How to Cite:
Balakrishna, C., & Saishanker, S. N. (2022). Shear wall analysis and optimised design for high rise buildings using ETABS. *International Journal of Health Sciences*, *6*(S2), 11018–11028. https://doi.org/10.53730/ijhs.v6nS2.7956

Shear wall analysis and optimised design for high rise buildings using ETABS

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***Abstract*---**Increased population density in India necessitates the development of urban areas in particular. Structural engineers in seismic zones around the planet also put pressure on multistory structures to be built with inconsistencies in stiffness, because they realize that these structures will be subject to seismic loading. In comparison to prior high-rise buildings, today's high-rise skyscrapers are more appealing and thin, which contributes to the chance of more sway. The dynamic response of tall buildings will be monitored by developing basic methodologies for tall buildings. With more appropriate construction types, such as shear walls and tube structures, as well as improved material qualities. The integrated structural operation of floor and roof structures with walls is overall project standard of current wall construction frameworks for behavior walls. The floor structure distributes vertical and lateral stresses to the walls, which are then transferred to the foundation, which acts as a diaphragm. Shear walls that are comparable to lateral charge method resist lateral forces from wind and earthquakes. Shear resistance and resistance to overturning allow these shear walls to transmit lateral stresses to the base. The current study covers a 45-story building with a platform up to the fourth floor level. There is no abrupt modification in design beyond podium level (4th storey level) if the structure is influenced by a major seismic force or any other less horizontal force, and if there is any quick shift, it will result in construction stiffness / torsional unpredictability. The optimization techniques used in this project start with the assumption that the shear wall size in the building is the same, and then analyses are performed as a consequence, the failing shear wall dimensions are extended to overcome the entire system, allowing the structure to be optimized for a number of times until it is stable enough to withstand

Manuscript submitted: 27 March 2022, Manuscript revised: 09 April 2022, Accepted for publication: 18 May 2022

pressures. The Etabs Software is used to design and optimize the shear wall in this project, and the shear walls are meant to resist lateral stresses in zone III across the construction allowing to Indian norms.

***Keywords*---**storey drifts, shear wall, storey stiffness, base shear.

Introduction

In general, a high-rise construction design involves a conceptual plan, a theoretical research, and a main plan with optimization to handle significant and lateral loads safely. Regular catastrophes such as earthquakes, tsunamis, earth slides, floods, and fires inflict enormous damage and suffering to people by destroying buildings, cutting off transportation networks, killing or trapping people and cattle, and so on. The progression of development is jeopardized by these catastrophic calamities. Civil engineers, on the other hand, as planners, can help mitigate harm by properly designing structures or making other constructive judgments.

Aim

This may be created using the precise model created at Etabs, which takes into account earthquake and wind effects. There are a variety of ways for assessing a unit's capability, including the ones listed below.

1. Model dependent on object
2. Shear architecture idealization and boundary line tests
3. Idealization to (or) verify flexural architecture

Objectives of This Study

The major purpose of this plan is to evaluate and compare several kinds of Shear walls using the ETABS now command in order to obtain optimal Shear wall placement inside the construction. The design comprises load estimates and analysis of the complete system using modelling software, with the main design method being a Limit State Design in accordance with the Indian Standard Code of Practice.

Need for Present Study

Shear walls are frequently spent in maximum RC constructions; pillars carry mostly gravity loads (i.e., those attributable to self-weight also construction content). Shear walls are designed for structures with high strength and stiffness, and the way they are aligned considerably decreases lateral tilt around the structure, reducing harm to the structure and its contents.

Geometry & Detailing of Shear Walls

Shear walls was rectangular in cross-section, with one cross-section measurement being much bigger than the other. Though four-sided cross-sections are common, L- and U-shaped segments are often utilized. Small walled deep RC shafts that operate as shear walls for the elevator principle of structures should also be used to endure shaking. One or two parallel coatings known as curtains, as well as vertical and horizontal reinforcement, are common dividers that may be found here. In every horizontal and vertical direction, the minimum area required for reinforced steel is 0.0025 times the cross-sectional capacity. It may be required in this condition to distribute this vertical reinforcement uniformly over the cross-section of the wall.

Scope

Earthquakes are happening more frequently these days. The goal of seismic research and building plan has historically been to reduce the probability of fatalities in the greatest projected earthquake. Different lateral loading solutions have been included in the constructions to lessen the impacts of earthquakes and wind loads. The placement of shear walls in asymmetrical constructions must be taken into account. It is critical to establish the greatest efficient and best position for the shear wall.

Function of Shear wall

Shear walls necessity have enough lateral strength to resist horizontal earthquake forces. When shear walls reach a certain weight, horizontal forces are transferred to further sections of the capacity route underneath them. Shear walls, floors, base walls, slabs, and footings are the other components that make up the load network. Shear walls also provide lateral stability, which prevents the roof or floor from swinging side to side. Shear walls with sufficient stiffness can prevent members from slipping off their supports in the floor and roof framing. Furthermore, buildings that are suitably stiff suffer less harm to their functionality.

Requirements of Structural Element in High Rise Buildings

The interaction about wind and seismic forces on multistory structures is a fundamental component of design. Developing the fundamental framework for high-rise structures will monitor their vibrant response by adding additional suitable fundamental elements, such as shear walls with tube frameworks, and will also improve substantial belongings; in recent decades, the extreme elevation of solid structure consumes has risen. To guarantee that the shear walls perform in a ductile manner, it is necessary to reinforce concrete in the shear wall finish expanses in a different way in order to bear load reversal without losing power.

Difference between Column and Shear Wall

The shear wall is made up of pillars and compression and shear resistant parts. Shear walls are vertical structural elements that resist lateral stresses in the wall plane over shear and bending. Shear walls are often given in equal length and breadth for structures. Shear walls is similar vertically concerned with large beams bearing downward loads of earthquake to base.

Analysis of Building

For seismic study, G+10 R.C.C. is assumed to be a hypothetical structure comprising of a residential and commercial complex. The structure's design is unusual in nature, although it appears to be typical to the casual observer. The home will be built on medium-sized soil in the Seismic Zone III.

Optimization

- What is optimization?
  The goal of structural optimization is to create an assemblage of materials that can bear mass in a favorable way. 'Making things better' is the simplest and most often used idea of optimization.
- what is 'Need' of the optimization?
  If the many types of construction are light and equally likely, it must be resistant to Buckling and have as much flexibility as possible. Restrictions were invented to play here since there were none. For example, minimization and maximization would be impossible. The most important optimization constraints are the objective function and restrictions.
- Optimum Problem Formulation
  A native of optimum plan may be achieved by equating a different plan explanation that is developed based on a priori considerate of difficulties. The problem project strategies utilized for various issues differ depending on the purpose and design factors.

Types of optimization problems

i. Sizing optimization
ii. Shape optimization
iii. Topology optimization

Optimization of the Building

The analysis's goal is to present optimization techniques into structural engineering. Typically, structural engineering contracts are based on the structure's consistency with protection, which implies that the structure is constructed in such a way that it can withstand a wide range of forces. Because the structure will be subjected to lateral stresses earthquakes, wind, and additional regular calamities, for example.

Literature Review

Early 1940s

When main shear walls were first invented in the early 1940s, they were widely used in multistory constructions to resist lateral stresses. particularly near support margins that could not be effectively constructed to meet lateral load requirements if unsupported often. Shear walls are the walls in a structure that can sustain lateral wind or earthquake stresses. RCC structural components are usually credited with a large amount of a structure's lateral load.

Mo and Jost (1993)

A nonlinear framework was used to predict seismic reactivity on reinforced concrete bordered shear walls. Beginning with the consequences, It was determined that concrete strength has a considerable impact on the surrounding shear walls because, according to the El Centro record, growing concrete strength from 25 MPa to 35.0 MPa reduces severe refraction by 30%.

Tabassum G Shrihatti (2015)

The findings of a typical study using RC and steel building construction stage analysis were analyzed. Three-dimensional RCC and 30-story steel structure modelling in Zone IV with solid sand form will be investigated, and the study's results will be obtained. In both buildings, a stiff frame is used to identify the structures.

Meghna B.S and T.H Sadashiva Murthy (2016)

The RC construction method for the G+ 5 fluctuation pillar has been swapped with an RC handover rafter outside location through a combination transmission strut with model investigation being passed obtainable utilizing ETABS software. Traditional study and sequence analysis of the construction are engaged here, as well as a contrast of metrics such as beam moments and deflection of both structures.

Methodology

Structural study was passed out with the help of a well-known processer software that distributed E-tabs for linear structural evaluation of structures exposed to static and dynamic stresses. With the idealism of structure as a categorization about structure, efficient model formulation with issue solution may be achieved using shear wall structures interconnected by floor diaphragms. The computer-assisted E-Tabs programme will be used to create a 10-story multistory structure with shear wall optimization. The design, which was developed in AutoCAD, is manually introduced and presented in ETABS. This ideal will be put to the test for axial and lateral loads, as well as consequences. The Etabs Software is utilized to generate the 3D model as well as conduct the analysis. The lateral loads applied to the constructions are created on Indian regulations using the equal lateral force method. The study is carried out for moderate and extreme seismic regions, in accordance with IS 1893:2002, for two sand scenarios, utilizing the model plan shown in the picture.

ETABS

The E-TABS tool is used to construct and analyze 3D space frame models. On ETABS, a thorough investigation of construction models is carried out. The ETABS-generated lateral stresses were applied to seismic area III with a 5% damped response spectrum (IS: 1893-2002). The ETABS participation, output, and numerical solution methodologies are especially designed to take advantage of certain physical and numerical features associated with structures in the building form for the purpose of generating money. The base package includes a modeler with a postprocessor in place of showing all effects, counting stress statistics, and bouncing forms, as well as a full range of Windows graphic tools and utilities.

Modelling with Etabs G+10 Building Procedure

The design of a building necessitates consideration of structure's provisioning requests. That is, the number of people in a room, the amount of power it has, how long it lasts, and how long it. The layout gives a front view of the structure's surface design. The design has a shear wall with beams and columns. The following expectations have been met, and the formation process has begun in order to maintain parallel settings in each of the four replicas:

1. The major block of each structure is taken into account. The flight of steps is not measured in the building process.
2. The structure is utilized for residential resolutions, then no walls will be provided because research will simply look at the frame configuration response.
3. On the ground level, slabs that were not part of the base were raised 2 meters above the ground.
4. The beams were resting in the centre of the piers in order to avoid odd circumstances. This was regularly accomplished using trendy ETABS.
5. M25 & Fe 500 are used for all structural characteristics.
6. The footings should not be laid out. Provisions are distributed in a predetermined support format.
7. Only horizontal (X & Y) seismic loads are known, and vertical (Z) seismic loads are thought to be minimal.

S.No	Building Details	Dimensions
1	Number of storey	G+10
2	Typical storey height	3m
3	Column size	500x500mm
4	Beam size	300mmx300mm
5	Slab thickness	200mm
6	Shear wall thickness	300mm
7	Grade of concrete	M25
8	Grade of steel	Fe500
9	Plinth level	2m
10	Total height of Building (G+10)	35m
11	Slab Thickness	200mm
12	Soil Type (as per IS:1893-2002)	Medium
13	Response Reduction Factor	5
14	Importance Factor	1

Table-1: Data Assumed

Optimization for G+ 10 Building

Shear walls are constructed close everything lift centers then edges regarding building in order to optimise distinct D.L & L.L components.

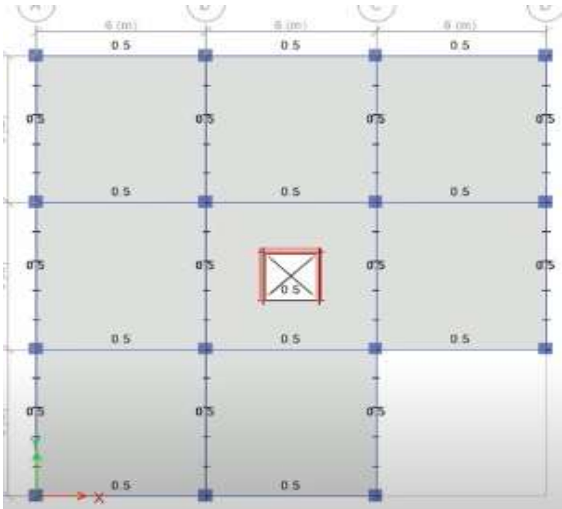

Fig-1: Top view Plan of the building (from Etabs)

This design individual make available a basic design, then building requirements for nearby situations were examined, resulting in a comprehensive isometric or 3D vision to better holistically grasp structural behavior.

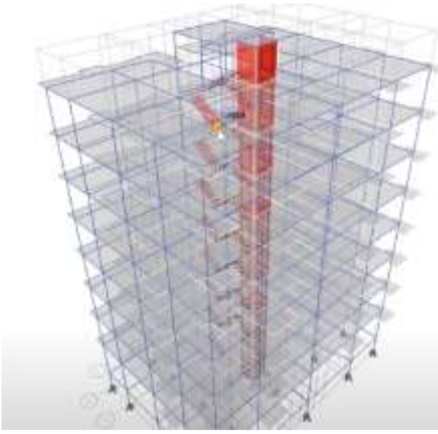

Fig-2: Isometric view of building (From Etabs)

The graphic depicts the structural activities of the building, which are typical of the complete structure, shear walls, and so on.

Analysis and Modelling

Analysis of G+10 Building

The impact entirely framed structures on the simulated building may be viewed as a straightforward study. The lateral drift / deflection relationship should be examined under transient seismic stresses in accordance with IS-1893:2002 section 7.11.1, i.e. The following restrictions are explored in order to existing a contrast among the various structures:

1. Maximum Storey Drift
2. Maximum Storey Displacement
3. Storey Shears

Results

Story Drifts

That be translation is over one degree and added is below one degree. Every storey must have a storey drift of no more than 0.004 times to elevation about the storey's elevation. After analyzing the structure, the findings determined for the whole design, including longitudinal and transverse instructions, may be obtained in a tabular format.

Story	Load	Point	X (KN/M²)	Y (KN/M²)	Z (KN/M²)	DriftX	DriftY
Story 10	DEAD	13	9.000	0.000	18.000	0.000033	0.000026
Story 9	DEAD	15	9.000	6.000	18.000	0.000034	0.000025
Story 8	DEAD	13	9.000	0.000	15.000	0.000033	0.000024
Story 7	DEAD	16	9.000	9.000	15.000	0.000032	0.000026
Story 6	DEAD	13	9.000	0.000	12.000	0.000033	0.000025
Story 5	DEAD	16	9.000	9.000	12.000	0.000031	0.000026
Story 4	DEAD	13	9.000	0.000	9.000	0.000030	0.000025
Story 3	DEAD	16	9.000	9.000	9.000	0.000033	0.000025
Story 2	DEAD	13	9.000	0.000	6.000	0.000024	0.000023
Story 1	DEAD	16	9.000	9.000	6.000	0.000020	0.000018
Base	DEAD	13	9.000	0.000	3.000	0.000018	0.000013

Table-2: Story Drift

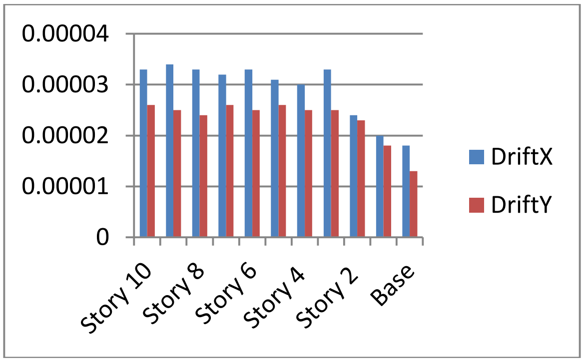

Fig-3: Graph for Story drifts

Story Shears

Story	Load	Loc	P	VX	VY	T	MX (KN/M²)	MY (KN/M²)
Story 10	DEAD	Top	888.70	-16.00	-16.00	-16.00	3983.162	-4015.162
Story 9	DEAD	Bottom	1780.29	-16.00	-16.00	-16.00	8043.321	-8075.321
Story 8	DEAD	Top	2669.00	-32.00	-32.00	-32.00	12026.483	-12090.483
Story 7	DEAD	Bottom	3560.59	-32.00	-32.00	-32.00	18134.642	-16198.842
Story 6	DEAD	Top	4449.29	-48.00	-48.00	-48.00	20117.804	-20213.804
Story 5	DEAD	Bottom	5340.88	-48.00	-48.00	-48.00	24273.963	-24369.963
Story 4	DEAD	Top	6229.58	-64.00	-64.00	-64.00	26257.125	-28385.125
Story 3	DEAD	Bottom	7121.17	-64.00	-64.00	-64.00	32461.285	-32589.285
Story 2	DEAD	Top	8009.88	-80.00	-80.00	-80.00	36444.446	-36604.445
Story 1	DEAD	Bottom	8901.47	-80.00	-80.00	-80.00	40696.606	-40856.606
Base	DEAD	Top	9790.17	-96.00	-96.00	-96.00	44679.767	-44871.767

Table-3: Story shear

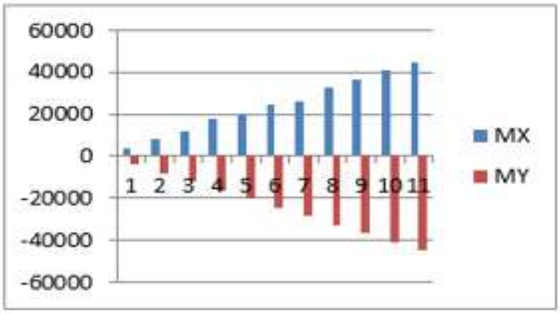

Fig-4: Graph for Story Shear

Story	Point	Load	FX	FY	FZ	MX (KN/M^2)	MY (KN/M^2)	MZ (KN/M^2)
Base	1	DEAD	42.68	44.04	741.02	1.297	-4.490	-1.011
Base	2	DEAD	1.71	-55.93	594.58	2.506	0.858	-1.023
Base	3	DEAD	1.79	31.48	491.04	3.741	0.967	-1.005
Base	4	DEAD	47.13	-64.01	825.86	4.882	-4.085	-1.030
Base	5	DEAD	-60.86	1.37	627.90	-2.639	-5.731	-1.006
Base	6	DEAD	-1.06	-1.34	684.02	-0.073	-1.773	-1.014
Base	7	DEAD	-0.97	-1.01	652.57	0.381	-1.647	-1.014
Base	8	DEAD	-66.16	-4.44	663.78	2.962	-5.731	-1.006
Base	9	DEAD	28.24	1.44	470.90	-2.675	-1.773	-1.022
Base	10	DEAD	-1.55	-1.29	652.14	-0.059	-1.647	-1.014
Base	11	DEAD	-1.59	-1.91	680.70	0.520	-5.311	-1.006

Table-4: Support Reactions

Support Reactions

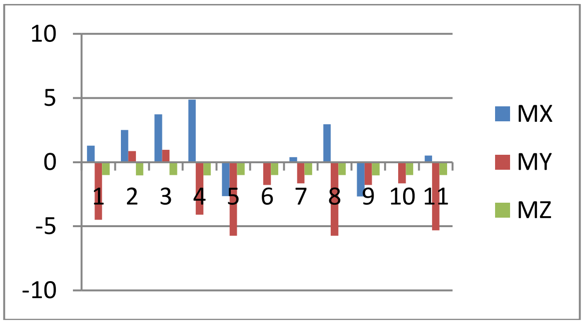

Fig-5: Graph for Support Reactions

Conclusions

The building was successfully constructed using ETABS, and the performance of the construction was evaluated using response spectrum research. The method worked well, as seen by the findings listed below.

1. The structure not being the same shape all around has changed the displacement of the structure in X and Y direction.
2. Displacement is greater in X direction than in Y direction.
3. The story drift is also very high when compared to the Y direction.
4. The shear walls are symmetrically distributed in X direction and asymmetric in the Y direction.
5. Shear wall configuration being symmetric reduces it damping effect than from an asymmetric arrangement.

Scope for Future Work

In this study, the ETABS Soft wear is used to assess a conventional multi-story (G+10) structure. The most productive placement around shear walls was chosen based on the findings of previous research. In comparison to other industries, the use of optimization in civil engineering is substantially lower in the current environment. The project includes optimization of shear wall structures.

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