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A COMPARATIVE STUDY ON ANALYSIS OF PRECAST LOAD BEARING AND FRAMED MULTI-STOREYED STRUCTURE USING ETABS

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ABSTRACT

Now a day, Pre-cast construction is increasing its prominence with the rapid infrastructure growth and is a well known technology in some standardized units which are manufactured in factories. Although the technology is developed for many years ago, the implementation is not up to the mark in our country. The present study emphasizes on analysis of G+14 storied building using Etabs software. In this context, analysis of pre-cast load bearing wall structure is compared with the framed structured building. Various wall forces, displacements and moments have been worked out for the different load combinations. Database is also presented for the worst load combination. This work is mainly constrained to the analysis of structural elements.

Key Words: Pre-cast concrete, pre-cast load bearing wall, ETABS, Pier and spandrel, framed structure, load combinations.

1. INTRODUCTION

A building or edifice is a structure with a roof and walls standing more or less permanently in one place, such as a house or factory. Buildings come in a variety of sizes, shapes and functions, and have been adapted throughout the history for a wide number of factors, from building materials available, to weather conditions, to land prices, ground conditions, specific uses and aesthetic reasons. Buildings serve several needs of society – primarily as shelter from weather, security, living space, privacy, to store belongings, and to comfortably live and work. A building as a shelter represents a physical division of the human habitat (a place of comfort and safety) and the outside (a place that at times may be harsh and harmful). Ever since the first cave paintings, buildings have also become objects or canvasses of much artistic expression. In recent years, interest in sustainable planning and building practices has also become an intentional part of the design process of many new buildings. A tall building is a multi-story structure in which most occupants depend on elevators to reach their destinations. The most prominent tall buildings are called high-rise buildings in most countries and tower blocks in Britain and some European countries. For any structure, the height can have a serious impact on evacuation. For most purposes, the cut-off point for high-rise buildings is around seven stories. Sometimes, seven stories or higher define a high-rise, and sometimes the definition is more than seven stories. Sometimes, the definition is stated in terms of linear height rather than stories. Reinforced concrete is a composite material in which concrete's relatively low tensile strength and ductility are counteracted by the inclusion of reinforcement having higher tensile strength or ductility. The reinforcement is usually, though not necessarily, steel reinforcing bars (rebar) and is usually embedded passively in the concrete before the concrete sets. Reinforcing schemes are generally designed to resist tensile stresses in particular regions of the concrete that might cause unacceptable cracking and/or structural failure. Modern reinforced concrete can contain varied reinforcing materials made of steel, polymers or alternate composite material in conjunction with rebar or not. Reinforced concrete may also be permanently stressed (in tension), so as to improve the behaviour of the final structure under working loads. Precast concrete is a construction product produced by casting concrete in a reusable mould or "form" which is then cured in a controlled environment, transported to the construction site and lifted into place. In contrast, standard concrete is poured into site-specific forms and cured on site. Precast stone is distinguished from precast concrete using a fine aggregate in the mixture, so the final product approaches the appearance of naturally occurring rock or stone. There are many different types of precast concrete forming systems for architectural applications, differing in size, function and cost. Precast architectural panels are also used to clad all or part of a building facades or free-standing walls used for landscaping, sound proofing and security walls and some can be prestressed concrete structural elements. Reinforcing concrete with steel improves strength and durability. On its own, concrete has good compressive strength, but lacks tension and shear strength and can be subject to cracking when bearing loads for long periods of time. Steel offers high tension and shear strength to make up for what concrete lacks. Steel behaves similarly to concrete in changing environments, which means it will shrink and expand with concrete, helping avoid cracking. Rebar is the most common form of concrete reinforcement. It is typically made from steel, manufactured with ribbing to bond with concrete as it cures. Rebar is versatile enough to be bent or assembled to support the shape of any concrete structure. Carbon steel is the most common rebar material. However, stainless steel, galvanized steel and epoxy coating can be used to prevent corrosion.

2 LITURATURE REVIEW

Mazen in 2013 has stressed that small openings in the shear wall will yield minor effect on the load capacity of shear walls, cracking pattern and maximum drift. In case of small openings, the shear walls behave as a coupled shear walls [1]. Thakkar in 2012 has concluded that the design of shear wall is a complex procedure, especially if the cross section of the shear wall is not regular in shape. The design of shear walls takes horizontal forces into account by shear and bending [2]. The design of shear in the walls can be managed by computing the shear stress distribution over the cross section of the wall and reinforcing appropriately. Benjamin in 1968 worked on variability analysis of shear wall structure where both rigidity and the strength of shear walls are highly variable [3]. Bozdogan et, al. in 2010 carried out vibration analysis of asymmetric shear wall structures using the transfer matrix method. He concluded that the governing differential equations of equivalent bending-warping torsion beam are formulated using the continuum approach [4].

3. METHODOLOGY

3.1 Methodology

In this present study, G+14 storey precast load bearing wall structure and framed structure is taken for analysis. The modeling and analysis has been done by using ETABS. This parametric study

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has been done to observe the effect of axial compression load, out of plane moments, tensile force, shear force, storey drift, lateral load and storey shear on shear walls. Finally data base is prepared for various storeys. Hence the emphasis on the analysis of load bearing wall structure and framed structure. In this case, G+14 storey wall building is considered for one acre of site with 350 units. Around 400 square feet of carpet area per unit is taken with 300 units per floor. The construction technology is total precast solution with load bearing RCC shear walls and slabs for the precast multi-storeyed building. For the framed structure, construction is completely based on masonry walls and reinforced concrete slabs, beams and columns.

3.1.1 Modeling

- The structure is divided into a distinct shell element. The shell element combines a membrane and plate bending behaviour. It has six degrees of freedom in each corner point. It is a simple quadrilateral shell element which has a size of 24 x 24 stiffness matrix.

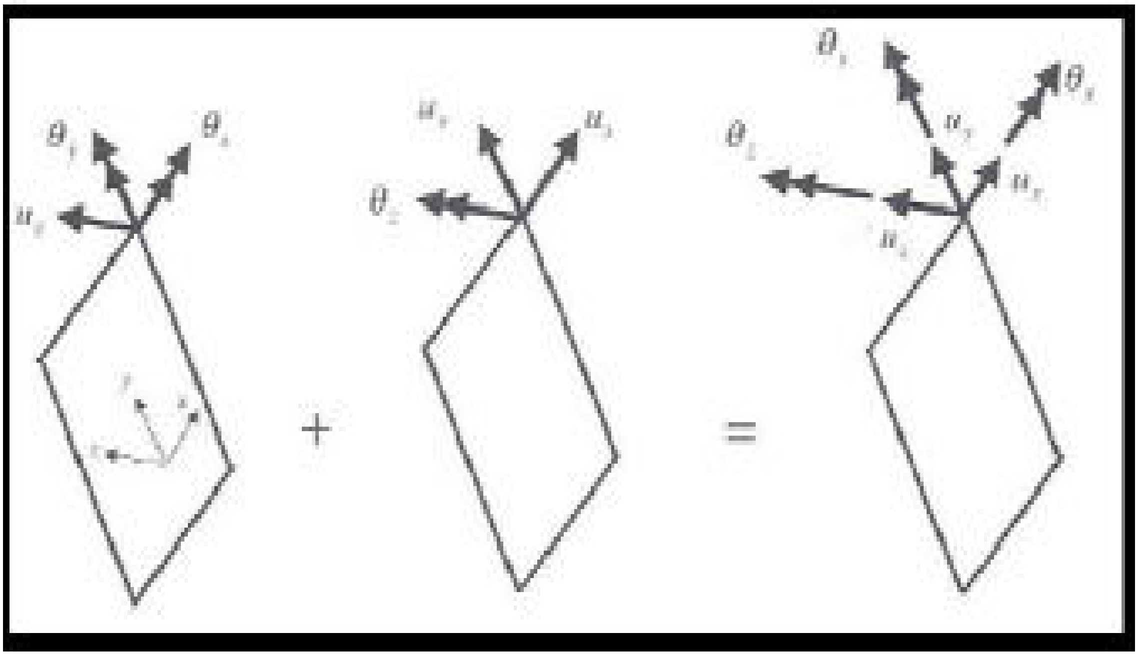

Fig.3.1 Shell element

- Grid lines are made for the x, y, z coordinates and the wall is drawn from the scratch.
- Boundary conditions are assigned to the nodes wherever it is required. Boundary conditions are assigned at the bottom of the wall i.e., at ground level where restraints should be against all movements to imitate the behaviour of shear wall.
- The material properties are defined such as mass, weight, Young's modulus, Poisson's ratio, strength characteristics etc. The material properties used in the models are shown in Table.

Table 3.1: Material and element property for wall element

Material name	Concrete
Type of material	Isotropic
Weight per unit volume	24 KN/m^2
Modulus of elasticity	26 KN/mm^2
Poisson's ratio	0.2
Concrete Strength	30 MPa
Section name	Wall
Wall thickness	300 mm

In ETABS single walls are modelled as a pier/spandrel system, that is, the wall is divided into vertical piers and horizontal spandrels. This is a powerful mechanism to obtain design moments, shear forces and normal forces across a wall section. Appropriate meshing and labelling is the key to proper modelling and design. Loads are only transferred to the wall at the corner points of the area objects that make up the wall. Generally the membrane or shell type element should be used to model walls. Here the shell type is used for modelling the wall element. There are three types of deformation that a single shell element can experience axial deformation, shear deformation and bending deformation as shown in Figure 3.2

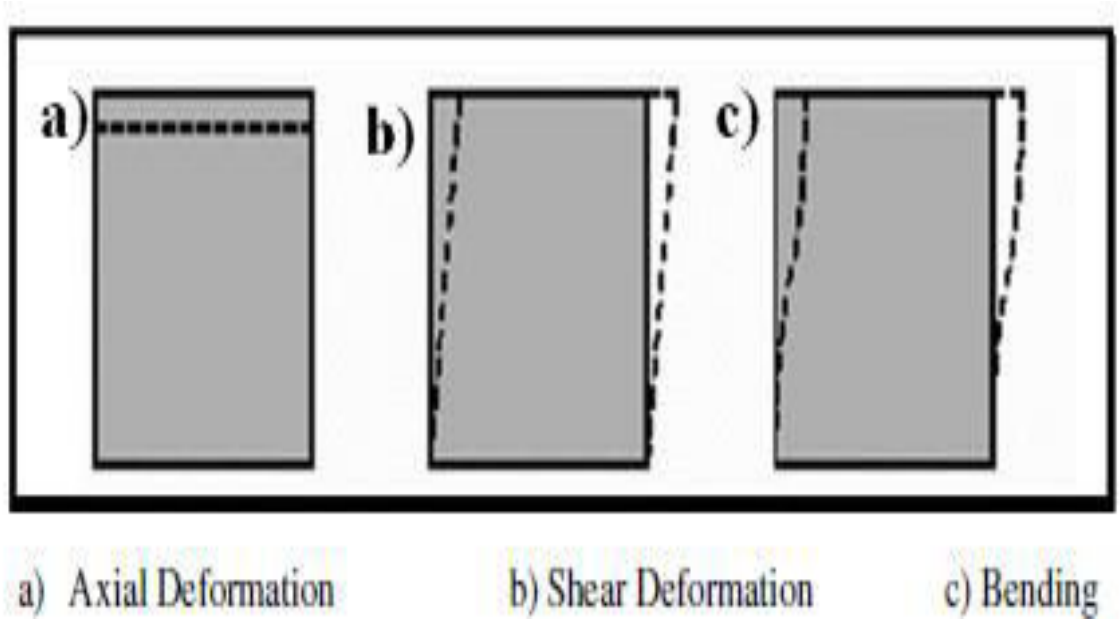

Fig.3.2 Deformation of a shell element

Wall pier forces are output at the top and bottom of wall pier elements and wall spandrel forces are output at the left and right ends of wall spandrel element, see Figure 3.3

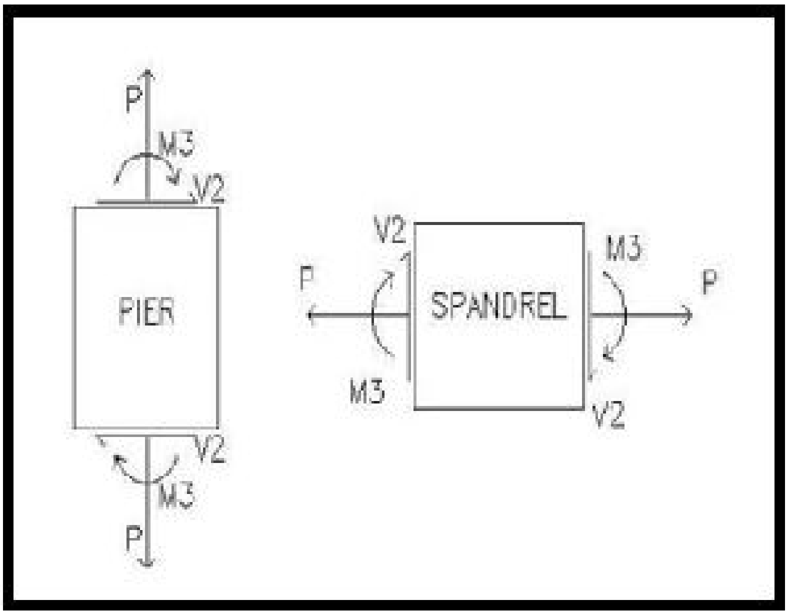

Fig.3.3 Pier and Spandrel forces

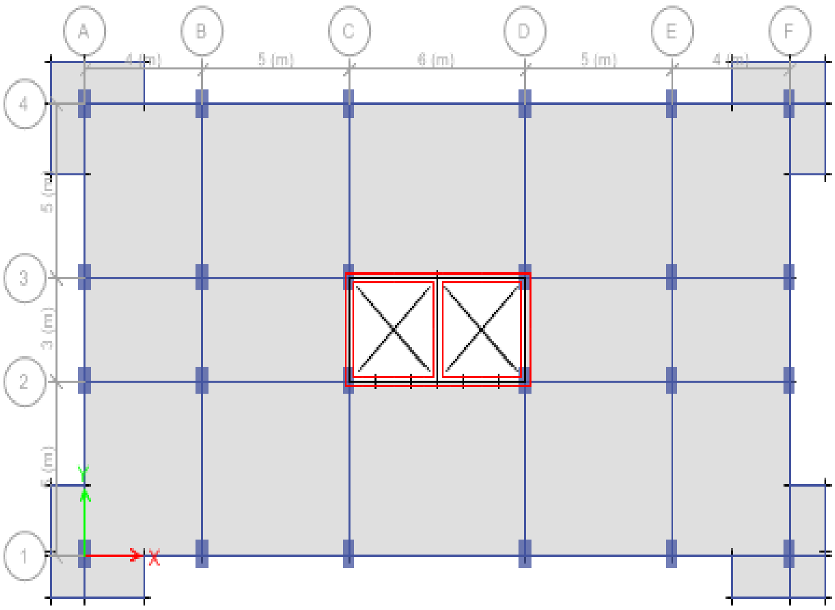

Fig.3.3 Plan of a G+14 storied building

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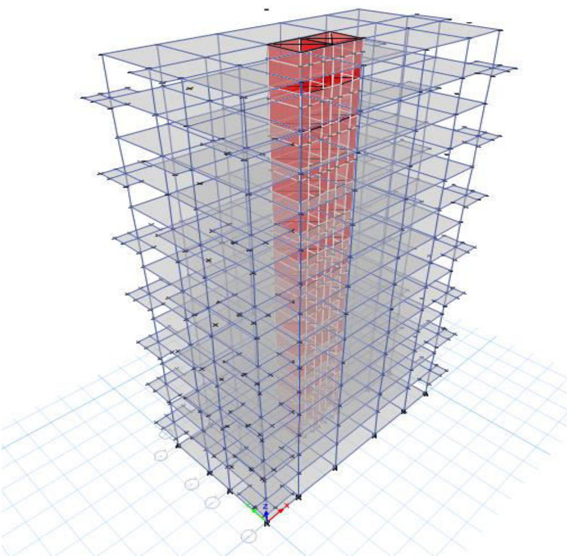

Fig.3.4 3D view

3.2 Analysis in ETABS

The model geometry information, including items such as story levels, point coordinates, and element connectivity is shown in the table below.

Table 3.2 - Story Data

Name	Height mm	Elevation mm	Master Story	Similar To	Splice Story
Story14	3000	46000	Yes	None	No
Story13	3000	43000	Yes	None	No
Story12	3000	40000	No	Story14	No
Story11	3000	37000	No	Story13	No
Story10	3000	34000	No	Story14	No
Story9	3000	31000	No	Story13	No
Story8	3000	28000	No	Story14	No
Story7	3000	25000	No	Story13	No
Story6	3000	22000	No	Story14	No
Story5	3000	19000	No	Story13	No
Story4	3000	16000	No	Story14	No
Story3	3000	13000	No	Story13	No
Story2	3000	10000	No	Story14	No
Story1	3000	7000	No	Story13	No
Base	4000	4000	No	None	No

The base reactions of the structure are shown in the table below.

Table 3.3 - Base Reactions

Load Case/Combo	FX kN	FY kN	FZ kN	MX kN-m	MY kN-m	MZ kN-m	X m	Y m	Z m
Dead	0	0	48652.0181	316698.6192	-583879	-3.826E-06	0	0	0
Live	0	0	11172.4965	72615.745	-134076	-1.11E-06	0	0	0
Surcharge	0	0	9543.1741	62025.9489	-114523	-9.485E-07	0	0	0
Dead wall	0	0	21210	137865	-254520	-1.475E-06	0	0	0
Wind load	-272.9868	-815.163	-1.051E-06	18591.9505	-5869.2156	-8007.5419	0	0	0
Partition Load	0	0	4655.2069	30256.5604	-55864.8514	0	0	0	0
DWal1	0	-7.287E-07	111167.2691	723225.3953	-1334090	-8.749E-06	0	0	0
DWal2	0	-8.343E-07	120610.556	784503.1704	-1447411	-1.002E-05	0	0	0
DWal3	-272.9868	-815.163	111113.934	741371.7377	-1339316	-8007.5419	0	0	0
DWal4	272.9868	815.163	111113.934	704187.8366	-1327577	8007.5419	0	0	0
DWal5	-272.9868	-815.163	71464.673	483522.5618	-863499	-8007.5419	0	0	0
DWal6	272.9868	815.163	71464.673	446338.6607	-851760	8007.5419	0	0	0

Load Case/Combo	FX kN	FY kN	FZ kN	MX kN-m	MY kN-m	MZ kN-m	X m	Y m	Z m
DCon1	0	-7.287E-07	111167.2691	723225.3953	-1334090	-8.749E-06	0	0	0
DCon2	0	-8.343E-07	120610.556	784503.1704	-1447411	-1.002E-05	0	0	0
DCon3	-272.9868	-815.163	111113.934	741371.7377	-1339316	-8007.5419	0	0	0
DCon4	272.9868	815.163	111113.934	704187.8366	-1327577	8007.5419	0	0	0
DCon5	-272.9868	-815.163	71464.673	483522.5618	-863499	-8007.5419	0	0	0
DCon6	272.9868	815.163	71464.673	446338.6607	-851760	8007.5419	0	0	0

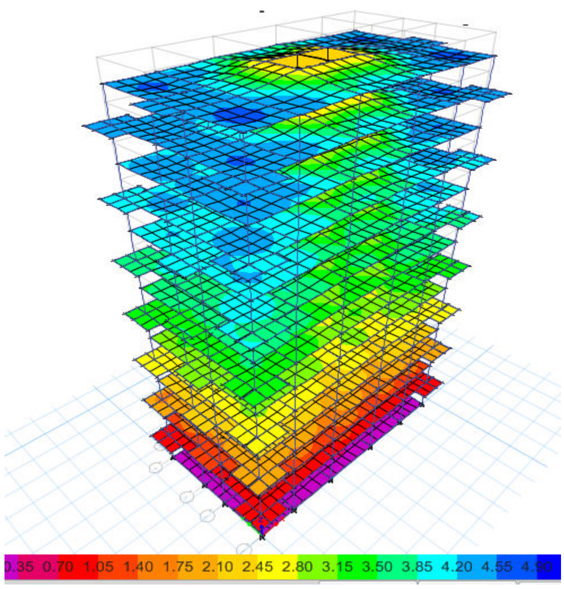

Fig.3.5 Storey displacements

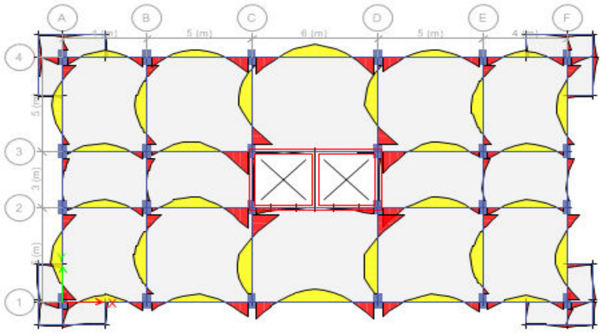

Fig.3.6 Bending moment

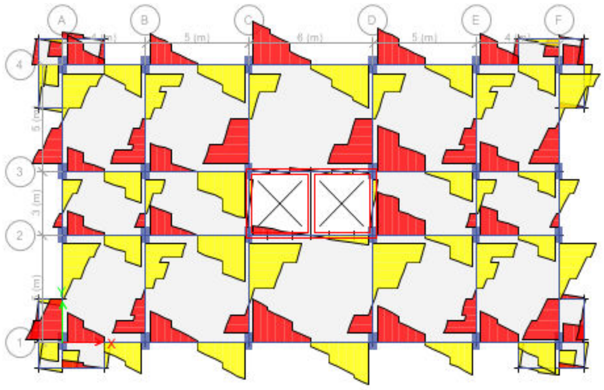

Fig.3.7 Shear force diagram

4. RESULT:

In this chapter the results and observations of the tests conducted are presented, analyzed and discussed. For precast load bearing and framed structure having G+ 14 storeys is analysed for gravity and lateral loads. The effect of axial force, out of plane moments, lateral loads, shear force, storey drift, storey shear and tensile force are observed for different stories. The analysis is carried out using ETABS and data base is prepared for different storey levels as follows:

Table 4.1: Database for precast load bearing wall structure

Storey	Wall location	Axial compression load (KN)	Out of plane moments (KN-m)	Max. Tensile force (KN)	Storey drift (mm)	Max. Shear force (KN)	Storey shear (KN)	Lateral load (KN)
14	Top	16.358	20.020	-16156.875	0.198	-907.75	-608.24	736.67
	Bottom	58.277	21.563					
13	Top	92.473	-37.395	-35756.748	0.198	-2012.31	-598.26	734.34
	Bottom	132.874	34.488					

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12	Top	171.653	-42.324	-51933.464	0.201	-2926.14	-1337.35	730.38
	Bottom	208.962	45.542					
11	Top	254.931	-46.166	-65018.626	0.20	-3665.54	-1946.63	604.65
	Bottom	292.969	57.064					
10	Top	341.620	-47.452	-75343.370	0.198	-4249.75	-2436.01	494.91
	Bottom	376.376	68.355					
9	Top	431.030	-46.715	-83238.762	0.188	-4695.04	-2855.51	387.15
	Bottom	466.494	79.326					
8	Top	522.423	-46.851	-89030.458	0.175	-5025.66	-3125.18	293.33
	Bottom	556.598	89.857					
7	Top	615.088	-55.156	-93048.644	0.161	-5253.87	-3334.91	217.51
	Bottom	647.985	100.015					
6	Top	708.363	-63.545	-95617.861	0.139	-5399.93	-3504.73	151.68
	Bottom	738.008	109.854					
5	Top	801.846	-71.953	-97062.078	0.120	-5482.08	-3604.56	97.79
	Bottom	832.300	120.048					
4	Top	895.543	-80.370	-97703.864	0.076	-5518.60	-3634.54	55.86
	Bottom	925.026	132.481					
3	Top	995.804	-89.397	-97864.254	0.035	-5525.73	-3674.56	25.84
	Bottom	1028.764	142.613					
2	Top	1079.521	-98.730	-98164.494	0.023	-5528.09	-3714.19	15.73
	Bottom	1110.328	151.725					
1	Top	1125.985	-111.235	-98667.518	0.016	-5530.02	-3744.38	12.58
	Bottom	1228.657	174.624					
Base	Top	1199.682	-131.235	-99563.283	0.010	-5558.65	-3986.35	11.43
	Bottom	1315.648	198.428					

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The load bearing wall structure mostly carries axial compression force and transfer on to the foundation. The entire vertical load of all the stories is carried by ground floor. In order to design, it is quite essential to understand the variation of axial force in the walls.

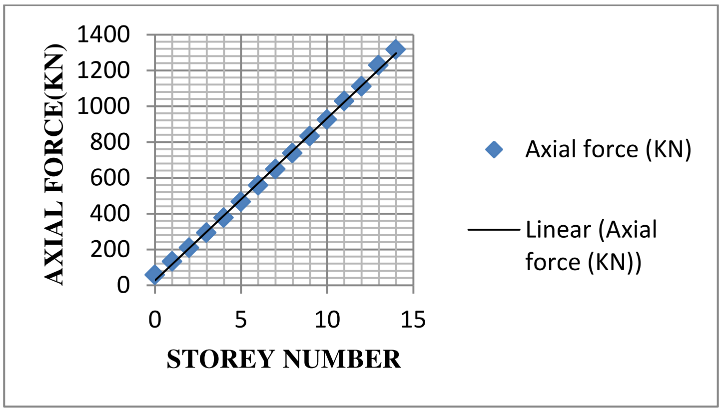

Figure 4.1: Axial force for precast load bearing structure

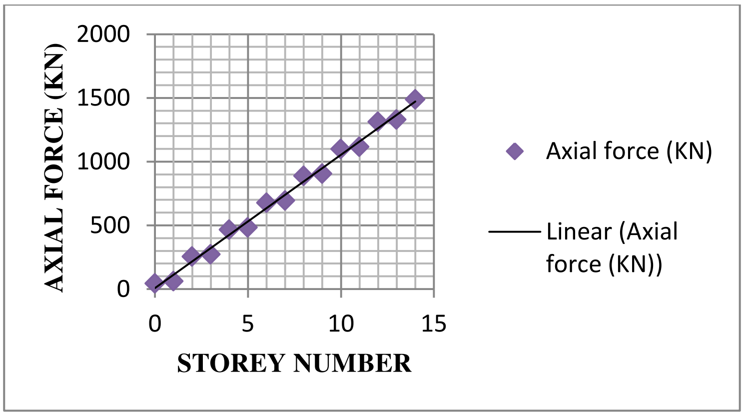

Figure 4.2: Axial force for framed structure

Most lateral loads are live loads whose main component is horizontal force acting on the structure. The intensity of these loads depends upon the building's geographic location, height and shape. For the worst load combination lateral load in the wall is shown against each storey level.

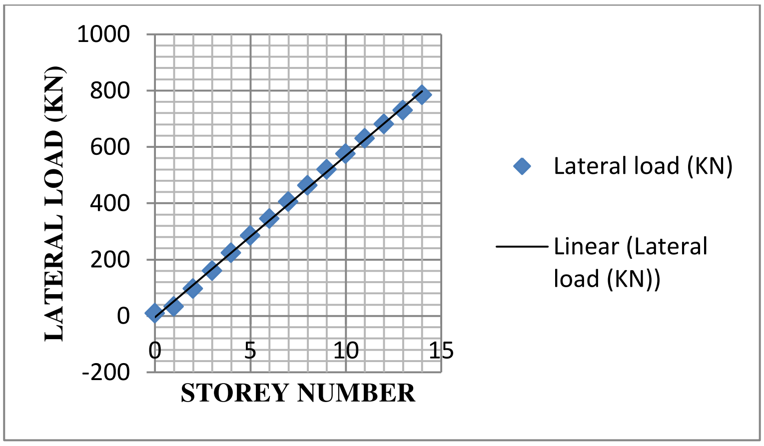

Figure 4.3: Lateral loads for framed structure

5. CONCLUSION

In this present work ETABS is used to analyse the precast load bearing wall and framed structure of G+14 considering the gravity and lateral loads. The following conclusion is drawn from present work.

- The variation of axial force in both cases is linear. The difference in maximum axial force between storey 14 and 15 for precast structure is 5.66 % and for framed structure 1.17%.
- The variation of out-of-plane moment in both cases is linear. The difference in maximum out-of-plane moment storey 14 and 15 for precast structure is 6.51 % and for framed structure 4.56%.
- The variation of lateral loads for precast is non-linear and framed structure is linear. The difference in maximum lateral loads between storey 14 and 15 for precast structure is 20.38 % and for framed structure 58.59%.
- The variation of shear force for precast is non-linear and framed structure is linear. The difference in maximum shear force between storey 14 and 15 for precast structure is 0.25 % and for framed structure 6.99%.
- Variation of storey drift with storey is non-linear in both the cases. The maximum storey drifts in storey 15 is 0.109 mm.
- Variation of storey shear with storey is non-linear. The maximum storey shear in storey one is 608.35kN.
- The variation of tensile force for precast is non-linear and framed structure is linear. The difference in maximum tensile force between storey 14 and 15 for precast structure is 19.68 % and for framed structure 27.31%.

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