Analysis and Design of Flat Slab, Grid Slab and Bubble Slab

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Abstract— In present era, large column free space is required in auditoriums, vestibules, theatre hall, shopping malls etc. The use of Flat slab, Grid slab and Bubble slab fulfils the requirement in terms of architectural flexibility, use of space, and shorter construction time. In the present work an "IT Park for Vidarbha InfoTech Ltd., Nagpur." building of 2B+G+10story is considered. For modelling, analysis and designing of flat flab and grid slab structures, SAFE software is used. The dead load and live load are considered as per IS 875-1987. The design is carried out as per IS 456-2000 and for reinforcement detailing SP 34 is used. Bubble Deck is intended to be a flat, two-way spanning slab supported directly by columns. The design of this system is generally regulated by the allowed maximum deflection during service loading; code used is BS8110 and only details of the Bubble slab is carried out. This paper states that the Flat slab with drop are preferable to use due to its increase negative moment capacity of slab, stiffness of the slab achieved and reduction of slab depth. Though concrete and steel required in flat slab is more compared to grid slab but using grid slab requires special formwork. Its formwork rate is double the rate of flat slab. Bubble slab reduces 50% of concrete and is to taken in action in India due to its various advantages.

Key words: Flat Slab, Grid Slab, Bubble Slab, SAFE

I. INTRODUCTION

With rapid growth in population along with development of industrial and commercial activities rapid urbanization has taken place which has resulted into continues migration of rural people to metro cities. Thus, the horizontal space constraint is reaching an alarming situation for metros. To cope with the situation maximum utilization of space vertically calls for the construction of multi-storey buildings in large numbers along with the cost effect design of such buildings.

A. Flat Slab

Flat slab is a reinforced concrete slab with or without drops, supported generally without beams, by columns with or without flared column heads. Punching shear is developed in the slab. In order to reduce the shear the column head is sometimes widened called as **column head.** Moments in the slabs are more near the column. Hence the slab is thickened near the columns by providing the drops called as capital of column. Thus following are the types of flat slab.

1) Slabs without drop and column head
2) Slabs without drop and column with column head
3) Slabs with drop and column without column head
4) Slabs with drop and column head

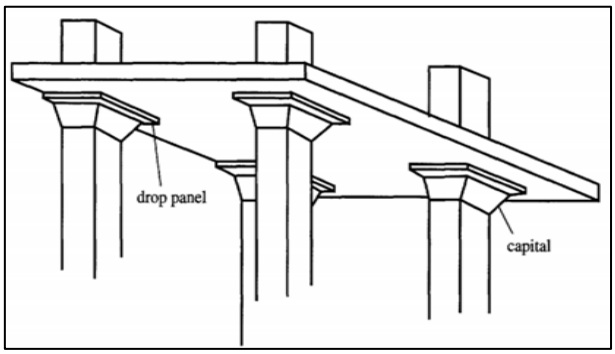


Fig. 1: Typical Flat slab

B. Grid Slab

Grid floors consist of closely spaced intersecting beams in two direction with monolithic slab on the top. It is generally adopted when large column free space is required and reduces the span to depth ration of rectangular grids. Grid found very efficient in load transferring. The rectangular or square void formed in the ceiling is advantageously utilized for concealed architectural lighting. Different patterns of grid are namely Rectangular, square and diagonal.

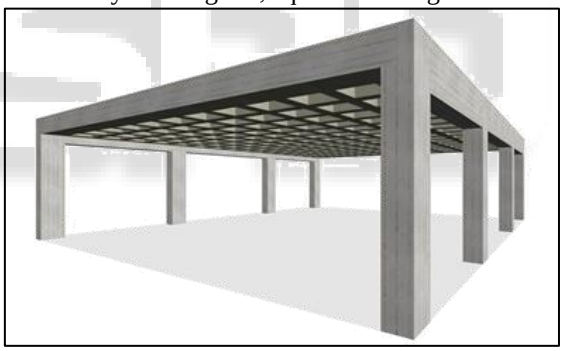


Fig. 2: Typical Grid Slab

C. Bubble Slab

Bubble Deck is generally designed using the conventional methods for solid floor slabs in accordance with the current reinforced concrete construction standards DIN1045(1988) or DIN1045(2001). It is a revolutionary biaxial concrete floor system developed in Europe in 1990's by Jorgen Breuning. Bubble deck slab uses hollow spherical balls made by recycled plastic and therefore it is an innovatory method of virtually eliminating the concrete part in the middle of conventional slab which does not contribute to the structural performance. This results in a dramatic reduction of dead weight by as much as 50% allowing much longer spans and less supporting structure than traditional solutions.

It is a green technology, according to the Bubbledeck company, 1 kg of recycled plastic which is an industrial waste, replaces 100 kg of concrete. Generally for every 5000 sq.m of Bubble deck floor slab, the owner can save

a) 1000 sq.m of on-site concrete
b) 166 concrete truck trips
c) 1798 tons of foundation load or 19 less piles
d) 1745 Gj of energy used in concrete production and transportation
e) 278 tons of CO2 emission

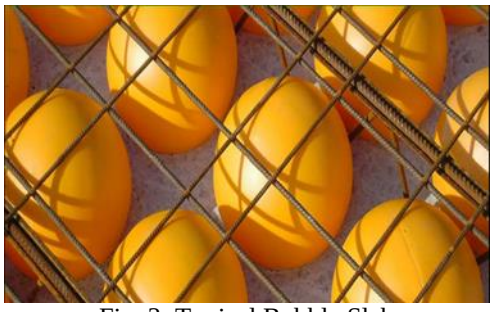


Fig. 3: Typical Bubble Slab

II. THEROTICAL DESIGN

The study has been carried out for 2B+G+10 story building models which having floor plan of 74.7m x 25.35m in rectangle. The floor plan of is divided into 9.3m x 8.5m c/c. The dead load and live load has been considered based on the IS 875 (Part 1&2). Figure 4 shows the details of floor plan adopted for the present study.

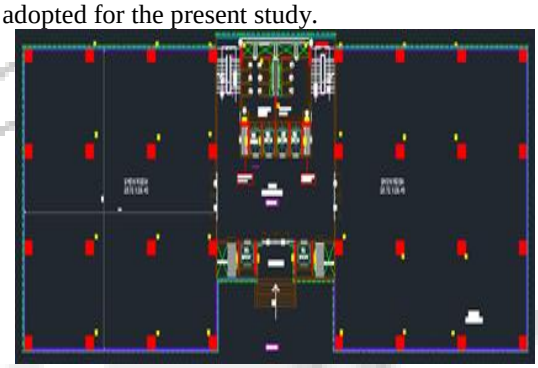


Fig. 4: Plan of a building

A. Load Calculations

1) Dead Load
   1) The self-weight of the slab
   2) Dead load on floor finishing: 1 kN/m^2
2) Live Load
   1) Live load on Floor: 4 kN/m^2

B. Material Properties

Grade of Concrete	M25
Density of concrete	25 KN/m^2
Grade of steel	Fe415 HYSD

Table 1: Material Properties

C. Dimension Calculations of Flat Slab

Panel Dimension				
Flat Slab	Along Width (m)		Along Length (m)	
	CS	MS	CS	MS
Without drop and column head				
	4.25	5.05	4.25	4.25
With drop				
	3.1	6.2	3.1	5.4
With drop and Column head				
	3.1	6.2	3.1	5.4

Table 2:

Exterior Panel Moment					
Exterior '-ve'		Interior '-ve'		'+ve' moment	
CS	MS	CS	MS	CS	MS
Along Length					
Without drop and column head					
908.09	0.00	718.67	239.559	314.72	209.185
With drop					
869.79	0.00	678.98	226.327	295.218	196.813
With drop and Column head					
753.60	0.00	586.20	195.401	273.73	182.49
Along Width					
Without drop and column head					
813.10	0.00	637.79	212.65	281.59	187.733
With drop					
777.33	0.00	602.88	220.962	264.5	176.334
With drop and Column head					
662.00	0.00	511.90	170.636	224.23	149.488

Table 3: Exterior Panel Moment

Interior Panel Moment			
Positive Moment		Negative moment	
CS	MS	CS	MS
Along Length			
Without drop and column head			
307.42	204.95	713.66	237.89
With drop			
290.950	193.97	675.430	225.14
With drop and Column head			
251.31	167.54	583.40	194.47
Along Width			
Without drop and column head			
273.20	182.13	634.21	211.40
With drop			
258.56	172.37	600.23	200.08
With drop and Column head			
219.63	146.42	509.85	169.95

Table 4: Interior Panel Moment

Thickness of Slab		
	Overall thickness of slab(mm)	Thickness of Drop(mm)
Without drop and column head	280	0.00
With drop	190	120
With drop and Column head	190	110

Table 5: Thickness of Slab

Reinforcement Details					
	CS	MS	Area	Ø	Spacing
Along Length					
Without drop and column head					
'-ve' Moment	908.09		12511.12	16	65
		239.56	2775.53	10	120
'+ve' Moment	314.72		3702.68	12	120
		209.81	2416.92	10	130
With drop					
'-ve' Moment	869.80		10866.30	16	50

		226.33	2297.87	10	180
'+ve' Moment	295.22		3106.23	12	110
		196.81	1991.34	10	210
With drop and Column head					
'-ve' Moment	753.61		9539.19	16	65
		195.40	2053.47	10	200
'+ve' Moment	273.73		2986.26	12	110
		182.49	1914.68	10	220
Along Width					
Without drop and column head					
'-ve' Moment	813.11		10853.01	16	75
		212.65	2435.08	10	130
'+ve' Moment	281.60		3290.50	12	140
		187.733	2141.17	10	150
With drop					
'-ve' Moment	777.34		9373.35	16	110
		200.96	2028.19	10	200
'+ve' Moment	264.50		2763.77	12	220
		176.334	1775.26	10	230
With drop and Column head					
'-ve' Moment	662		8093.40	16	130
		170.64	1782.50	10	230
'+ve' Moment	224.23		2417.53	12	250
		149.488	1558.31	10	270

Table 6: Reinforcement Details

D. Dimension Calculations Of Grid Slab

Considering Slab with two adjacent edge discontinuous.

Reinforcement Details				
Size of grid	Area(mm^2)		Bars(mm)	
	Shorter Length	Longer Length	Shorter Length	Longer Length
1.5*1.5	400	360	4@12	3@12
1.0*1.0	300	260	3@12	3@12
1.5*2.0	300	400	3@12	4@12
1.0*1.5	400	460	4@12	4@12

Table 7:

E. Form Work Calculations

Slab	Rate of Shuttering (Rs)
Flat slab with drop	361.4166
Grid slab (1.5*2)	685.82286

Table 8:

F. Dimension Calculations of Bubble Slab

Considering the slab as continuously supported floors, the BubbleDeck slab depth for given spans

Span/ Effective depth =41

i.e, d= 226.82 mm

D= 226.82+39= 265 mm

Thus, minimum BD voided slab thickness of 258 mm requiring BD 280 slab type for this span condition.

Ball Diameter = 225 mm

Maximum axis spacing = 250 mm

Maximum no. of balls = 16/m2

Thickness of slab= 280 mm

Load reduction per ball =0.15KN

Max. load reduction per sq.m= 2.39 KN/m2

Rigidity factor= 0.87

Shear factor = 0.6

G. Estimation of Flat Slab, Grid Slab and Bubble Slab

Slab	Concrete Req.(cu.m/m^2)	Steel Req.(kg/m^2)
Without drop and column head	0.2800	32.71
With drop	0.2195	26.21
With drop & Col^n head	0.2755	23.40
1.5*1.5	0.1443	17.9837
1.0*1.0	0.1656	19.1755
1.5*2.0	0.1369	18.1108
1.0*1.5	0.1618	20.0591
Bubble deck	0.142	-

Table 9:

H. Graphs

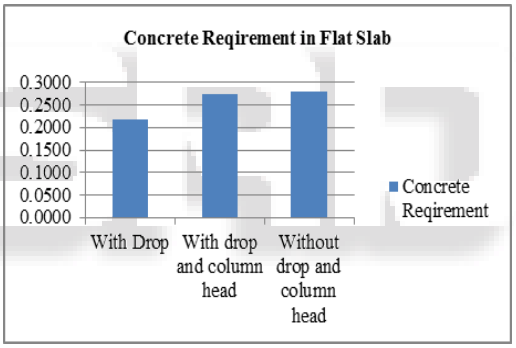
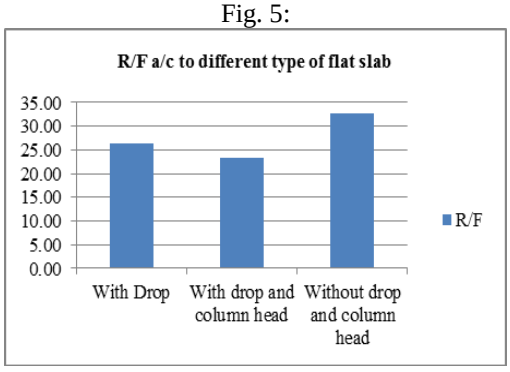


Fig. 5:



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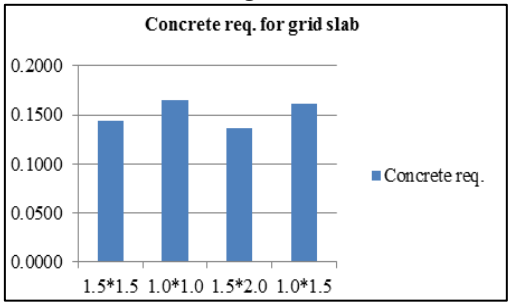
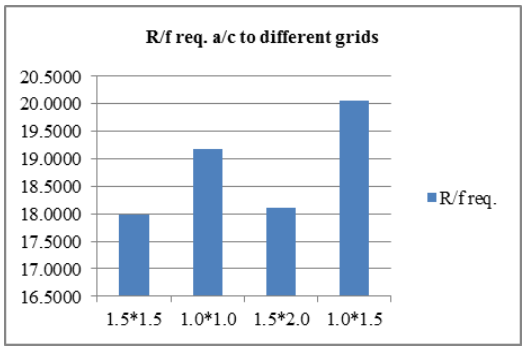


Fig. 7:



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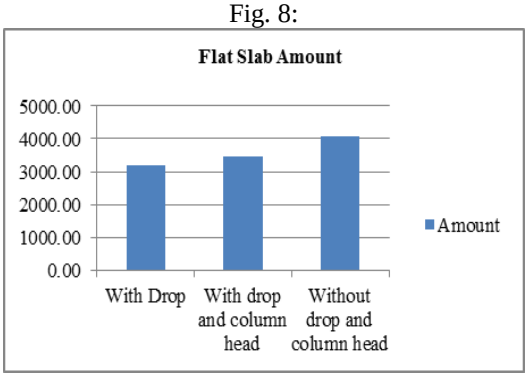

Fig. 9:

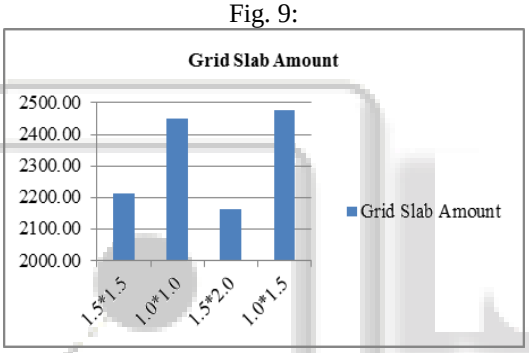

Fig. 10:

III. CONCLUSION

Compared to different types of Flat slab, Concrete and steel required is less in Flat with Drop panel. Drops are important criteria in increasing the shear strength of slab.

For high rise structure, In order to increase rigidity of slab, column heads are incorporated.

Drop panel increase negative moment capacity of slab. It stiffens the slab and hence reduce deflection.

Compared to different grids of grid Slab, Concrete and steel required is less in (1.5*2.0 m) grid panel.

Concrete required in bubble slab is less. The Bubble Deck has many advantages as compare to traditional concrete slab, such as: lower total cost, reduced material use, enhanced structural efficiency and decreased construction time.

Rate of shuttering of grid slab is almost double the rate of Flat slab.

Grid slab requires special or proprietary formwork, due to which flat slab with drop is preffered.

SAFE results are more economical than the therotical values.

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