TECH-CHRONICLE
AN INTERNATIONAL E-JOURNAL ON
EMERGING TRENDS IN SCIENCE, TECHNOLOGY AND MANAGEMENT

Parametric Study Of Multisoried R.C.C. Flat Slab Structure Under Seismic Effect Having Different Plan Aspect Ratio And Slenderness Ratio

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Abstract— Flat-slab building structures possesses major advantages over traditional slab-beam-column structures because of the free design of space, shorter construction time, architectural –functional and economical aspects. Because of the absence of deep beams and shear walls, flat-slab structural system is significantly more flexible for lateral loads then traditional RC frame system and that make the system more vulnerable under seismic events. The critical moment in design of these systems is the slab-column connection, i.e., the shear force in the slab at the connection, which should retain its bearing capacity even at maximal displacements. The behavior of flat slab building during earthquake depends critically on 'Building Configuration'. This fact has resulted in to ensure safety against earthquake forces of tall structures hence, there is need to determine seismic responses of such building for designing earthquake resistant structures. Response Spectrum analysis is one of the important techniques for structural seismic analysis. In the present work dynamic analysis of 15 models of multi-storied RCC Flat slab structure is carried out by response spectrum analysis.

The BIS guideline in IS 1893:2002 {Clause 7.1} says "Regular and Irregular Configuration to perform well in an earthquake, a building should possess four main attributes, namely simple and regular configuration, and adequate lateral strength, stiffness and ductility. Buildings having simple regular geometry and uniformly distributed mass and stiffness in plan as well as in elevation, suffer much less damage than buildings with irregular configurations". Similarly in IS 4326:1993 {Clause 4.4.1} it is mentioned that "The building should have a simple rectangular plan and be symmetrical both with respect to mass and rigidity so that the center of mass and rigidity of the building coincide with each other." But the limiting "plan aspect ratio" and "Slenderness ratio" for the regular structure is not prescribed.

This study is concerned with the behavior of structure having same plan area but different plan aspect ratio (L/B) and slenderness ratio (H/B) under seismic condition. The structures are simulated in ETABS 13 software and analyzed using Response Spectrum method.

Keywords— *Aspect Ratio, Slenderness Ratio, Response Spectrum Analysis, Drift , Displacement, Storey shear, SMRF R.C.C. flat slab structure.*

Introduction

A slab is a flat, two dimensional, planar structural element having thickness small compared to its other two dimensions. It provides a working flat surface or a covering shelter in buildings. It supports mainly transverse loads and transfers then to support primarily by bending element just like flat plate. Common practice of design and construction is to support the slabs by beams and support the beams by columns. This may be called as beam-slab construction. The beams reduce the available net clear ceiling height. Hence in warehouses, offices and public halls sometimes beams are avoided and slabs are directly supported by columns. These types of construction are aesthetically appealing also. These slabs which are directly supported by columns are called Flat Slabs.

Components of flat slab

- span in the direction moments are being determined, measured centre to centre of supports and $L_2$is the span transverse to L_1,measured centre to centre of supports

Middle Strip:

- Middle strip means a design strip bounded on each of its opposite sides by the column strip.

Panel:

- Panel is defined as a part of a slab bounded on-each of its four sides by the centre-line of a Column or centre-lines of adjacent-spans.

Drops:

- The drops when provided shall be rectangular in plan, and have a length in each direction not less than one-third of the panel length in that direction. For exterior panels, the width of drops at right angles to the non- continuous edge and measured from the centre -line of the columns shall be equal to one -half the width of drop for interior panels.

Column Head:

- Where column heads are provided, that portion of a column head which lies within the largest right circular cone or pyramid that has a vertex angle of 90^0 and can be included entirely within the outlines of the column and the column head, shall be considered for design purposes.

Column Strip:

- Column strip means a design strip having a width of $0.25L_2$, but not greater than $0.25L_1$, on each side of the column centre-line, where L_1 is the

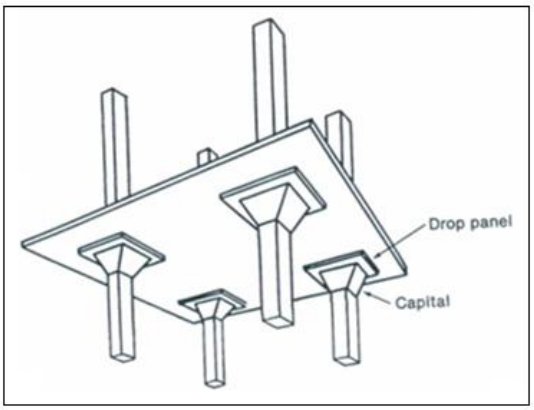

Fig. 1. Showing Drop pannel of flat slab

"The term Flat slab means a reinforced concrete slab with or without drops, Supported generally without beams, by columns with or without flared column head."

Objectives

A detailed literature survey is carried out to define the objectives of the thesis.
Based on the literature review presented later, the salient objectives of the present study have been identified a follows:

- To perform parametric study on behaviour of multi storied R.C.C. flat slab structure having same plan area but different plan aspect ratio (L/B) and slenderness ratio (H/B), under seismic condition.
- To perform analysis using Response Spectrum analysis.
- To study the behaviour of structure situated in seismic Zone III.
- To study effect on structure due to change in aspect ratio and change in slenderness ratio for structure, under seismic condition by observing results of analysis.

Method Of Analysis

A. The Present Study Done for the Below Mentioned Analysis
Equivalent static analysis Method
Response spectrum method.
The steps undertaken in the present study to achieve the above-mentioned objectives areas follows:

- Carry out extensive literature review, to establish the objectives of the research work.
- Select an exhaustive set of R.C.C. flat slab building models with different number of storey (4 to 12 storeys), Aspect ratio (1to 5) in plan and constant plan area. (900 m^2)
- Perform Response Spectrum Analysis for each of the 25 models.

- Analyse and compare the result obtained from response spectrum analysis of models which are base shear, storey drift, stiffness, natural time period, and frequency of earthquake. **Drop** from the slab to the column at it support.

- To resist this negative moment the area at the support needs to be increased, this is facilitated by providing column capital/heads flat slab.

- The drops when provided shall be rectangular in plan.

- To resist the punching shear which is predominant at the contact of slab and column Support, the drop dimension should not be less than one -third of panel length in that direction

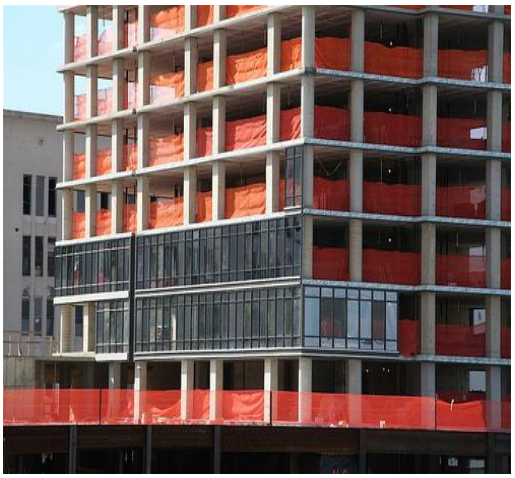

Fig. 2. Showing flat slab structure

Column Heads

- Certain amount of negative moment is transferred

SR	CODE	TITLE
1	IS 1893:2002	CRITERIA FOR EARTHQUAKE RESISTANT DESIGN OF STRUCTURES _
2	IS 4326:1993	EARTHQUAKE RESISTANT DESIGN AND CONSTRUCTION OF BUILDINGS
3	SP 22	HANDBOOK ON CODES FOR EARTHQUAKE ENGINEERING (1893 & 4326)
4	IS 13920:1993	DUCTILE DETAILING OF REINFORCED CONCRETE STRUCTURES SUBJECTED TO SEISMIC FORCES

Data Assumed

Data assumed for the current study is categorized as followed and presented in tabulated form

- Material properties and geometric parameters
- Load considered for designing building
- Seismic design data

Material Properties and Geometric Parameters

Sr. No.	Design Parameter	Value
1	Unit weight of concrete	25 kN/m^3
2	Characteristic strength of concrete	30 MPa
3	Characteristic strength of steel	415 MPa
4	Modulus of elasticity of steel	2 x e^5 MPa
5	Plan area	900 square meters
6	Slab thickness	200 mm

7	Drop thickness	300 mm
8	Depth of foundation	3.5m
9	Floor height	3.6m

Load Considered For Analysis Of Building

Sr.No.	Load Type	Value
1	Self-weight of Slab and Column	As per Dimension and Unit weight of concrete
2	Dead load of structural components	As per IS 875 Part-1
3	Live Load	As per IS 875 Part -2
4	Live load : on Roof and Typical floor	4.0 kN/m^2
5	Floor Finish	2.0 kN/m^2

Seismic Design Data

Sr.No.	Design Parameter	Value
1	Earthquake Load	As Per IS 1893 (Part 1)-2002
2	Type Of Foundation	Isolated Column Footing
3	Depth Of Foundation	3.5m
4	Type Of Soil	Type II, Medium As Per IS 1893:2002
5	Bearing Capacity Of Soil	200 kN/m2
6	Seismic Zone	IV
7	Zone factor (Z)	0.24
8	Response reduction factor (R)	5
9	Importance Factor	1
10	Percentage Damping	5%
11	Type Of Frame	Special Moment Resisting Frame

The cross sectional dimension of column are shown in table below

Cross Sectional Dimension for Column

Sr. No.	Type of Structure	Column sizes
1	G+ 3 (5 storey structure)	600 mm X 600 mm
2	G+ 5 (7 Storey structure)	600 mm X 600 mm
3	G+ 7 (9 Storey structure)	600 mm X 600 mm
4	G+ 9 (11 Storey structure)	600 mm X 600 mm
5	G+ 11 (13 Storey structure)	600 mm X 600 mm

Modeling of Structural Element

Beam and columns are modeled as frame elements available in ETABS 15 structural analysis software, with central lines joined at nodes. Column slab joint are considered as rigid slab-column joints. The floor slabs are assumed to act as diaphragms, which ensure integral action of all the vertical lateral load resisting elements. The weight of the slab was distributed as shell load distribution. The columns ends are fixed. A response spectrum analysis applied for analysis of all the 25 models.

Literature Review

The literature survey is carried out in following major areas. These are:

- Research papers on response of buildings (regular or irregular configuration) under seismic loading,
- Importance of Indian seismic design codes and their introduction in brief.
- Discussion about Building configuration.
- Literature based on behavior of structure under Seismic condition.

The first part of this chapter is devoted to a review of published literature related to behavior of building configuration under seismic loading. The response quantities include storey drift, lateral displacement, fundamental modal time period, fundamental frequencies, lateral forces, base shear and mode shapes.

The second half of this chapter is devoted to a review of design code perspective on Building configuration, Seismic analysis of structure using Response Spectrum method and seismic effect on structure. This part describes different parameters used in analysis of structure and their importance, which will aid in framing the outcomes of analysis.

The research paper and literatures collected on the various topics is listed below.

1. Rucha S. Banginwar and M. R. Vyawahare, (2012)
2. K S Sable (2012)
3. Arun Solomon (2013)
4. Mohit Sharma, SavitaMaru, (2014)

Conclusion

- Use of flat slabs with drop results in increase in drift values in shorter plans and decrease in larger plans, marginally in a range of 0.5mm to 3mm. Still all drift values are within permissible limits even without shear walls.
- Provision of part shear walls in zone V is not enough to keep maximum displacements within permissible limits, whether it is a beam slab framed structure or framed structure with flat slabs with drop.
- The present study reveals that the square configuration, which has the Aspect Ratio 1 (both Horizontal and Vertical) performs seismically amongst the best, on the bases of the above seismic parameters, would be the most suitable plan configuration option to be chosen.
- Building with shear wall is preferred because of considerable difference in storey displacement, time period, base shear and storey drift.
- Structure with shear wall along periphery is suitable for the effect of wind load and earthquake load on the performance of building.

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