

# Seismic Analysis of Flat Slab by using ETABS

S. Dhana Sree, E. Arunakanthi



**Abstract:** The flat slab is a two-way reinforced concrete slab that usually does not have beams and girders, and the loads are transferred directly to the supporting concrete columns. ETABS automates several slab and mat design tasks. Specially, it integrates slab design moments across design strips and designs the required reinforcement; it checks slab punching shear around column supports and concentrated loads; and it designs shear link and shear stud if needed. The actual design algorithms vary based on the specific design code chosen by the user. This manual describes the algorithms used for the various codes. Recent earthquakes in which many concrete structures have been severely damaged or collapsed, have indicated the need for evaluating the seismic adequacy of existing buildings. About 60% of the land area of our country is susceptible to damaging levels of seismic hazard. Many existing flat slab buildings may not have been designed for seismic forces. Hence it is important to study their response under seismic conditions and to evaluate seismic retrofit schemes. This system is very simple to construct, and is efficient in that it requires the minimum building height for a given number of stories. Unfortunately, earthquake experience has proved that this form of construction is vulnerable to failure, when not designed and detailed properly, in which the thin concrete slab fractures around the supporting columns and drops downward, leading potentially to a complete progressive collapse of a building as one floor cascades down onto the floors below. Although flat slabs have been in construction for more than a century now, analysis and design of flat slabs are still the active areas of research and there is still no general agreement on the best design procedure. To study the effect of drop panels on the behavior of flat slab during lateral loads, flat plate system is also analyzed. Zone factor and soil conditions- the other two important parameters which influence the behavior of the structure, are also covered. Software ETABS is used for this purpose. In this study relation between the number of stories, zone and soil condition is developed.

**Keywords:** Concrete column, Drop panels, ETABS, Flat slab, Minimum building height, Seismic force.

## I. INTRODUCTION

In the present world, with the increase in population growth, need for shelter and growth of country's economy demanding for infrastructure growth in the limited land area suitable for construction. With the view of limited suitable land, cost of land and building materials cost, construction plays a prominent role in effective execution of a building. Earthquake phenomenon plays important role due to movement of tectonic plates in Earth's lithosphere. Earthquake does not kill cause much damage to life but cause severe damages to concrete structures like buildings, roads, bridges and many more. Therefore, design of a concrete structure should be done properly keeping in view of various parameters.

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There are various techniques which are used in present world to overcome the boundaries in construction sector. A structure could be analyzed both by manually and through software accordingly to maintain quality and perfection in design.

Flat slabs are the cost effective and built in shorter durations. This paper is the analysis of seismic forces in flat slabs. These flat slabs reduce the usage of number of beams by directly resting the slab on columns and column heads. This provides decrease in cost of construction along with aesthetic view and fast rate in construction time. There are many techniques for the analysis of structures under different type of loading conditions. Among them Non-Linear Time history is accurate. For less important or seismic hazard, other methods like Non-Linear Static methods are used.

These flat slabs are mostly used in commercial complexes like cinema halls, shopping malls, high rise buildings and many more structures.

## II. FLAT SLABS

Slabs are generally two types based on length to depth ratio as one way and two way slabs which rests on horizontal members like beams. When the ratio of length to depth is less than two then it is called two way slab and when the ratio is greater than two is called one way slab. Various types of loads acting upon the slabs are transferred from beams to columns, walls, lintels then to foundations and finally distributed over soil. Number of stories could be increased through proper design by reducing floor height while going to upper stories to maintain stability to the structure.

Flat slabs are widely implemented when there are many stories for commercial buildings in order to reduce cost of construction along with good aesthetic view in shorter duration. Due to elimination of unnecessary beams ceiling can be used to maximum extent which leaves a pleasant experience. Partitions could be made easily along with mechanical and electrical maintenance.

## III. LITERATURE REVIEW

Many researchers carried out their work in finding responses of structures towards earthquake and many loading conditions like static and dynamic loads along with the view of soil pressures.

Lan N Robertson (1997) performed analysis of flat slab building by considering a three dimensional model when loads acting on horizontal and vertical frame elements. These are correlated to experimental studies. This analysis give values about horizontal drift. These models are incapable to re-obtain the flexural moments at 0.5 or 1.5 % drift levels. Replacement of one beam with two at contra flexure, the difference in the positive and negative moments were calculated.



R. P. Apostolska, G. S. Neenska-Cvetanovska, (2008) in their paper summary flat slabs with proper design and modifications with consideration of other parameters improve resistance, durability and seismic behavior of flat slabs in construction.

K. S. Sable et al (2012), comparison between flat slab and conventional structure made. The modeling and analyzing done by using STAAD Pro 2007. Analysis made for 11 storied structure. Though storey increase provision of shear wall make it same.

Salman I Khan and R. Mundhada (2015), analyzed with 12, 15, 18 storey by taking into account seismic zones using ETABS. It is found that at terrace level base shear of flat slab is more than grid slab. The storey drift and time period will be more for flat slab than the grid slab.

#### IV. PROCEDURE

Consideration of earthquake effect makes the structure withstand the trembling effect to maximum extent. Design should consider severity of horizontal movement of building obtained by following mode shapes. First mode is called fundamental mode which indicates the movement of a structure predominantly.

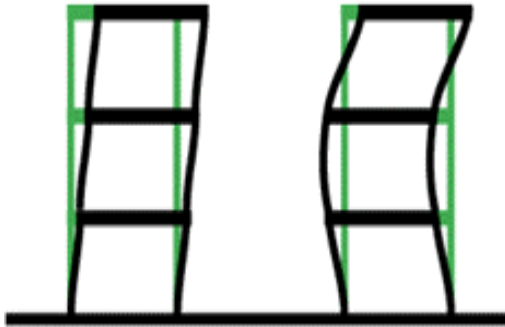


Fig. 1. First and second modes of building seismic response

##### A. Linear Static Analysis

Single degrees of freedom (SDOF) is the linear static analysis with viscous damping coefficient. There are various methods to determine the stresses and strains objective to produce the same stresses and strains using Rayleigh method, spectrum method, time history. Parameters like second degree effects, stiffness and reduction in force. Force is distributed to different stories in order to reduce more impact. Linear static analysis is considered in many codes. Their usage is less due to its predominance of first mode in normal structures.

##### B. Earthquake Resistant Design of Buildings

Earthquake resistant structures are capable of sustaining the severe effect of horizontal movement of the earth. Indian code IS 456-2002 is used to design structures resistant towards earthquake. Intensity of earthquake determined by using an instrument called Richter scale. Proper care must be taken while designing a structure. Earthquake zones are divided as Zones from I-V whereas, Zone I the safest place to resist the damage due to earthquake. Zone II is next safe place. Zone III, Zone IV and Zone V are much prone to earthquake damages. Based on the zone of structure to be constructed various parameters must be considered like response reduction factor, intensity factor, importance factor and so on to make the structure earthquake resistant.

##### C. Modeling in ETABS

ETABS is used to view the response of a structure towards earthquake vibrations.

M-25 concrete grade is utilized and Fe-415 reinforcing steel is used as per IS 456-2000.

a. Elasticity of Steel,  $E_s=21,000\text{MPa}$

b. Elasticity of Concrete,  $E_c=22360.68\text{MPa}$

c. Compressive strength of concrete,  $f_{ck}=25\text{MPa}$

d. Yield stress for steel,  $f_y=415\text{MPa}$

##### D. Design Variables for Analysis

Design variable	Value	Remarks
<b>Static loads</b>		
(a) Masonry	20kN/m <sup>3</sup>	IS 875:1987(Part-1)
(b) Concrete	25kN/m <sup>3</sup>	
<b>Dynamic loads</b>		
(a) Floor load	2kN/m <sup>2</sup>	IS 875:1987(Part-1)
(b) Roof load	1.5kN/m <sup>2</sup>	
(c) Floor finishes	1.0kN/m <sup>2</sup>	
Importance factor	1.0	IS 1893:2002
Seismic zone factor	0.36	IS 1893:2002
Response reduction factor	5	IS 1893:2002

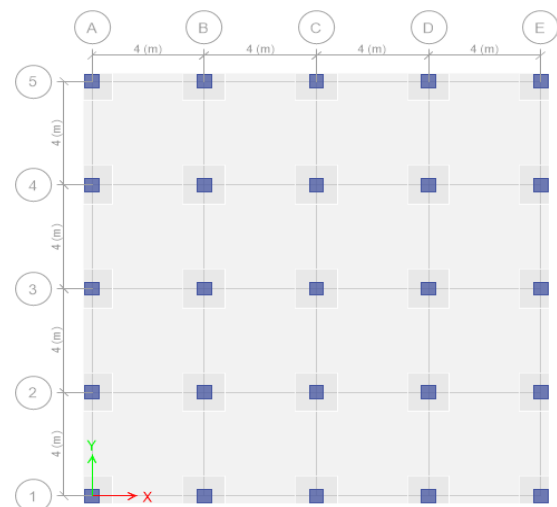


Fig. 2. Plan of G+17 Structure

## V. RESULTS AND DISCUSSIONS

Structure Data					
Name	Height Mm	Elevation mm	Master Story	Similar To	Splice Story
Story18	3000	54000	Yes	None	No
Story17	3000	51000	No	Story18	No
Story16	3000	48000	No	Story18	No
Story15	3000	45000	No	Story18	No
Story14	3000	42000	No	Story18	No
Story13	3000	39000	No	Story18	No
Story12	3000	36000	No	Story18	No
Story11	3000	33000	No	Story18	No
Story10	3000	30000	No	Story18	No
Story9	3000	27000	No	Story18	No
Story8	3000	24000	No	Story18	No
Story7	3000	21000	No	Story18	No
Story6	3000	18000	No	Story18	No
Story5	3000	15000	No	Story18	No
Story4	3000	12000	No	Story18	No
Story3	3000	9000	No	Story18	No
Story2	3000	6000	No	Story18	No
Story1	3000	3000	No	Story18	No
Base	0	0	No	None	No

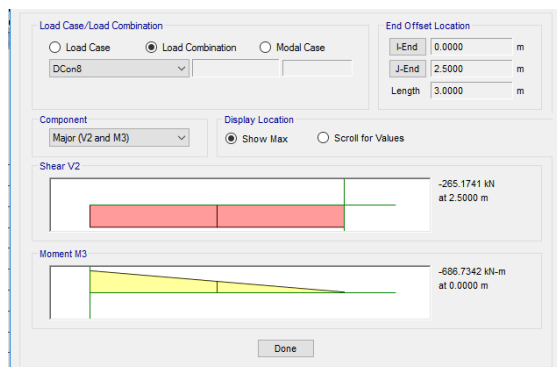


Fig. 3. Axial force and bending moment of conventional slab (Ground Floor)

## VI. CONCLUSIONS

Flat slab structures give aesthetic appearance along with economical gain and resisting capacity towards earth movement. Due to no beams with more depth, flat slab structures are able to take lateral loads and results in more vulnerable under seismic events.

1. The bending moments and axial forces are maximum for flat slab building.
2. The maximum displacements of both the structures are within the permissible limit. Storey displacement is more at top storey and less at base of the structure. With increase in building height displacement also increases.
3. Storey drifts are maximum in the middle stories. That means columns are stiffer in bottom and top stories and weaker in the mid level of the structure.

4. Above results shows that flat slab with proper design against earthquake could resist the damage to considerable extent.

To increase the resistance towards lateral and longitudinal effects on a concrete structure factor of safety parameters and also other loading parameters need to be considered while designing the structure.

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