International Journal of Recent Trends in Engineering & Research
ISSN (ONLINE) : 2455 – 1457 IMPACT FACTOR : 4.101

USE OF FLAT SLABS IN MULTI-STOREY COMMERCIAL BUILDING

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Abstract: - "Flat Slab" is better understood as the slab without beams resting directly on supports (like columns & or walls).By virtue of that large Bending Moment & Shear Forces are developed close to the columns. Flat slabs system of construction is one in which the beams used in t he conventional methods of constructions are done away with. The slab directly rests on the column and load from the slab is directly transferred to the columns and then to the foundation. To support heavy loads the thickness of slab near the support with the column is increased and these are called drops, or columns are generally provided with enlarged heads called column heads or capitals. Absence of beam gives a plain ceiling, thus giving better architectural appearance and also less vulnerability in case of fire than in usual cases where beams are used. Plain ceiling diffuses light better, easier to construct and requires cheaper form work. As per local conditions and availability of materials different countries have adopted different me thuds for design of flat slabs and given their guidelines in their respective codes. The Finite element analysis & Equivalent frame analysis is carried out by using software ETABS, The analysis & design is performed by Equivalent Frame Method with staggered column & without staggered column as prescribed in the different codes like IS 456-2000, ACI 318-08 are compared. In this process moments are distributed as column strip moments & middle strip moments. For carrying out this project an interior panel of a flat slab with dimensions 6.6 x 5.6 m and super imposed load 7.75 KN /m2 was designed using the codes given above.

I. INTRODUCTION

1.1 General

A 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. They are subjected to both vertical and lateral loads. Lateral loads due to wind and earthquake governs the design rather than the vertical loads. The buildings designed for vertical load may not have the capacity to resist the lateral loads. The lateral loads are the premier ones because in contrast to vertical load that may be assumed to increase linearly with height; lateral loads are quite variable and increase rapidly with height. Under a uniform wind and earthquake loads the overturning moment at the base is very large and varies in proportion to the square of the height of the building. The lateral loads are considerably higher in the top storey rather than the bottom storey due to which building tends to act as cantilever. These lateral forces tend to sway the frame. In many of the seismic prone areas there are several instances of failure of buildings which have not been designed for earthquake loads. All these reaction makes the study of the effect of lateral loads very important. In general normal frame construction utilizes columns, slabs & beams. However it may be possible to undertake construction without providing beams, in such a case the frame system would consist of slab and column without beams. These types of slabs are called flat slab, since their behavior resembles the bending of flat plates. Pure rigid frame system or frame action obtained by the interaction of slabs, beam and column is not adequate. The frame alone fails to provide the required lateral stiffness for buildings taller than 15 to 20 (50m to 60m) stories. It is because of the shear taking component of deflection. Produced by the bending of columns and slab causes the building to deflect excessively. There are two ways to satisfy these requirements. First is to increase the size of members beyond and above the strength requirements and second is to change the form of structure into more rigid and stable to confine deformation. First approach has its own limits, whereas second one is more elegant which increases rigidity and stability of the structure and also confine the deformation requirement. In earthquake engineering, the structure is designed for critical force condition among the load combination. In the present study the response of multi-storey commercial reinforced concrete. Frame and r c flat slab to the lateral and vertical loads have been done.

1.2 Scope of the study

This work includes the design and estimate for flat slabs of various spans, ranging from 6.0 m to 12.0 m, by reinforced concrete's. And prestressed concrete techniques. For smaller spans, associated with normal building works, prestressed concrete construction becomes too cumbersome, irrespective of the economics involved. Intensity of assumed loading is kept sufficient enough, so that the factored bending moment will be comparable to that developing in cases of commercial buildings. Post-tensioning is preferred as it is in vogue, in construction of large span slabs. All structural costs, floor framing is usually the largest component. Likewise, the majority of a structure's formwork cost is usually associated with the horizontal elements. Consequently, the first priority in designing for economy is selecting the structural system that offers lowest overall cost while meeting load requirements. Post tensioning is the key to cost-effective multifamily construction. In addition, post-tensioned structures can be designed to have minimal deflection and cracking, even under full load. Thinner floors provide lower building weight, which creates a corresponding reduction in other structural elements. There are also some associated labour and time savings

1.3. Objectives

- To study the performance of flat slab and conventional slab structure subjected to various loads and conditions.
- To the study the behavior of both structure for the parameters like storey shear, storey displacement drift ratio, axial forces.
- Comparisons of flat and conventional building for the above parameters.
- The main objective of the analysis is to study the different forces acting on a building. The analysis is carried out in etabs software. Results of conventional reinforced concrete.c structure i.e. Slab, beam and column and flat slab reinforced concrete.c structure for different heights are discussed below.
- Conventional reinforced concrete.c structure and flat slab reinforced concrete.c for different height are modeled and analyzed for the different combinations of dynamic loading. The comparison is made between the conventional reinforced concrete.c structure and flat slab reinforced concrete.c. Buildings are situated in seismic zone IV.
- To study the vulnerability of purely frame and purely flat-slab models under different factors which are storey drift, lateral displacement, time period and base shear have been obtained for.

II. RESULTS AND ANALYSIS

General

ETABS is a special-purpose computer program developed specifically for building structures. It provides the Structural Engineer with all the tools necessary to create, modify, analyze, design, and optimize building models. These features are fully integrated in a single, Windows-based, graphical user interface that is unmatched in terms of ease of- use, productivity, and capability. The innovative and revolutionary new ETABS is the ultimate integrated software package for the Structural analysis and design of buildings. Incorporating 40 years of continuous research and development, this latest ETABS offers unmatched 3D object based modeling and visualization tools, blazingly fast linear and nonlinear analytical power, sophisticated and comprehensive design capabilities for a wide-range of materials, and insightful graphic displays, reports, and schematic drawings that allow users to quickly and easily decipher and understand analysis and design results.

From the start of design conception through the production of schematic drawings, ETABS integrates every aspect of the engineering design process. Creation of models has never been easier - intuitive drawing commands allow for the rapid generation of floor and elevation framing. CAD drawings can be converted directly into ETABS models or used as templates onto which ETABS objects may be overlaid. Design of steel and concrete frames (with automated optimization), composite beams, composite columns, steel joists, and concrete and masonry shear walls is included, as is the capacity check for steel connections and base plates. Models may be realistically rendered, and all results can be shown directly on the structure. Comprehensive and customizable reports are available for all analysis and design output, and schematic construction drawings of framing plans, schedules, details, and cross-sections may be generated for concrete and steel structures. ETABS provides an unequaled suite of tools for structural engineers designing buildings, whether they are working on one-story industrial structures or the tallest commercial high-rises. Immensely capable, yet easy-to-use has been the hallmark of ETABS since its introduction decades ago, and this latest release continues that tradition by providing engineers with the technologically-advanced, yet intuitive, software they require to be their most productive.

Finite element method

The finite element method is a numerical technique to find approximate solutions of partial differential equations. It was originated from the need of solving complex elasticity and structural analysis problems in civil, mechanical and aerospace engineering. In a structural simulation, finite element method helps in producing stiffness and strength visualizations. It also helps to minimize material weight and its cost of the structures. Finite element method allows for detailed visualization and indicates the distribution of stresses and strains inside the body of a structure. Many of fe software are powerful yet complex tool meant for professional engineers with the training and education necessary to properly interpret the results. This powerful design tool has significantly improved both the standard of engineering designs and the methodology of the design process in many industrial applications. The use of finite element method has significantly decreased the time to take products from concept to the production line. One must take the advantage of the advent of faster generation of personal computers for the analysis and design of engineering product with precision level of accuracy

Etabsnanalysis and design procedure

- Define Plan Grids and Story Data
- Define Material Properties
- Define Frame Sections
- Define Slab Sections
- Define Load Cases
- Draw Beam Objects (Frame Members)
- Draw Column Objects (Frame Members)
- Assign Slab Sections
- Assign Restrains
- Assign Slab Loads
- View Input Data in Tabular Form
- Run the Analysis
- View Analysis Results Graphically
- Design Concrete Frame Element

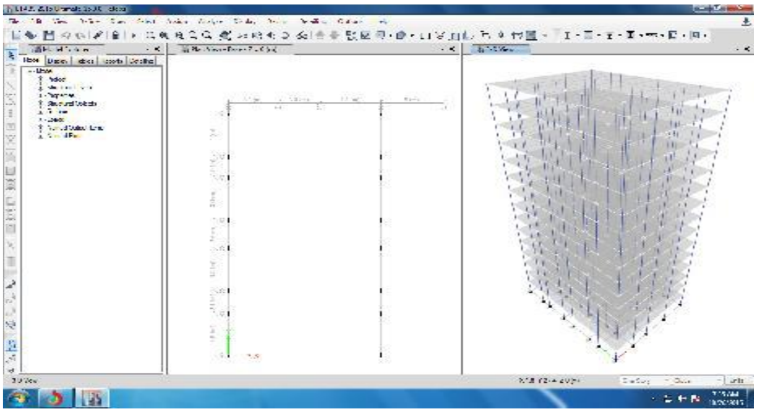

Fig .1 view of whole structure data

III. STRUCTURE DATA

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

3.2 Story data

Table .1 - story data

Table .1 - story data

Name	Height Mm	Elevation Mm	Master story	Similar to	S
Story15	2800	42200	Yes	None	
Story14	2800	39400	No	Story15	
Story13	2800	36600	No	Story15	
Story12	2800	33800	No	Story15	
Story11	2800	31000	No	Story15	
Story10	2800	28200	No	Story15	
Story9	2800	25400	No	Story15	
Story8	2800	22600	No	Story15	
Story7	2800	19800	No	Story15	
Story6	2800	17000	No	Story15	
Story5	2800	14200	No	Story15	
Story4	2800	11400	No	Story15	
Story3	2800	8600	No	Story15	
Story2	2800	5800	No	Story15	
Story1	3000	3000	No	Story15	
Base	0	0	No	None	

Name	Type	Story range	X origin M	Y origin M	Rotation Deg	Bubble size Mm	Colo
G1	Cartesian	Default	0	0	0	300	Ffa0a 0

Table 3 - grid lines

Grid system	Grid direction	Grid id	Visible	Bubble location	Ordinate M
G1	X	A	Yes	End	0
G1	X	B	Yes	End	5.4.9
G1	X	C	Yes	End	7.2
G1	X	D	Yes	End	12
G1	X	E	Yes	End	17
G1	Y	1	Yes	Start	0
G1	Y	2	Yes	Start	5.4.8
G1	Y	3	Yes	Start	5.9
G1	Y	4	Yes	Start	9.8

Grid system	Grid direction	Grid id	Visible	Bubble location	Ordinate M
G1	Y	5	Yes	Start	15.5.4
G1	Y	6	Yes	Start	16.3
G1	Y	7	Yes	Start	18.2
G1	Y	8	Yes	Start	25.5.2

3.4. Point coordinates

Table 4. - joint coordinates data

Label	X Mm	Y Mm	Δz below Mm
1	0	0	0
2	0	3800	0
3	0	5900	0
4	0	9800	0
5	0	12400	0
6	0	16300	0
7	0	18200	0
8	0	22200	0
9	3900	0	0
10	3900	3800	0
11	3900	5900	0
12	3900	9800	0
13	3900	12400	0
14	3900	16300	0
15	3900	18200	0
16	3900	22200	0
17	7200	0	0
18	7200	3800	0
19	7200	5900	0
20	7200	9800	0
21	7200	12400	0
22	7200	16300	0
23	7200	18200	0
24	7200	22200	0
25	12000	0	0
26	12000	3800	0
27	12000	5900	0
28	12000	9800	0
29	12000	12400	0
30	12000	16300	0
31	12000	18200	0
32	12000	22200	0
33	17000	0	0
34	17000	3800	0

Label	X Mm	Y Mm	Δz below Mm
35	17000	5900	0
36	17000	9800	0
37	17000	12400	0
38	17000	16300	0
39	17000	18200	0
40	17000	22200	0
41	225	0	0
42	225	225	0
43	0	225	0
44	3675	0	0
45	4125	0	0
46	4125	225	0
47	3675	225	0
48	6975	0	0
49	7425	0	0
50	7425	225	0
51	6975	225	0
52	11775	0	0
53	12225	0	0
54	12225	225	0
55	11775	225	0
56	16775	0	0
57	17000	225	0
58	16775	225	0
59	0	3575	0
60	225	3575	0
61	225	4025	0
62	0	4025	0
63	3675	3575	0
64	4125	3575	0
65	4125	4025	0
66	3675	4025	0
67	6975	3575	0
68	7425	3575	0
69	7425	4025	0
70	6975	4025	0
71	11775	3575	0
72	12225	3575	0
73	12225	4025	0
74	11775	4025	0
75	16775	3575	0
76	17000	3575	0
77	17000	4025	0

Label	X Mm	Y Mm	Δz below Mm
78	16775	4025	0
79	0	5675	0
80	225	5675	0
81	225	6125	0
82	0	6125	0
83	3675	5675	0
84	4125	5675	0
85	4125	6125	0
86	3675	6125	0
87	6975	5675	0
88	7425	5675	0
89	7425	6125	0
90	6975	6125	0
91	11775	5675	0
92	12225	5675	0
93	12225	6125	0
94	11775	6125	0
95	16775	5675	0
96	17000	5675	0
97	17000	6125	0
98	16775	6125	0
99	0	9575	0
100	225	9575	0
101	225	10025	0
102	0	10025	0
103	3675	9575	0
104	4125	9575	0
105	4125	10025	0
106	3675	10025	0
107	6975	9575	0
108	7425	9575	0
109	7425	10025	0
110	6975	10025	0
111	11775	9575	0
112	12225	9575	0
113	12225	10025	0
114	11775	10025	0
115	16775	9575	0
116	17000	9575	0
117	17000	10025	0
118	16775	10025	0
119	0	12175	0
120	225	12175	0

Label	X Mm	Y Mm	Δz below Mm
121	225	12625	0
122	0	12625	0
123	3675	12175	0
124	4125	12175	0
125	4125	12625	0
126	3675	12625	0
127	6975	12175	0
128	7425	12175	0
129	7425	12625	0
130	6975	12625	0
131	11775	12175	0
132	12225	12175	0
133	12225	12625	0
134	11775	12625	0
135	16775	12175	0
136	17000	12175	0
137	17000	12625	0
138	16775	12625	0
139	0	16075	0
140	225	16075	0
141	225	16525	0
142	0	16525	0
143	3675	16075	0
144	4125	16075	0
145	4125	16525	0
146	3675	16525	0
147	6975	16075	0
148	7425	16075	0
149	7425	16525	0
150	6975	16525	0
151	11775	16075	0
152	12225	16075	0
153	12225	16525	0
154	11775	16525	0
155	16775	16075	0
156	17000	16075	0
157	17000	16525	0
158	16775	16525	0
159	0	17975	0
160	225	17975	0
161	225	18425	0
162	0	18425	0
163	3675	17975	0

Label	X Mm	Y Mm	Δz below Mm
164	4125	17975	0
165	4125	18425	0
166	3675	18425	0
167	6975	17975	0
168	7425	17975	0
169	7425	18425	0
170	6975	18425	0
171	11775	17975	0
172	12225	17975	0
173	12225	18425	0
174	11775	18425	0
175	16775	17975	0
176	17000	17975	0
177	17000	18425	0
178	16775	18425	0
179	0	21975	0
180	225	21975	0
181	225	22200	0
182	3675	21975	0
183	4125	21975	0
184	4125	22200	0
185	3675	22200	0
186	6975	21975	0
187	7425	21975	0
188	7425	22200	0
189	6975	22200	0
190	11775	21975	0
191	12225	21975	0
192	12225	22200	0
193	11775	22200	0
194	16775	21975	0
195	17000	21975	0
196	16775	22200	0

3.5 Properties

This chapter provides property information for materials, frame sections, shell sections, and links.

3.5.1 Materials

Table 5. - Material properties – summary

Name	Type	E Mpa	N	Unit weight Kn/m³	Design strengths
4000psi	Concrete	24855.58	0.2	25.4.5631	Fc=27.58 mpa
Name	**Type**	**E Mpa**	**N**	**Unit weight Kn/m³**	**Design strengths**
A615gr60	Rebar	199947.98	0.3	76.9729	Fy=415.4.69 mpa, fu=620.53 mpa

3.5.2 Frame sections

Table 6. - frame sections - summary

Name	Material	Shape
Conccol	4000psi	Concrete rectangular

3.5.3 Shell sections

Table 7- shell sections - summary

Name	Design type	Element type	Material	Total thickness Mm
Drop1	Slab	Shell-thin	4000psi	350
Slab1	Slab	Shell-thin	4000psi	200

3.5.4 Reinforcement sizes

Table 8. - reinforcing bar sizes

Name	Diameter Mm	Area Mm^2
10	10	79
20	20	314

3.6 Assignments

This chapter provides a listing of the assignments applied to the model.

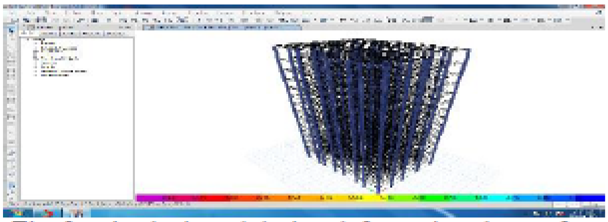

Fig 2. : Analysis and design deformation shape of whole structure

IV. RECOMUNDATIONS AND CONCLUSION

4.1. Recomendations

After completing this main project, based on our experience the following recommendations are made.

1. One cannot ignore the importance of the geotechnical engineering report which indicates the estimation of soil bearing capacity.
2. The engineering who is involved in analysis and design of multistoried building should have the proper back ground in the following technical areas.
    a. Engineering mechanics
    b. Engineering drawing
    c. Strength of materials
    d. Structural analysis
    e. Structural design of RCC and steel
3. In addition to the technical skill one should have the following basic skills.
    a. Communication skills
    b. Report writing skills
    c. Microsoft office
    d. AUTOCAD
    e. Structural engineering soft wares
    f. Architectural soft wares
4. The design engineer should have the basic background in electrical and plumbing engineering also.
5. A novice design engineer may use our main project report as a guide line.

4.2. Scope of future work

- Absence of beams allows lower story heights and as a result cost saving in vertical cladding, partition walls, mechanical systems, plumbing and a large number of other items of construction especially for medium and high rise building.
- Total height of building is restricted using flat slab results in more stories accommodated within the set height.

- Comparisons of flat plate (without drop) and flat slab (with drop) can be studied for all seismic zones.
- Comparisons of pretension and post tensioned flat slab with or without drops.
- Cost comparisons of various types of slabs available.
- In this project comparison of conventional beam slab and grid slab is made on the basis of major material requirements of the slab.

V. CONCLUSION

- Flat plate/slab construction is a developing technology in India flat slabs has many advantages over conventional slabs and hence it can be a very good option for modern constructions demanding structural stability and state of art aesthetic aspects and prospects.
- Flat plate/slab can be designed and built either by conventional reinforced concrete. or post tensioning. However, due to issues mentioned above with post- tensioning construction in India and its higher cost, conventional reinforced concrete design should be the preferred choice for spans up to 10 meters.
- Design of conventional reinforced concrete. Flat plate/slab in India, utilizing Indian codes, has many shortcomings, which have to be addressed and revised soon.

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