Comparison of High Rise Building with and without Shear Wall

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Abstract— Shear wall systems are one of the most commonly used lateral load resisting systems in buildings. Shear walls are one of the most efficient lateral force resisting elements in buildings. In the seismic design of buildings, reinforced concrete structural walls, or shear walls, act as major earthquake resisting members. Shear walls have very high in plane stiffness and strength, which can be used to simultaneously resist large horizontal loads and support gravity loads, making them quite advantageous in many structural engineering applications. The design and analysis of high-rise building with software helps in reducing economy in construction without reducing the strength and serviceability of the structure as a whole. A residential building of G+10, plot of 540 square yard regular structure is considered for the analysis. To evaluate the seismic response of the buildings and analysis will be performed by using response spectrum method using software-ETABS. The properties of these seismic shear walls dominate the response of the buildings, and therefore, it is important to evaluate the response of the building.

Key words:

I. Introduction

A. Introduction of Project

The objective of structural design is to plan a structure which meets the basic requirements of structural science and those of the user. The basic requirements of structural design are safety serviceability, durability and economy. In this project work it is proposed to design a multistoried residential building consisting of 10 floors. Each floor consists of 4 flats. The building is served by one stair case.

B. Importance of Multistoried Buildings

The rapid increase in population and Industrial growth and of shelter there is considerable rise in the price of shelter there is considerable rise in the price of city land and as the space is limited, horizontal expansion is difficult. Hence vertical expansion has become compulsory. This has led to the conception of apartments or flats. An apartment consists of 3 to 7 storeys and each storey may accommodate 2 to 4 tenements. The land and other amenities of apartments are shared by all the occupants.

Multi storied building has been broadly classified into five types

- Load bearing constructions.
- Composite Constructions.
- Framed Constructions.
- Reinforced Concrete framed Constructions.
- Steel framed Constructions.

The first method has got the limitation that it will be economical only up to 2 to 3 storeys. By means of composite constructions technique, the economy is achieved if the number is in between 3 to 5. Any building having more than 6 storeys has to be dealt by means of framed constructions building having more than 6 storeys has to be dealt by means of framed constructions.

II. Literate Review

H.-S. Kim, D.-G. Lee "Analysis of shear wall with openings using super elements" Engineering Structures 25 (2003) 981–991. Three-dimensional analysis of building structure is a very complex problem and solution of this problem is often obtained via finite element method. The paper presents a set of finite elements used for the modelling of building structures taking into account soil-structures interaction. Finite elements of the structure are derived by using beam schemes including Timoshenko type beam. The finite elements descriptions are completed by plate state. The way of elements connections and the global system of equations are also defined. The finite elements of wall panels, floor slabs, joints ant contact type subsoil proposed in this study significantly reduce the number of unknowns. Two computational examples proved the efficiency and the computing possibilities of the presented model.

Anshumn. S, Dipendu Bhunia, Bhavin Rmjiyani (2011), "Solution of shear wall location in Multi-storey building." International Journal of Civil Engineering Vol. 9, No.2Pages 493-506. Shear wall systems are one of the most commonly used lateral-load resisting systems in highrise buildings. Shear walls have very high in-plane stiffness and strength, which can be used to simultaneously resist large horizontal loads and support gravity loads, making them quite advantageous in many structural engineering applications. There are lots of literatures available to design and analyse the shear wall. However, the decision about the location of shear wall in multi-storey building is not much discussed in any literatures. In this paper, therefore, main focus is to determine the solution for shear wall location in multi-storey building based on its both elastic and elasto-plastic behaviours. An earthquake load is calculated and applied to a building of fifteen stories located in zone IV. Elastic and elasto-plastic analyses were performed using both STAAD Pro 2004 and SAP V 10.0.5 (2000) software packages. Shear forces, bending moment and story drift were computed in both the cases and location of shear wall was established based upon the above computations.

III. Methodology

General Structural analysis was carried out by means of well-known computer program E-tabs issued for the linear structural analysis of buildings subjected to static and dynamic loads, is documented. Efficient model formulation and problem solution is achieved by idealizing the building as a system of frame and shear wall substructures inter-connected by floor diaphragms.

A. Method of Analysis

Model of 16 storey high rise building with and without shear wall is done by computer aided software E-Tabs. Material properties such as grade of concrete and rebar is defined.

Section properties of column, beam, slab, masonry wall and shear wall is defined. Load pattern such as dead, live, seismic, wind are defined. Normal static analysis is done and design check is performed. Model is analyzed for axial load, lateral loads, Wind loads and the results are studied. After this Response spectrum functions are defined and analysis is done. Results for the displacements of different load cases for both the models are observed. For optimization of shear wall location, shear wall is placed at corner locations and the results obtained such as displacements are studied and compared.

B. Sequence of Work

- MATERIAL PROPERTIES
- SECTION PROPERTIES
- LOAD CASES
- MODEL CREATION
- NORMAL STATIC ANALYSIS
- DESIGN CHECK
- RESPONSE SPECTRUM FUNCTION
- RESPONSE SPECTRUM ANALYSIS
- DISPLACEMENT RESULTS

C. Structure Data without Shear Wall

This chapter provides model geometry information, including items such as story levels, point coordinates, and element connectivity.

1) Story Data

Name	Height	Elevation	Master Story	Similar To	Splice Story
	mm	mm			
Story 11	3000	32000	No	Story1	No
Story 10	3000	29000	No	Story1	No
Story 9	3000	26000	No	Story1	No
Story 8	3000	23000	No	Story1	No
Story 7	3000	20000	No	Story1	No
Story 6	3000	17000	No	Story1	No
Story 5	3000	14000	No	Story1	No
Story 4	3000	11000	No	Story1	No
Story 3	3000	8000	No	Story1	No
Story 2	3000	5000	No	Story1	No
Story 1	2000	2000	Yes	None	No
Base	0	0	No	None	No

Table 3.1: Story Data

2) Grid Data

Grid System	Grid Direction	Grid ID	Visible	Bubble Location	Ordinate
					m
G1	X	A	Yes	End	0
G1	X	B	Yes	End	2
G1	X	C	Yes	End	3
G1	X	D	Yes	End	5
G1	X	E	Yes	End	7
G1	X	F	Yes	End	8
G1	X	G	Yes	End	10
G1	X	H	Yes	End	12.89
G1	X	I	Yes	End	14.89
G1	X	J	Yes	End	15.89
G1	X	K	Yes	End	17.89
G1	X	L	Yes	End	19.89
G1	X	M	Yes	End	20.89
G1	X	N	Yes	End	22.89
G1	Y	1	Yes	Start	0
G1	Y	1a	Yes	Start	1.2
G1	Y	2	Yes	Start	3
G1	Y	3	Yes	Start	6
G1	Y	4	Yes	Start	9
G1	Y	5	Yes	Start	11.4
G1	Y	6	Yes	Start	14.4
G1	Y	7	Yes	Start	17.4
G1	Y	7a	Yes	Start	19.2
G1	Y	8	Yes	Start	20.4

Table 3.2: Grid Lines

3) Highrise Building without Shear Wall

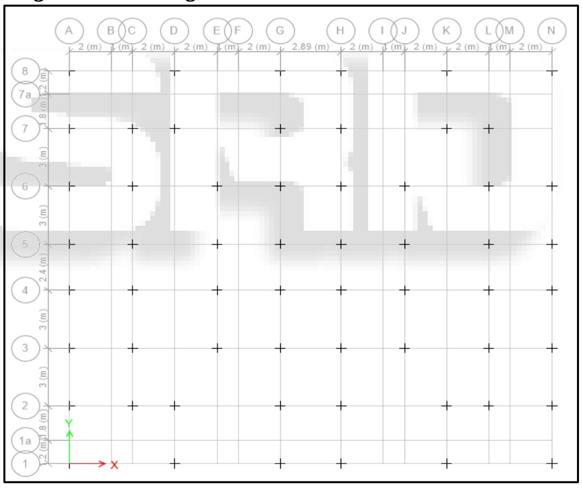

Fig. 1: Plan Showing Base Level (Storey) In ETABS

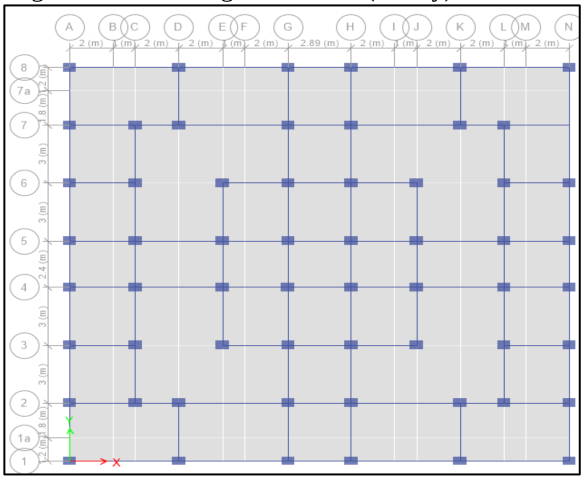

Fig. 2: Plan Showing 11th Floor Level (Storey) In ETABS

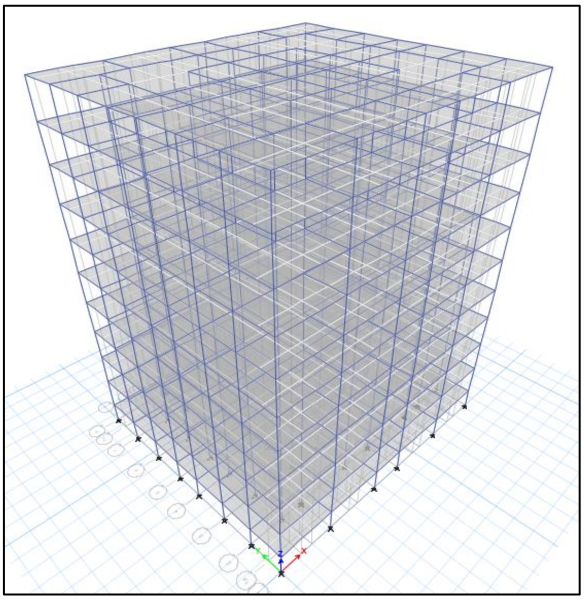

Fig.3. 3D Model of Highrise Building

IV. STRUCTURE DATA WITH SHEAR WALL

This chapter provides model geometry information, including items such as story levels, point coordinates, and element connectivity.

A. *Story Data*

Name	Height mm	Elevation mm	Master Story	Similar To	Splice Story
Story11	3000	32000	No	Story1	No
Story10	3000	29000	No	Story1	No
Story9	3000	26000	No	Story1	No
Story8	3000	23000	No	Story1	No
Story7	3000	20000	No	Story1	No
Story6	3000	17000	No	Story1	No
Story5	3000	14000	No	Story1	No
Story4	3000	11000	No	Story1	No
Story3	3000	8000	No	Story1	No
Story2	3000	5000	No	Story1	No
Story1	2000	2000	Yes	None	No
Base	0	0	No	None	No

Table 4.1: Story Data

B. *GRID Data*

Grid Syste m	Grid Directio n	Gri d ID	Visibl e	Bubble Locatio n	Ordinat e m
G1	X	A	Yes	End	0
G1	X	B	Yes	End	2
G1	X	C	Yes	End	3
G1	X	D	Yes	End	5
G1	X	E	Yes	End	7
G1	X	F	Yes	End	8
G1	X	G	Yes	End	10
G1	X	H	Yes	End	12.89
G1	X	I	Yes	End	14.89
G1	X	J	Yes	End	15.89
G1	X	K	Yes	End	17.89
G1	X	L	Yes	End	19.89
G1	X	M	Yes	End	20.89
G1	X	N	Yes	End	22.89
G1	Y	1	Yes	Start	0
G1	Y	1a	Yes	Start	1.2
G1	Y	2	Yes	Start	3
G1	Y	3	Yes	Start	6
G1	Y	4	Yes	Start	9
G1	Y	5	Yes	Start	11.4
G1	Y	6	Yes	Start	14.4
G1	Y	7	Yes	Start	17.4
G1	Y	7a	Yes	Start	19.2
G1	Y	8	Yes	Start	20.4

Table 4.2: Grid Lines

1) *Highrise Building with Shear Wall*

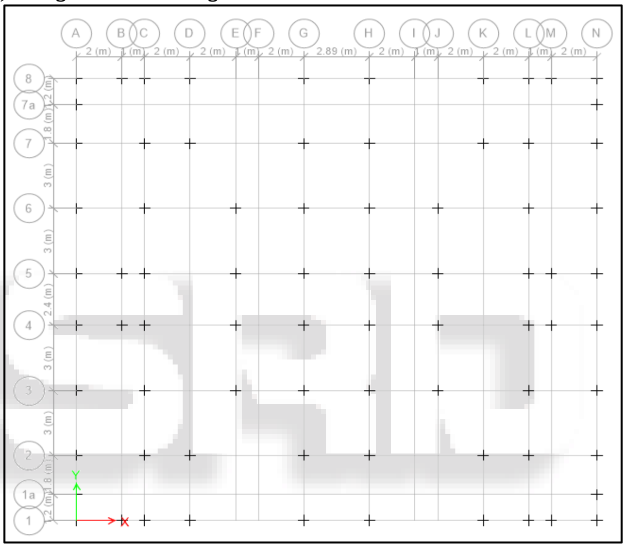

Fig. 4: Plan Showing Base Level (Storey) In ETABS

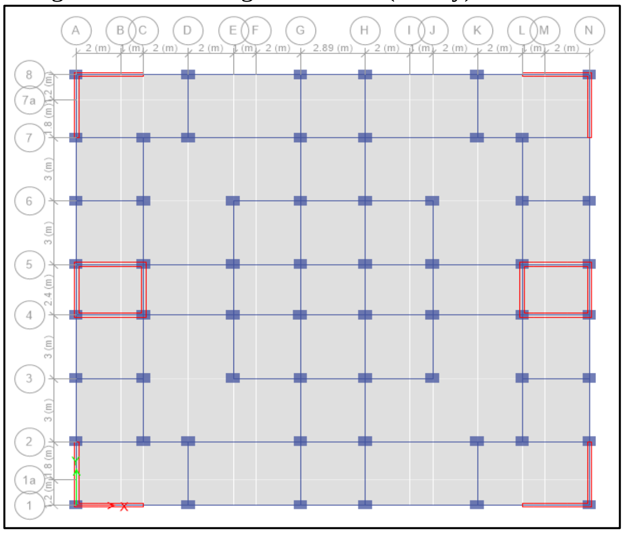

Fig. 5: Plan Showing 11th Floor Level (Storey) In ETABS

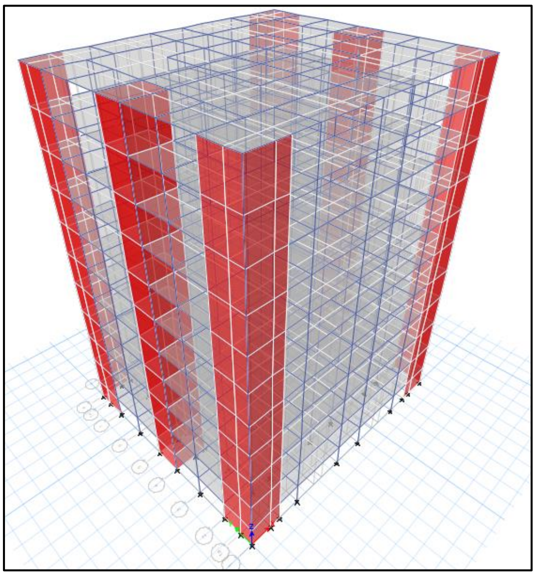

Fig. 6: 3D Model of Highrise Building

V. ANALYSIS & RESULTS (WITHOUT SHEARWALL)

This chapter provides analysis results.

A. *Structure Results*

Load Case/Combo	FX	FY	FZ	MX	MY	MZ
	kN	kN	kN	kN-m	kN-m	kN-m
Dead	0.00	0.00	47938.70	487753.17	-546672.00	0.00
Live	0.00	0.00	15409.55	157177.39	-176362.00	0.00
FFLOOR FINISH	0.00	0.00	5136.52	52392.46	-58787.43	0.00
WALL LOAD	0.00	0.00	16424.73	167212.27	-187940.00	0.00
EQX 1	-3235.86	0.00	0.00	0.00	-81545.07	32922.59
EQX 2	-3235.86	0.00	0.00	0.00	-81545.07	32922.59
EQX 3	-3235.86	0.00	0.00	0.00	-81545.07	32922.59
EQY 1	0.00	-3235.86	0.00	81545.07	0.00	-36955.19
EQY 2	0.00	-3235.86	0.00	81545.07	0.00	-36955.19
EQY 3	0.00	-3235.86	0.00	81545.07	0.00	-36955.19

Table 5.1: Base Reactions

B. *Analysis Results (With Shearwall)*

1) *Structure Results*

Load Case/Combo	FX	FY	FZ	MX	MY	MZ
	kN	kN	kN	kN-m	kN-m	kN-m
Dead	0.00	0.00	55533.71	565222.27	-633597.00	0.00
Live	0.00	0.00	15409.55	157177.39	-176362.00	0.00
FFLOOR FINISH	0.00	0.00	5136.52	52392.46	-58787.43	0.00
WALL LOAD	0.00	0.00	13985.73	142202.71	-159775.00	0.00
EQX 1	-5077.50	0.00	0.00	0.00	-127270.00	51643.72
EQX 2	-5077.50	0.00	0.00	0.00	-127270.00	51643.72
EQX 3	-5077.50	0.00	0.00	0.00	-127270.00	51643.72
EQY 1	0.00	-5043.15	0.00	126409.19	0.00	-57558.38
EQY 2	0.00	-5043.15	0.00	126409.19	0.00	-57558.38
EQY 3	0.00	-5043.15	0.00	126409.19	0.00	-57558.38

Table 5.2: Base Reactions

- FX= Force in X direction.
- FY= Force in Y direction.
- FZ= Force in Z direction.
- MX= Momentum in X direction.
- MY= Momentum in Y direction.
- MZ= Momentum in Z direction.

VI. CONCLUSION

From all the above analysis, it is observed that the displacements in high rise building with shear wall is lesser than the high rise building without shear wall.

1) Lateral forces are reducing when the shear walls are added at the corner locations of frames having minimum lateral forces.
2) Shear walls are more resistant to lateral loads in an regular structure. Also they can be used to reduce the effects of torsion.
3) Static analysis not sufficient for high-rise buildings and it is necessary to provide dynamic analysis.
4) Response spectrum analysis can be seen that the displacement values in both X and Y directions are least in model with shear wall in core and corners when compared to other model.
5) Displacement at different level in multi-storeyed building with shear wall is comparatively lesser as compared to R.C.C. building Without Shear Wall.

After comparing the load cases, displacement and story drift in building with shear wall is lesser than the building without shear wall as displayed in the table below:

SL.NO.	LOAD	WITHOUT		WITH		PERCENTAGE DECREASE	
	CASE	X-AXIS	Y-AXIS	X-AXIS	Y-AXIS	X-AXIS	Y-AXIS
DISPLACEMENT							
1	DEAD	0.401	0.205	0.176	0.171	66%	27%
2	LIVE	0.163	0.085	0.061	0.055	63%	36%
3	EQX	25.15	0.299	20.396	0.251	19%	17%
4	EQY	0.674	28.046	0.41	20.198	40%	28%
STORY DRIFTS						INCREASE	
1	DEAD	2.3E-05	9E-06	1.7E-05	1.4E-05	27%	55%
2	LIVE	0.00001	4E-06	8E-06	5E-06	20%	25%
3	EQX	0.00038	5E-06	0.00062	1.5E-05	65%	200%
4	EQY	0.00001	0.00037	0.00002	0.00059	100%	59%

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