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Flat Salb Dynamic Analysis

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Abstract - The seismic effect on the structure is the most important factor while designing the civil Engineering structures which will cause adverse effect later on. In present study efforts being taken while analyzing the structure for Earthquake resistance. In this we have taken a live project a five storied building with flat slab and dynamic analysis is done by Response Spectrum Method taking all load combinations as per IS-1893.We have used software SAP 2000 for this purpose. Main emphasis is given on the structural response when flat slab is provided. Behaviour of the structure is studied for four types of models like a flat slab only, Flat slab with head, with drop and with both head and drop with equal thickness as well unequal thickness. The results of all four types are then compared for time period, axial forces, shear forces, moments in each direction and the slab panel moments. The structure is designed as per IS-456-2000 and IS-13920 guidelines.

Keyword - **Response spectrum Method, SAP-2000, IS CODES-1893, 456-2000, 13920.**

1. Introduction

1.1 General

Flat slab is a reinforced concrete slab supported by columns with, or without drops. The columns may be with, or without, column heads. Flat-slab is one of the most widely used systems in reinforced concrete construction because of its high degree of structural efficiency. It use simple formwork and reinforcing arrangements, and requires the least storey height. Although efficient in resisting gravity load, the flat slab system is inherently flexible and can have excessive lateral drift when subjected to seismic loading. Its susceptibility to severe damage during strong earthquakes is well documented (Rosenblueth 1986; Hawkins 1980).

In zone of high seismicity, the flat-slab systems are designed such that slab-column space frame supports gravity loads and the shear walls provide resistance to lateral load (Wey and Durani 1992; Robertson and Durani1992; Moehle and Diebold 1985). However, it is required by the building codes [IS: 456; ACI: building 1989] that the gravity load subsystem must be able to deform with the lateral load resisting system without any loss of its load carrying capacity. Thus, in realty the two subsystems act together. Furthermore, since the design seismic force recommended by the codes are generally much less than what the structure would experience during a major earthquake , a certain degree of nonlinear response is to be expected.

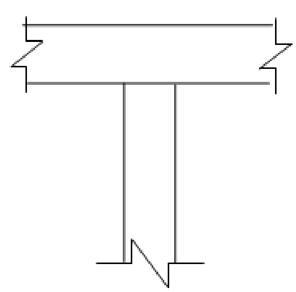


Figure 1.1 Without Drop &No Column Head

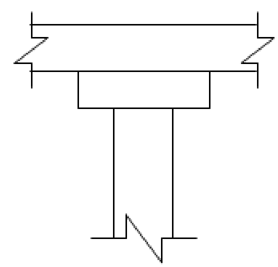


Figure 1.2 With Drop & No Column Head

1.2 Advantages

Some of the advantages of Flat Slab are:-

1. Rapid construction
2. Maximum design flexibility
3. Economy
4. Headroom height requirements large
5. Minimum storey heights
6. Controlled deflection
7. Optimum clear span
8. Sufficient lateral displacement capacity

1.3 Terminology Related With Flat Slab

1.3.1 Column Strip

Column strip means a design strip having a width of 0.25 l_1, but not greater than 0.25 l_2, on each side of the column centerline, where I_1, is the 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.

1.3.2 Middle Strip

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

1.3.3 Panel

Panel means that part of a slab bounded on-each of its four sides by the centre-line of a column or centre-lines of adjacent-spans.

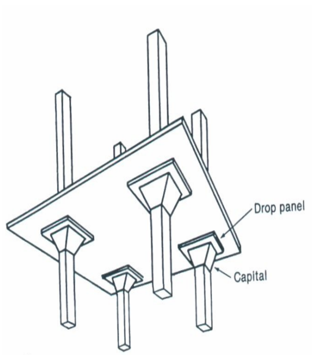


Figure 1.4 Flat slab with drop & column Head Structure

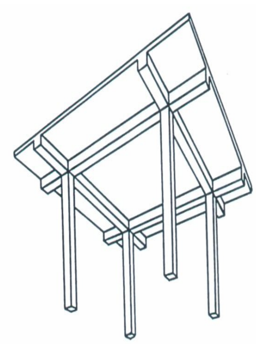


Figure 1.5 Slab Beam Structure

2. Analysis of Flat Slab by Response Spectrum Method

2.1 Introduction to Problem

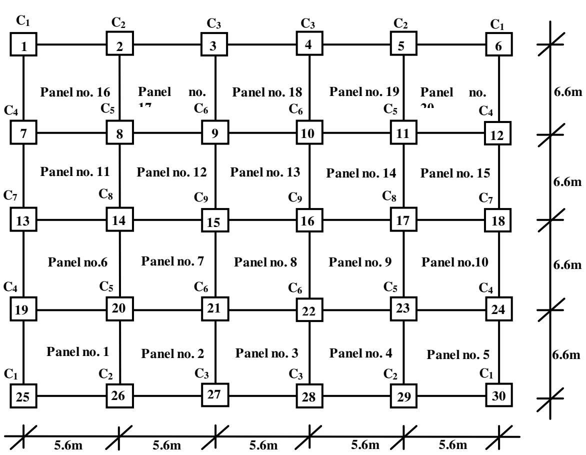
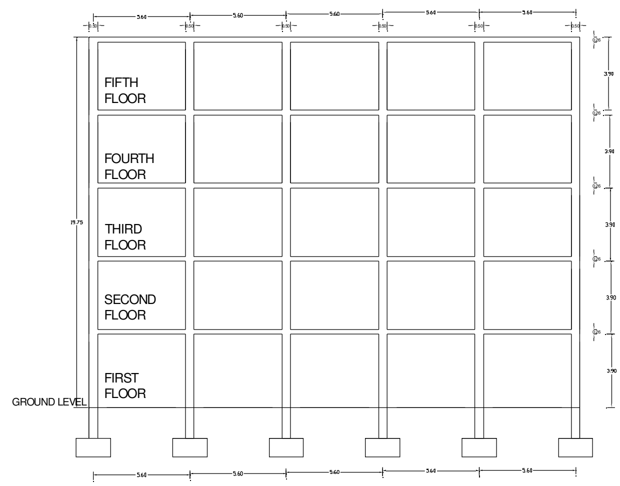


Fig.2.1Line Plan of Structure



2.2 Modeling of flat slab for Response Spectrum

- Column size (500x500)mm
- Slab thickness 200 mm without drop
- Live load on all floors 6 kN/m^2 (50% for earthquake)
- Grade of concrete M25 & steel Fe 415N/mm²
- Brick wall external & internal 230 mm
- Density of brick wall including plaster 20kN/m^3
- Density of brick wall including plaster 20kN/m^3
- Drop size external (1100x1000)mm
- Drop size internal (2200x 2000)mm
- Depth of Head 400mm
- Head at bottom (500x500)mm
- Head at top (1200x1200)mm

2.2.1 Mathematical Model

Table No. 2.1 Mathematical Model

Sr.No	Perticulars
1	The mathematical model includes five storey building with 30 column in each floor and 20 slab section
2	All columns are modeled as beam element and slab is modeled as plate element having area type shell
3	Each plate is sub divided into 9*8 =72 plate element
4	For dynamic analysis of structure response spectrum method was used

2.2.2 Soil Strata

It is assumed that the footing is resting at 1.5m from GL

Medium soil

2.2.3 Seismic Force Calculation

Zone II for Nagpur city Z=0.1
Hence spectra for medium soil \

Importance factor =1.5

Sa/g=1+15T0.00 $\leq$ T $\leq$ 0.101

Damping 5%

= 2.5 0.1 $\leq$ T $\leq$ 0.55

Soil type medium
= 1.36/T 0.55 $\leq$ T $\leq$ 4.0

R for SMRF=5 & OMRF=3

1. Time period in long direction Tx =0.09H/√d =0.09x21/√28 =0.357sec

2. Time period in short direction Ty=0.09H/√d =0.09x21/√26.4 =0.368sec

Take Sa/g for both direction = 2.5

2.2.4 Scale Factor

$$f = \frac{1}{2} x \frac{I}{R} = 0.15$$

Where, I= Importance factor =1.5

R=Response reduction factor=5

2.2.5 Response Spectrum for Zone II:-Soil Type II (Medium Soil)

Table No. 2.2 Time Period Vs Acceleration

Period(Sec)	Acceleration
0	0.1
0.1	0.25
0.55	0.25
0.8	0.17
1	0.136
1.2	0.1133
1.4	0.0971
1.6	0.085
1.8	0.0756
2	0.068
2.5	0.0544
3	0.0453
3.5	0.0389
4	0.034
4.5	0.034
5	0.034
5.5	0.034
6	0.034
6.5	0.034
7	0.034
7.5	0.034
8	0.034
8.5	0.034
9	0.034
8.5	0.034
10	0.034

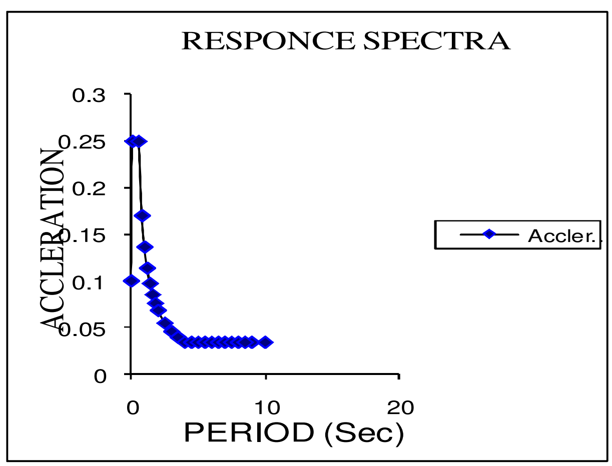


Figure 2.6 Response Spectra for Zone II

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2.3 Results and Discussion

2.3.1 Comparison of Time Period (sec)

Table No.2.3 Comparison of Time Period (sec)

TYPE	FLAT SLAB	DROP	WITH HEAD	DROP WITH HEAD
C1	593	573	581	569
C2	728	708	716	699
C3	708	689	695	681
C4	722	703	712	693
C5	836	819	825	809
C6	833	810	821	799
C7	715	695	708	689
C8	838	815	827	806
C9	869	879	888	876

TIME PERIOD FOR ALL FLAT SLABS (Sec)				
MODES	**FLAT**	**HEAD**	**DROP**	**DROP HEAD**
1	1.60	1.61	1.65	1.66
2	1.56	1.57	1.61	1.62
3	1.47	1.50	1.53	1.53
4	0.47	0.47	0.49	0.49
5	0.46	0.46	0.48	0.48
6	0.43	0.43	0.44	0.44
7	0.23	0.23	0.24	0.42
8	0.23	0.23	0.23	0.24
9	0.21	0.21	0.21	0.23
10	0.14	0.13	0.14	0.23
11	0.14	0.13	0.14	0.21
12	0.12	0.12	0.12	0.21

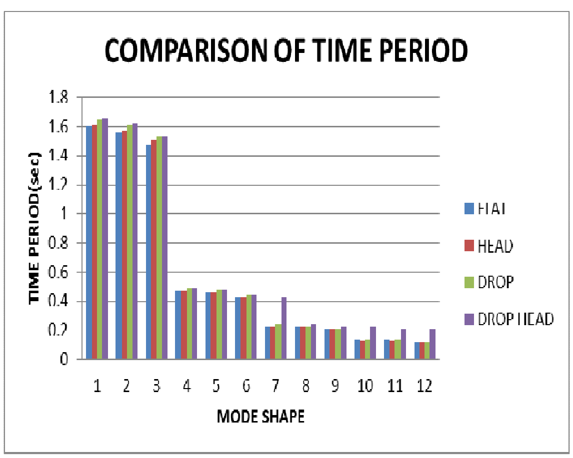


Fig. 2.7 Comparison of Time Period (sec)

Description & Interaction (Time Period)

As it is seen from SAP-Results there are many modes out of which if we consider the first two modes it has been seen that the time period of flat slab without Head & Drop seems to be low due to which Sa/g will be less and lateral forces will also be less

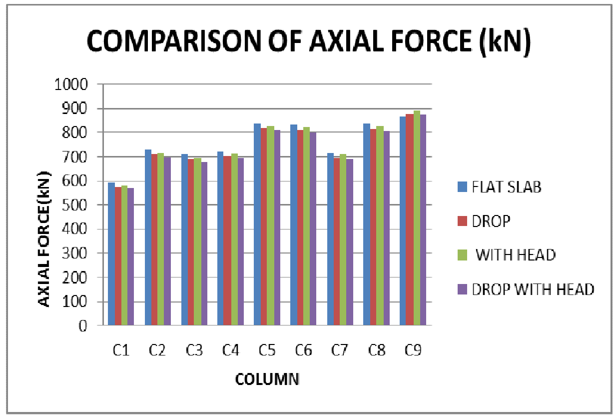


Fig.2.8 Comparison of Axial Force (kN) First Storey

Description & Interaction (Axial Force)

As we go from fifth Story to the first story we can see the first story have long column and we have maximum axial force to be developed in the column of first story with drop and head.

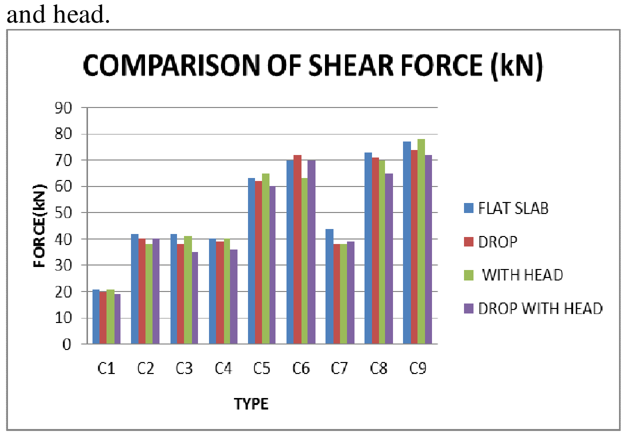
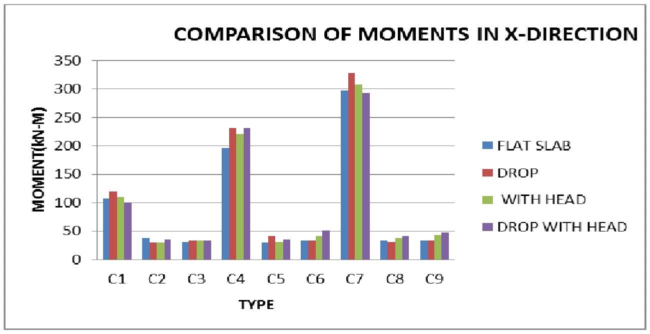


Fig.2.9Comparison of Shear Force (kN) First Storey

Description & Interaction (Shear Force)

From SAP Result it is seen that due to lateral forces developed are in decreasing order from flat to drop with head & there is not much differences in the models with only drop & only head.



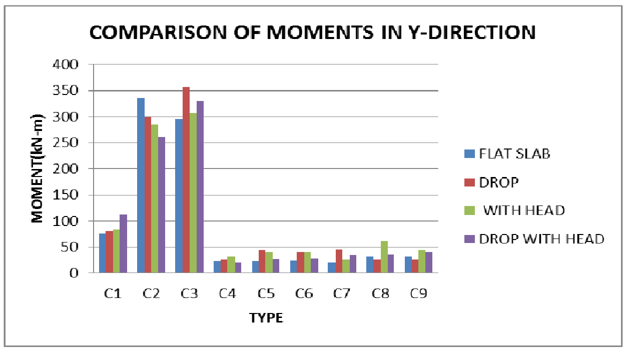


Fig2.10Comparison of Moment in X- Direction (kN-m)

Description & Interaction (Moments)

From the graph it is found that the moments are directly proportional to the stiffness. Since the stiffness is going to increase from flat to drop with head & if we compare Slab with the head & Slab with the drop. The stiffness will not very much there fore the moment variation are not much.

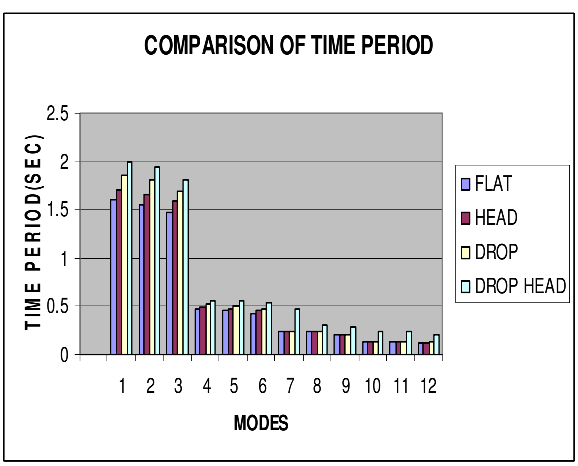


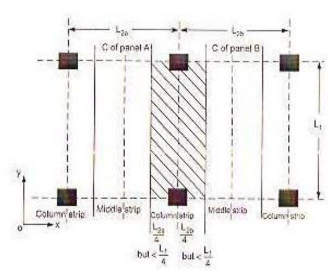
Fig. 3.1 Comparison of Time Period (sec)

4. DESIGN OF FLAT SLAB BY IS 456:2000

	FLAT SLAB		DROP		WITH HEAD		DROP WITH HEAD	
TYPE	M2	M3	M2	M3	M2	M3	M2	M3
C1	76	107	80	120	84	110	112	101
C2	335	38	300	30	285	30	261	35
C3	295	31	357	32	306	32	330	32
C4	22	196	25	231	32	221	21	231
C5	23	30	45	41	40	31	27	35
C6	24	32	40	32	40	41	28	51
C7	21	298	46	328	25	307	34	293
C8	31	32	25	31	62	37	36	41
C9	31	32	26	32	45	42	40	48

The term flat slab means a reinforced concrete slab with or without drops, supported generally without beams, by columns with or without flared column heads. A flat slab may be solid slab or may have recesses formed on the soffit so that the soffit comprises a series of ribs in two directions. The recesses may be formed by removable or permanent filler blocks.

4.1 Components of flat slab design



4.1.1 Column Strip

Column strip means a design strip having a width of 0.25 I_1, but not greater than $0.25l_2$, on each side of the column centre-line, where I, is the span in the direction moments are being determined, measured centre to centre of supports and 1_1, is the -span transverse to 1_2, measured centre to centre of supports.

4.1.2 Middle Strip

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

Type	Main R/F IS 456-2000	Main R/F IS 13920-1993	Stirrups IS 456-2000	Stirrups IS 13920-1993
C1	6-25Φ+2-16Φ	6-25Φ+2-16Φ	8mmDia. 2L@180mm	1)8mmDia. 2L@250mm 2)8mmDia. 3L@80mm

4.1.3 Panel

Longer span	Shorter span
L_1=6.6m, L_2=5.6m (i) column strip = 0.25 L_2= 1.65m But not greater than 0.25 L_1 =1.4 m (ii) Middle strip =6.6-(1.4+1.4)=3.8m	L_1=5.6m,L_2=6.6m (i) column strip = 0.25 L_2 = 1.4m But not greater than 0.25 L_1= 1.4m (ii) Middle strip =5.6-(1.4+1.4)=2.8m

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

Division into column and middle strip along:

Table 4.1 Span Calculations

4.1.4 Drop

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.

Since the span is large it is desirable to provide drop.

Panel	Longer span	Shorter span
Column strip	-956kN-m	-568kN-m
Middle strip	+134 kN-m	+104 kN-m
Column strip	-956 kN-m	-956 kN-m
Reinforcement	4664mm^2	3512mm^2
–ve steel	1938mm^2	1508 mm^2
Reinforcement	20mm ϕ @130c/c	20mm ϕ @130c/c
+ve steel	16mm ϕ @100c/c	16mm ϕ @130/c
Spacing –ve steel		
Spacing +ve steel		

Drop dimensions along:

Table 4.6 Steel Calculation

4.7 Design Of column by IS-456-2000 and IS-13920

Detailing of C3 Column for First Storey

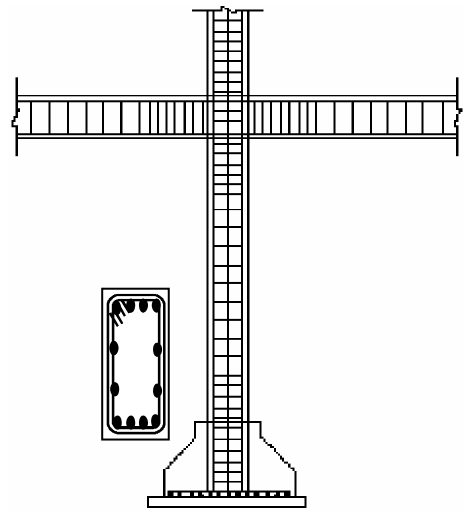


Figure 4.2 Detailing of C3 column as per IS 13920:1993

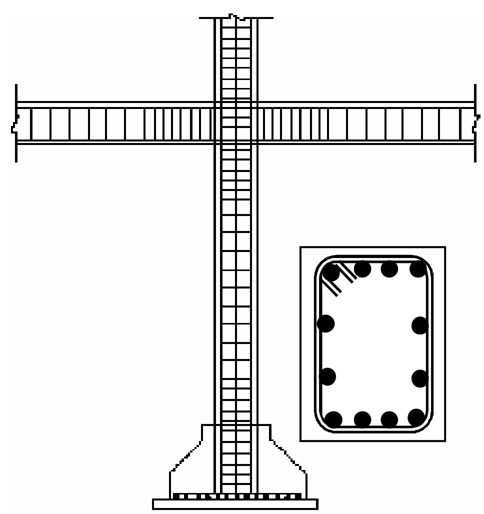


Figure 4.3 Detailing of C1 column as per IS 13920:1993

5. Conclusions

1. Drops are important criteria in increasing the shear strength of the slab.
2. By incorporating heads in slab, we are increasing rigidity of slab.
3. The dynamic analysis results indicate that the lowest mode of vibration i.e. third mode was the torsional mode. This seems to be a typical of flat-slab building with a central core of shear walls.
4. Modeling of flat plate slab with diaphragm and without diaphragm in case of response spectrum method there is no variation in axial force, shear force and moment as moment of inertia of slab is very high it acts as rigid.
5. The negative moment's section shall be designed to resist the larger of the two interior negative design moments for the span framing into common supports.
6. Enhance resistance to punching failure at the junction of concrete slab & column by providing drop with head.
7. Drop with head & Flat slab head is very good combination to reduce the moment with less thickness of slab.
8. In earthquake zone we shall provide only flat slab drop with head & ductile detailing for all structure.

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