Seismic Analysis of High-Rise Building G+24 Using ETABS

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Abstract - *Earthquake in the past decade is observed to be more devastating, so it is now important to consider the effect of earthquake for the construction of medium to high rise buildings. Due to scarcity of space caused by migration of people from rural to urban area, hence it is necessary to construct high rise buildings. In high rise buildings earthquake forces should be considered before determining the safety of a structure. Hence stiffness of columns must be ensured to stay safe during an earthquake, it was found that for providing high stiffness in the columns, the size of columns increase drastically and it is difficult to construct large size columns due to congestion of space. Hence an alternative is found for high rise building. Shear wall behaves as a wide column. It carries heavy load and provides resistance against lateral forces. Shear walls when placed in the most appropriate locations in the building, they resist the lateral loads caused by earthquakes.*

A 3-D analysis of shear wall structures has been carried out using ETABS software, two models are analyzed viz., model-1 as the uniform grade of concrete in all floors of structure, model-2 as different grades of concrete. Response spectrum method analysis have been used according to IS: 1893(Part-1). The seismic analysis of the frame models has been analyzed for various load combinations according to IS: 1893(Part-1). Different parameters studied are deflection, vertical irregularities, storey drift and storey displacement. Based on these parameters, best model has been suggested.

***Key Words*: Etabs, response spectrum, shear wall, storey drift, displacement, Stiffness.**

1. INTRODUCTION

The urban centralization is causing suffocation of place for the survival of people in the urban areas, hence to fix this issue and to avoid the creation of slums; vertical living is applied in many metropolitan cities. The construction of these high rise structures is a difficult task for the engineers as it has many criteria's such as lateral forces, soil condition, strength of the structure, stiffness of the structure, economical etc. Nowadays in the construction of the high rise buildings there are many advancements implemented, one of the latest advancements is Shear wall. It is a vertical element which withstands the lateral forces for shear and bending. Shear wall is designed as shell type, shell elements have both bending as well as in-plane stiffness which can resists moments and forces from all direction. Shear wall can withstand lateral forces (Wind and earthquake effect) to a greater extent.

The structure can be analyzed and designed for lateral forces by many methods, the utilization of software for the analysis and design is in more nowadays as it provides most appropriate values within less time when compared to the manual works. ETABS is one such software where the analysis and design can be carried out easily.

2. SCOPE AND OBJECTIVE

The main objective is to compare the two different models with same plan, dimensions, but change in the grade of concrete.

- Design of multi storied building with shear walls using ETABS
- To compare the bending moment, shear force, deflection for model-1 and model-2
- To analyze and compare storey drift, storey stiffness, displacement.

3. METHODOLOGY

For the purpose of project, a structure of G+24 Storey reinforced concrete residential building is analyzed. The uniqueness in the structure is that shear walls are constructed instead of columns. The framing arrangement and location of shear walls in building were provided according to the structural and architectural plans. The Residential apartment building is RCC frame structure with Shear wall beams and slabs.

All RCC structures, shear walls, beams, slab, etc. is designed according to limit state method as per Indian Standard Codes. Seismic analysis should be carried for the buildings that have lack of resistance to lateral loads.

Seismic analysis considers dynamic effects however, liner static analysis is carried for simple and low-rise buildings where as Dynamic analysis is carried out for high rise structures and seismic prone areas as per IS 1893:2016 part-1. Dynamic analysis is done by Response Spectrum Method in ETABS which indicates maximum values of Response in the structure. For the purpose of design of the structure Indian Standard Codes are referred.

4. MODELING

Modelling is done by using ETABS (17.0.1 version) software. Preliminary step is to prepare Centre line plan and import the AutoCAD file to ETABS. Material properties are defined, preliminary sizes of beams, shear walls, slab are assigned. After this, loads coming on the building are calculated. Load combinations are defined by referring to IS456-2000, seismic analysis is done by using response spectrum method as per the specifications of IS 1893-2016.

A response spectrum is a role of period or frequency which shows the response of simple harmonic oscillator which are subjected to be temporary. Response Spectrum Analysis is a method used to estimate the response of the structure to earthquakes and wind effects.

In the project two models are under study model-1 as the uniform grade of concrete in all floors of structure, model-2 as different grades of concrete in all the floors of structure.

Model-1: M40 grade of concrete is used for all the floors in structure.

Model-2: Different grades of concrete is used for different floors in the structure

M50 grade – foundation to 5th floor

M45 grade – 6th floor to 10th floor

M40 grade – 11th floor to 14th floor -

M35 grade – 15th to terrace floor

Table-1: Parameters taken for Analysis

Building configuration	G+ 24
Structure type	Residential Apartment
Building length in X direction	22.82m
Building length in Y direction	20.60m
Floor area	450m^2
Height of structure	85.05m
Bearing capacity of soil	220 KN/m^2
Footing depth	3m
Slab Thickness	150mm 250mm for lift machine room
Shear wall thickness	250mm, 300mm
Beam dimensions	B1 250x450mm, B2 200x600mm, B3 350X450m, B4 250x850mm.
Storey height	Lower basement: 3.4m, Upper basement: 4.15m, Typical floor: 3.0 m
Wall thickness	230 mm main wall 152mm partition wall
Parapet wall	230mm thick, 1.2m height

Table-2: Material Specifications

Grade of concrete	(M35), (M40), (M45), (M50)
Density of concrete	25KN/m^3 as per IS 456:2000
Modulus of elasticity	$Ec = 5000\sqrt{fck}$ N/mm^2 as per IS 456:2000 Clause 6.2.3.1
Grade of steel	Fe 550 HYSD bars
Density of walls considered	Autoclave Aerated concrete blocks. (AAC) with density 7 KN/m^3

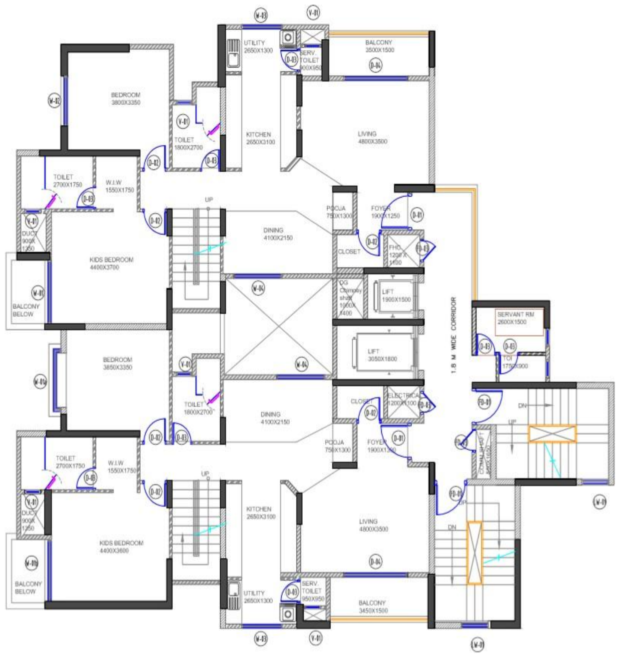

Figure- 1: Typical Floor Plan of Model

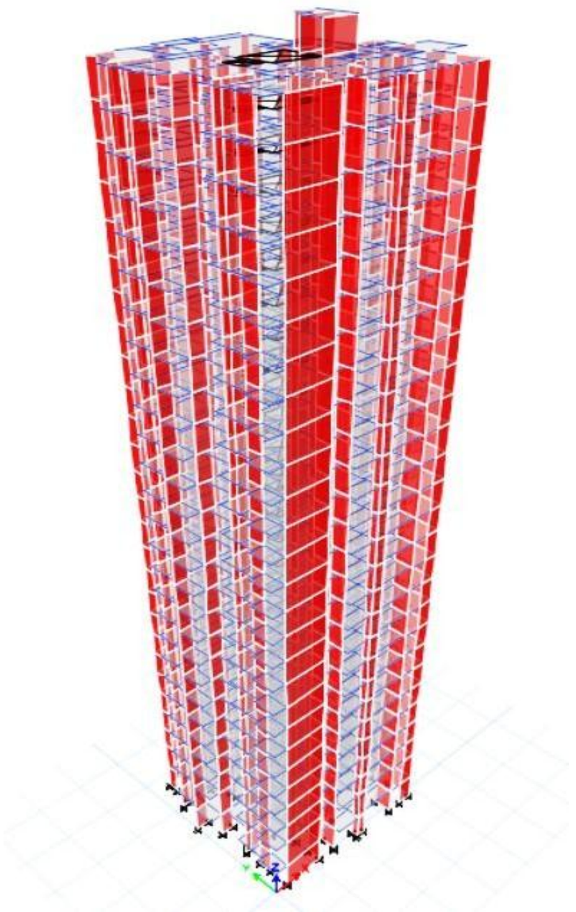

Figure- 2: 3D representation of Shear wall location in the structure in ETABS

5. RESULT AND DISCUSSION

5.1. DESIGN DETAILS OF SHEAR WALL FOR SELECTED PIER (P33)

Shear wall design details (critical shear wall)

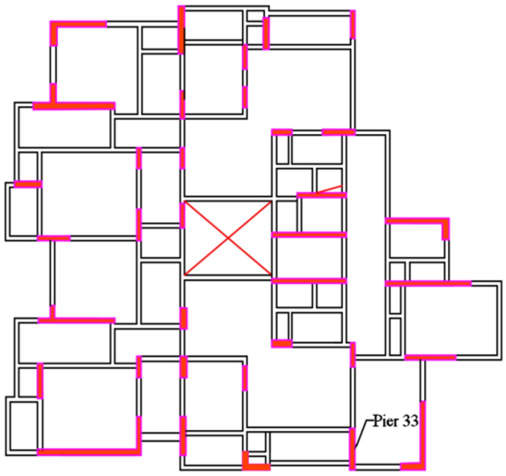

Figure-3: Plan showing the location of Pier 33 (Critical shear wall)

Table-3: Shear Design for Shear Wall (Model-1)

Storey	Station location	P_u KN	M_u KN-m	V_u KN	V_c+V_s KN
Base 1	Top	1699.3	26.98	100.71	463.95
Base 1	Bottom	1501.8	167.8	94.25	465.20
Terrace	Top	77.01	99.61	70.658	434.75
Terrace	Bottom	50.86	58.88	69.758	434.28

Table-4: Shear Design for Shear Wall (Model-2)

Storey	Station location	P_u KN	M_u KN-m	V_u KN	V_c+V_s KN
Base1	Top	1689.9	32.17	108.3	486.59
Base1	Bottom	1478.6	196.7	115.5	483.54
Terrace	Top	68.87	95.80	70.96	431.13
Terrace	Bottom	39.093	61.22	70.13	430.53

Table-5: Flexural Design for Shear Wall (Model-1)

Storey	Required Rft. ratio	Current Rft. ratio	P_u KN	M_{u2} KN-m	M_{u3} KN-m
Base 1	0.0025	0.0035	3010.5	60.21	63.83
Base 1	0.0033	0.0035	289.02	18.75	217.16
Terrace	0.0025	0.0035	67.8	1.36	69.01
Terrace	0.0025	0.0035	123.67	2.47	17.13

Table -6: Flexural Design for Shear Wall (Model-2)

Storey	Required Rft. ratio	Current Rft. ratio	P_u KN	M_{u2} KN-m	M_{u3} KN-m
Base 1	0.0025	0.0033	3247.1	64.9	69.59
Base 1	0.0029	0.0033	259.53	13.7	232.2
Terrace	0.0025	0.0028	61.95	1.24	66.04
Terrace	0.0025	0.0028	122.12	2.44	17.21

Figure-4: Plan showing the location of Beam B91

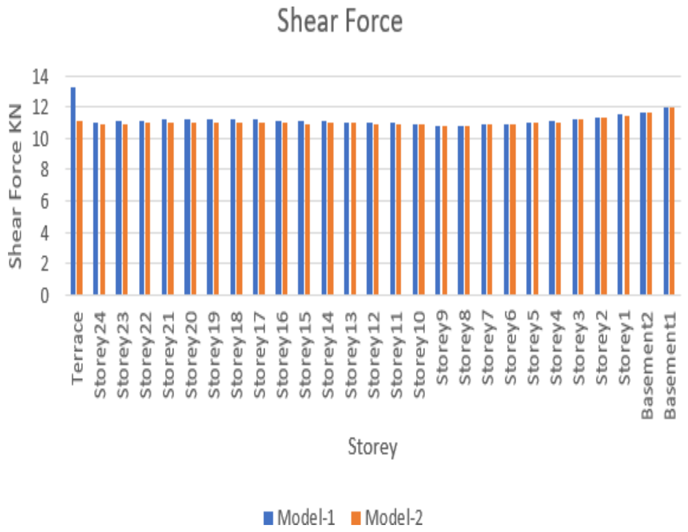

Chart-1: Shear Force comparison for Model-1 and Model-2

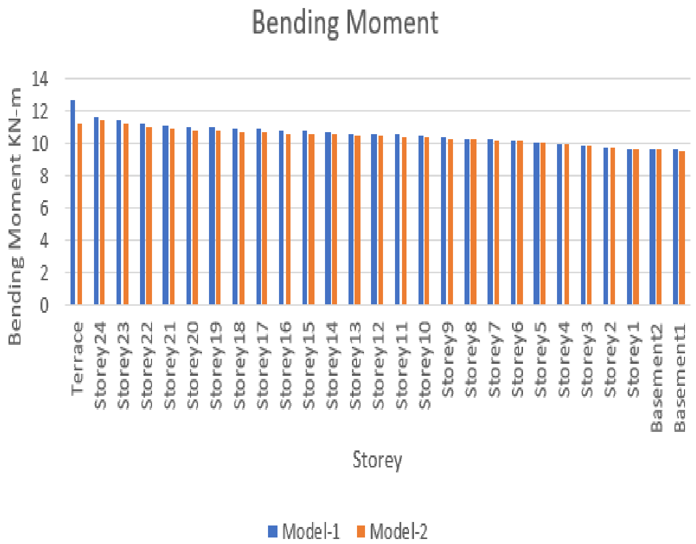

Chart-2: Bending Moment comparison for Model-1 and Model-2

In model-1, Shear force is increased by 2.6% from basement to terrace, bending moment is increased by 24% from basement to terrace

In model-2, Shear force is decreased by 7.4% from basement to terrace, bending moment is increased by 15% from basement to terrace

As the Shear Force and Bending Moment increases the area of steel also increases, model-2 is considered as more economical structure as compared to model-1.

5.2. STOREY DISPLACEMENT

The maximum displacement caused in a storey with respect to the base storey is known as Maximum Storey Displacement.

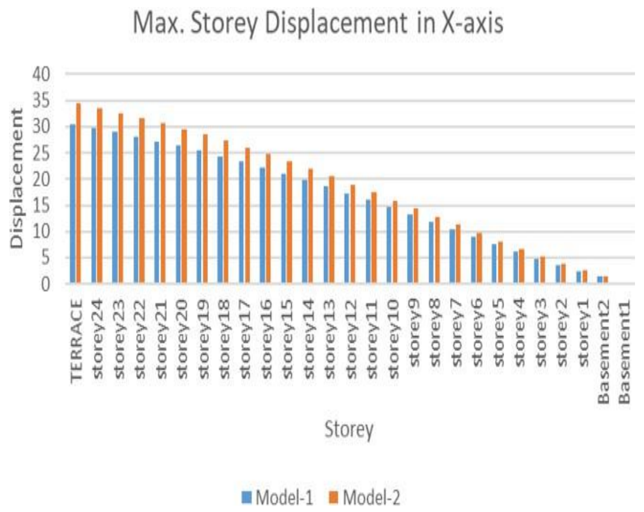

Chart-3: Displacement comparison for model-1 and model-2 (X- Axis)

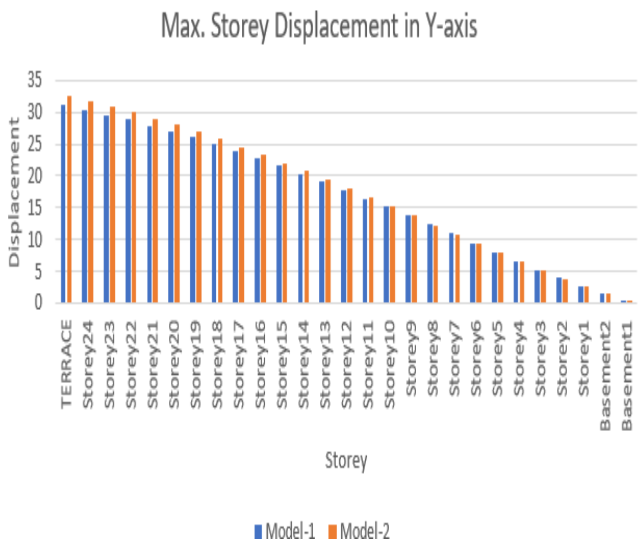

Chart-4: Displacement comparison of for model- 1 and model- 2 (Y-Axis)

It is observed that model-2 has the 8% more displacementas compared to model-1. In model 1 concrete grade is uniform throughout the structure.

In Model-2 different grades of concrete is used from foundation level to terrace which results in slight increasein displacement, lower the concrete grade higher the displacement.

5.3. STOREY STIFFNESS

The amount of deformation up to which a storey can resist without causing any distress in the structure in response to the applied load is known as Storey Stiffness.

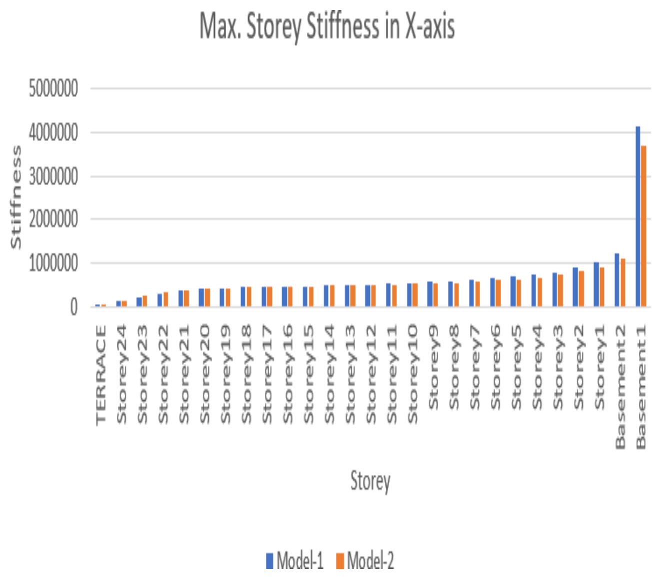

Chart-5: Stiffness comparison for model-1 and model-2 (X-Axis)

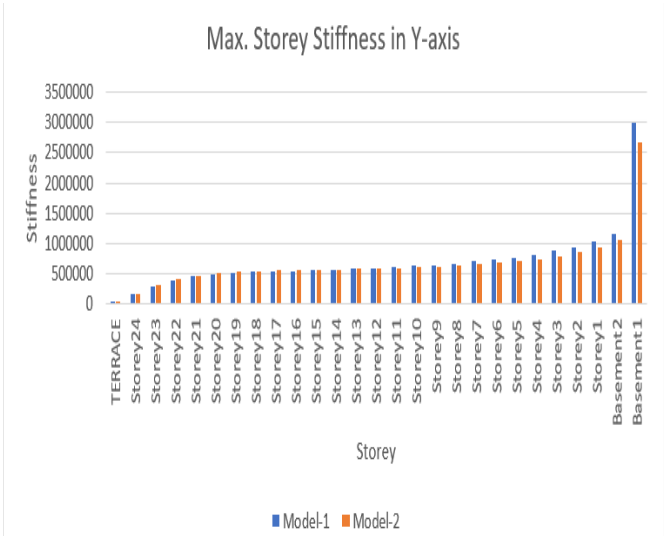

Chart-6: Stiffness comparison for model-1 and model-2 (Y-Axis)

As stiffness is related to modulus of elasticity, in high grade concrete the modulus of elasticity will be more which results in model-1 (concrete grade M40) to achieve 16% more stiffness as compare to model-2

5.4. STOREY DRIFT

The amount of sway between two adjacent stories of a building caused due to lateral loads in a structure is known as Storey Drift which is used for the design of partition walls or curtain walls.

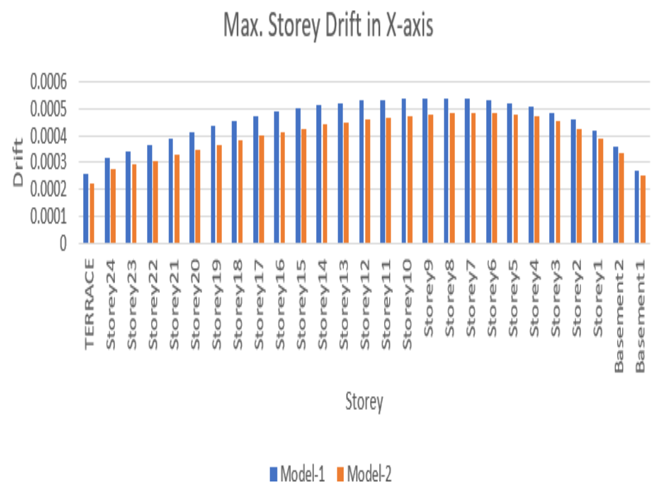

Chart-7: Drift comparison for model-1 and model-2 (X-Axis)

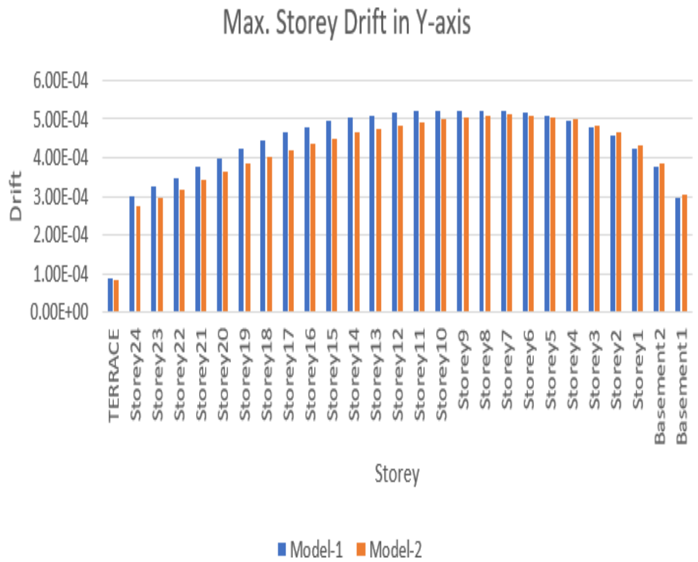

Chart-8: Drift comparison for model-1 and model-2 (Y-Axis)

Model 1 has more Storey drift than the model-2 which means model-2 is safer under collapse of structure; due to change in concrete grade drift value of 12.28% reduced as compared to model-1.

6. CONCLUSIONS

1) Providing Shear walls increases in stiffness of building and reduces the displacement in both X and Y directions.
2) Good seismic resistive building will have high lateral stiffness, low stiffness results to deformation and damage.
3) The ratio of storey drifts value in model-2 is decreasing which reduces the probability of collapse of building.
4) As the grade of concrete increase, the displacement of the structure decreases. Maximum storey displacement is less than 5% i.e., within the Engineering limits.
5) The values of shear force, bending moment, storey displacement, storey stiffness and storey drift are clearly shown in the bar graph.
6) All the building components are analyzed using ETABS.

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BIOGRAPHIES

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