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RESEARCH ARTICLE

Seismic Analysis of a Reinforced Concrete Structure with and without Shear Wall at Zone-II with Etabs

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ABSTRACT

Shear wall systems are one of the most commonly used lateral load resisting strategies in high-rise buildings, and they are also one of the most expensive. The in-plane stiffness and strength of shear walls are high, and this enables them to withstand considerable horizontal stresses while still supporting gravity loads, making them valuable in a wide range of structural engineering applications. Typically, shear walls are seen in high-rise buildings to prevent the structure from collapsing as a result of lateral loads.. Shear walls are primarily flexural elements that are designed to withstand lateral stresses induced by earthquake and other phenomena. The seismic study in this research is based on an 11-story RCC structure in Zone II. There is a wealth of information available to help you design and analyze a shear wall. However, there is little discussion in the literature on where the shear wall should be placed in a multi-story building. The major goal of this work is to find a solution for shear wall placement in multi-story buildings. The construction is an RCC structure in HYDERABAD that is susceptible to seismic loads in zone II. IS 1893 (PART–I):2002 is used to compute an earthquake load utilizing the seismic coefficient technique. ETABS was used to conduct these analyses.

Keywords: Multi-storey, RC structure, seismic analysis, RC with shear wall and without shear wall, ETABS.

INTRODUCTION

As the construction's mass grows, we must choose for heavier sections to counteract the seismic forces, which will increase the structure's mass, resulting in increased seismic forces. Ductility may be simply produced in a enclosed building with suitable reinforcing details, then when the building rises over a certain height, massive sections are necessary to counter forces, making it practically impracticable. Control of lateral displacement caused by lateral forces is currently one of the most important requirements in building RCC structures in seismic zones. The influence of Shear Wall location on lateral displacement and Storey. Drift in RCC Structures was investigated in this thesis.

Why High Rise Buildings?

The increasing urban people expansion with the resulting demand on restricted space has had a significant impact on city residential construction. The high cost of land, the desire to avoid ongoing urban development, and the necessity to protect key agricultural output have all contributed to the increasing trend in residential construction. Local topographical limits kind towering structures the only viable answer for housing demands in some places, such as Hong Kong and Rio de Janeiro.

Structural System in High Rise Building

Columns and walls are the two principal vertical load acting components of tall structures, with the latter serving as shear walls or shear wall cores in assemblies. The supply of everything to divide and enclose space, as well as cores to hold and carry utilities like elevators, would automatically follow the building purpose. Gravity loads and, in some types of constructions, horizontal loads will be transmitted via columns in then unsupported locations.

SHEAR WALLS

In adding to slabs, beams, and columns, shear walls are vertically concerned with elements that can withstand lateral stresses. RCC shear walls have a high in-plane stiffness while resisting huge horizontal weights and supporting gravity masses in the way of the walls' alignment, making them useful in a wide range of structural engineering applications and lowering the danger of Building damage.

SHEAR WALL – FRAME BUILDINGS

Shear Walls

A shear wall is a structural system made up of braced panels that are used to mitigate the effects of lateral loads on a structure. Shear walls are typically constructed to withstand wind and earthquake stresses. Exterior wall lines in wood or steel surround structure necessity be braced according to numerous construction requirements. Shear walls, on the other hand, when positioned in a favorable position, constitute an effective lateral force resisting structure.

DIFFERENT SHAPES OF SHEAR WALLS

The form and placement of the shear wall have an effect on the structural behaviour of the structure when subjected to lateral stresses. A horizontal diaphragm serves to convey lateral loads parallel to the force of the action. Lateral loads are delivered to the shear walls, where they are absorbed by the shear walls, which serve as a horizontal diaphragm. When viewed in relation to the structural elements, the eccentrically positioned core is required to fulfil a variety of activities, including torque, bending, and direct shear. These shear walls are able to withstand horizontal pressures while remaining upright due to their high stiffness as deep beams that react to shear and flexure against overturning. While rectangular cross sections are the most common in structural applications, L- and U-shaped cross sections are also common. Shear walls constructed of thin-walled deep RC shafts around the elevator core of the building should be used to resist seismic effects. It is included in this part to provide information on the shear wall forms that were employed in this project, as seen in Fig. 1.

- U Section
- W Section
- H Section
- T Section

BASIC ASPECTS OF SEISMIC DESIGN

Because earthquakes generate inertia forces proportional to the mass of the structure under construction, the mass of the structure under construction has an influence on seismic design in addition to the stiffness of the structure under construction. As a consequence, it is possible that the structure will need to undergo damage in order to release the energy that has been absorbed by the earthquake. To counteract this effect, the traditional earthquake-resistant design philosophy stipulates those typical constructions must be capable of withstanding any of the following:

a) Mild to moderate shaking that occurs on a regular basis with minimal harm to structural or non-structural components;
b) Moderate shaking with only minimal structural damage and some non-structural damage; and
c) Severe (and sporadic) shaking results in structural damage but no collapse (in order to spare lives and property inside and next to the structure).

Under design wind forces, on the other hand, structural damage is unacceptable. As a result, earthquake resistant design, rather than earthquake-proof design, is used to describe earthquake-resistant construction, as shown fig.2,

SEISMIC ZONES OF INDIA

The seismic zone map has been altered, with just four zones instead of five, based on the intensities suffered by severe prior earthquakes. Zone I was once split into two zones, one of which is now known as Zone II. As a result, only Zones II, III, IV, and V are included in the new zoning system. About Seismic Zoning Map of India. The first seismic zoning map of India was produced in 1935 by the Geological Survey of India (G. S. I.). This map was originally based on the amount of damage experienced by various parts of India as a result of earthquakes, with multiple adjustments made afterwards. This map depicts India's four unique seismic zones, which are color-coded in varying degrees of red. The following are the country's several seismic zones, as seen on the map, shown in fig3,
Zone - II: This is said to be the least active seismic zone.
Zone - III: It is included in the moderate seismic zone.
Zone - IV: This is considered to be the high seismic zone.
Zone - V: It is the highest seismic zone.

Function of Shear wall

To be able to withstand horizontal earthquake forces, shear walls must possess the necessary lateral strength. Shear walls would convey horizontal forces to other components in the load channel below them as soon as their strength was determined to be sufficient. Shear walls provide additional lateral stiffness to a structure, preventing the roof or floor from swaying excessively to one side. Shear walls with appropriate stiffness will prevent the sliding away of floor and roof bordering members once their supports have been removed. Furthermore, structures that are sufficiently robust may absorb less non-functional damage as a result of their construction. Shear walls also offer lateral stiffness, which prevents the ceiling or floor from moving excessively in either direction sideways.

Requirements of Structural Element In High Rise Buildings

As high-rise buildings are built, the wind and seismic forces to which they are subjected become more important considerations in the design and construction of the structures. It is now possible to improve tall building structural systems in order to manage their dynamic responses as a result of the dramatic increase in the maximum height of concrete buildings over the last few decades, which includes the incorporation of more appropriate structural elements such as shear walls and tube structures, as well as improved concrete material qualities used in their construction. The margins of shear walls are especially sensitive to severe compressive and tensile stresses as a consequence of the massive overturning effects induced by horizontal earthquake pressures, which may cause the wall to collapse. In order for shear walls to be capable of withstanding load reversals while retaining their strength, a certain kind of reinforcement must be employed in the concrete at the end parts of the walls. This is referred to as the "ductile reinforcement strategy" in the technical literature. In construction, boundary components are the terminal elements of a wall that are more constrained in their movement than the remainder of the wall structure. Rather than being employed throughout the frame as a restricting element, transverse reinforcement, similar to that found in the columns of a reinforced concrete frame, is used just in the border components. In certain instances, the thickness of the shear wall in these border components is also increased in order to compensate for the increased loading.

RC Shear Wall

As an alternative to slabs, beams, and columns, they are vertical plate-like reinforced concrete (RC) walls that are often employed in reinforced concrete buildings to give extra structural support in addition to slabs, beams, and columns. Shear walls are made of reinforced concrete (RC), and they have a similar appearance to plate-like walls. These walls are often constructed by beginning at the ground level and ascending to the maximum height of the building in a series of steps. When used in tall constructions, they may be as thin as 150 mm or as thick as 400 mm in thickness, depending on the application and the needs of the structure. A well-known consulting engineer from the United States, Mark Fintel, believes we "can not afford to construct concrete structures meant for severe earthquakes without shear walls." "Concrete buildings intended for severe earthquakes without shear walls" is not an option, he argues. Then he said something like, "We can't afford to create concrete structures that are designed to withstand big earthquakes without including shear walls in the design."In particular, the overturning effects of shear walls are remarkable because they carry significant horizontal earthquake forces to the ground underneath them. Shear walls must be organised in a symmetrical manner in order to prevent the harmful effects of twisting on the structural stability of a building's foundation. Asymmetry in plan along one or both directions is possible, as is symmetrical positioning in plan along one or both directions. It is more advantageous for shear walls to be situated on the external perimeter of a structure than on the inside perimeter of a structure. As a consequence of this configuration, the twisting resistance of the structure is enhanced.RCC shear walls have a high in-plane stiffness while resisting huge horizontal weights and supporting gravity masses in the direction of the walls' orientation, making them useful in a variety of structural engineering applications and lowering the risk of structural damage. Shear walls also provide lateral rigidity to avoid excessive side-sway of the roof or floor above. Shear walls also provide lateral rigidity, preventing excessive side-sway of the roof or floor above. Shear walls come in a variety of shapes and sizes, including rectangular and irregular cores like channel, T, L, barbell, and box. The location of a shear wall in a structure has an impact on the structure's behavior.

Function of Shear Wall

Earthquakes are vibrations that occur under the earth's surface, resulting in the death of people and the destruction of structures. The major goal of the structural systems in the building is to properly transmit gravity loads such as dead load, living load, and snow load. Buildings are susceptible to lateral loads induced by wind, blasting, or earthquakes, which can create significant stresses, sway, or vibration in addition to gravity loads. The combination of sufficient vertical strength and enough stiffness can efficiently withstand lateral forces. hear walls in a structure withstand a mixture of shear, moment, and axial loads resulting from lateral and gravity loads.

Objectives

The objectives are as follows,

1. With the help of the ETABS software, a multi-story structure with a shear wall was analysed.
2. To investigate the behaviour of the structure when the shear wall is placed at various locations.
3. Natural Period, storey shear, storey displacement, and storey drift are all factors that will be investigated and compared in this research.
4. In order to establish the most advantageous site for the construction,
5. Shear walls are used to prevent structures from collapsing due to earthquakes.

LITERATURE REVIEW

[Greifenhagen and Lestuzzi, 2005]

According to the results of the investigation, a squat reinforced shear wall, which was not meant to withstand seismic stimulation, has high strength and deformation capacity under load. The outcomes of a series of static cycle tests performed on a poorly reinforced concrete shear wall of an existing building with the purpose of measuring the deformation capacity of the wall are presented in this paper. Before making any suggestions for earthquake-resistant design, this study will conduct a more realistic seismic assessment of existing shear walls in order to offer better earthquake-resistant design recommendations. A multitude of parameters, including cross section type, reinforcement details and quantity, reinforcing steel characteristics, and boundary conditions, may cause failure modes to manifest themselves, but the most common are as follows:

[Elwood, et-al., 2006]

Using a beam–pillar frame construction, the capabilities of an earthquake-resistant structure are examined in this paper. According to the conclusions of this investigation, a beam pillar construction should be strengthened against earthquake loads by applying compression and tension braces diagonally to it. To test the performance of tension braces with a thickness of 200 mm, connectors and tap bolts are attached to the braces and then released (tap bolts on two perpendicular sides of the connections on the pillar-beam element). As an alternative, we investigate compression braces with the same thickness as the walls, and we find that they are particularly advantageous in such situations since they are simple to install and effective at boosting seismicity. In order to prevent any possible difficulties that may occur during the demolition and subsequent rebuilding of the structure for reinforcement, the major goal of this inquiry was to identify them. According to the findings of this research, tensile braces are efficient whether they are employed globally or just as a last option.

METHODOLOGY

Vibrations caused by earthquakes produce inertia forces in the structure. As a result, a structure must be capable of securely transmitting the horizontal and vertical inertia forces created by the superstructure to the earth via the foundation. Seismic codes will help a designer construct a structure that will be safe for its intended use. There are a variety of approaches for analyzing structures for earthquakes; two of them are discussed below. The approach used to assess the seismic behavior of regular and irregular structures with and without shear walls. There are two types of G+11 Storey building geometry: regular buildings with and without shear walls, and irregular buildings with and without shear walls. ETABS 2016 is used to model and evaluate the buildings. The equivalent static approach and the response spectrum method are used to analyze structures. According to the IS: 1893-2002(Part 1) code of practice, models are used for zone factor V and soil type II (Medium). Maximum displacement, stiffness, and storey drift are among the characteristics evaluated in the study.

a A thorough analysis of the literature to gain a better understanding of seismic evaluation of building structures and to determine the most effective and efficient placement of shear walls inside the structure.
b Creating a model of a forty-story structure. Shear walls with apertures are given at the central core and at the centre of each side of the exterior perimeter.
c Checking the building's design for dead load, live load, and seismic load in accordance with Indian standards.
d Using linear static dynamic analysis, i.e., Response Spectrum Analysis, to analyze the building.
e Interpreting the findings and drawing inferences.

The following approaches may be used to model a shear wall: -CAD (computer-aided design)

1. Using the equivalence frame approach,
2. The braced frame approach is also known as

3. The finite element approach is a kind of numerical analysis. The shear wall is modelled in ETAB, utilising the Finite Element Method and Surface Meshing to get the desired results.

Load Conditions

1. The dead load criterion for all of the models is one kilonewton per metre.
2. In all cases, the live load criterion is 3KN/M for all of the various types.
3. In accordance with IS 1893 (PART 1):2002, the lateral load is the seismic load that is applied to the mass centre of the building.

MODELLING AND ANALYSIS PROGRAM

MODELING

Four distinct types of infill materials are considered in this study: traditional brick, cement concrete block, hollow block, and light weight brick. The computer software ETABS-2009 was used to develop and evaluate the building models using various types of infill materials, and the results were compared.

Material Specifications

Table: 2 Specifications of Materials

Analysis

The building is being analysed with the help of the programme ETABS. ETABS was responsible for the creation of the models. The programme makes use of a variety of RC shear wall cross sections, including the box type, the L type, and the cross type, and these cross sections are placed in various positions, including the perimeter, the corner, and the centre.

METHODS OF ANALYSIS

When a structure is subjected to earthquake ground motion, earthquake response analysis is an art form that employs dynamics and a mathematical model of the structure to simulate the structure's behavior.To do the proper analysis, precise modelling of the behaviour of the materials, components, and connections to the structure will be necessary. Taking into consideration the study's purpose, the number of degrees of freedom should be properly calculated in the model. Given that each node has its own displacement, a three-dimensional model may be used to simulate any kind of behaviour. Because of the difficulties associated with modelling, verification, and numerical calculation, the three-dimensional model has not yet been included in the most sophisticated design methodologies. This research was carried out with the help of the ETABS 2006 software package.

Frame analysis

The appropriate sort of member requirements are used to define three-dimensional (3D) beam or column components in this study. Each node has six degrees of freedom (Ux, Uy, Uz, Rx, Ry, Rz).

Seismic method of analysis

Following the selection of a structural model, it is possible to conduct an analysis to determine the presence of seismically induced forces in a structure. It is the present emphasis of the study to conduct linear static analysis or a similar kind of static analysis for regular structures with limited height.

ETABS INTRODUCTION

Extended 3D (Three-Dimensional) Analysis of Building Systems (ETABS) is a term that refers to the increased 3D (Three-Dimensional) Analysis of Buildings (ETA This is done using finite element software and the stiffness matrix. The analysis and design are carried out in accordance with Indian standards to ensure that all of the checks are met. Finally, a data base for diverse structural reactions is created. TABS Software: Structural analysis and building design

are made easier with the revolutionary new ETABS software package, which is the most complete software solution available today. This version of ETABS lacks comparable 3D modelling and visualisation tools, as well as quick linear and nonlinear analytical power, complex and comprehensive design capabilities for a wide range of materials, and incisive graphic presentations, reports, and schematic drawings. Direct conversion of CAD drawings into ETABS models is possible. The examination of the G+6 Building exposed to loads is the primary focus of this paper. The methods for structural analysis that we will offer in this study were developed using software (ETABS).
ETABS is a structural and seismic engineering programmed developed by Computer and Structural Inc (CSI). The world's tallest structure, the Burj Khalifa, was also planned and assessed using this software.
The following are some of the reasons we picked ETABS:

- ◎ Easy to use interface,
- ◎ Confirmation with the Indian Standard Codes
- ◎ Versatile nature of solving any type of problem,
- ◎ Accuracy of the solution

MODELLING IN ETABS

53D View of the Building in ETABS

RESULTS

Storey displacement, storey drift, Natural period, and storey shear are the results of the study, which are produced for all models in both lateral directions (X and Y). For multistory building with bare frame model at various positions of shear wall, results are obtained and graphs are generated.

STOREY DISPLACEMENT

Table: 3 Storey Displacement (mm) , Graph1:Storey Displacement (mm)

Story Drift

Table: 4 Storey Drift (m), Graph2:Storey Drift (m)

STOREY SHEAR

Table: 5 Storey Drift (m), Graph3:Storey Drift (m)

CONCLUSIONS

The current investigation aims to determine the impact of a shear wall on a structure in an earthquake-prone zone. For all models, the load combination 1.5DL+1.5EQX is shown to be the most essential. ETABS was used to conduct the investigation. According on the findings of the study, the following conclusions may be drawn.

1. All models show that when the storey height rises, the displacements increase.
2. Storey displacement is lower for structures with shear walls at corners than for structures with shear walls in the middle and structures without shear walls. As a result, it is possible to construct a shear wall at the corners.
3. In comparison to structures with shear walls in the middle, structures with shear walls at the corners yield greater values. As a result, shear walls at corners are a viable option.
4. It is clear from the preceding observations that constructions with shear walls at corners perform better than other structure.

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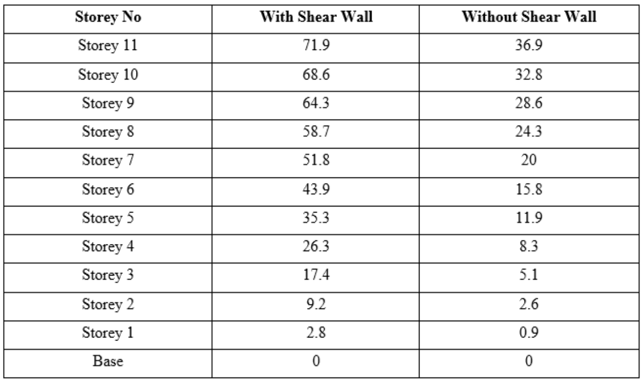
Table : 1 Details of building

Number of storeys	11
Story Height	3m
Size of Beam	30X60
Size of column	50X50
Slab thickness	15cm
Support condition	Fixed
Thickness External wall	20cm
Grade of steel	Fe-415
Grade of concrete for Beam	M 25
Grade of concrete for column	M 30
Response Reduction Factor	5
Importance Factor	1
Soil condition	Medium
Type of soil	II
Zone	II
Zone Factor	0.36

Table 2. Specifications of Materials

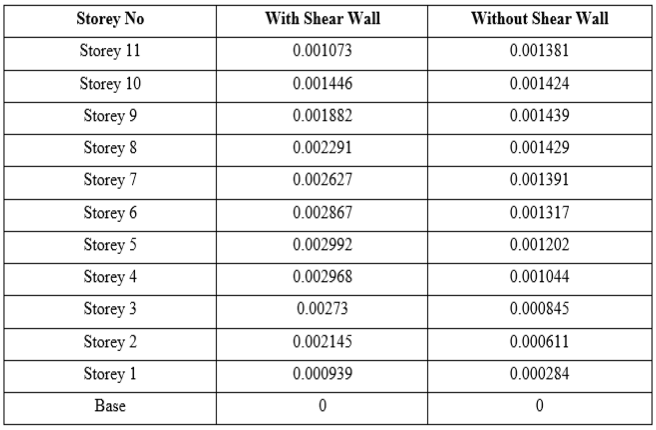
Material Specifications	
Grade of concrete M 30	f_{ck}=30N/mm^2
Grade of Steel	f_y=415N/mm^2
Density of concrete	Γ_c=25N/mm^2
Density of brick walls concrete	Γ_{brick}=20N/mm^2

Table: 3 Storey Displacement (mm)



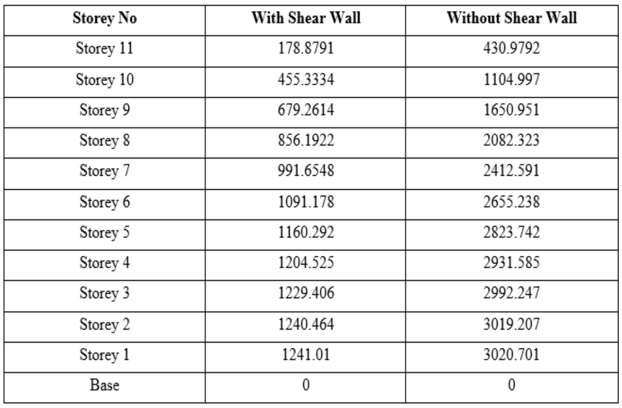
Storey No	With Shear Wall	Without Shear Wall
Storey 11	71.9	36.9
Storey 10	68.6	32.8
Storey 9	64.3	28.6
Storey 8	58.7	24.3
Storey 7	51.8	20
Storey 6	43.9	15.8
Storey 5	35.3	11.9
Storey 4	26.3	8.3
Storey 3	17.4	5.1
Storey 2	9.2	2.6
Storey 1	2.8	0.9
Base	0	0

Table : 4 Storey Drift (m)



Storey No	With Shear Wall	Without Shear Wall
Storey 11	0.001073	0.001381
Storey 10	0.001446	0.001424
Storey 9	0.001882	0.001439
Storey 8	0.002291	0.001429
Storey 7	0.002627	0.001391
Storey 6	0.002867	0.001317
Storey 5	0.002992	0.001202
Storey 4	0.002968	0.001044
Storey 3	0.00273	0.000845
Storey 2	0.002145	0.000611
Storey 1	0.000939	0.000284
Base	0	0

Table: 5 Storey Drift (m)



Storey No	With Shear Wall	Without Shear Wall
Storey 11	178.8791	430.9792
Storey 10	455.3334	1104.997
Storey 9	679.2614	1650.951
Storey 8	856.1922	2082.323
Storey 7	991.6548	2412.591
Storey 6	1091.178	2655.238
Storey 5	1160.292	2823.742
Storey 4	1204.525	2931.585
Storey 3	1229.406	2992.247
Storey 2	1240.464	3019.207
Storey 1	1241.01	3020.701
Base	0	0

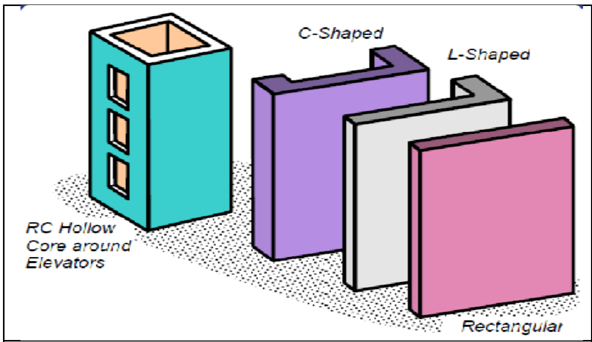


Fig. 1. Various Types of Shear Walls

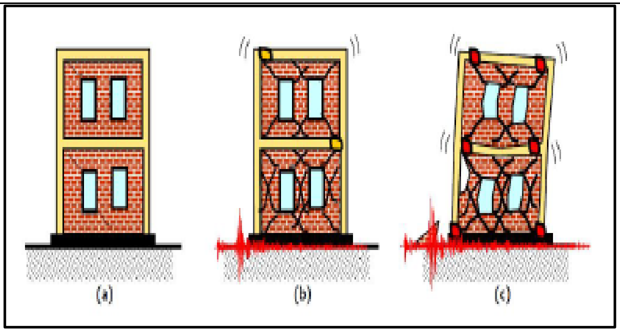


Fig. 2 Earthquake-Resistant philosophy for building

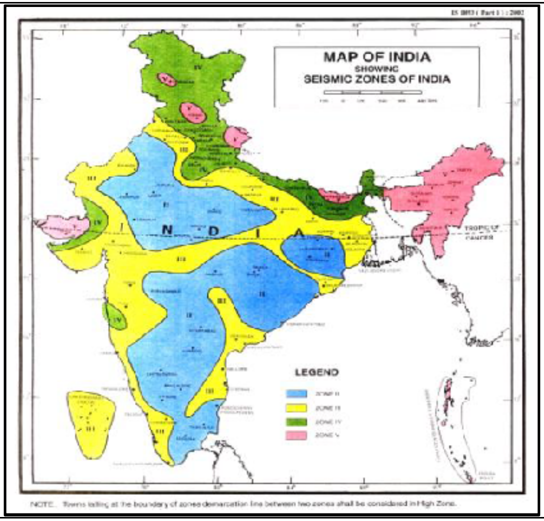
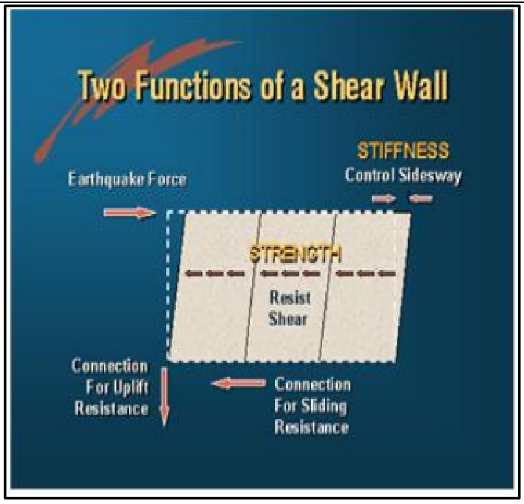


Fig. 3. Modified seismic zones of INDIA (IS 1893-PART 1 2002)



Two Functions of a Shear Wall

Earthquake Force

STIFFNESS
Control Sidesway

STRENGTH
Resist Shear

Connection For Uplift Resistance

Connection For Sliding Resistance

Fig-4: Function of Shear Wall

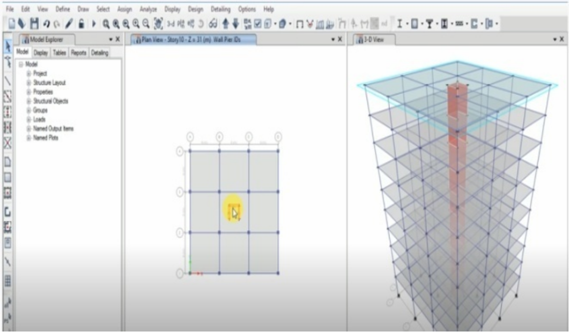
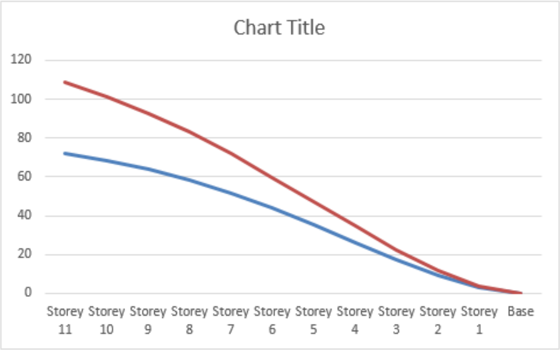
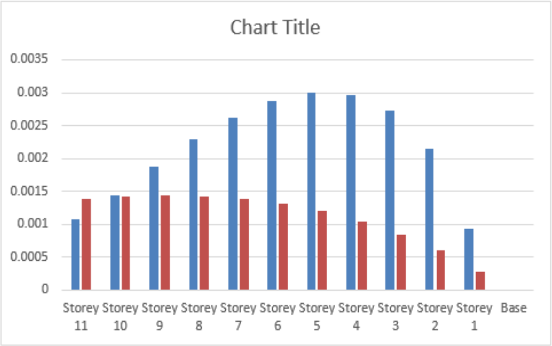


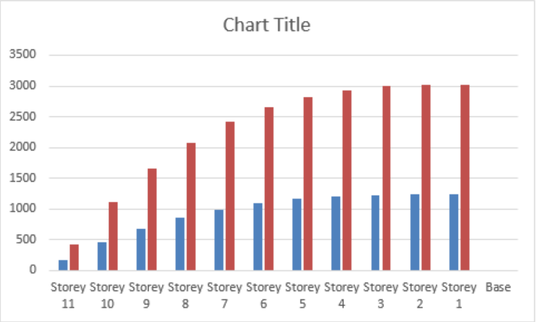
Fig. 5. 3D View of the Building in ETABS



Graph 1. Storey Displacement (mm)



Graph 2 .Storey Drift (m)



Graph 3 Storey Drift (m)