in the analysis of shear wall structures which, in essence, means to determine the share of storey shear resisted by each sheet wall for each storey in succession. It is assumed or that the frames, if present, do not participate in ninety rigid in its own plane or at least it is more rigid than any of the shear walls joining it and that the foundation of shear wall is sufficiently rigid to ensure its fixity at base.

Importance Of Seismic Design Codes

Ground vibration during earthquake cause forces and deformations in structures. Structures need to be designed withstand such forces and deformations. Seismic codes help to improve the behavior of structures so that may withstand the earthquake effect without significant loss of life and property. Countries around the world have procedures outlined in seismic code to help design engineers in the planning, designing, detailing and constructing of structures.

A) An earthquake resistant has four virtues in it, namely

i. **Good Structural Configuration**: its size, shape and structural system carrying loads are such that they ensure a direct and smooth flow of inertia forces to the ground.
ii. **Lateral Strength:** The maximum lateral (horizontal) force that it can resist is such that the damage induced in it does not result in collapse.
iii. **Adequate Stiffness:** Its lateral load resisting system is such that the earthquake – indeed deformations in it do not damage its contents under low-to- moderate shaking.
iv. **Good Ductility**: Its capacity to undergo large deformations under severe earthquake shaking even after yielding is improved by favorable design and detailing strategies.

B) Indian Seismic Codes

Seismic codes are unique to a particular region or country. They take into account the local seismology, accepted level of seismic risk, buildings typologies, and materials and methods used in construction.

The Bureau of Indian Standards (BIS) the following Seismic Codes:

IS 1893 (PART 1) 2002, *Indian Standard Criteria* for Earthquakes Resistant of Design Structures (5^{th} revision).

IS 4326, 1993, Indian Standard Code of practice for Earthquake Resistant Design and Construction of Buildings. (2^{nd} revision).

IS 13827, 1993, Indian Standard Guidelines for improving Earthquake Resistant of Earthen buildings.

IS 13828, 1993 Indian Standard Guidelines for improving Earthquake Resistant of Low Strength Masonry Buildings.

IS 13920, 1993, Indian Standard Code for practice for Ductile Detailing of Reinforced Concrete Structures Subjected to Seismic Forces.

The regulations in these standards do not ensure that structures suffer no damage during earthquake of all magnitude. But, to the extent possible, they ensure that structures are able to respond to earthquake shaking of moderate intensities without structural damage and of heavy intensities wit out total collapse.

Shear wall Analysis and Design

Each shear wall acts like a column under vertical load (P) from the supported floors and it's self-weight. The wall shall be designed as a column, taking into account joint moments and additional moment due to slenderness. The horizontal shears at each floor level on a wall element produce shear (H) and overturning moment (M) in wall, with the wall being regarded as a vertical cantilever beam fixed at base. Each section of wall has to be designed for P,M and H, taking advantage of increased stresses or lowered load factors as the overturning moment M and the horizontal shear H are both the result of either wind or earthquake forces.

ISSN 2348 – 8034
Impact Factor- 4.022

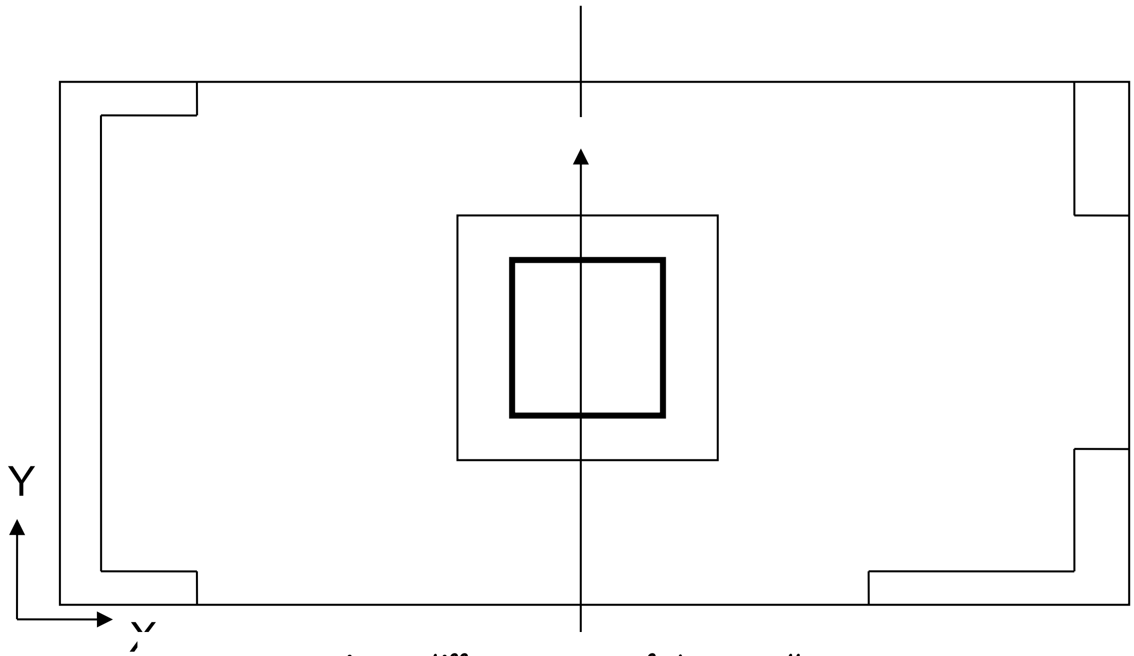

Figure different types of shear walls

Critical issues for the design of high rise buildings in regions prone to significant wind and seismic effects typically include:

1. High base overturning moment and foundation design (wind, Seismic).
2. High shear capacity requirements near base (seismic).
3. High gravity stresses in the vertical elements (and use of high strength materials) to minimize structural design and to maximize net floor area.
4. Development of ductility in elements at the base of a structure under high compressive gravity stress (Seismic).
5. Controlling lateral accelerations (wind).
6. Controlling storey drift (wind and seismic).
7. Controlling damage so as to permit repair (seismic).
8. Ensuring ductile energy dissipation mechanisms and preventing brittle failures (seismic).

IV. METHODOLOGY

Sesicmic Analysis Procedure As Per The Code

When a structure is subjected to earthquake, it responds by vibrating. An earthquake force can be resolved into three mutually perpendicular directions-the two horizontal directions (x and y) and the vertical direction (z). This motion causes the structure to vibrate or shake in all three directions; the predominant direction of shaking is horizontal. All the structures are primarily designed for gravity loads-force equal to mass time's gravity in the vertical direction. Because of the inherent factor of safety used in the design specifications, most structures tend to be adequately protected against vertical shaking. Vertical acceleration should also be considered in structures with large spans, those in which stability for design, or for overall stability analysis of structures.

The basic intent of design theory for earthquake resistant structures is that buildings should be able to resist minor earthquakes without damage, resist moderate earthquakes without structural damage but with some non-structural damage, and resist major earthquakes without collapse but with some structural and non-structural damage. To avoid collapse during a major earthquake, members must be ductile enough to absorb and dissipate energy by post-elastic deformation. Redundancy in the structural system permits redistribution of internal forces in the event of the failure of key elements. When the primary element or system yields or fails, the lateral force can be redistributed to a secondary system to prevent progressive failure.

IS 1893 (part-1) code recommends that detailed dynamic analysis, or pseudo static analysis should be carried out depending on the importance of the problem. IS 1893(part1): 2002 recommends use of modal analysis using response spectrum method and equivalent lateral force method for building of height less than 40 m in all seismic zones.

In all the methods of analyzing multi-storey buildings recommended in the code, the structure is treated as discrete system having concentrated masses at floor levels, which include half of that of columns and walls above and below the floor. In addition, appropriate amount of live load at this floor is also lumped with it.

Earthquake motion causes vibration of the structure leading to inertia forces. Thus a structure must be able to safely transmit the horizontal and the vertical inertia forces generated in the super structure through the foundation to the ground. Hence, for most of the ordinary structures, earthquake-resistant design requires that the structure has adequate lateral load carrying capacity. Seismic codes will guide a designer to safely design the structure for its intended purpose.

Seismic codes are unique to a particular region or country. In India, IS 1893(Part-I): 2002 is the main code that provides outline for calculating seismic design forces for buildings. This force depends on the mass and seismic coefficient of the structure and the latter in turn depends on properties like seismic zone in which structure lies, importance of the structure, its stiffness, the soil on which it rests, and its ductility. IS 1893(part1):2002 deals with assessment of seismic loads on various structures and buildings. The whole code centers on the calculation of base shear and its distribution over height. Depending on the height of the structure and zone to which it belongs, type of analysis i.e., static analysis or dynamic analysis is performed.

Basic theory includes the idealization of whole structure into lumped masses at each floor level.

A number of methods are available for the earthquake analysis of buildings; two of them are presented here:

(1) Equivalent Static Lateral Force Method (pseudo static method)
(2) Dynamic analysis

i. Response spectrum method.
ii. Time history method.

Equivalent Stastic Lateral Force (Seismic Coefficient) Method

In all the methods of analyzing multi storey buildings recommended in the code, the structure is treated as discrete system having concentrated masses at floor levels which includes half of that of columns and below the floor. In addition, the appropriate amount of live load at this is also lumped with it. It is also assumed that the structure is flexible and will deflect with respect to the position of foundation. The lumped mass system reduces to the solution of a system of second order differential equations. These equations are formed by distribution of mass and stiffness in a structure, together with its damping characteristics of the ground motion.

Time Period

The approximate fundamental natural period of vibration T_a in seconds, of a moment resisting frame building without brick infill panels may be estimated by the following empirical formula (IS 1893 (Part 1):2002 (Clause 7.6.1))

$T_a = 0.075\, h^{0.75}$ For RC frame building ____ (5.3)

$T_a = 0.085\, h^{0.75}$ For steel frame building ____ (5.4)

The approximate fundamental natural period of vibration in seconds of all other, buildings including moment resisting frame buildings with brick infill panels may be estimated by the following expression. (IS 1893 (Part 1):2002 (Clause 7.6.2))

$$T_a = \frac{0.09\,h}{\sqrt{d}} \quad \text{——} \quad (5.5)$$

As per IS 1893: 2002 in clause 7.7.1 mentioned that the force thus obtained shall be distributed along the height of the building as per the following expression:

$$Q_i = \frac{V_b\, W_i\, h_i^2}{\sum_{j=1}^{n} W_j\, h_j^2} \quad \text{——} \quad (5.6)$$

V. DYNAMIC ANALYSIS

Time history method- The usage of this method shall be on an appropriate ground motion and shall be performed using accepted principles of dynamics.

Response spectrum method- This method shall be performed using the design spectrum specified in code or by a site-specific design spectrum for a structure prepared at a project site.

Design Of Wind Loads

Distirbution Of Shear Base In X Direction Of The Building

X x L) (7.3)

→

Numerical Modelling And Analysis

4 Parameters For Analysis And Design

The mathematical models developed are subjected to dead load, live load, wind load and earthquake load to analysis and design using ETABS VERSION 9.5 software. In this term we are taking Displacements story drift In 20 story building we have compared different models (Models without opening & with 5%, 10%,15%, 20% of opening) with respect to displacement, drift.

VI. RESULT AND DISCUSSION

Percentage displacement and drift of shear wall without opening is compared with different percentage openings and tabulated. With the percentage increase in the opening, the displacement is increasing.

[Anwar, 4(7): July 2017] ISSN 2348 – 8034
DOI- 10.5281/zenodo.830199 Impact Factor- 4.022

Table Percentage of increasing values in tabular

Shear wall with % of openings	Displacement in X direction	Displacement in Y direction	Drift in X direction	Drift in Y direction
5%	5.4%	2.4%	0.04%	0.01%
10%	9.8%	7.2%	0.07%	0.04%
15%	13%	12%	0.09%	0.07%
20%	16%	16%	0.10%	0.09%

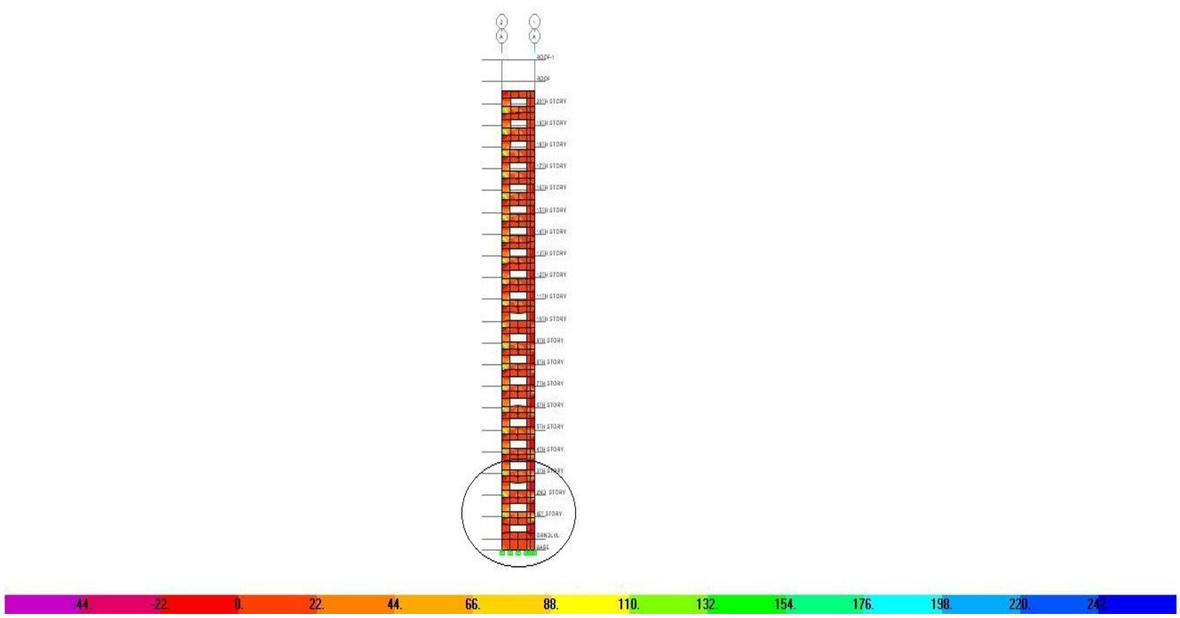

Fig 9.32(a) stress distribution

 ISSN 2348 – 8034
Impact Factor- 4.022

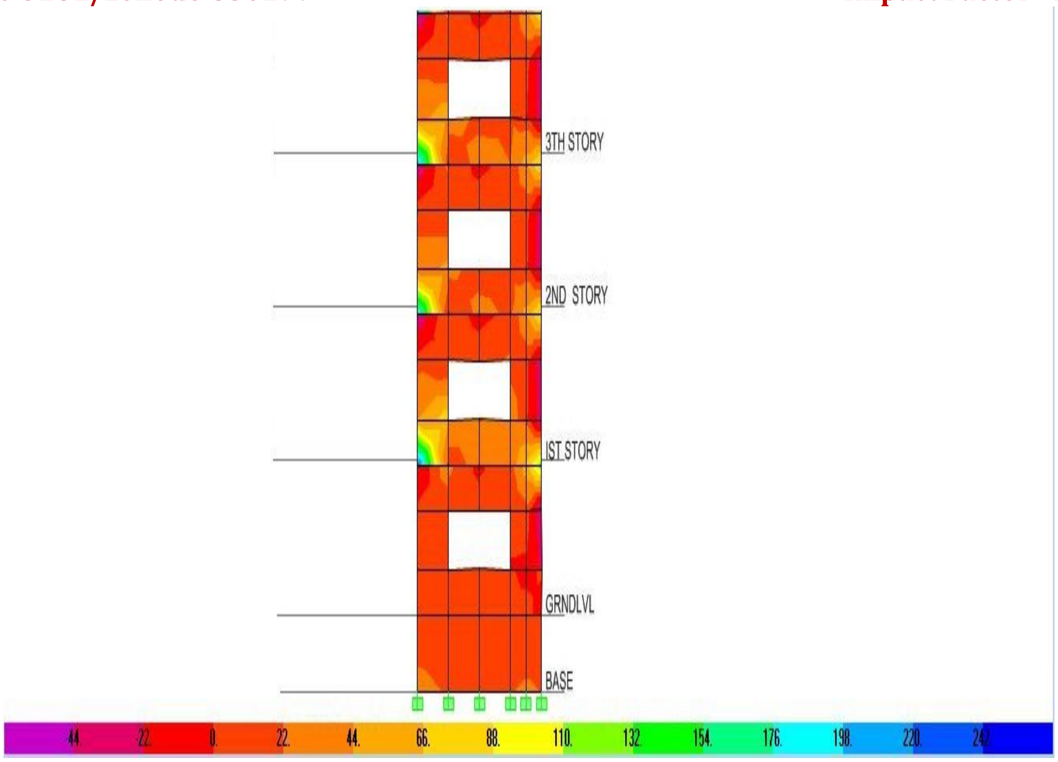

Fig 9.32(b) stress distribution

VII. CONCLUSION

From the study of parametric study on shear walls without & with 5%,10%,15% and 20%,Openings it is observed that the Displacement are increasing with the increase in the percentage of opening.
From the study of parametric study on shear walls without & with 5%,10%,15% and 20%,Openings it is observed that the Drift are increasing with the increase in the percentage of opening.

It is observed that the stiffness of the shear wall are decreasing with the increase in the percentage of opening.
It is observed that the torsion are neglible due to the location of 'L' shape shearwalls at the corners

VIII. SCOPE FOR STUDY

Due to the time limitations for the study, different assumptions and limitations have been adopted for simplicity in modeling the proposed structures. In reality, it might affect on results. Thus, all factors which may influence on the behavior of the structures should be considered in the modeling. For the further study, to obtain the real responses of the structures, the following recommendations are made:

1. Since the study was performed for only one type of shear wall, the further investigations should be made for different types of shear walls.
2. Further investigations should be done for shear walls with different aspect ratio (h/L), in frame-shear wall structures.
3. A flexible foundation will affect the overall stability of the structure by reducing the effective lateral stiffness. So the soil structure interaction should be considered in further study.
4. Shear wall structure have been shown to perform well in earthquakes, for which ductility becomes an important consideration. Thus, the further study should be made considering geometric and material non-linear behavior of the members concerned

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