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Design of Mulitsotried Building C+G+10 Earthquake Resistant Grid Slab using E-Tabs

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Abstract: Grid floor systems consisting of beams spaced at regular intervals in perpendicular directions monolithic with slab. They are generally employed for architectural reasons for large rooms such as auditoriums, vestibules, theatre halls, show rooms of shops where column free space is often the main requirement. The rectangular or square void formed in the ceiling is advantageously utilized for concealed architectural lighting. The sizes of the beams running in perpendicular directions are generally kept the same. Instead of rectangular beam grid, a diagonal. In the present problem C+G+10 Building is consider and analysis and design is done for both Gravity and lateral (earth quake and wind) loads. And this is compared with the flat slab. Grid is highly redundant structural system and therefore statically indeterminate. Grid floor systems consisting of beams spaced at regular intervals in perpendicular directions, monolithic with slab. They are generally employed for architectural reasons for large rooms such as auditoriums, vestibules, theatre halls, show rooms of shops where column free space is often the main requirement. The rectangular or square void formed in the ceiling is advantageously utilized for concealed architectural lighting. The sizes of the beams running in perpendicular directions are generally kept the same. Instead of rectangular beam grid, a diagonal. In the present problem, C+G+5 building is considered and analysis and design is done for both Gravity and lateral (earthquake and wind) loads. And this is compared with the flat slab.

Keywords: Building, Wind and Earth Quake, ETABS, Grid Slab.

I. INTRODUCTION

A building is a man-made structure with a roof and walls standing more or less permanently in one place. Buildings come in a variety of shapes, sizes and functions, and have been adapted throughout history for a wide number of factors, from building materials available, to weather conditions, to land prices, ground conditions, specific uses and aesthetic reasons. To better understand the term building compares the list of nonbinding structures. 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). A Multi-Stored building has multiple floors above the ground in the building. These type of buildings are mainly to increase the floor area of the building without increasing the area of the land where building is built, so it is saving land. The process of built multi-stored buildings are requires practical aspects knowledge, recent design codes, bye laws, intuition and judgment of the structures. To be knowledgeable about the planning and designing of such multi-storeyed Buildings. Advancements of computer packages have given many tools to the designer towards achieving the best and accuracy in their work an attempt is made in this project to utilize the computer packages and comparing the results with manual procedures. Grid Slab Grid floor systems consisting of beams spaced at regular interval in perpendicular directions, monolithic with slab. Slabs spanning in one direction will be supported at two ends. Slabs supporting on all four sides: These are further classified into two types based on aspect ratio(ly/lx),

- One way slabs: If (ly/lx)>2
- Two way slabs: If (ly/lx)<2

If a solid slab supported on two opposite edges, carries concentrated loads, the maximum B.M developed by the concentrated loads shall be assumed to be resisted by an effective width of slab (measured parallel to the supporting edges). Building construction is the engineering deals with the construction of building such as residential houses. In a simple building can be define as an enclose space by walls with roof, food, cloth and the basic needs of human beings. In the early ancient times humans lived in caves, over trees or under trees, to protect themselves from wild animals, rain, sun, etc. as the times passed as humans being started living in huts made of timber branches. The shelters of those old have been developed nowadays into beautiful houses. Rich people live in sophisticated condition houses. Buildings are the important indicator of social progress of the county. Every human has desire to own comfortable homes on an average generally one spends his two-third life time's in the houses. The security civic sense of the responsibility.

II. GRID SLAB

An assembly of intersecting beams placed at regular interval and interconnected to a slab of nominal thickness is known as Grid floor or Waffle floor. These slabs are used to cover a large column free area and therefore are good choice for public assembly halls. The structure is monolithic in nature and has more stiffness. It gives pleasing appearance. The maintenance cost of these floors is less. However, construction of the grid slabs is cost prohibitive. By investigating various parameters the cost effective solution can be found for the grid slabs, for which proper method of analysis need to be used. There are various approaches available for analysing the grid slab system. They are generally employed for architectural reasons for large rooms such as auditoriums, vestibules, theatre halls, show rooms of shops where column free space is often the main requirement. The rectangular or square void formed in the ceiling is advantageously utilized for concealed architectural lighting. The sizes of the beams running in perpendicular directions are generally kept the same. Owning houses. Nowadays the house building is major work of the social progress of the county.

III. BEHAVIOR OF STRUCTURE UNDER LATERAL LOADS

Recently there has been a considerable increase in the number of tall buildings, both residential and commercial, and the modern trend is towards taller and more slender structures. Thus the effects of lateral loads like wind loads, earthquake forces and blast forces etc, are assigning importance and almost every designer is faced with the problem of providing adequate strength and stability against lateral loads. This is a new development, as the earlier building designers usually designed for the vertical loads, and as an afterthought, checked the final design for lateral loads as well. Generally those buildings had sufficient strength against lateral loads due to numerous partitions and short span beams and cross beams and no modification in the design was needed. Now, the situation is quite different and a clear understanding of the effects of lateral loads on a building and the behaviour of various components under these loads, is essential. Shear walls are specially designed structural walls incorporated in the plane of the wall due to wind, earthquake and other forces. The term 'shear wall' is rather misleading as such walls behave more like flexural members. They are usually provided in tall buildings and have been found immense use to avoid total collapse of buildings under seismic forces. It is always advisable to incorporate them in buildings built in regions likely to experience earthquake of large intensity or high winds. Shear walls for wind are designed as simple concrete walls. The design of these walls for seismic forces requires special considerations as they should be safe under repeated loads. Shear walls are generally made of concrete or masonry. They are usually provided between columns, in stairwells, lift wells, toilets, utility shafts, etc. tall buildings with flat slabs should invariably have shear walls. Such systems are compared to slabs with beams have very little resistance even to moderate lateral loads. Initially shear walls were used in reinforced concrete buildings to resist wind forces. These came into general practice only as late as 1940. With the introduction of shear walls, concrete construction can be used for tall buildings also. However, the most important property of shear walls for seismic design, as different from design for wind, is that it should have good ductility under reversible and repeated overloads. In planning shear walls, we should try to reduce the bending tensile stresses due to lateral loads as much as possible by loading them with as much gravity forces as it can safely take. They should be also laid symmetrically to avoid tensional stresses.

IV. TYPES OF LOADS

The buildings are subjected to both vertical and horizontal loads. At the preliminary design stage all the components of buildings are designed for vertical loads only. Ideally an efficient system should not require an increase in the sizes of members when the effect of lateral load is also incorporated. Such designers are known as 'premium free' designers and may be different to achieve. Horizontal loads can be divided into the following three categories:

- Wind loads
- Earthquake loads

Wind Loads: A mass of air moving at a certain velocity has a kinetic energy to 1/2MV*V, where M and V are the mass and velocity of air in motion. When an obstacle like a building is met in its path, a part of the kinetic energy of air in motion gets converted to potential energy of pressure. The actual intensity of wind pressure depends on a number of factors like angle of incidence of the wind, roughness of the surrounding area, effects of architecture features, i.e., shape of the structure etc. and lateral resistance of the structure. Apart from these, the maximum design wind pressure depends on the duration of the gusts and the probability of occurrence of an exceptional wind pressure. However, for most of the buildings, the wind pressure, specified in the code (Indian Standards, I.S 875-1964) are usually sufficient. In every tall and slender building (not common in India) aerodynamic instability may develop. This is because of the fact that during a wind storm the building is constantly buffeted by gusts and starts vibrating in its fundamental mode. If the energy absorbed by the building is more than the energy it can dissipate by structural damping, the amplitude of the vibration goes on increasing till failure occurs. A detailed study supported by wind tunnel experiments is often necessary in these cases. Some useful details about dynamic wind loads on structure have been by Davenport.

Earthquake Loads: An earthquake (also known as a quake, tremor or temblor) is the result of a sudden release of energy in the Earth'scrust that creates seismic waves. The seismicity, seismic or seismic activity of an area refers to the frequency, type and size of earthquakes experienced over a period of time. Earthquakes are measured using observations from seismometers. The moment magnitude is the most common scale on which earthquakes larger than approximately 5 are reported for the entire globe. The more numerous earthquakes smaller than magnitude 5 reported by national seismological observatories are measured mostly on the local magnitude scale, also referred to as the Richter scale. These two scales are numerically similar over their range of validity. Magnitude 3 or lower earthquakes are mostly almost imperceptible or weak and magnitudes 7 and over potentially cause serious damage over larger areas, depending on their depth. The largest earthquakes in historic times have been of magnitude slightly over 9, although there is no limit to the possible magnitude. The most recent large earthquake of magnitude 9.0 or larger was a 9.0 magnitude earthquake in Japan in 2011 (as of October 2012), and it was the largest Japanese earthquake since records began. Intensity of shaking is measured on the modified Mercalli scale. The shallower an earthquake, the more damage to structures it causes, all else being equal.

ETABS: The latest version of ETABS continues in that tradition, incorporating structural element terminology that is used on a daily basis (Columns, Beams, Bracings, Shear Walls etc.), contrary to the common civil engineering programs that use terms such as nodes, members etc. Additionally, it offers many automatic functions for the formation, analysis and design of the structural system in an efficient, fast and easy way. The user can easily create a model, apply any kind of load to it and then take advantage of the superior capabilities of ETABS to perform a start or art analysis and design. ETABS is the solution, whether you are designing a simple 2D frame or performing a dynamic analysis of a complex high-rise that utilizes non-linear dampers for inter-story drift control.

Areas of Application:

- Analysis and design of building structures with a structural system consisting of beams, slabs, columns, shear walls and bracings. Different materials can be assigned to the structural elements within the same model such as steel, RC, composite or any other user-defined material.
- Easy and automatic generation of gravity and lateral loads (seismic and wind loads) when compared with other FE general analysis programs.

Advantages:

- Graphic input and editing for easy and fast model generation
- 3D generation of the model through plan views and elevations
  Fast model generation using the concept of Similar stories
- Easy editing through the Move, Merge, Mirror and Copy commands
- Accuracy in dimensions by using Snaps (end, perpendicular, middle etc.)
- Fast object creation with one click of the mouse
- Multiple viewing windows.
- 3D view with zoom and pan capability
- 3D axonometric view of the model, plan view, elevation view, elevation development view, custom view defined by the user
- Graphic input of cross sections of any geometry and material (Section Designer)
- Copy and Paste of the geometry of a model to and from spreadsheets
- Export of the model geometry to .dxf files
- Integration with EC – Praxis 3J for the analysis and design of steel connections
- Integration with STEREOSTATIKA for easy import of model geometry and design of RC structures according to Greek Code
- Integration with e-Tools for the design of RC structures according to Greek Code, masonry structures according to Euro code 6, RC jackets according to Greek Code and automatic creation of plastic hinges for pushover analysis
- Integration with SAP2000 for 3D analysis and design of structural elements including bridges, dams, tanks and buildings

Objective: The main objective of this study is to identify various parameters that affected the Grid slabs. Analysis and Design of Multi Storeyed Residential Building using E-TABS. The ETABS stands for extended 3D analysis for building system. This is based on the stiffness matrix and finite element based software. The analysis and design is done to satisfy all the checks as per Indian standards. Finally data base is prepared for various structural responses.

Scope of Work: The analysis is implemented for Analysis and Design of Multi Storeyed Building using ETABS. The structure is analysed for both gravity and lateral loads (seismic and wind loads). The individual structural elements are designed for worst load combinations.

3D View:

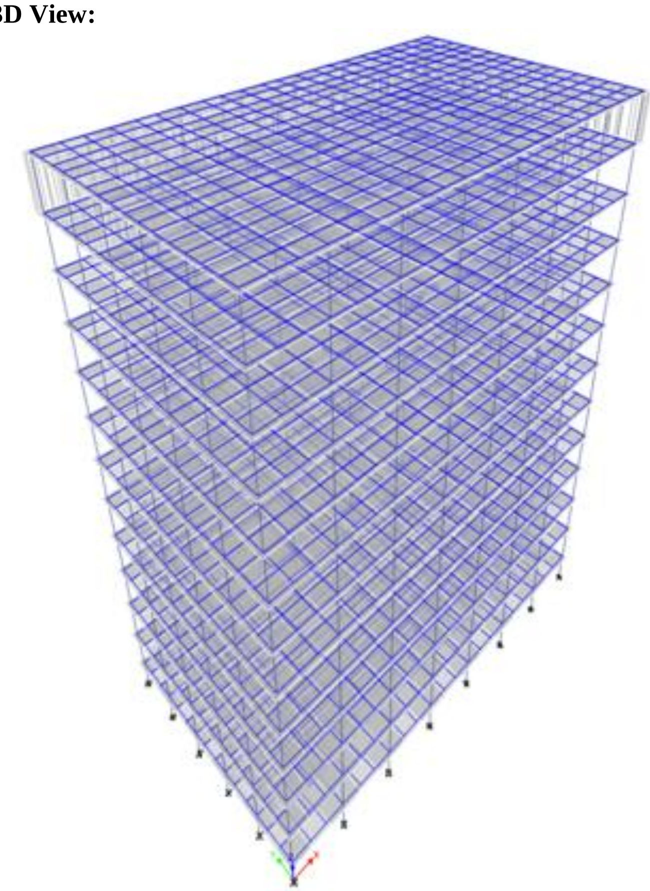

Fig1. Structure Data.

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

Table 1. Story Data

Name	Height mm	Elevation mm	Master Story	Similar To	Splice Story
STORY13	3000	38000	Yes	None	No
STORY12	3000	35000	No	STORY13	No
STORY11	3000	32000	No	STORY13	No
STORY10	3000	29000	No	STORY13	No
STORY9	3000	26000	No	STORY13	No
STORY8	3000	23000	No	STORY13	No
STORY7	3000	20000	No	STORY13	No
STORY6	3000	17000	No	STORY13	No
STORY5	3000	14000	No	STORY13	No
STORY4	3000	11000	No	STORY13	No
STORY3	3000	8000	No	STORY13	No
STORY2	3000	5000	No	STORY13	No
STORY1	2000	2000	No	STORY13	No
BASE	0	0	No	None	No

Table2. Load Patterns

Name	Type	Self Weight Multiplier	Auto Load
DEAD	Dead	1	
LIVE	Live	0	
WALL	Dead	1	
WLX	Wind	0	Indian IS875:1987
WLY	Wind	0	Indian IS875:1987
EQX	Seismic	0	IS1893 2002
EQY	Seismic	0	IS1893 2002

Indian IS875:1987 Auto Wind Load Calculation: This calculation presents the automatically generated lateral wind loads for load pattern WLX according to Indian IS875:1987, as calculated by ETABS.

Exposure Parameters

Exposure From = Diaphragms
Structure Class = Class B
Terrain Category = Category 2
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 = STORY13
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] $V_z = V_b k_1 k_2 k_3$

Design Wind Pressure, p_z [IS 5.4] $p_z = 0.6 V_z^2$

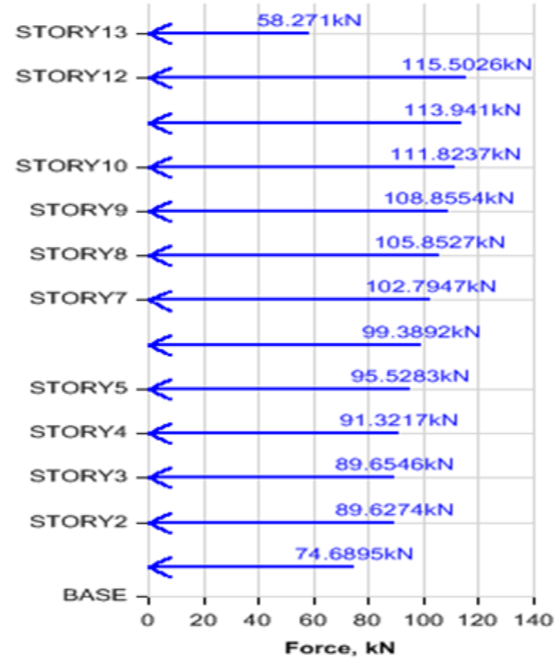

Fig2. Applied Story Forces

Lateral Load to Stories -0°

Table1.

Story	Elevation	X-Dir	Y-Dir
	m	kN	kN
STORY13	38	58.271	0
STORY12	35	115.5026	0
STORY11	32	113.941	0
STORY10	29	111.8237	0
STORY9	26	108.8554	0
STORY8	23	105.8527	0
STORY7	20	102.7947	0
STORY6	17	99.3892	0
STORY5	14	95.5283	0
STORY4	11	91.3217	0
STORY3	8	89.6546	0
STORY2	5	89.6274	0
STORY1	2	74.6895	0
BASE	0	0	0

IS1893 2002 Auto Seismic Load Calculation:

This calculation presents the automatically generated lateral seismic loads for load pattern EQX according to IS1893 2002, as calculated by ETABS.

Direction and Eccentricity

Direction = X

Structural Period

Period Calculation Method = Program Calculated

Factors and Coefficients

Seismic Zone Factor, Z [IS Table 2] $Z = 0.16$

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] $\frac{S_a}{g} = \frac{1.36}{T}$

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	1.44	111715.8399	1687.8555

Applied Story Forces:

Modal Results:

Table3. Modal Periods and Frequencies

Case	Mode	Period sec	Frequency cyc/sec	Circular Frequency rad/sec	Eigenvalue rad²/sec²
Modal	1	1.44	0.694	4.3626	19.0319
Modal	2	1.405	0.712	4.4716	19.9954
Modal	3	1.303	0.767	4.8205	23.2373
Modal	4	0.469	2.131	13.3919	179.344
Modal	5	0.456	2.191	13.769	189.5858
Modal	6	0.425	2.355	14.7975	218.9674
Modal	7	0.269	3.717	23.3516	545.2972
Modal	8	0.26	3.85	24.1899	585.1528
Modal	9	0.244	4.106	25.7967	665.4715
Modal	10	0.183	5.466	34.3418	1179.3571
Modal	11	0.177	5.644	35.464	1257.6958
Modal	12	0.166	6.034	37.9148	1437.5315

Table4. Modal Participating Mass Ratios (Part 1 of 2)

Case	Mode	Period sec	UX	UY	UZ	Sum UX	Sum UY	Sum UZ
Modal	1	1.44	0.7809	0	0	0.7809	0	0
Modal	2	1.405	0	0.7768	0	0.7809	0.7768	0
Modal	3	1.303	0	0	0	0.7809	0.7768	0
Modal	4	0.469	0.0951	0	0	0.876	0.7768	0
Modal	5	0.456	0	0.0999	0	0.876	0.8766	0
Modal	6	0.425	0	0	0	0.876	0.8766	0
Modal	7	0.269	0.0357	0	0	0.9117	0.8766	0
Modal	8	0.26	0	0.0358	0	0.9117	0.9124	0
Modal	9	0.244	0	0	0	0.9117	0.9124	0
Modal	10	0.183	0.0199	0	0	0.9316	0.9124	0

Table5. Modal Load Participation Ratios

Case	Item Type	Item	Static %	Dynamic %
Modal	Acceleration	UX	99.97	93.16
Modal	Acceleration	UY	99.97	93.22
Modal	Acceleration	UZ	0	0

Table6. Modal Direction Factors

Case	Mode	Period sec	UX	UY	UZ	RZ
Modal	1	1.44	1	0	0	0
Modal	2	1.405	0	1	0	0
Modal	3	1.303	0	0	0	1
Modal	4	0.469	1	0	0	0
Modal	5	0.456	0	1	0	0
Modal	6	0.425	0	0	0	1
Modal	7	0.269	1	0	0	0
Modal	8	0.26	0	1	0	0
Modal	9	0.244	0	0	0	1
Modal	10	0.183	1	0	0	0
Modal	11	0.177	0	1	0	0
Modal	12	0.166	0	0	0	1

V. CONCLUSION

- In this present work ETABS is used to analysis the R.C moment resting frame structure of C+G+10 considering the gravity and lateral loads. The following conclusion is drawn from present work. Maximum time period is 3.53901 for mode -1 in the structure.
- For maximum time period the natural frequency is 0.28256 cycles/sec
- Modal participating mass ratios for mode-10 are trans is 97% and Y-trans is 99%
- Maximum axial force in the structure is 23031.36 kN
- Maximum tensile force in the frame is 7350.726 kN.
- Maximum diaphragm drift is 0.007700.
- Design of R.C.C column) Size 230 x 450
- Reinforcement 8no's of 12dia c) 0.874 %reinforcement
- Design of R.C.C Beam. a) Size 230 x 380 b) 0.85 % reinforcement
- Design of R.C.C slab a) 200 mm thickness b) 8 dia230mm spacing 10. Design of R.C.C footing a) 2.5m x 2.3m
- Maximum displacement is observed in flat slab with drop compare to grid slab with and without infill in both zones, but deflection is more in zone IV than zone III.
- Maximum Time period of grid slab is less in compare with flat slab with and without drop with and without infill structures in zone IV. Structures without infill having significantly more time period compare to structure with infill.
- Grid slab structures possess maximum base shear in comparison with flat slab with and without drop in both zones.
- Storey drift values of different types of buildings are within the permissible limit as per IS- 1893-2002 code provision i.e. 0.4% of the floor height.

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