Analysis of (G+1)-Story Building by ETAB Software

It's known that technology has advanced to new heights, thus engineers need to keep up with the rapid changes in the field. It has caused several changes in the way engineers work and behave. Because of the creation of some incredible apps, technology has not only made life easier, but it has also inspired engineers to deliver more. One of the world's top software companies for structural and seismic engineering analysis and design is Computers and Structures, Inc. with its product is ETABS. It covers the creation of schematic drawings in addition to all other aspects of the design process. As many of us know, it can be difficult to carefully sketch out a structure on paper, paying attention to every little detail. This is the exact point at which ETABS can help people who are confused about the procedure. To ascertain the specifics of the reinforcement, deflections, bending moments, and shear pressures for the specified (G+1)-story building, the ETABS examines the (G+1)-story building in this project. Beams, columns, and slabs have all been analysed and designed using ETABS software. Fe-415 and M-30 concrete have both been used as building materials. The design and analysis of (G+1)-story buildings are finished according to IS-Code specifications. To conduct the structural analysis and design of the building without experiencing any kind of failure, the IS 456-2000 standards were followed in the design of the reinforcement and concrete. Indian Standard Codes were used to understand the fundamentals of construction; the limitations of the design for the structural elements of slabs, beams, and columns were understood; and the ETABS software was used to create a detailed analysis and design of the structure's 3D model. Thus, in the present research work, the design and analysis of a (G+1)-story building were carried out by using ETABS software and successfully verified as per IS456:2000.

Keywords: *Analysis, Design, grade of concrete, Grade of steel, Poisson's ratio, Bending moment, Shear force, Reinforcement, displacement*

Introduction

The engineer performing performance design can take advantage of state-of-the-art technology with full dynamic analysis, which includes static nonlinear pushover characteristics and nonlinear time-history capabilities for seismic base isolation and viscous dampers. Significant time savings in the design cycle are achieved by powerful features that allow for the selection and optimization of vertical framing members as well as the identification of crucial components for lateral drift control. Furthermore, the time usually spent transferring data between analysis and design tools has been avoided because ETABS provides comprehensive and detailed steel and concrete design calculations for beams and columns, braces, walls, and slabs. Production drawings can be produced more quickly and accurately thanks to this design integration and the CAD output files that ETABS provides. Long a favourite for building analysis and design, ETABS most recent release provides all the tools required to generate rapid, effective, and elegant engineering solutions whether the project involves a one-story retail complex or the world's tallest structure. An engineering software program called ETABS is designed to analyse and design multistorey buildings. Code-based load prescriptions, modelling tools and templates, analysis approaches, and solution methodologies all work in tandem with the structure's distinct grid-like shape. With ETABS, systems, whether simple or complex, can be assessed in static or dynamic environments. Modal and direct-integration time-history analyses may combine with P-Delta and Large Displacement effects for a more complex evaluation of seismic performance. Under monotonic or hysteretic behaviour, material nonlinearity may be captured by nonlinear connections, concentrated PMM, or fibre hinges. It is feasible to develop applications of any complexity thanks to intuitive and integrated features. For designs ranging from straightforward 2D frames to intricate modern high-rises, ETABS is a coordinated and effective tool because of its interoperability with several design and documentation platforms. In the twenty-first century, many intricate and asymmetrical structures are built to withstand wind, earthquakes, and other natural disasters. These structures must be analysed and designed using a variety of software programs, such as ETABS, STAAD.Pro, and TEKLA. In this project, we used the ETABS software per the company's recommendation to find the area reinforcement for the column, the shear force for the beam, and the stress analysis in the slab. The foundation's design is dependent upon the reaction, and the site and the soil's safe bearing capacity determine the foundation's level. The retaining wall was purposefully designed for stability [V.L.S Banu, *et al,* 2016]. The ETABS software has been used for analysis and design of the superstructure, or the building frame. According to Indian norms, the G+5 Residential building will be assessed and planned for gravity and lateral loads (wind and earthquake) in the current project [Sd. Farhana Tabasum, *et al,* 2023]. The G+6 commercial building is the current design. The gap between floors is 3.6 meters. There are numerous traditional approaches for resolving design issues, and new software is being developed over time. Here, the design and analysis of a multistorey G+6 building with an RCC structure are done with the ETABS software. Structural engineers use ETABS, an efficient piece of software, to analyse and design their structures. In this project, ETABS is used to analyse and design the multi-story skyscraper. comparing software findings to support more cost-effective options or selecting the most appropriate software for design and building a structure with more stories [Sanath Kumar, K. P., and Manohar, D. R., 2021]. An overview of the goals, methods, and conclusions of the study would normally be included in a dynamic analysis of a G+5 residential building in Zone-4 utilizing ETABS. The study's objectives are to assess the building's seismic reaction and guarantee its structural stability when subjected to seismic loads. The process entails using the ETABS program to create a 3D model of the building, which is then analysed using dynamic analytic techniques like response spectrum analysis and time history analysis. The study's conclusions will shed light on the behaviour of the building in various earthquake situations, including time history response, spectrum acceleration, and peak ground acceleration. The goal of the research is to make suggestions for strengthening the building's overall structural stability and seismic performance. The study's findings demonstrated that the

G+5 residential building functioned effectively within the building code's required design seismic pressures. The maximum displacement, acceleration, and base shear were all found to be well within allowable bounds by the analysis. It was discovered that the building's lateral stiffness was sufficient to withstand the lateral stresses specified. Overall, the study showed that the ETABS software is a useful instrument for evaluating a building's seismic performance in a high seismic zone. Engineers and designers may find the study's findings helpful in planning and assessing the seismic performance of comparable structures in seismic zone 4. [Harsha Sri, *et al*, 2023]. Because of overpopulation and rising land costs, there is less land available in this era of fast-developing urbanization. The only way to address this growing issue is to choose multistorey structures. Globally, the necessity of designing and building earthquake-resistant structures effectively cannot be overstated. For a variety of gravitational, thermal, and lateral stresses, ETABS offers both static and dynamic analysis. The primary focus of this investigation is the use of AutoCAD software to study plans. Its purpose is to examine the G+5-story building's design. For any kind of structure, seismic analysis is a crucial part of working in high seismic locations. Structures can be planned and built to survive significant lateral crustal motions during earthquakes with the aid of seismic analysis [Umer Bin Fayaz, and Brahamjeet Singh, 2023]. The main goal of this project is to use ETABS to plan, analyse, and design a multi-story structure [G + 4(3D frame)]. The design entails an ETABS analysis of the entire building. Limit State Design by the Indian Standard Code of Practice is the design methodology utilised in ETABS analysis. Modern user interface design, visualisation tools, robust analysis, and design engines with sophisticated finite element and dynamic analysis capabilities are all aspects of ETABS. ETABS is the professional's choice for model creation, analysis, and design as well as for result verification and visualisation. Simple 2D frame analysis was the first step, and the accuracy of the software was personally verified using the output. All feasible load combinations (dead, live, wind, and seismic loads) showed highly accurate results. [Fathima Shalbana, *et al*, 2022]. This endeavour's main goal is to examine and evaluate how wind and seismic activity affect the structures. Situated in Raipur city, the capital of Chhattisgarh state, the residential building is a G+5 story structure. Zone II pertains to the building's location based on the seismic load evaluation criteria. Every building is vulnerable to a range of forces over the course of its lifetime, including those resulting from wind, seismic activity, dead load, and living load. While dead load and imposed load only contribute to the static load, wind load and earthquake load both contribute to the dynamic load. The Staad Pro tool was utilized to assess the entire structure [Apurba Rakha, *et al,* 2023].

The structural Engineering field is facing a lot of challenges of late in the Civil Engineering domain in developing the required infrastructure for the needs of mankind. In the present project-based learning, a Hospital Building under construction is selected to evaluate demands on a reinforced concrete structure using the Structural analysis software E-TABS. Gravity loads, Wind loads as per IS 875, and Earthquake loads as per IS1893-2016 are considered acting on the structure, and the design is carried out per IS456-2000. The design of foundations will be done using SAFE software, and detailing of reinforcement is carried out following SP34 and SP13920 using Csi detailing software. Manual design calculations will be done for representative structural elements, slab, beam, column, and footing to validate software results. The analysis design and detailed results will be compared with professional respective outcomes and drawings. The behaviour of the structure when acted upon by static and dynamic loads is presented with the help of stress resultants, namely axial forces, bending moments, and shear forces in all structural elements for safety, following IS456-2000. Displacements will be checked for serviceability limit states to control cracks and vibrations in the structure. Results and discussions will be presented with the help of tables and charts [Sridhara S, *et al*, 2023]. In modern construction, the typical slab is frequently supported by a beam. The weight is distributed from the beam to the column with a small slab width and a large beam depth. The flat slab allows architects to build partition barriers wherever they are needed. It is well-liked since it promotes rapid development, helps with weight loss, and is reasonably priced. Comparably, the classic slab has improved with time and now offers advantages like increased rigidity. It is good and affordable and has a greater weight-bearing capacity. If the span is greater than one span, grid slabs must be used; if the span is smaller, grid beams are provided. Grid slabs remove voids that would otherwise occur in dead load, making them suitable for longer spans with heavy loads. Certain slabs are more vibration-resistant and less expensive. The goal of the study is to identify which of the three types of slabs, grid slab, normal slab, and flat slab with drop, offers the greatest advantages. A G+5 This study examined story drift, bending moment, shear force, and story displacement in a residential multi-story building with a distinct slab [S. S. Solanke and Pankaj Hulke, 2023]. The main objective of this project is to design and examine a multi-story residential apartment complex (G+7) in Visakhapatnam. For this project, AutoCAD is used to create the drawings and details, and ETABS software is used for analysis and design. In the end, the best possible structure was created, and this is reflected in the finished drawings. Furthermore, the analysis conducted at the base of the columns yields foundation loads, which will be utilised in the subsequent construction of the foundation design [Ashish Kumar *et al,* 2020]. Gaining a sufficient understanding of architectural design, analysis, and planning is the main objective of the project. Practical knowledge is an essential skill for any engineer to possess. The research and design of multi-story buildings require a basic understanding of structural engineering, both theoretically and practically. In this project, the analysis and design of (G+1) residential buildings are predominantly done using ETABS. The present research work is an attempt to interpret the Bending moment, Shear force, and Percentage of Steel reinforcement in concrete Beams/Columns/Slabs to achieve the specified code limits in case of analysis and design. The overall goal of this research is to use ETABS software to construct a given structure and analyse variations in building analysis and design. The software ETABS was used for structural analysis and design. The following codes were utilised for design and analysis: IS:4566-2000 Code/IS 13920:2016.

Methodology

In the present research work, the design and analysis of (G+1)-story building were carried out by using ETABS software, in which Geometric and Material properties were highlighted as shown in Table 1-2. Furthermore, the cross-section and longitudinal cross-section of the beam (300x400) as shown in Figure 1.

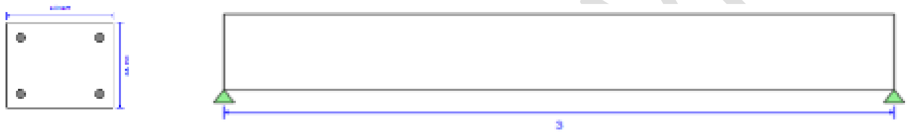
Table 1. *Geometric Properties*

Beam Label	Section Property	Length	Section Width	Section Depth	Distance to Top Rebar Center
50	B0.3X0.4	3 m	400 mm	300 mm	50 mm

Table 2. *Material properties*

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
27386.13	30	1	413.69	413.69

Figure 1. *Cross section and Longitudinal section of Beam*



IS 456:2000 + IS 13920:2016 Beam Section Design

From the design and analysis of Beam element type (Table 3), it's possible to interpret the following parameters such as factored forces and moments, design moments, design moments and flexural reinforcement for moment, shear force and reinforcement for shear, torsion and torsion reinforcement for torsion, which are represented as in Table 4 to Table 8.

Table 3. *Beam Element Details Type: Ductile Frame (Summary)*

Level	Element	Unique Name	Section ID	Combo ID	Station Loc	Length (mm)	LLRF
Story2	B17	50	B0.3X0.4	DCon18	1066.7	3000	1

Table 4. *Factored Forces and Moments*

Factored M_{u3} kN-m	Factored T_u kN-m	Factored V_{u2} kN	Factored P_u kN
10.0294	0.6976	11.7613	0

Table 5. *Design Moments, M_{u3} & M_t*

Factored Moment kN-m	Factored M_t kN-m	Positive Moment kN-m	Negative Moment kN-m
10.0294	0.7181	10.7475	0

Table 6. D*esign Moments, M_{u3} & T_u*

Design +Moment kN-m	Design -Moment kN-m	Factored M_{u3} kN-m	Torsion T_u kN-m	Special M_t kN-m
10.7475	0	10.0294	0.6976	0.7181

Table 7. *Design Moment and Flexural Reinforcement for Moment, M_{u3} & T_u*

	Design -Moment kN-m	Design +Moment kN-m	-Moment Rebar mm²	+Moment Rebar mm²	Minimum Rebar mm²	Required Rebar mm²
Top (+2 Axis)	0		108	0	0	108
Bottom (-2 Axis)		10.7475	318	122	0	318

Table 8. *Shear Force and Reinforcement for Shear, V_{u2} & T_u*

Shear V_e kN	Shear V_c kN	Shear V_s kN	Shear V_p kN	Rebar A_{sv} /s mm²/m
46.7781	0	49.5684	35.0168	551.18

From the design and analysis of the beam element type (Table 3), it's possible to interpret the following parameters as Torsion forces and reinforcement for torsion, Flexural reinforcement, Flexural design moments, shear force and reinforcement for shear, which is represented in Table 9 to Table 21.

Table 9. *Torsion Force and Torsion Reinforcement for Torsion, T_u & V_{U2}*

T_u kN-m	V_u kN	Core b_1 mm	Core d_1 mm	Rebar A_{svt} /s mm²/m
0.6976	11.7613	320	220	0

Table 10. *Flexural Reinforcement for Major Axis Moment, M_{u3}*

	End-I Rebar Area mm²	End-I Rebar %	Middle Rebar Area mm²	Middle Rebar %	End-J Rebar Area mm²	End-J Rebar %
Top (+2 Axis)	327	0.27	318	0.26	432	0.36
Bot (-2 Axis)	318	0.26	318	0.26	318	0.26

Table 11. *Flexural Design Moment, M_{u3}*

	End-I Design M_u kN-m	End-I Station Loc mm	Middle Design M_u kN-m	Middle Station Loc mm	End-J Design M_u kN-m	End-J Station Loc mm
Top (+2 Axis)	-28.0298	200	-3.545	1933.3	-36.518	2800
Combo	DCon20		DCon23		DCon19	
Bot (-2 Axis)	2.2503	633.3	5.4964	1933.3	13.9228	2800
Combo	DCon26		DCon26		DCon24	

Table 12. *Shear Reinforcement for Major Shear, V_{u2}*

End-I Rebar A_{sv} /s mm²/m	**Middle Rebar A_{sv} /s mm²/m**	**End-J Rebar A_{sv} /s mm²/m**
754.6	590.26	802.74

Table 13. *Design Shear Force for Major Shear, V_{u2}*

End-I Design V_u kN	**End-I Station Loc mm**	**Middle Design V_u kN**	**Middle Station Loc mm**	**End-J Design V_u kN**	**End-J Station Loc mm**
65.3167	200	0.0505	1933.3	69.6456	2800
DCon21		DCon21		DCon21	

Table 14. *Design Torsion Force*

Design T_u kN-m	**Station Loc mm**	**Design T_u kN-m**	**Station Loc mm**
0.6365	2800	0.872	2800
DCon19		DCon2	

Table 15. *Shear/Torsion Design for V_{u2} & T_u*

Rbar A_{sv} /s mm²/m	**Rbar A_{svt} /s mm²/m**	**Design V_{u2} kN**	**Design T_u kN-m**	**Design P_u kN**
551.18	0	46.7781	0.6976	0

Table 16. *Design Forces*

Factored V_{u2} kN	**Factored T_u kN-m**	**Equivalent V_e kN**	**Capacity V_p kN**	**Gravity V_g kN**
11.7613	0.6976	49.5684	35.0168	-11.7613

Table 17. *Capacity Moment*

	Long.Rebar A_s (Bottom) mm²	**Long.Rebar A_s (Top) mm²**	**Capacity Moment M_{pos} kN-m**	**Capacity Moment M_{neg} kN-m**
Left	318	327	27.7299	28.4771
Right	318	432	27.7299	37.3013

Table 18. *Design Basis*

Design V_{u2} kN	**Conc.Area A_c cm²**	**Area A_g cm²**	**Tensn.Reinf A_{st} mm²**	**Strength f_{ys} MPa**	**Strength f_{ck} MPa**	**LtWt.Reduc Factor Unitless**
46.7781	1000	1200	318	413.69	30	1

Table 19. *Concrete Capacity*

Conc.Area A_c cm²	Tensn.Rein A_{st} mm²	A_{st} %	Basic τ_c MPa	Strength f_{ys} MPa	CompFactor δ Unitless	DepthFactr k Unitless	Strengh Factor Unitless
1000	318	0.318	0.41	413.69	1	1	1

Table 20. *Shear Rebar Design*

Design V_e kN	Stress τ MPa	Concrete τ_{cd} MPa	Limit $\tau_{c.max}$ MPa	Rebar Area A_{sv} /s mm²/m	Shear V_c kN	Shear V_s kN	Shear V_n kN
49.5684	0.5	0	3.5	551.18	0	49.5684	49.5684

Table 21. *Torsion Capacity*

Rebar A_{svt} /s mm²/m	Torsion T_u kN-m	Shear V_u kN	Core b_1 mm	Core d_1 mm
0	0.6976	11.7613	320	220

IS 456:2000 + IS 13920:2016 Column Section Design (Envelope)

From the design and analysis of Column element type (Table 22-Table 24), it's possible to interpret the following parameters as Longitudinal reinforcement design, design axial force and Biaxial moment, and shear force reinforcement which is represented in Table 25 to Table 30.

Table 22. *Column Element Details Type: Ductile Frame (Summary)*

Level	Element	Unique Name	Section ID	Combo ID	Station Loc	Length (mm)	LLRF
Story2	C3	56	C0.4X0.4	DCon26	2700	3000	1

Table 23. *Section Properties*

b (mm)	h (mm)	dc (mm)	Cover (Torsion) (mm)
400	400	68	40

Table 24. *Material Properties*

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
27386.13	30	1	413.69	413.69

Table 25. *Axial Force and Biaxial Moment Design For P_u , M_{u2} , M_{u3}*

Design P_u kN	Design M_{u2} kN-m	Design M_{u3} kN-m	Minimum M_2 kN-m	Minimum M_3 kN-m	Rebar Area mm²	Rebar % %
22.1105	13.7677	7.2269	0.4422	0.4422	1280	0.8

Table 26. *Axial Force and Biaxial Moment Factors*

	K Factor Unitless	Length mm	Initial Moment kN-m	Additional Moment kN-m	Minimum Moment kN-m
Major Bend(M3)	0.842673	2700	2.8908	0	0.4422
Minor Bend(M2)	0.842673	2700	5.5071	0	0.4422

Table 27. *Shear Design for V_{u2} , V_{u3}*

	Shear V_u kN	Shear V_c kN	Shear V_s kN	Shear V_p kN	Rebar A_{sv} /s mm²/m
Major, V_{u2}	25.9833	66.0525	53.1203	25.9833	444.78
Minor, V_{u3}	33.9383	66.0525	53.1203	33.9383	444.78

Table 28. *Joint Shear Check/Design*

	Joint Shear Force kN	Shear V_{Top} kN	Shear $V_{u,Tot}$ kN	Shear V_c kN	Joint Area cm²	Shear Ratio Unitless
Major Shear, V_{u2}	0	0	114.772	876.3561	1600	0.131
Minor Shear, V_{u3}	0	0	151.3919	876.3561	1600	0.173

Table 29. *Additional Moment Reduction Factor k (IS 39.7.1.1)*

A_g cm²	A_{sc} cm²	P_{uz} kN	P_b kN	P_u kN	k Unitless
1600	12.8	2557.1381	951.5801	22.1105	1

Table 30. *Additional Moment (IS 39.7.1)*

	Consider M_a	Length Factor	Section Depth (mm)	KL/Depth Ratio	KL/Depth Limit	KL/Depth Exceeded	M_a Moment (kN-m)
Major Bending (M_3)	Yes	0.9	400	5.688	12	No	0
Minor Bending (M_2)	Yes	0.9	400	5.688	12	No	0

Indian IS875:1987 Auto Wind Load Calculation

This calculation presents the automatically generated lateral wind loads for load pattern Wx according to Indian IS875:1987, as calculated by ETABS. The variation of Lateral load versus Force variation is represented in (Figure 2) in the case of wind direction 0^0. A lateral load is a live load with the horizontal force acting as the main component. A lateral load acts parallel to the ground, unlike vertical loads that act downward. Commonly known lateral loads are wind, seismic, water, and earth pressure. The most common bracing methods for resisting lateral forces in commercial buildings include moment frames, shear walls, and braced frames. These vertical elements transfer lateral loads, including wind, seismic forces, and stability forces through floor or roof diaphragms to the building's foundation. To resist lateral loads, buildings typically use shear walls, moment frames, steel bracing, or a combination of them. Shear walls are designed to resist lateral forces by transferring them to the foundation through the building's floors, walls, and roof. The lateral force is calculated using the formula. Lateral Force = Lateral Seismic Force/Vertical Distribution Factor. It means you find the lateral force acting on a structure by dividing the lateral seismic force by a factor related to how the vertical forces are distributed. Recent studies show that, positioning shear walls at corners, core or a combination of both results in a good lateral load-resisting performance. For medium buildings, shear walls at cores are a good option. But for high-rise buildings, longer shear walls towards the periphery are better. MLLs are sets of notional lateral loads that can be applied to cater to a minimum lateral loading for wind. It can create up to two minimum lateral load sets, 'Case A' and 'Case B'. The loads in each set are specified as a percentage of gravity loading. This type of lateral load-resisting system engages a vertical element of the building, usually concrete or masonry, to transfer the horizontal forces to the ground by a primary shear behaviour. Shear walls are inherently stiff elements and are therefore extremely effective at resisting lateral wind loads. The resulting allowable load shall not be more than one-half of the load that produces a gross lateral movement of 1 inch (25 mm) at the lower of the top of the foundation element and the ground surface unless it can be shown that the predicted lateral movement shall cause neither harmful distortion of, nor instability in the structure. Interior walls and partitions that exceed 6 feet (1828.8 mm) in height, including their finish materials, shall have adequate strength and stiffness to resist the loads to which they are subjected but not less than a horizontal load of (0.240 kN/m^2). Adding reinforced concrete walls results in a drastic increase in lateral stiffness and strength of the structure. These RC walls carry the bulk of the horizontal loads in the event of an earthquake. The lateral stiffness and strength of a structure are quite independent of the slab-column system. One of the methods of increasing the strength and lateral stiffness of structures is to add infill. Adding infill walls increases the stiffness and reduces the fundamental period of the structure by up to 20%, indicating the effect of the infill on the structural stiffness.

Exposure Parameters

Exposure From = Diaphragms
Structure Class = Class B
Terrain Category = Category 4
Wind Direction = 0 degrees

Basic Wind Speed, V_b [IS Fig. 1] $V_b = 44 \frac{\text{meter}}{\text{sec}}$

Windward Coefficient, $C_{p,wind}$ $C_{p,wind} = 0.8$

Leeward Coefficient, $C_{p,lee}$ $C_{p,lee} = 0.5$

Top Story = Story2
Bottom Story = Base
Include Parapet = No

Factors and Coefficients

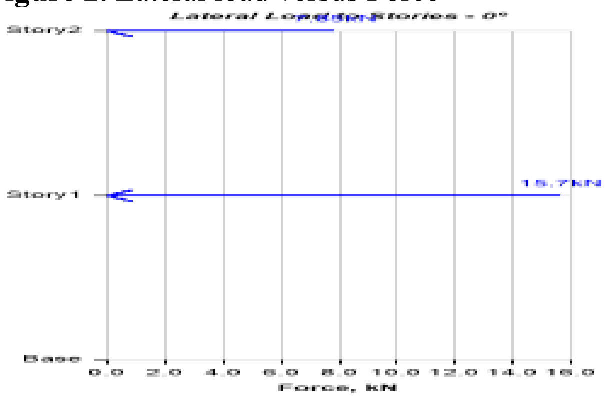
Risk Coefficient, k_1 [IS 5.3.1]		$k_1 = 1$
Topography Factor, k_3 [IS 5.3.3]		$k_3 = 1$

Lateral Loading

Design Wind Speed, V_z [IS 5.3]	$V_z = V_b k_1 k_2 k_3$	$V_z = 33.44$
Design Wind Pressure, p_z [IS 5.4]	$p_z = 0.6 V_z^2$	

Applied story Forces

Figure 2. Lateral load versus Force



Indian IS875:1987 Auto Wind Load Calculation

This calculation presents the automatically generated lateral wind loads for load pattern Wy according to Indian IS875:1987, as calculated by ETABS. The variation of Lateral load versus Force variation in the case of wind direction 90^0 is represented in (Figure 3). The primary characteristic of Class B buildings is the reinforced concrete frame in which the columns and beams can be either formed or precast concrete. They may be mechanically stressed. Class B buildings are fire-resistant structures. Floors and roofs in Class B structures are formed or precast concrete slabs. They are normally older than 15 years, putting them slightly out of touch with modern building trends. However, they normally provide adequate facilities and middle-of-the-line experiences. In turn, Class B buildings tend to generate average market rents. There are some methods used to help buildings withstand earthquakes, such as: Creating a Flexible Foundation; One way to resist ground forces is to “lift” the building's foundation above the earth; Counter Forces with Damping; Shield Buildings from Vibrations; Reinforce the Building's Structure; and Steel and Wood. The effective seismic weight of a structure includes the dead load above the base and other loads above the base as follows: In areas used for storage, a minimum of 25% of the floor live load. The earthquake load is a 'dynamic load', which means it brings about the vibration of structures. Other loads, such as dead, live, and snow loads, generally act on structures very slowly and do not cause any rapid movement or vibration. These are called 'static loads'. The following factors affect the seismic load: soil condition, building heights, the relative difference between the building's heights, the separation between adjacent buildings, the lateral load resisting structural system, the location of the collision points, and the peak ground acceleration of the earthquake at the location of the building. In designing and analysing slopes, FOS is generally taken equal to or greater than 1.5 to ensure that the slope will be safely stable. Common strategies for designing structures to withstand seismic loads include using seismic codes and standards to guide the design and analysis of the structure, response spectrum or time history analysis to evaluate the dynamic response of the structure, and base isolation or energy dissipation devices to reduce seismic forces.

Exposure Parameters

Exposure From = Diaphragms
Structure Class = Class B
Terrain Category = Category 4
Wind Direction = 90 degrees

Basic Wind Speed, Vb [IS Fig. 1]		$V_b = 44 \frac{\text{meter}}{\text{sec}}$
Windward Coefficient, Cp,wind		$C_{p,wind} = 0.8$
Leeward Coefficient, Cp,lee		$C_{p,lee} = 0.5$

Top Story = Story2
Bottom Story = Base
Include Parapet = No

Factors and Coefficients

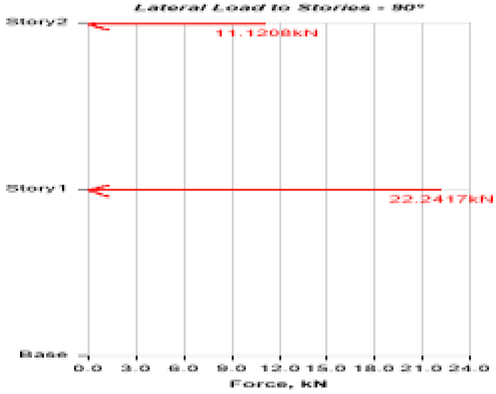
Risk Coefficient, k1 [IS 5.3.1]		$k_1 = 1$
Topography Factor, k3 [IS 5.3.3]		$k_3 = 1$

Lateral Loading

Design Wind Speed, Vz [IS 5.3]	$V_z = V_b k_1 k_2 k_3$	$V_z = 33.44$
Design Wind Pressure, pz [IS 5.4]	$p_z = 0.6 {V_z}^2$	

Applied story forces

Figure 3. *Lateral load versus Force*



IS1893 2002 Auto Seismic Load Calculation

This calculation presents the automatically generated lateral seismic loads for load pattern Ex according to IS1893 2002, as calculated by ETABS. The variation of Lateral load versus Force variation in the case of seismic load is represented in Figure 4. Seismic loading is one of the basic concepts of earthquake engineering, which means the application of a seismic oscillation to a structure. It happens at contact surfaces of a structure, either with the ground or with adjacent structures. Seismic loads, on the other hand, are considered to be dynamic loads, meaning that they are applied to the structure suddenly and can cause the structure to vibrate. The seismic load is calculated by taking the total Seismic weight and converting it into a horizontal direction by multiplying it by the seismic response coefficient Cs. Seismic loads are directly proportional to the exposed area of the building. Reinforced concrete walls (shear walls) on well-designed foundations are probably the best system to resist seismic loads in low to medium-rise construction. Some engineers always use RC shear walls. However, they are expensive, require expensive foundations, and limit the internal layout. The following factors affect the seismic load: soil condition, building heights, the relative difference between building heights, a separation between adjacent buildings, the lateral load resisting structural system, the location of the collision points, and the peak ground acceleration of the earthquake at the location of the building. Common strategies for designing structures to withstand seismic loads include using seismic codes and standards to guide the design and analysis of the structure, response spectrum or time history analysis to evaluate the dynamic response of the structure, and base isolation or energy dissipation devices to reduce seismic forces. The Seismic Coefficients are dimensionless coefficients that represent the (maximum) earthquake acceleration as a fraction of the acceleration due to gravity. Typical values are in the range of 0.1 to 0.3. The most common method is the introduction of frame encasement, using steel bracing systems, which consists of the filling of selected frame panels with truss systems of V shape, Λ shape or X shape to increase the ductility and stiffness of the structure. Seismic methods involve measuring the propagation of seismic waves through earth materials. In seismic surveys, seismic waves radiate outward from a sound source at the surface, which can be an explosive charge or a mechanical impact. A seismogram is a record of the ground motions caused by seismic waves from an earthquake. A seismograph or seismometer is the measuring instrument that creates the seismogram.

Direction and Eccentricity

Direction = X

Structural Period

Period Calculation Method = Program Calculated

Factors and Coefficients

Seismic Zone Factor, Z [IS Table 2]	$Z = 0.36$
Response Reduction Factor, R [IS Table 7]	$R = 5$
Importance Factor, I [IS Table 6]	$I = 1$
Site Type [IS Table 1] = II	

Seismic Response

Spectral Acceleration Coefficient, S_a /g [IS 6.4.5]	$\frac{S_a}{g} = 2.5$	$\frac{S_a}{g} = 2.5$

Equivalent Lateral Forces

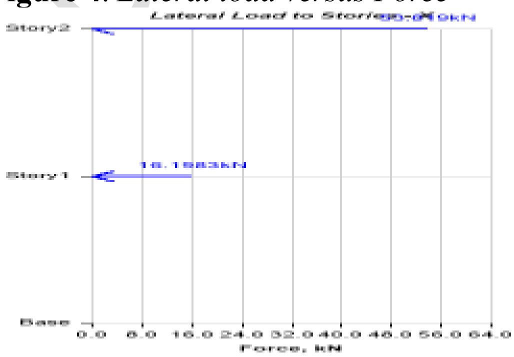
Seismic Coefficient, A_h [IS 6.4.2]	$A_h = \frac{ZI\frac{S_a}{g}}{2R}$

Calculated Base Shear

Direction	Period Used (sec)	W (kN)	V_b (kN)
X	0.175	777.9702	70.0173

Applied Story Forces

Figure 4. *Lateral load versus Force*



IS1893 2002 Auto Seismic Load Calculation

This calculation presents the automatically generated lateral seismic loads for load pattern Ey according to IS1893 2002, as calculated by ETABS. The variation of Lateral load versus Force variation (Y direction) in the case of seismic load is represented in Figure 5.

Direction and Eccentricity

Direction = Y

Structural Period

Period Calculation Method = Program Calculated

Factors and Coefficients

Seismic Zone Factor, Z [IS Table 2]		$Z = 0.36$
Response Reduction Factor, R [IS Table 7]		$R = 5$
Importance Factor, I [IS Table 6]		$I = 1$
Site Type [IS Table 1] = II		

Seismic Response

Spectral Acceleration Coefficient, S_a /g [IS 6.4.5]	$\frac{S_a}{g} = 2.5$	$\frac{S_a}{g} = 2.5$

Equivalent Lateral Forces

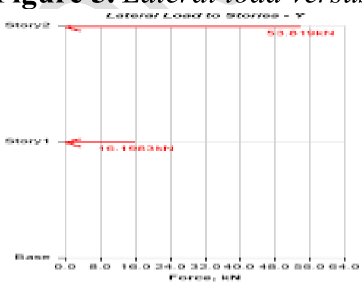
Seismic Coefficient, A_h [IS 6.4.2]	$A_h = \frac{ZI\frac{S_a}{g}}{2R}$

Calculated Base Shear

Direction	Period Used (sec)	W (kN)	V_b (kN)
Y	0.183	777.9702	70.0173

Applied Story Forces

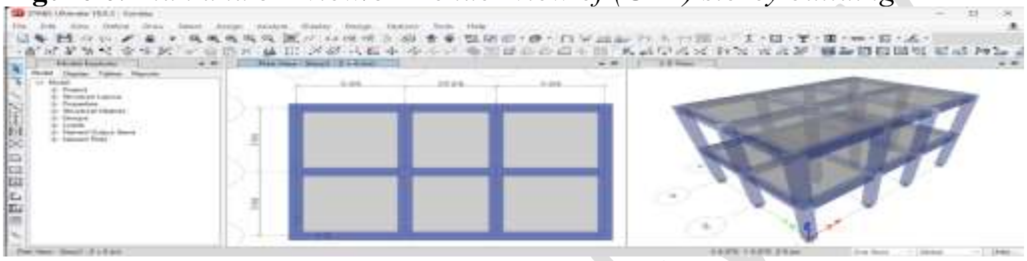
Figure 5. *Lateral load versus Force*



Design and Analysis of (G+1)-story building

The (G+1)-story building was designed and analysed by ETABS software as per the Indian standard code IS:456-2000. The size of building (8.5mx6m) in which the following parameters were considered for design as Beam size-300x400mm; Beam longitudinal length-3m, 2.5m and 3m; Beam lateral length-3m, 3m; Beam area-1200 cm², grade of concrete-M30, E_c (MPa)- 27386.13, grade of steel (Fe550)-Isotropic type with grade (Fe345), Slab-120mm thickness; Element type-Membrane; Grade of concrete-M30-Isotropic type, Column Element details-Column size-400X400mm; Column length-3m; Column area-1600 cm². The geometry (Figure 6) was created as per the given dimensions, such as columns, beams, and slabs, assigned material properties and support conditions, assigned dead/live load value and then designed and analysed the building system as per the stipulated code condition.

Figure 6. *Plan and 3D view/3D render view of (G+1) storey building*



In structural engineering, a diaphragm is a structural element that transmits lateral loads to the vertical resisting elements of a structure (such as shear walls or frames). Diaphragms are typically horizontal but can be sloped in a gable roof on a wood structure or concrete ramp in a parking garage. Diaphragm walls ensure the stability of nearby structures during construction. They prevent the movement of soil, protecting adjacent buildings and infrastructure. Installation at Greater Depths: Diaphragm walls can be installed at greater depths than many other types of walls. A diaphragm is a flat structural unit acting like a deep, thin beam. The term “diaphragm” is usually applied to roofs and floors. A shear wall, however, is a vertical, cantilevered diaphragm. These construction systems can be used when designing a building for wind or seismic lateral loads. Diaphragm Action is an additional capacity of the panel to transfer the lateral loads to the outside edges of the panel to the eave for roof panels and to the ground for wall panels. This stiffness provides stability and replaces the need for other bracing elements. Shear and moment diagrams are graphs that show the internal shear and bending moment plotted along the length of the beam. They allow us to see where the maximum loads occur so that we can optimize the design to prevent failures and reduce the overall weight and cost of the structure. Shear force and bending moment diagrams are analytical tools used in conjunction with structural analysis to help perform structural design by determining the value of shear forces and bending moments at a given point of a structural element such as a beam. Shear forces are, thus, tangential and coplanar forces that act along the face of the body, and when there are two opposite shear forces relative to one another, the body is said to be under a shearing effect. The bending moment results from shear forces acting on a body during shearing that causes the body to bend. for a uniformly loaded beam, the maximum moment occurs at mid-span and the value of the moment is $(w*l^2)/8$.

The maximum moment is (P*l)/4 for a point load at the centre. If the load is not centred, the maximum moment is (P*a*b)/l and it occurs at the location of the point load. The minimum bending moment in a simply supported beam is at the end supports. The maximum bending moment is at the centre, assuming a uniform load on the beam. If the force produces a clockwise rotation about the given turning point in the rigid body, it is called a negative moment. Thus, anti-clockwise rotation can be considered a positive moment of force while clockwise rotation can be considered a negative moment of force. The direction of a moment is opposite to the direction of the force. The convention is that: clockwise moments are positive. anti-clockwise moments are negative. The tendency of the force to act in the opposite direction and the unequal force will create the moment of force. Hence the negative moment having rotation in anti-clockwise is having a clockwise force (Figures 7-9).

Figure 7. *Plan and 3D view of Diaphragm/Moment diagram of (G+1) story building*

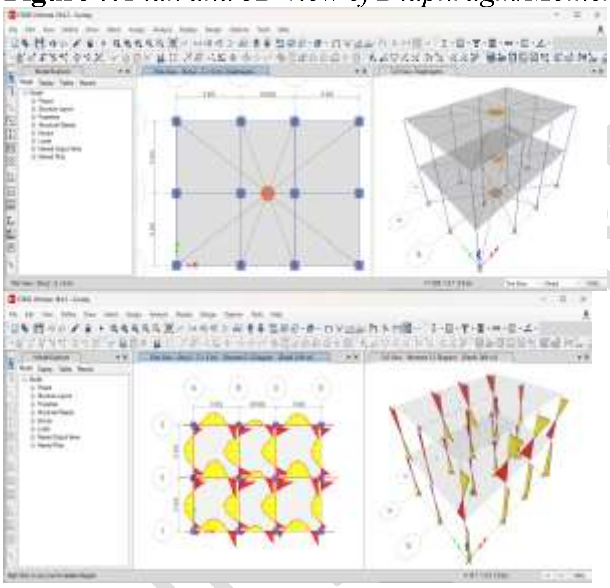
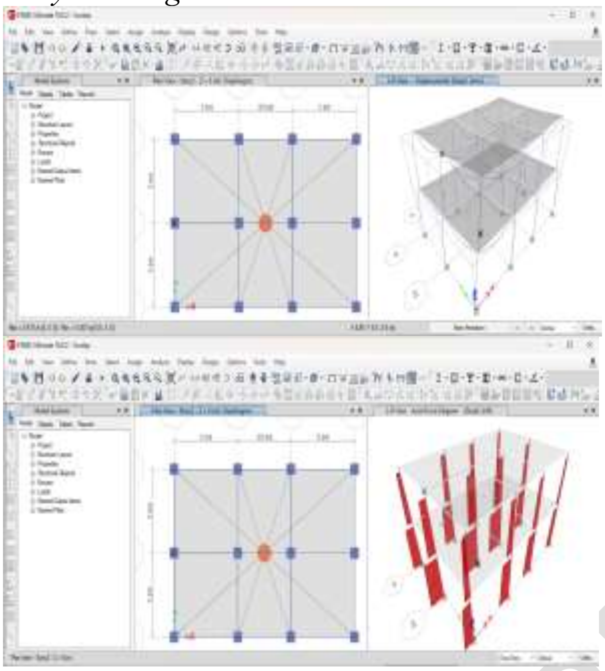
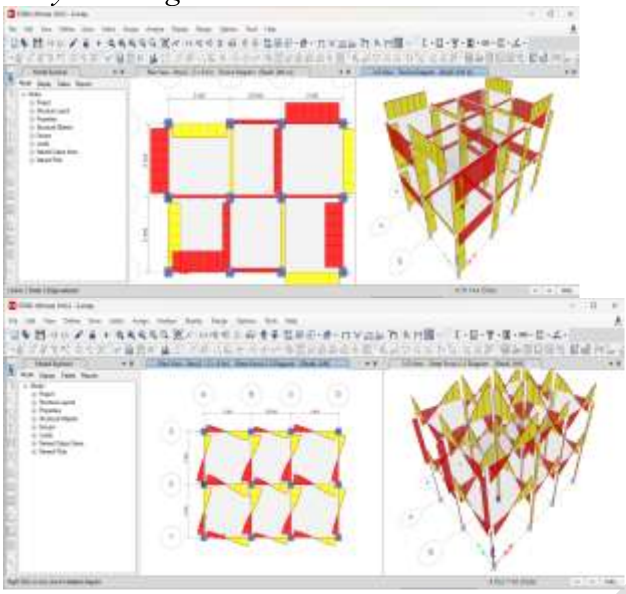


Figure 8. *Plan and 3D view of Displacement /Axial force diagram of (G+1) story building*



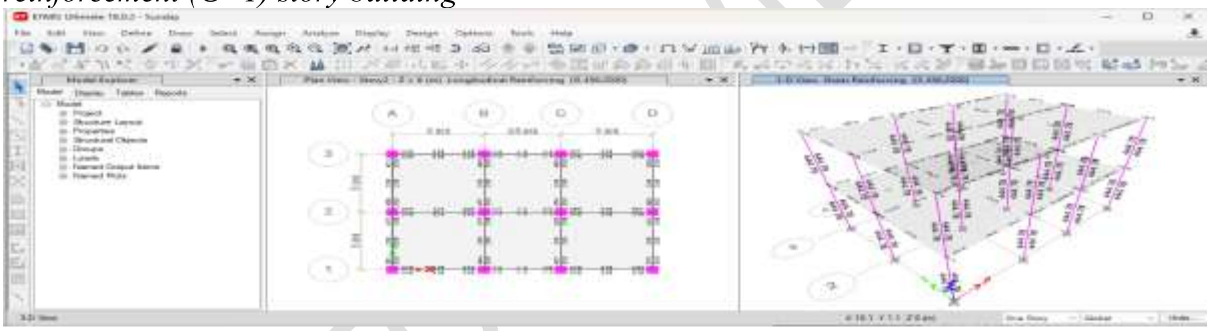
The deformed shape can be described as the shape of the centroid line of the structure after deformation and is a result of loading patterns on the beam. The load perpendicular to the longitudinal axis causes a deformation of the beam (bending). The following factors affect deformation as Tensional stress expands rocks; Compressional stress-This kind of stress creates tall mountain ranges like the Himalayas and Smokey Mountains; and Shear stress- Fault lines are the outcomes of shear stress. Torsion is the twisting of a beam under the action of a torque (twisting moment). It is systematically applied to screws, nuts, axles, drive shafts and is also generated more randomly under service conditions in car bodies, boat hulls, aircraft fuselages, bridges, springs, and many other structures and components. The torsion force (twist force) is the force applied to the structural member or an object, causing one end to twist with respect to the other end. This twist further causes shear stress to be exerted along the object's cross-section or structural member. Because of torsion, the beam fails in diagonal tension, forming the spiral cracks around the beam. Warping of the section does not allow a plane section to remain as a plane after. Another factor to consider is the design of the beam itself, such as using a pre-twisted beam or considering the effects of Poisson's ratio. Overall, a combination of proper bracing, design considerations, and the use of side plates or cover plates can help minimise torsion in beams. When a beam supports a slab (or when it carries another beam only on one side), it is subjected to direct torsion. For common buildings in areas with high seismic activity, torsion is quite a dangerous stress condition because it is a statically determined stress. Torsion in beams arises generally from the action of shear loads whose points of application do not coincide with the shear centre of the beam section.

Figure 9. *Plan and 3D view of Torsion diagram/Shear force diagram of (G+1) story building*



Longitudinal reinforcement will only be utilized if it lies on the tension side of the neutral axis. Reinforcement is only considered at sections where it is fully developed. The area of prestressing strands will not be considered. Longitudinal reinforcement handles the bending moment stresses and transverse reinforcement handles shear stresses. The cover of the longitudinal reinforcing bar in a beam subjected to sea spray should not be less than 70 mm. Note: Since the minimum value is 50 mm that's why 25 and 40 mm will be below the criteria and 90 mm is too large to consider. Hence most appropriate answer is 70 mm. Transverse reinforcement bars, also known as stirrups, are essential to reinforced concrete structures. These bars are perpendicular to the longitudinal reinforcement bars and help strengthen the concrete members, such as beams and columns, by resisting shear and torsional forces. longitudinal reinforcement required for torsion shall be distributed around the perimeter of the closed stirrups with a maximum spacing of 300mm. Longitudinal Reinforcement C/S area of longitudinal reinforcement shall not be less than 0.8% and not more than 6% of the gross c/s area of the column. *Minimum no. of longitudinal bars in column = 4 in rectangular and 6 in circular columns. *For Helical Reinforcement = at least 6 bars for longitudinal reinforcement. The longitudinal rebars are placed to resist the flexural tensile stresses that appear along the beam axis while stirrups are used to carry the diagonal tensile stresses caused by shear. Moreover, stirrups help in the confinement of longitudinal reinforcement in critical areas. As per IS: 456-2000 the cross-sectional area of the longitudinal reinforcement in columns, shall not be less than 0.8% nor more than 6% of the gross cross-sectional area of the column. The diameter of longitudinal reinforcement is considered (cross-sectional area of bars with input diameter) minimal number of bars per edge is 2. The number of bars is rounded to an integer. corner bars are taken into account for all edges (half of the bar is taken into account for one edge, and half of the bar for the second edge). Shear reinforcement is to provide resistance against shear forces to which a beam is subjected to and is usually in the form of stirrups which also serve the purpose of holding the main tensile and compression reinforcement in place. The maximum spacing of shear reinforcement measured along the axis of the member shall not exceed 0.75d for vertical stirrups and d for inclined stirrups at 45^0 where d is the effective depth of the section under consideration. In no case shall the spacing exceed 300 mm. The minimum percentage of reinforcement is 0.12% of the gross cross-sectional area if HYSD bars (Fe 415) are used. The minimum percentage of reinforcement is 0.15% of the gross cross-sectional area if mild steel bars are used. The purpose of shear reinforcement is to prevent shear failure, increase beam ductility, and reduce the likelihood of sudden failure. Normally, the inclined shear cracks start at the middle height of the beam near support at approximately 450 and extend toward the compression zone (Figure 10).

Figure 10. *Plan view of Longitudinal reinforcement /3D render view of Shear reinforcement (G+1) story building*



Base reactions are calculated for each mode before modes are combined using the CQC or SRSS modal-combination rule. Joint reactions, on the other hand, are calculated using modal combinations, which are applied to each joint. For example, consider a structural system with four joints and two modes. It is defined as the horizontal reactions at the supports. It is represented in terms of 'KN' (Table 31).

Table 31. *Base Reactions*

Output Case	Case Type	Step Type	Step Number	FX	FY	FZ	MX	MY	MZ
				kN	kN	kN	kN-m	kN-m	kN-m
Dead	LinStatic			-48	-48	2583.9489	7883.8468	-11209.783	-108
Live	LinStatic			0	0	408	1224	-1734	0
Modal	LinModEigen	Mode	1	0	-9.8601	0	48.6261	0	-41.9055
Modal	LinModEigen	Mode	2	10.7476	0	0	0	52.8163	-32.2429
Modal	LinModEigen	Mode	3	0	0	0	0	0	-50.5764
Modal	LinModEigen	Mode	4	0	41.601	0	-18.7294	0	176.8043
Modal	LinModEigen	Mode	5	-41.703	0	0	0	-13.6517	125.1089
Modal	LinModEigen	Mode	6	0	0	0	0	0	183.017
Ex	LinStatic			-274.0173	0	0	0	-1289.509	822.052
Ey	LinStatic			0	-274.0173	0	1289.509	0	-1164.5736
Wx	LinStatic			-23.55	0	0	0	-94.2	70.65
Wy	LinStatic			0	-33.3625	0	133.45	0	-141.7906

Drift is defined as the ratio of the displacement between two consecutive floors to the height. The maximum permissible drift is limited to 0.004 times the height of the story. It is a very important term used for research purposes in earthquake engineering. The story drifts in any story due to the maximum specified design lateral force, with a partial load factor of 1. The variation of story drifts was indicated in dead load and live load (Table 32-33). As per the Indian standard, Criteria for earthquake resistant design of structures, IS 1893(Part 1): 2016, the story drift in any story shall not exceed 0.004 times the story height. Increasing the flexural (bending) stiffness of the main frame members, especially columns of the structure, and trying relatively small steps in commercial steel sizes until the story drift is within acceptable limits, assuming that the frame is composed of standard/rolled structural shapes. The importance of story drift is in the design of partitions/curtain walls.

Table 32. *Story Drifts*

Story	Output Case	Case Type	Step Type	Step Number	Direction	Drift
Story2	Dead	LinStatic			X	0.000125
Story2	Dead	LinStatic			Y	0.0001
Story2	Live	LinStatic			X	0
Story2	Live	LinStatic			Y	0
Story2	Modal	LinModEigen	Mode	1	Y	0.000027
Story2	Modal	LinModEigen	Mode	2	X	0.000026
Story2	Modal	LinModEigen	Mode	3	X	0.000021
Story2	Modal	LinModEigen	Mode	3	Y	0.00003
Story2	Modal	LinModEigen	Mode	4	Y	0.00007
Story2	Modal	LinModEigen	Mode	5	X	0.00007
Story2	Modal	LinModEigen	Mode	6	X	0.000058
Story2	Modal	LinModEigen	Mode	6	Y	0.000081
Story2	Ex	LinStatic			X	0.000614
Story2	Ey	LinStatic			Y	0.000684
Story2	Wx	LinStatic			X	0.000038
Story2	Wy	LinStatic			Y	0.00006
Story1	Dead	LinStatic			X	0.000099
Story1	Dead	LinStatic			Y	0.000096
Story1	Live	LinStatic			X	0
Story1	Live	LinStatic			Y	0
Story1	Modal	LinModEigen	Mode	1	Y	0.000023
Story1	Modal	LinModEigen	Mode	2	X	0.000023
Story1	Modal	LinModEigen	Mode	3	X	0.000019
Story1	Modal	LinModEigen	Mode	3	Y	0.000027
Story1	Modal	LinModEigen	Mode	4	Y	0.000045
Story1	Modal	LinModEigen	Mode	5	X	0.000045
Story1	Modal	LinModEigen	Mode	6	X	0.000036
Story1	Modal	LinModEigen	Mode	6	Y	0.000051
Story1	Ex	LinStatic			X	0.000579
Story1	Ey	LinStatic			Y	0.000617
Story1	Wx	LinStatic			X	0.000046
Story1	Wy	LinStatic			Y	0.000069

Table 33. *Story max over average Drifts*

Story	Output Case	Case Type	Step Type	Step Number	Direction	Max Drift	Avg Drift	Ratio
						mm	mm	
Story2	Dead	LinStatic			X	0.376	0.329	1.142
Story2	Dead	LinStatic			Y	0.299	0.233	1.284
Story2	Live	LinStatic			X	0	0	1.171
Story2	Live	LinStatic			Y	0	0	1.091
Story2	Modal	LinModEigen	Mode	1	Y	0.08	0.08	1
Story2	Modal	LinModEigen	Mode	2	X	0.078	0.078	1
Story2	Modal	LinModEigen	Mode	3	X	0.063	0	2.642E+13
Story2	Modal	LinModEigen	Mode	3	Y	0.089	0	1.652E+13
Story2	Modal	LinModEigen	Mode	4	Y	0.211	0.211	1
Story2	Modal	LinModEigen	Mode	5	X	0.211	0.211	1
Story2	Modal	LinModEigen	Mode	6	X	0.173	0	2.571E+14
Story2	Modal	LinModEigen	Mode	6	Y	0.244	0	1.351E+14
Story2	Ex	LinStatic			X	1.843	1.843	1
Story2	Ey	LinStatic			Y	2.053	2.053	1
Story2	Wx	LinStatic			X	0.114	0.114	1
Story2	Wy	LinStatic			Y	0.181	0.181	1
Story1	Dead	LinStatic			X	0.297	0.256	1.163
Story1	Dead	LinStatic			Y	0.287	0.228	1.258
Story1	Live	LinStatic			X	0	0	1.179
Story1	Live	LinStatic			Y	0	0	1.094
Story1	Modal	LinModEigen	Mode	1	Y	0.068	0.068	1
Story1	Modal	LinModEigen	Mode	2	X	0.07	0.07	1
Story1	Modal	LinModEigen	Mode	3	X	0.058	0	2.687E+13
Story1	Modal	LinModEigen	Mode	3	Y	0.082	0	1.77E+13
Story1	Modal	LinModEigen	Mode	4	Y	0.136	0.136	1
Story1	Modal	LinModEigen	Mode	5	X	0.135	0.135	1
Story1	Modal	LinModEigen	Mode	6	X	0.108	0	2.534E+14
Story1	Modal	LinModEigen	Mode	6	Y	0.153	0	1.346E+14
Story1	Ex	LinStatic			X	1.738	1.738	1
Story1	Ey	LinStatic			Y	1.85	1.85	1
Story1	Wx	LinStatic			X	0.138	0.138	1
Story1	Wy	LinStatic			Y	0.206	0.206	1

The story forces graph shows the lateral force that is applied at each floor level, but does not include any lateral forces that are applied to columns or walls between the floors. For a seismic analysis, the story forces come from the lateral acceleration of the masses on each floor. In ETABS, go to Display > Show tables > Select story drifts and story forces tables > and see if there are any story drifts or story forces present in there. Or else there is some connectivity issue between members in the model, and perform the check model function for this issue. Joint reaction is an analysis for calculating resultant forces and moments at joints. Specifically, it calculates the joint forces and moments transferred between consecutive bodies as a result of all loads acting on the model (Table 34).

Table 34. *Joint Design Reactions*

Story	Label	Unique Name	Output Case	Case Type	Step Type	Step Number	FX	FY	FZ	MX	MY	MZ
							kN	kN	kN	kN-m	kN-m	kN-m
Base	1	37	Dead	LinStatic			-2.1388	-1.1234	149.8456	1.3167	-5.9718	-1.1903
Base	1	37	Live	LinStatic			0.4334	0.4341	17.6072	-0.423	0.4223	0
Base	1	37	Modal	LinModEigen	Mode	1	0	-0.7595	-1.1819	1.6279	0	0
Base	1	37	Modal	LinModEigen	Mode	2	0.7933	0	1.159	0	1.6787	0
Base	1	37	Modal	LinModEigen	Mode	3	-0.6931	0.9724	0.3953	-2.01	-1.4253	-0.2641
Base	1	37	Modal	LinModEigen	Mode	4	0	3.4099	-1.7892	-5.0837	0	0
Base	1	37	Modal	LinModEigen	Mode	5	-3.4044	0	1.801	0	-5.0692	0
Base	1	37	Modal	LinModEigen	Mode	6	2.765	-3.9066	0.6169	5.796	4.0985	0.4944
Base	1	37	Ex	LinStatic			-20.3233	0	-27.6693	0	-42.3683	0
Base	1	37	Ey	LinStatic			0	-21.1757	-30.5975	44.6474	0	0
Base	1	37	Wx	LinStatic			-1.775	0	-1.8306	0	-3.5157	0
Base	1	37	Wy	LinStatic			0	-2.6042	-2.8694	5.2105	0	0
Base	2	38	Dead	LinStatic			-0.7209	-3.5764	223.1116	3.7068	-4.0497	-1.1903
Base	2	38	Live	LinStatic			0.845	0	36.3664	0	0.8233	0
Base	2	38	Modal	LinModEigen	Mode	1	0	-0.946	0	1.8096	0	0
Base	2	38	Modal	LinModEigen	Mode	2	0.7933	0	1.159	0	1.6787	0
Base	2	38	Modal	LinModEigen	Mode	3	0	1.1841	0	-2.2163	0	-0.2641
Base	2	38	Modal	LinModEigen	Mode	4	0	3.5804	0	-5.2499	0	0
Base	2	38	Modal	LinModEigen	Mode	5	-3.4044	0	1.801	0	-5.0692	0
Base	2	38	Modal	LinModEigen	Mode	6	0	-4.0658	0	5.9511	0	0.4944
Base	2	38	Ex	LinStatic			-20.3233	0	-27.6693	0	-42.3683	0
Base	2	38	Ey	LinStatic			0	-26.153	0	49.4973	0	0
Base	2	38	Wx	LinStatic			-1.775	0	-1.8306	0	-3.5157	0
Base	2	38	Wy	LinStatic			0	-3.1323	0	5.7252	0	0
Base	3	39	Dead	LinStatic			-1.1547	-5.0759	155.3771	5.168	-3.932	-1.1903
Base	3	39	Live	LinStatic			0.4334	-0.4341	17.6072	0.423	0.4223	0
Base	3	39	Modal	LinModEigen	Mode	1	0	-0.7595	1.1819	1.6279	0	0
Base	3	39	Modal	LinModEigen	Mode	2	0.7933	0	1.159	0	1.6787	0
Base	3	39	Modal	LinModEigen	Mode	3	0.6931	0.9724	-0.3953	-2.01	1.4253	-0.2641
Base	3	39	Modal	LinModEigen	Mode	4	0	3.4099	1.7892	-5.0837	0	0
Base	3	39	Modal	LinModEigen	Mode	5	-3.4044	0	1.801	0	-5.0692	0
Base	3	39	Modal	LinModEigen	Mode	6	-2.765	-3.9066	-0.6169	5.796	-4.0985	0.4944
Base	3	39	Ex	LinStatic			-20.3233	0	-27.6693	0	-42.3683	0
Base	3	39	Ey	LinStatic			0	-21.1757	30.5975	44.6474	0	0
Base	3	39	Wx	LinStatic			-1.775	0	-1.8306	0	-3.5157	0
Base	3	39	Wy	LinStatic			0	-2.6042	2.8694	5.2105	0	0
Base	4	40	Dead	LinStatic			-5.6374	-0.7165	209.9879	1.4606	-9.3808	-1.1903
Base	4	40	Live	LinStatic			-0.1602	0.8336	32.6321	-0.8123	-0.1561	0
Base	4	40	Modal	LinModEigen	Mode	1	0	-0.7595	-1.1819	1.6279	0	0
Base	4	40	Modal	LinModEigen	Mode	2	0.998	0	0.2563	0	1.8781	0
Base	4	40	Modal	LinModEigen	Mode	3	-0.8532	0.2795	0.1823	-0.5849	-1.5813	-0.2641
Base	4	40	Modal	LinModEigen	Mode	4	0	3.4099	-1.7892	-5.0837	0	0
Base	4	40	Modal	LinModEigen	Mode	5	-3.5461	0	0.2776	0	-5.2073	0
Base	4	40	Modal	LinModEigen	Mode	6	2.8513	-1.1446	0.3701	1.7004	4.1826	0.4944
Base	4	40	Ex	LinStatic			-25.3463	0	-6.1542	0	-47.2626	0
Base	4	40	Ey	LinStatic			0	-21.1757	-30.5975	44.6474	0	0
Base	4	40	Wx	LinStatic			-2.15	0	-0.4184	0	-3.8811	0
Base	4	40	Wy	LinStatic			0	-2.6042	-2.8694	5.2105	0	0
Base	5	41	Dead	LinStatic			-5.37	-4.1752	318.8751	4.8308	-8.5798	-1.1903
Base	5	41	Live	LinStatic			-0.3118	0	67.1549	0	-0.3039	0
Base	5	41	Modal	LinModEigen	Mode	1	0	-0.946	0	1.8096	0	0
Base	5	41	Modal	LinModEigen	Mode	2	0.998	0	0.2563	0	1.8781	0
Base	5	41	Modal	LinModEigen	Mode	3	0	0.344	0	-0.6477	0	-0.2641
Base	5	41	Modal	LinModEigen	Mode	4	0	3.5804	0	-5.2499	0	0
Base	5	41	Modal	LinModEigen	Mode	5	-3.5461	0	0.2776	0	-5.2073	0
Base	5	41	Modal	LinModEigen	Mode	6	0	-1.1971	0	1.7516	0	0.4944
Base	5	41	Ex	LinStatic			-25.3463	0	-6.1542	0	-47.2626	0
Base	5	41	Ey	LinStatic			0	-26.153	0	49.4973	0	0
Base	5	41	Wx	LinStatic			-2.15	0	-0.4184	0	-3.8811	0
Base	5	41	Wy	LinStatic			0	-3.1323	0	5.7252	0	0
Base	6	42	Dead	LinStatic			-4.4205	-6.4666	215.8328	7.0635	-7.1141	-1.1903
Base	6	42	Live	LinStatic			-0.1602	-0.8336	32.6321	0.8123	-0.1561	0
Base	6	42	Modal	LinModEigen	Mode	1	0	-0.7595	1.1819	1.6279	0	0
Base	6	42	Modal	LinModEigen	Mode	2	0.998	0	0.2563	0	1.8781	0
Base	6	42	Modal	LinModEigen	Mode	3	0.8532	0.2795	-0.1823	-0.5849	1.5813	-0.2641
Base	6	42	Modal	LinModEigen	Mode	4	0	3.4099	1.7892	-5.0837	0	0
Base	6	42	Modal	LinModEigen	Mode	5	-3.5461	0	0.2776	0	-5.2073	0
Base	6	42	Modal	LinModEigen	Mode	6	-2.8513	-1.1446	-0.3701	1.7004	-4.1826	0.4944
Base	6	42	Ex	LinStatic			-25.3463	0	-6.1542	0	-47.2626	0
Base	6	42	Ey	LinStatic			0	-21.1757	30.5975	44.6474	0	0
Base	6	42	Wx	LinStatic			-2.15	0	-0.4184	0	-3.8811	0
Base	6	42	Wy	LinStatic			0	-2.6042	2.8694	5.2105	0	0
Base	7	43	Dead	LinStatic			-4.3391	-1.1131	211.9364	2.2974	-8.1158	-1.1903
Base	7	43	Live	LinStatic			0.1602	0.8336	32.6321	-0.8123	0.1561	0
Base	7	43	Modal	LinModEigen	Mode	1	0	-0.7595	-1.1819	1.6279	0	0
Base	7	43	Modal	LinModEigen	Mode	2	0.998	0	-0.2563	0	1.8781	0
Base	7	43	Modal	LinModEigen	Mode	3	-0.8532	-0.2795	-0.1823	0.5849	-1.5813	-0.2641
Base	7	43	Modal	LinModEigen	Mode	4	0	3.4099	-1.7892	-5.0837	0	0
Base	7	43	Modal	LinModEigen	Mode	5	-3.5461	0	-0.2776	0	-5.2073	0
Base	7	43	Modal	LinModEigen	Mode	6	2.8513	1.1446	-0.3701	-1.7004	4.1826	0.4944
Base	7	43	Ex	LinStatic			-25.3463	0	6.1542	0	-47.2626	0
Base	7	43	Ey	LinStatic			0	-21.1757	-30.5975	44.6474	0	0
Base	7	43	Wx	LinStatic			-2.15	0	0.4184	0	-3.8811	0
Base	7	43	Wy	LinStatic			0	-2.6042	-2.8694	5.2105	0	0
Base	8	44	Dead	LinStatic			-3.3896	-4.6654	321.0935	5.7588	-6.6501	-1.1903
Base	8	44	Live	LinStatic			0.3118	0	67.1549	0	0.3039	0
Base	8	44	Modal	LinModEigen	Mode	1	0	-0.946	0	1.8096	0	0
Base	8	44	Modal	LinModEigen	Mode	2	0.998	0	-0.2563	0	1.8781	0
Base	8	44	Modal	LinModEigen	Mode	3	0	-0.344	0	0.6477	0	-0.2641
Base	8	44	Modal	LinModEigen	Mode	4	0	3.5804	0	-5.2499	0	0
Base	8	44	Modal	LinModEigen	Mode	5	-3.5461	0	-0.2776	0	-5.2073	0
Base	8	44	Modal	LinModEigen	Mode	6	0	1.1971	0	-1.7516	0	0.4944
Base	8	44	Ex	LinStatic			-25.3463	0	6.1542	0	-47.2626	0
Base	8	44	Ey	LinStatic			0	-26.153	0	49.4973	0	0
Base	8	44	Wx	LinStatic			-2.15	0	0.4184	0	-3.8811	0
Base	8	44	Wy	LinStatic			0	-3.1323	0	5.7252	0	0
Base	9	45	Dead	LinStatic			-3.1222	-6.8632	218.3211	7.9004	-5.8491	-1.1903
Base	9	45	Live	LinStatic			0.1602	-0.8336	32.6321	0.8123	0.1561	0
Base	9	45	Modal	LinModEigen	Mode	1	0	-0.7595	1.1819	1.6279	0	0
Base	9	45	Modal	LinModEigen	Mode	2	0.998	0	-0.2563	0	1.8781	0
Base	9	45	Modal	LinModEigen	Mode	3	0.8532	-0.2795	0.1823	0.5849	1.5813	-0.2641
Base	9	45	Modal	LinModEigen	Mode	4	0	3.4099	1.7892	-5.0837	0	0
Base	9	45	Modal	LinModEigen	Mode	5	-3.5461	0	-0.2776	0	-5.2073	0
Base	9	45	Modal	LinModEigen	Mode	6	-2.8513	1.1446	0.3701	-1.7004	-4.1826	0.4944
Base	9	45	Ex	LinStatic			-25.3463	0	6.1542	0	-47.2626	0
Base	9	45	Ey	LinStatic			0	-21.1757	30.5975	44.6474	0	0
Base	9	45	Wx	LinStatic			-2.15	0	0.4184	0	-3.8811	0
Base	9	45	Wy	LinStatic			0	-2.6042	2.8694	5.2105	0	0
Base	10	46	Dead	LinStatic			-6.0857	-2.5038	159.6735	4.193	-9.8176	-1.1903
Base	10	46	Live	LinStatic			-0.4334	0.4341	17.6072	-0.423	-0.4223	0
Base	10	46	Modal	LinModEigen	Mode	1	0	-0.7595	-1.1819	1.6279	0	0
Base	10	46	Modal	LinModEigen	Mode	2	0.7933	0	-1.159	0	1.6787	0
Base	10	46	Modal	LinModEigen	Mode	3	-0.6931	-0.9724	-0.3953	2.01	-1.4253	-0.2641
Base	10	46	Modal	LinModEigen	Mode	4	0	3.4099	-1.7892	-5.0837	0	0
Base	10	46	Modal	LinModEigen	Mode	5	-3.4044	0	-1.801	0	-5.0692	0
Base	10	46	Modal	LinModEigen	Mode	6	2.765	3.9066	-0.6169	-5.796	4.0985	0.4944
Base	10	46	Ex	LinStatic			-20.3233	0	27.6693	0	-42.3683	0
Base	10	46	Ey	LinStatic			0	-21.1757	-30.5975	44.6474	0	0
Base	10	46	Wx	LinStatic			-1.775	0	1.8306	0	-3.5157	0
Base	10	46	Wy	LinStatic			0	-2.6042	-2.8694	5.2105	0	0
Base	11	47	Dead	LinStatic			-6.5195	-5.2642	233.5227	6.8828	-9.6998	-1.1903
Base	11	47	Live	LinStatic			-0.845	0	36.3664	0	-0.8233	0
Base	11	47	Modal	LinModEigen	Mode	1	0	-0.946	0	1.8096	0	0
Base	11	47	Modal	LinModEigen	Mode	2	0.7933	0	-1.159	0	1.6787	0
Base	11	47	Modal	LinModEigen	Mode	3	0	-1.1841	0	2.2163	0	-0.2641
Base	11	47	Modal	LinModEigen	Mode	4	0	3.5804	0	-5.2499	0	0
Base	11	47	Modal	LinModEigen	Mode	5	-3.4044	0	-1.801	0	-5.0692	0
Base	11	47	Modal	LinModEigen	Mode	6	0	4.0658	0	-5.9511	0	0.4944
Base	11	47	Ex	LinStatic			-20.3233	0	27.6693	0	-42.3683	0
Base	11	47	Ey	LinStatic			0	-26.153	0	49.4973	0	0
Base	11	47	Wx	LinStatic			-1.775	0	1.8306	0	-3.5157	0
Base	11	47	Wy	LinStatic			0	-3.1323	0	5.7252	0	0
Base	12	48	Dead	LinStatic			-5.1016	-6.4563	166.3716	8.0443	-7.7778	-1.1903
Base	12	48	Live	LinStatic			-0.4334	-0.4341	17.6072	0.423	-0.4223	0
Base	12	48	Modal	LinModEigen	Mode	1	0	-0.7595	1.1819	1.6279	0	0
Base	12	48	Modal	LinModEigen	Mode	2	0.7933	0	-1.159	0	1.6787	0
Base	12	48	Modal	LinModEigen	Mode	3	0.6931	-0.9724	0.3953	2.01	1.4253	-0.2641
Base	12	48	Modal	LinModEigen	Mode	4	0	3.4099	1.7892	-5.0837	0	0
Base	12	48	Modal	LinModEigen	Mode	5	-3.4044	0	-1.801	0	-5.0692	0
Base	12	48	Modal	LinModEigen	Mode	6	-2.765	3.9066	0.6169	-5.796	-4.0985	0.4944
Base	12	48	Ex	LinStatic			-20.3233	0	27.6693	0	-42.3683	0
Base	12	48	Ey	LinStatic			0	-21.1757	30.5975	44.6474	0	0
Base	12	48	Wx	LinStatic			-1.775	0	1.8306	0	-3.5157	0
Base	12	48	Wy	LinStatic			0	-2.6042	2.8694	5.2105	0	0

Drift shall be caused by the accumulated deformations of each member, such as a beam, column, or shear wall. Lateral forces due to wind or seismic loading must be considered for tall building design along with gravity forces and vertical loads. For the amount of permissible drift, the appendix suggests an overall building limit between h/400 and h/600 (where h = building height in feet), or a single-story limit for inter-story drift of 0.4 inches to limit damage to non-structural components (Table 35-36).

Table 35. *Joint drifts in Story 1*

Story	Label	Unique Name	Output Case	Case Type	Step Type	Step Number	Disp X	Disp Y	Drift X	Drift Y
							mm	mm		
Story1	1	15	Dead	LinStatic			0.297	0.169	0.000099	0.000056
Story1	1	15	Live	LinStatic			0	0	0	0
Story1	1	15	Modal	LinModEigen	Mode	1	0	0.068	0	0.000023
Story1	1	15	Modal	LinModEigen	Mode	2	-0.07	0	0.000023	0
Story1	1	15	Modal	LinModEigen	Mode	3	0.058	-0.082	0.000019	0.000027
Story1	1	15	Modal	LinModEigen	Mode	4	0	-0.136	0	0.000045
Story1	1	15	Modal	LinModEigen	Mode	5	0.135	0	0.000045	0
Story1	1	15	Modal	LinModEigen	Mode	6	-0.108	0.153	0.000036	0.000051
Story1	1	15	Ex	LinStatic			1.738	0	0.000579	0
Story1	1	15	Ey	LinStatic			0	1.85	0	0.000617
Story1	1	15	Wx	LinStatic			0.138	0	0.000046	0
Story1	1	15	Wy	LinStatic			0	0.206	0	0.000069
Story1	2	16	Dead	LinStatic			0.256	0.169	0.000085	0.000056
Story1	2	16	Live	LinStatic			0	0	0	0
Story1	2	16	Modal	LinModEigen	Mode	1	0	0.068	0	0.000023
Story1	2	16	Modal	LinModEigen	Mode	2	-0.07	0	0.000023	0
Story1	2	16	Modal	LinModEigen	Mode	3	0	-0.082	0	0.000027
Story1	2	16	Modal	LinModEigen	Mode	4	0	-0.136	0	0.000045
Story1	2	16	Modal	LinModEigen	Mode	5	0.135	0	0.000045	0
Story1	2	16	Modal	LinModEigen	Mode	6	0	0.153	0	0.000051
Story1	2	16	Ex	LinStatic			1.738	0	0.000579	0
Story1	2	16	Ey	LinStatic			0	1.85	0	0.000617
Story1	2	16	Wx	LinStatic			0.138	0	0.000046	0
Story1	2	16	Wy	LinStatic			0	0.206	0	0.000069
Story1	3	18	Dead	LinStatic			0.214	0.169	0.000071	0.000056
Story1	3	18	Live	LinStatic			0	0	0	0
Story1	3	18	Modal	LinModEigen	Mode	1	0	0.068	0	0.000023
Story1	3	18	Modal	LinModEigen	Mode	2	-0.07	0	0.000023	0
Story1	3	18	Modal	LinModEigen	Mode	3	-0.058	-0.082	0.000019	0.000027
Story1	3	18	Modal	LinModEigen	Mode	4	0	-0.136	0	0.000045
Story1	3	18	Modal	LinModEigen	Mode	5	0.135	0	0.000045	0
Story1	3	18	Modal	LinModEigen	Mode	6	0.108	0.153	0.000036	0.000051
Story1	3	18	Ex	LinStatic			1.738	0	0.000579	0
Story1	3	18	Ey	LinStatic			0	1.85	0	0.000617
Story1	3	18	Wx	LinStatic			0.138	0	0.000046	0
Story1	3	18	Wy	LinStatic			0	0.206	0	0.000069
Story1	4	21	Dead	LinStatic			0.297	0.211	0.000099	0.00007
Story1	4	21	Live	LinStatic			0	0	0	0
Story1	4	21	Modal	LinModEigen	Mode	1	0	0.068	0	0.000023
Story1	4	21	Modal	LinModEigen	Mode	2	-0.07	0	0.000023	0
Story1	4	21	Modal	LinModEigen	Mode	3	0.058	-0.024	0.000019	0.000008
Story1	4	21	Modal	LinModEigen	Mode	4	0	-0.136	0	0.000045
Story1	4	21	Modal	LinModEigen	Mode	5	0.135	0	0.000045	0
Story1	4	21	Modal	LinModEigen	Mode	6	-0.108	0.045	0.000036	0.000015
Story1	4	21	Ex	LinStatic			1.738	0	0.000579	0
Story1	4	21	Ey	LinStatic			0	1.85	0	0.000617
Story1	4	21	Wx	LinStatic			0.138	0	0.000046	0
Story1	4	21	Wy	LinStatic			0	0.206	0	0.000069
Story1	5	22	Dead	LinStatic			0.256	0.211	0.000085	0.00007
Story1	5	22	Live	LinStatic			0	0	0	0
Story1	5	22	Modal	LinModEigen	Mode	1	0	0.068	0	0.000023
Story1	5	22	Modal	LinModEigen	Mode	2	-0.07	0	0.000023	0
Story1	5	22	Modal	LinModEigen	Mode	3	0	-0.024	0	0.000008
Story1	5	22	Modal	LinModEigen	Mode	4	0	-0.136	0	0.000045
Story1	5	22	Modal	LinModEigen	Mode	5	0.135	0	0.000045	0
Story1	5	22	Modal	LinModEigen	Mode	6	0	0.045	0	0.000015
Story1	5	22	Ex	LinStatic			1.738	0	0.000579	0
Story1	5	22	Ey	LinStatic			0	1.85	0	0.000617
Story1	5	22	Wx	LinStatic			0.138	0	0.000046	0
Story1	5	22	Wy	LinStatic			0	0.206	0	0.000069
Story1	6	24	Dead	LinStatic			0.214	0.211	0.000071	0.00007
Story1	6	24	Live	LinStatic			0	0	0	0
Story1	6	24	Modal	LinModEigen	Mode	1	0	0.068	0	0.000023
Story1	6	24	Modal	LinModEigen	Mode	2	-0.07	0	0.000023	0
Story1	6	24	Modal	LinModEigen	Mode	3	-0.058	-0.024	0.000019	0.000008
Story1	6	24	Modal	LinModEigen	Mode	4	0	-0.136	0	0.000045
Story1	6	24	Modal	LinModEigen	Mode	5	0.135	0	0.000045	0
Story1	6	24	Modal	LinModEigen	Mode	6	0.108	0.045	0.000036	0.000015
Story1	6	24	Ex	LinStatic			1.738	0	0.000579	0
Story1	6	24	Ey	LinStatic			0	1.85	0	0.000617
Story1	6	24	Wx	LinStatic			0.138	0	0.000046	0
Story1	6	24	Wy	LinStatic			0	0.206	0	0.000069
Story1	7	27	Dead	LinStatic			0.297	0.245	0.000099	0.000082
Story1	7	27	Live	LinStatic			0	0	0	0
Story1	7	27	Modal	LinModEigen	Mode	1	0	0.068	0	0.000023
Story1	7	27	Modal	LinModEigen	Mode	2	-0.07	0	0.000023	0
Story1	7	27	Modal	LinModEigen	Mode	3	0.058	0.024	0.000019	0.000008
Story1	7	27	Modal	LinModEigen	Mode	4	0	-0.136	0	0.000045
Story1	7	27	Modal	LinModEigen	Mode	5	0.135	0	0.000045	0
Story1	7	27	Modal	LinModEigen	Mode	6	-0.108	-0.045	0.000036	0.000015
Story1	7	27	Ex	LinStatic			1.738	0	0.000579	0
Story1	7	27	Ey	LinStatic			0	1.85	0	0.000617
Story1	7	27	Wx	LinStatic			0.138	0	0.000046	0
Story1	7	27	Wy	LinStatic			0	0.206	0	0.000069
Story1	8	28	Dead	LinStatic			0.256	0.245	0.000085	0.000082
Story1	8	28	Live	LinStatic			0	0	0	0
Story1	8	28	Modal	LinModEigen	Mode	1	0	0.068	0	0.000023
Story1	8	28	Modal	LinModEigen	Mode	2	-0.07	0	0.000023	0
Story1	8	28	Modal	LinModEigen	Mode	3	0	0.024	0	0.000008
Story1	8	28	Modal	LinModEigen	Mode	4	0	-0.136	0	0.000045
Story1	8	28	Modal	LinModEigen	Mode	5	0.135	0	0.000045	0
Story1	8	28	Modal	LinModEigen	Mode	6	0	-0.045	0	0.000015
Story1	8	28	Ex	LinStatic			1.738	0	0.000579	0
Story1	8	28	Ey	LinStatic			0	1.85	0	0.000617
Story1	8	28	Wx	LinStatic			0.138	0	0.000046	0
Story1	8	28	Wy	LinStatic			0	0.206	0	0.000069
Story1	9	30	Dead	LinStatic			0.214	0.245	0.000071	0.000082
Story1	9	30	Live	LinStatic			0	0	0	0
Story1	9	30	Modal	LinModEigen	Mode	1	0	0.068	0	0.000023
Story1	9	30	Modal	LinModEigen	Mode	2	-0.07	0	0.000023	0
Story1	9	30	Modal	LinModEigen	Mode	3	-0.058	0.024	0.000019	0.000008
Story1	9	30	Modal	LinModEigen	Mode	4	0	-0.136	0	0.000045
Story1	9	30	Modal	LinModEigen	Mode	5	0.135	0	0.000045	0
Story1	9	30	Modal	LinModEigen	Mode	6	0.108	-0.045	0.000036	0.000015
Story1	9	30	Ex	LinStatic			1.738	0	0.000579	0
Story1	9	30	Ey	LinStatic			0	1.85	0	0.000617
Story1	9	30	Wx	LinStatic			0.138	0	0.000046	0
Story1	9	30	Wy	LinStatic			0	0.206	0	0.000069
Story1	10	33	Dead	LinStatic			0.297	0.287	0.000099	0.000096
Story1	10	33	Live	LinStatic			0	0	0	0
Story1	10	33	Modal	LinModEigen	Mode	1	0	0.068	0	0.000023
Story1	10	33	Modal	LinModEigen	Mode	2	-0.07	0	0.000023	0
Story1	10	33	Modal	LinModEigen	Mode	3	0.058	0.082	0.000019	0.000027
Story1	10	33	Modal	LinModEigen	Mode	4	0	-0.136	0	0.000045
Story1	10	33	Modal	LinModEigen	Mode	5	0.135	0	0.000045	0
Story1	10	33	Modal	LinModEigen	Mode	6	-0.108	-0.153	0.000036	0.000051
Story1	10	33	Ex	LinStatic			1.738	0	0.000579	0
Story1	10	33	Ey	LinStatic			0	1.85	0	0.000617
Story1	10	33	Wx	LinStatic			0.138	0	0.000046	0
Story1	10	33	Wy	LinStatic			0	0.206	0	0.000069
Story1	11	34	Dead	LinStatic			0.256	0.287	0.000085	0.000096
Story1	11	34	Live	LinStatic			0	0	0	0
Story1	11	34	Modal	LinModEigen	Mode	1	0	0.068	0	0.000023
Story1	11	34	Modal	LinModEigen	Mode	2	-0.07	0	0.000023	0
Story1	11	34	Modal	LinModEigen	Mode	3	0	0.082	0	0.000027
Story1	11	34	Modal	LinModEigen	Mode	4	0	-0.136	0	0.000045
Story1	11	34	Modal	LinModEigen	Mode	5	0.135	0	0.000045	0
Story1	11	34	Modal	LinModEigen	Mode	6	0	-0.153	0	0.000051
Story1	11	34	Ex	LinStatic			1.738	0	0.000579	0
Story1	11	34	Ey	LinStatic			0	1.85	0	0.000617
Story1	11	34	Wx	LinStatic			0.138	0	0.000046	0
Story1	11	34	Wy	LinStatic			0	0.206	0	0.000069
Story1	12	36	Dead	LinStatic			0.214	0.287	0.000071	0.000096
Story1	12	36	Live	LinStatic			0	0	0	0
Story1	12	36	Modal	LinModEigen	Mode	1	0	0.068	0	0.000023
Story1	12	36	Modal	LinModEigen	Mode	2	-0.07	0	0.000023	0
Story1	12	36	Modal	LinModEigen	Mode	3	-0.058	0.082	0.000019	0.000027
Story1	12	36	Modal	LinModEigen	Mode	4	0	-0.136	0	0.000045
Story1	12	36	Modal	LinModEigen	Mode	5	0.135	0	0.000045	0
Story1	12	36	Modal	LinModEigen	Mode	6	0.108	-0.153	0.000036	0.000051
Story1	12	36	Ex	LinStatic			1.738	0	0.000579	0
Story1	12	36	Ey	LinStatic			0	1.85	0	0.000617
Story1	12	36	Wx	LinStatic			0.138	0	0.000046	0
Story1	12	36	Wy	LinStatic			0	0.206	0	0.000069

Table 36. *Joint drifts in Story 2*

Story	Label	Unique Name	Output Case	Case Type	Step Type	Step Number	Disp X	Disp Y	Drift X	Drift Y
							mm	mm		
Story2	1	13	Dead	LinStatic			0.673	0.336	0.000125	0.000056
Story2	1	13	Live	LinStatic			0	0	0	0
Story2	1	13	Modal	LinModEigen	Mode	1	0	0.149	0	0.000027
Story2	1	13	Modal	LinModEigen	Mode	2	-0.148	0	0.000026	0
Story2	1	13	Modal	LinModEigen	Mode	3	0.12	-0.171	0.000021	0.00003
Story2	1	13	Modal	LinModEigen	Mode	4	0	0.075	0	0.00007
Story2	1	13	Modal	LinModEigen	Mode	5	-0.077	0	0.00007	0
Story2	1	13	Modal	LinModEigen	Mode	6	0.064	-0.091	0.000058	0.000081
Story2	1	13	Ex	LinStatic			3.581	0	0.000614	0
Story2	1	13	Ey	LinStatic			0	3.903	0	0.000684
Story2	1	13	Wx	LinStatic			0.251	0	0.000038	0
Story2	1	13	Wy	LinStatic			0	0.386	0	0.00006
Story2	2	14	Dead	LinStatic			0.585	0.336	0.00011	0.000056
Story2	2	14	Live	LinStatic			0	0	0	0
Story2	2	14	Modal	LinModEigen	Mode	1	0	0.149	0	0.000027
Story2	2	14	Modal	LinModEigen	Mode	2	-0.148	0	0.000026	0
Story2	2	14	Modal	LinModEigen	Mode	3	0	-0.171	0	0.00003
Story2	2	14	Modal	LinModEigen	Mode	4	0	0.075	0	0.00007
Story2	2	14	Modal	LinModEigen	Mode	5	-0.077	0	0.00007	0
Story2	2	14	Modal	LinModEigen	Mode	6	0	-0.091	0	0.000081
Story2	2	14	Ex	LinStatic			3.581	0	0.000614	0
Story2	2	14	Ey	LinStatic			0	3.903	0	0.000684
Story2	2	14	Wx	LinStatic			0.251	0	0.000038	0
Story2	2	14	Wy	LinStatic			0	0.386	0	0.00006
Story2	3	17	Dead	LinStatic			0.496	0.336	0.000094	0.000056
Story2	3	17	Live	LinStatic			0	0	0	0
Story2	3	17	Modal	LinModEigen	Mode	1	0	0.149	0	0.000027
Story2	3	17	Modal	LinModEigen	Mode	2	-0.148	0	0.000026	0
Story2	3	17	Modal	LinModEigen	Mode	3	-0.12	-0.171	0.000021	0.00003
Story2	3	17	Modal	LinModEigen	Mode	4	0	0.075	0	0.00007
Story2	3	17	Modal	LinModEigen	Mode	5	-0.077	0	0.00007	0
Story2	3	17	Modal	LinModEigen	Mode	6	-0.064	-0.091	0.000058	0.000081
Story2	3	17	Ex	LinStatic			3.581	0	0.000614	0
Story2	3	17	Ey	LinStatic			0	3.903	0	0.000684
Story2	3	17	Wx	LinStatic			0.251	0	0.000038	0
Story2	3	17	Wy	LinStatic			0	0.386	0	0.00006
Story2	4	19	Dead	LinStatic			0.673	0.424	0.000125	0.000071
Story2	4	19	Live	LinStatic			0	0	0	0
Story2	4	19	Modal	LinModEigen	Mode	1	0	0.149	0	0.000027
Story2	4	19	Modal	LinModEigen	Mode	2	-0.148	0	0.000026	0
Story2	4	19	Modal	LinModEigen	Mode	3	0.12	-0.05	0.000021	0.000009
Story2	4	19	Modal	LinModEigen	Mode	4	0	0.075	0	0.00007
Story2	4	19	Modal	LinModEigen	Mode	5	-0.077	0	0.00007	0
Story2	4	19	Modal	LinModEigen	Mode	6	0.064	-0.027	0.000058	0.000024
Story2	4	19	Ex	LinStatic			3.581	0	0.000614	0
Story2	4	19	Ey	LinStatic			0	3.903	0	0.000684
Story2	4	19	Wx	LinStatic			0.251	0	0.000038	0
Story2	4	19	Wy	LinStatic			0	0.386	0	0.00006
Story2	5	20	Dead	LinStatic			0.585	0.424	0.00011	0.000071
Story2	5	20	Live	LinStatic			0	0	0	0
Story2	5	20	Modal	LinModEigen	Mode	1	0	0.149	0	0.000027
Story2	5	20	Modal	LinModEigen	Mode	2	-0.148	0	0.000026	0
Story2	5	20	Modal	LinModEigen	Mode	3	0	-0.05	0	0.000009
Story2	5	20	Modal	LinModEigen	Mode	4	0	0.075	0	0.00007
Story2	5	20	Modal	LinModEigen	Mode	5	-0.077	0	0.00007	0
Story2	5	20	Modal	LinModEigen	Mode	6	0	-0.027	0	0.000024
Story2	5	20	Ex	LinStatic			3.581	0	0.000614	0
Story2	5	20	Ey	LinStatic			0	3.903	0	0.000684
Story2	5	20	Wx	LinStatic			0.251	0	0.000038	0
Story2	5	20	Wy	LinStatic			0	0.386	0	0.00006
Story2	6	23	Dead	LinStatic			0.496	0.424	0.000094	0.000071
Story2	6	23	Live	LinStatic			0	0	0	0
Story2	6	23	Modal	LinModEigen	Mode	1	0	0.149	0	0.000027
Story2	6	23	Modal	LinModEigen	Mode	2	-0.148	0	0.000026	0
Story2	6	23	Modal	LinModEigen	Mode	3	-0.12	-0.05	0.000021	0.000009
Story2	6	23	Modal	LinModEigen	Mode	4	0	0.075	0	0.00007
Story2	6	23	Modal	LinModEigen	Mode	5	-0.077	0	0.00007	0
Story2	6	23	Modal	LinModEigen	Mode	6	-0.064	-0.027	0.000058	0.000024
Story2	6	23	Ex	LinStatic			3.581	0	0.000614	0
Story2	6	23	Ey	LinStatic			0	3.903	0	0.000684
Story2	6	23	Wx	LinStatic			0.251	0	0.000038	0
Story2	6	23	Wy	LinStatic			0	0.386	0	0.00006
Story2	7	25	Dead	LinStatic			0.673	0.498	0.000125	0.000084
Story2	7	25	Live	LinStatic			0	0	0	0
Story2	7	25	Modal	LinModEigen	Mode	1	0	0.149	0	0.000027
Story2	7	25	Modal	LinModEigen	Mode	2	-0.148	0	0.000026	0
Story2	7	25	Modal	LinModEigen	Mode	3	0.12	0.05	0.000021	0.000009
Story2	7	25	Modal	LinModEigen	Mode	4	0	0.075	0	0.00007
Story2	7	25	Modal	LinModEigen	Mode	5	-0.077	0	0.00007	0
Story2	7	25	Modal	LinModEigen	Mode	6	0.064	0.027	0.000058	0.000024
Story2	7	25	Ex	LinStatic			3.581	0	0.000614	0
Story2	7	25	Ey	LinStatic			0	3.903	0	0.000684
Story2	7	25	Wx	LinStatic			0.251	0	0.000038	0
Story2	7	25	Wy	LinStatic			0	0.386	0	0.00006
Story2	8	26	Dead	LinStatic			0.585	0.498	0.00011	0.000084
Story2	8	26	Live	LinStatic			0	0	0	0
Story2	8	26	Modal	LinModEigen	Mode	1	0	0.149	0	0.000027
Story2	8	26	Modal	LinModEigen	Mode	2	-0.148	0	0.000026	0
Story2	8	26	Modal	LinModEigen	Mode	3	0	0.05	0	0.000009
Story2	8	26	Modal	LinModEigen	Mode	4	0	0.075	0	0.00007
Story2	8	26	Modal	LinModEigen	Mode	5	-0.077	0	0.00007	0
Story2	8	26	Modal	LinModEigen	Mode	6	0	0.027	0	0.000024
Story2	8	26	Ex	LinStatic			3.581	0	0.000614	0
Story2	8	26	Ey	LinStatic			0	3.903	0	0.000684
Story2	8	26	Wx	LinStatic			0.251	0	0.000038	0
Story2	8	26	Wy	LinStatic			0	0.386	0	0.00006
Story2	9	29	Dead	LinStatic			0.496	0.498	0.000094	0.000084
Story2	9	29	Live	LinStatic			0	0	0	0
Story2	9	29	Modal	LinModEigen	Mode	1	0	0.149	0	0.000027
Story2	9	29	Modal	LinModEigen	Mode	2	-0.148	0	0.000026	0
Story2	9	29	Modal	LinModEigen	Mode	3	-0.12	0.05	0.000021	0.000009
Story2	9	29	Modal	LinModEigen	Mode	4	0	0.075	0	0.00007
Story2	9	29	Modal	LinModEigen	Mode	5	-0.077	0	0.00007	0
Story2	9	29	Modal	LinModEigen	Mode	6	-0.064	0.027	0.000058	0.000024
Story2	9	29	Ex	LinStatic			3.581	0	0.000614	0
Story2	9	29	Ey	LinStatic			0	3.903	0	0.000684
Story2	9	29	Wx	LinStatic			0.251	0	0.000038	0
Story2	9	29	Wy	LinStatic			0	0.386	0	0.00006
Story2	10	31	Dead	LinStatic			0.673	0.586	0.000125	0.0001
Story2	10	31	Live	LinStatic			0	0	0	0
Story2	10	31	Modal	LinModEigen	Mode	1	0	0.149	0	0.000027
Story2	10	31	Modal	LinModEigen	Mode	2	-0.148	0	0.000026	0
Story2	10	31	Modal	LinModEigen	Mode	3	0.12	0.171	0.000021	0.00003
Story2	10	31	Modal	LinModEigen	Mode	4	0	0.075	0	0.00007
Story2	10	31	Modal	LinModEigen	Mode	5	-0.077	0	0.00007	0
Story2	10	31	Modal	LinModEigen	Mode	6	0.064	0.091	0.000058	0.000081
Story2	10	31	Ex	LinStatic			3.581	0	0.000614	0
Story2	10	31	Ey	LinStatic			0	3.903	0	0.000684
Story2	10	31	Wx	LinStatic			0.251	0	0.000038	0
Story2	10	31	Wy	LinStatic			0	0.386	0	0.00006
Story2	11	32	Dead	LinStatic			0.585	0.586	0.00011	0.0001
Story2	11	32	Live	LinStatic			0	0	0	0
Story2	11	32	Modal	LinModEigen	Mode	1	0	0.149	0	0.000027
Story2	11	32	Modal	LinModEigen	Mode	2	-0.148	0	0.000026	0
Story2	11	32	Modal	LinModEigen	Mode	3	0	0.171	0	0.00003
Story2	11	32	Modal	LinModEigen	Mode	4	0	0.075	0	0.00007
Story2	11	32	Modal	LinModEigen	Mode	5	-0.077	0	0.00007	0
Story2	11	32	Modal	LinModEigen	Mode	6	0	0.091	0	0.000081
Story2	11	32	Ex	LinStatic			3.581	0	0.000614	0
Story2	11	32	Ey	LinStatic			0	3.903	0	0.000684
Story2	11	32	Wx	LinStatic			0.251	0	0.000038	0
Story2	11	32	Wy	LinStatic			0	0.386	0	0.00006
Story2	12	35	Dead	LinStatic			0.496	0.586	0.000094	0.0001
Story2	12	35	Live	LinStatic			0	0	0	0
Story2	12	35	Modal	LinModEigen	Mode	1	0	0.149	0	0.000027
Story2	12	35	Modal	LinModEigen	Mode	2	-0.148	0	0.000026	0
Story2	12	35	Modal	LinModEigen	Mode	3	-0.12	0.171	0.000021	0.00003
Story2	12	35	Modal	LinModEigen	Mode	4	0	0.075	0	0.00007
Story2	12	35	Modal	LinModEigen	Mode	5	-0.077	0	0.00007	0
Story2	12	35	Modal	LinModEigen	Mode	6	-0.064	0.091	0.000058	0.000081
Story2	12	35	Ex	LinStatic			3.581	0	0.000614	0
Story2	12	35	Ey	LinStatic			0	3.903	0	0.000684
Story2	12	35	Wx	LinStatic			0.251	0	0.000038	0
Story2	12	35	Wy	LinStatic			0	0.386	0	0.00006

Story displacement means the displacement that occurred at each story level. In multi-storied buildings, maximum storey displacement will be observed at the top stories. As the height increases, the story displacement will have maximum value (Table 37).

Table 37. *Story max over average Displacements*

Story	Output Case	Case Type	Step Type	Step Number	Direction	Maximum	Average	Ratio
						mm	mm	
Story2	Dead	LinStatic			X	0.673	0.585	1.151
Story2	Dead	LinStatic			Y	0.586	0.461	1.271
Story1	Dead	LinStatic			X	0.297	0.256	1.163
Story1	Dead	LinStatic			Y	0.287	0.228	1.258
Story2	Live	LinStatic			X	0	0	1.173
Story2	Live	LinStatic			Y	0	0	1.092
Story1	Live	LinStatic			X	0	0	1.179
Story1	Live	LinStatic			Y	0	0	1.094
Story2	Modal	LinModEigen	Mode	1	Y	0.149	0.149	1
Story1	Modal	LinModEigen	Mode	1	Y	0.068	0.068	1
Story2	Modal	LinModEigen	Mode	2	X	0.148	0.148	1
Story1	Modal	LinModEigen	Mode	2	X	0.07	0.07	1
Story2	Modal	LinModEigen	Mode	3	X	0.12	0	2.663E+13
Story2	Modal	LinModEigen	Mode	3	Y	0.171	0	1.706E+13
Story1	Modal	LinModEigen	Mode	3	X	0.058	0	2.686E+13
Story1	Modal	LinModEigen	Mode	3	Y	0.082	0	1.768E+13
Story2	Modal	LinModEigen	Mode	4	Y	0.075	0.075	1
Story1	Modal	LinModEigen	Mode	4	Y	0.136	0.136	1
Story2	Modal	LinModEigen	Mode	5	X	0.077	0.077	1
Story1	Modal	LinModEigen	Mode	5	X	0.135	0.135	1
Story2	Modal	LinModEigen	Mode	6	X	0.064	0	2.727E+14
Story2	Modal	LinModEigen	Mode	6	Y	0.091	0	1.354E+14
Story1	Modal	LinModEigen	Mode	6	X	0.108	0	2.514E+14
Story1	Modal	LinModEigen	Mode	6	Y	0.153	0	1.346E+14
Story2	Ex	LinStatic			X	3.581	3.581	1
Story1	Ex	LinStatic			X	1.738	1.738	1
Story2	Ey	LinStatic			Y	3.903	3.903	1
Story1	Ey	LinStatic			Y	1.85	1.85	1
Story2	Wx	LinStatic			X	0.251	0.251	1
Story1	Wx	LinStatic			X	0.138	0.138	1
Story2	Wy	LinStatic			Y	0.386	0.386	1
Story1	Wy	LinStatic			Y	0.206	0.206	1

The centre of mass is the point where the entire mass of the floor acts, and the centre of rigidity is the point where the entire stiffness of the building acts. The centre of rigidity is the stiffness centroid within a floor-diaphragm plan. When the centre of rigidity is subjected to lateral loading, the floor diaphragm will experience only translational displacement. Other levels are free to translate and rotate since behaviour is coupled both in plan and along height (Table 38).

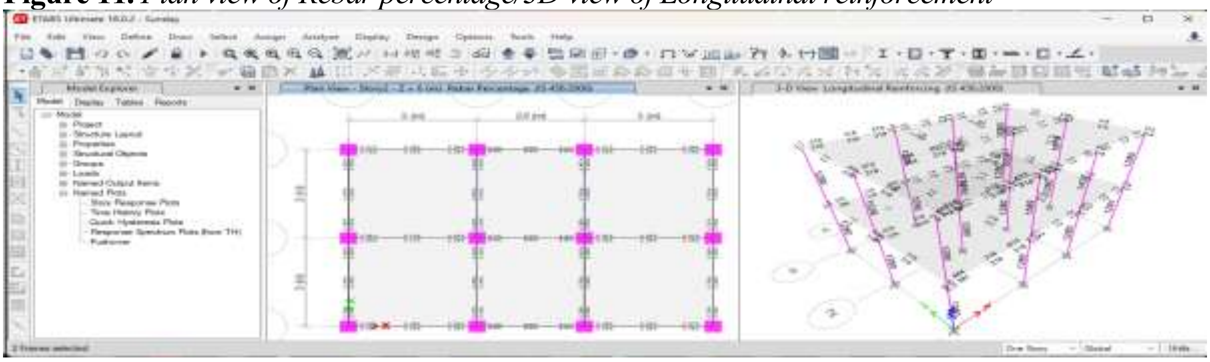
Table 38. *Diaphragm Centre of Mass Displacements*

Story	Diaphragm	Output Case	Case Type	Step Type	Step Number	UX	UY	RZ	Point	X	Y	Z
						mm	mm	rad		m	m	m
Story2	D1	Dead	LinStatic			0.585	0.461	0.000029	1	4.25	3	6
Story2	D1	Live	LinStatic			0	0	0	1	4.25	3	6
Story2	D1	Modal	LinModEigen	Mode	1	0	0.149	0	1	4.25	3	6
Story2	D1	Modal	LinModEigen	Mode	2	-0.148	0	0	1	4.25	3	6
Story2	D1	Modal	LinModEigen	Mode	3	0	0	0.00004	1	4.25	3	6
Story2	D1	Modal	LinModEigen	Mode	4	0	0.075	0	1	4.25	3	6
Story2	D1	Modal	LinModEigen	Mode	5	-0.077	0	0	1	4.25	3	6
Story2	D1	Modal	LinModEigen	Mode	6	0	0	0.000021	1	4.25	3	6
Story2	D1	Ex	LinStatic			3.581	0	0	1	4.25	3	6
Story2	D1	Ey	LinStatic			0	3.903	0	1	4.25	3	6
Story2	D1	Wx	LinStatic			0.251	0	0	1	4.25	3	6
Story2	D1	Wy	LinStatic			0	0.386	0	1	4.25	3	6
Story1	D1	Dead	LinStatic			0.256	0.228	0.000014	2	4.25	3	3
Story1	D1	Live	LinStatic			0	0	0	2	4.25	3	3
Story1	D1	Modal	LinModEigen	Mode	1	0	0.068	0	2	4.25	3	3
Story1	D1	Modal	LinModEigen	Mode	2	-0.07	0	0	2	4.25	3	3
Story1	D1	Modal	LinModEigen	Mode	3	0	0	0.000019	2	4.25	3	3
Story1	D1	Modal	LinModEigen	Mode	4	0	-0.136	0	2	4.25	3	3
Story1	D1	Modal	LinModEigen	Mode	5	0.135	0	0	2	4.25	3	3
Story1	D1	Modal	LinModEigen	Mode	6	0	0	-0.000036	2	4.25	3	3
Story1	D1	Ex	LinStatic			1.738	0	0	2	4.25	3	3
Story1	D1	Ey	LinStatic			0	1.85	0	2	4.25	3	3
Story1	D1	Wx	LinStatic			0.138	0	0	2	4.25	3	3
Story1	D1	Wy	LinStatic			0	0.206	0	2	4.25	3	3
Base	D1	Dead	LinStatic			0	0	0	3	4.25	3	0
Base	D1	Live	LinStatic			0	0	0	3	4.25	3	0
Base	D1	Modal	LinModEigen	Mode	1	0	0	0	3	4.25	3	0
Base	D1	Modal	LinModEigen	Mode	2	0	0	0	3	4.25	3	0
Base	D1	Modal	LinModEigen	Mode	3	0	0	0	3	4.25	3	0
Base	D1	Modal	LinModEigen	Mode	4	0	0	0	3	4.25	3	0
Base	D1	Modal	LinModEigen	Mode	5	0	0	0	3	4.25	3	0
Base	D1	Modal	LinModEigen	Mode	6	0	0	0	3	4.25	3	0
Base	D1	Ex	LinStatic			0	0	0	3	4.25	3	0
Base	D1	Ey	LinStatic			0	0	0	3	4.25	3	0
Base	D1	Wx	LinStatic			0	0	0	3	4.25	3	0
Base	D1	Wy	LinStatic			0	0	0	3	4.25	3	0

Results and Discussion

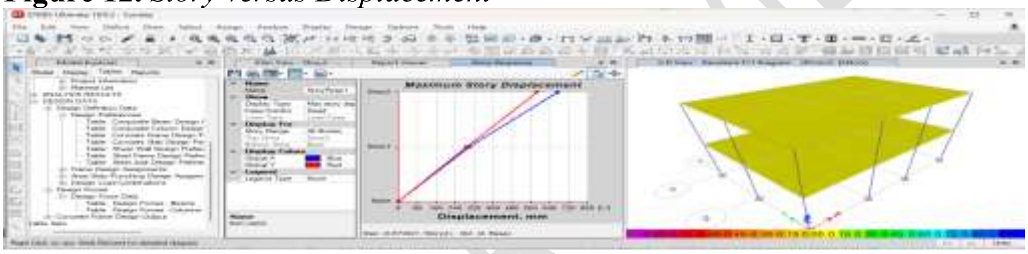
The present research attempted to design and analyse a (G+1) story-building as per the Indian standard code IS:456-2000 by ETABS software. In IS 456:2000 Clause 26, a requirement related to reinforcement used in RCC is given. In beams, the maximum percentage of steel is 4% of the gross area. In the column, the maximum % of steel is 4%. It is defined (story drift) as the ratio of the displacement of two consecutive floors to the height of that floor. It is a very important term used for research purposes in earthquake engineering. The story drifts in any story due to the minimum specified design lateral force, with a partial load factor of 1.0, which shall not exceed 0.004 times the story height. It is the total displacement of its story concerning ground and there is a maximum permissible limit prescribed in IS codes for buildings. The deflection at any point on the axis of the beam is the distance between its position before and after loading. Shear force is the force applied perpendicular to a surface, in opposition to an offset force acting in the opposite direction. This results in a shear strain. In simple terms, one part of the surface is pushed in one direction, while another part of the surface is pushed in the opposite direction. The bending moment is a measure of the bending effect that can occur when an external force or moment is applied to a structural element. This concept is important in structural engineering as it can be used to calculate where and how much bending may occur when forces are applied. As per IS 456:2000 in slabs per Clause 26.5. 2.1 Min reinforcement shall be 0.15% of the total cross-sectional area for mild steel bars and 0.12% of the total cross-sectional area for HYSD (Fe415) bars. Maximum tension and compression reinforcement for the beam is 4% of the total cross-sectional area of the beam. According to Clause 26.5. 3.1 of IS 456: 2000, the maximum longitudinal steel reinforcement for the column is 6 % of the gross column area. For very large columns, the minimum longitudinal steel reinforcement for the column is 0.8 % of the actual column area. It is observed in the present research work that the percentage of reinforcement value obtained from design and analysis was within the stipulated limits code value (Figure 11). Shear and moment diagrams are graphs that show the internal shear and bending moment plotted along the length of the beam. They allow us to see where the maximum loads occur so that it can optimise the design to prevent failures and reduce the overall weight and cost of the structure.

Figure 11. *Plan view of Rebar percentage/3D view of Longitudinal reinforcement*



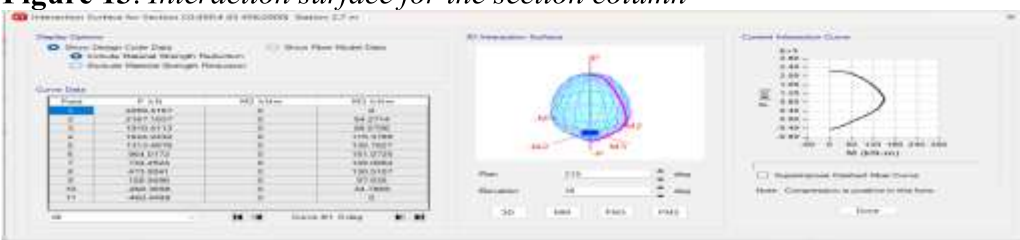
If movement (expansion and/or contraction) is restricted within a young concrete element, tensile stresses will develop, which will lead to cracking. This restriction on movement is normally referred to as restraint. Restraints may be internal or external to the element. It's possible to interpret the story for the displacement magnitude in any building structure for a given load condition, support condition, dynamic or static condition, as per the stipulated standard code. Story displacement is the deflection of a single story relative to the base or ground level of the structure. Intuitively, we can expect higher total displacement values as we move up the structure. Graph showing the story to displacement magnitude (dead load case) as represented in Figure 12. Story displacement was maximum for story 2 and minimum (zero) at the base of the story. Story displacement means the displacement that occurred at each story level. In multi-storied buildings, maximum storey displacement will be observed at the top stories. As the height increases, the storey displacement will have a maximum value.

Figure 12. *Story versus Displacement*



An interaction diagram in a column is a graph that shows a plot for the axial load P (KN) that a column could carry versus its moment capacity, M (KN-m). This diagram is very useful in analysing the strength of a column, which varies according to its loads and moments. The interaction surface for the section column (Figure 13) indicates Design code data (including material strength reduction), Axial load (-ve axial load, +ve axial load), and Moment (M2-ve/+ve, M3-ve/+ve). The P-M interaction curve indicates the capacity for P and M that reinforced concrete can resist. Vertical members of a building frame are subjected to combined axial loads and bending moments. These forces develop due to external loads like dead, live, and wind.

Figure 13. *Interaction surface for the section column*



The interaction surface for the section column (Figure 14) indicates Design code data (excluding material strength reduction), Axial load (-ve axial load, +ve axial load), and Moment (M2-ve/+ve, M3-ve/+ve). P-M interaction curve indicates the capacity for P and M that reinforced concrete can resist in case of dead load and live load. For the design of a column to be considered adequate (safe), the combination of action effects (M, P) must be less than the combination of design strengths (M, P) from the interaction curve. It's possible to represent the interaction surface for the section column in case of including material strength reduction and superimposed fibre curve as indicated in Figure 15-17.

Figure 14. *Interaction surface section column*

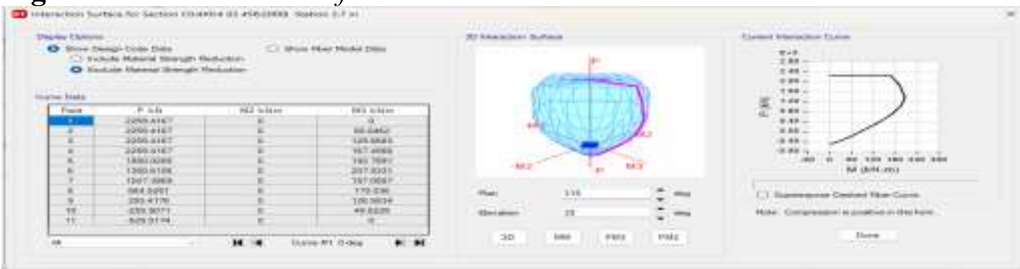


Figure 15. *Interaction surface for section column*

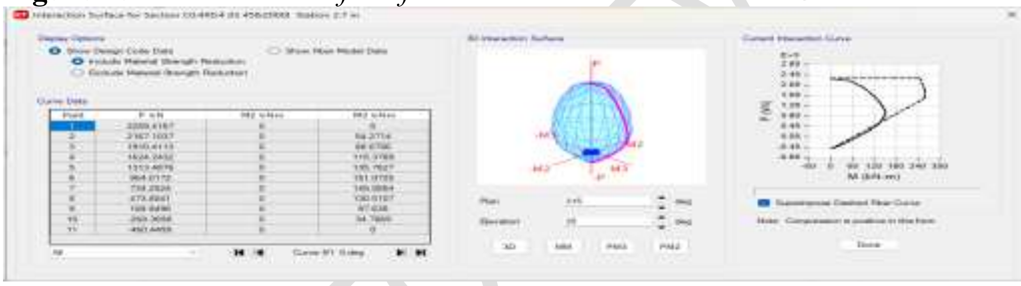
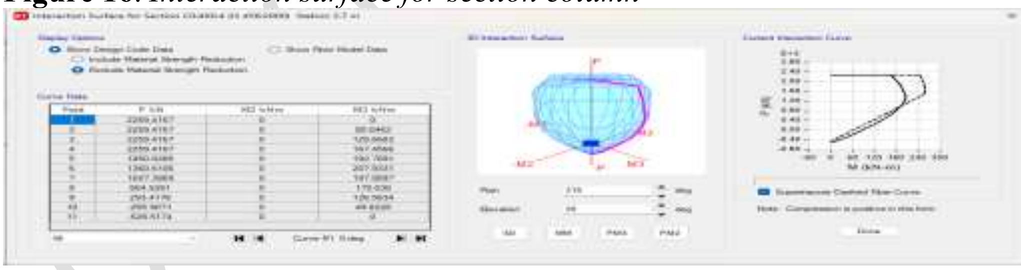
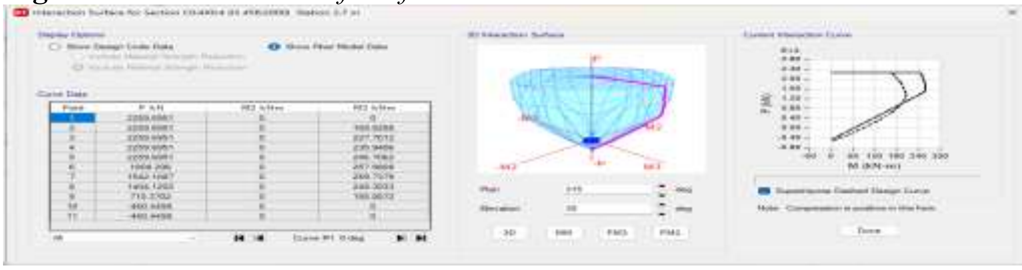


Figure 16. *Interaction surface for section column*



Story displacement is the deflection of a single story relative to the base or ground level of the structure. Intuitively, it can be expected that higher total displacement values will occur as we move up the structure. The importance of story drift is in the design of partitions/ curtain walls. As per the Indian standard, Criteria for earthquake resistant design of structures, IS 1893(Part 1): 2016, the story drift in any story shall not exceed 0.004 times the story height. Lateral displacement is important when structures are subjected to lateral loads like earthquakes and wind loads. Lateral displacement depends on the height of the structure and the slenderness of the structure because structures are more vulnerable as the height of the building increases by becoming more flexible to lateral loads.

Figure 17. *Interaction surface for section column*



It's noted from (Figure 18) that the magnitude of displacement (0.004928 mm) is between base and story 1. Furthermore, it's also observed that the maximum displacement at story 1 was 0.0440 mm and the minimum (0 mm) at the base in the case of live load. It's inferred from (Figure 19) that the magnitude of displacement (0.034 mm) is between base and story 1. Furthermore, it's also observed that the maximum displacement at story 1 was 0.440 mm and the minimum (0 mm) at the base in the case of load combination (live load and dead load).

Figure 18. *Story versus Displacement*

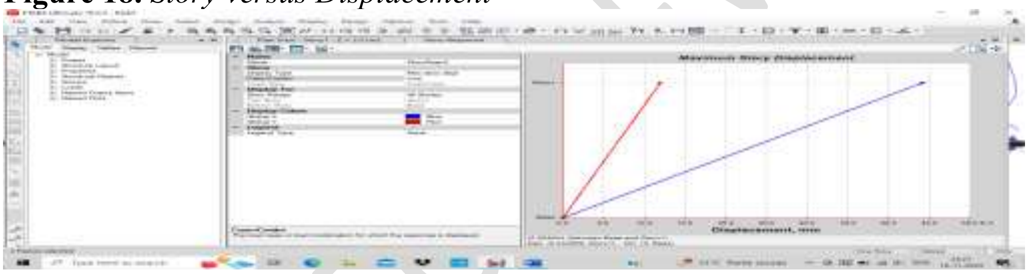
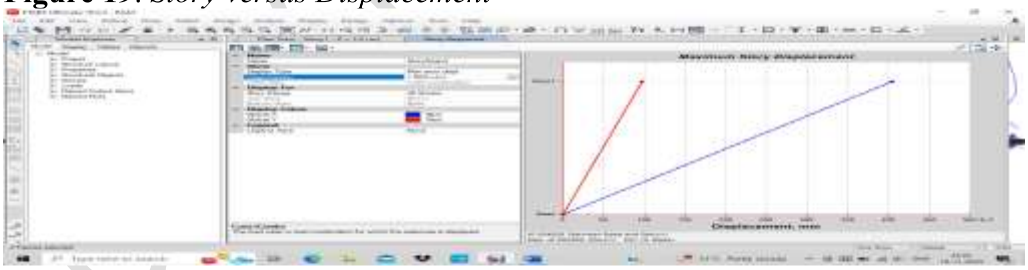


Figure 19. *Story versus Displacement*



Conclusions

- Thus, in the present research work, the design and analysis of a (G+1)-story building was carried out by ETABS software and successfully verified as per IS456:2000.
- Calculation by ETABS software analysis gives results within the permissible limit as per IS code.
- Usage of ETABS software minimizes the lot of time required for analysis and design.

- It can easily be added and removed the number of stories in a building.

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