www.ijiarec.com

ISSN:2348-2079 Volume-5 Issue-1

International Journal of Intellectual Advancements and Research in Engineering Computations

Comparative study on flat slab with and without column head using American code and is code

Mr.B.Rajkumar[1] and Dr.M.Arun[2]
[1]PG Final year Student, [2]Assistant Professor(Sr.G)
Department of Civil Engineering, Bannari Amman Institute of Technology,Sathyamangalam, Erode, Tamilnadu, India rajkumar.st15@bitsathy.ac.in and arunm@bithsathy.ac.in

Abstract— **As per local conditions and availability of materials different countries have adopted different methods for design of flat slabs and given their guidelines in their respective codes. The aim of this analytical study is to try and illustrate the methods used for flat slab design with and without column head using ACI-318, NZ- 3101 part 1,Eurocode part 2 and IS: 456- 2000 design codes. For carrying out this study an interior panel of a flat slab with dimensions 6.6 x 5.6 m and super imposed load 7.75 KN/m^{2}were adopted.**

Keywords: Flat slab, ACI-318, NZ- 3101 part 1,Euro code part 2, IS: 456- 2000 design codes

I. Introduction:

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.

This study is concerned with the Analysis and Design of Flat slab with and without column head and to prepare the worksheet for analysis and design of flat slabs. The scope of work will be as below. Analysis and design of flat slabs with and without column head is to be carried out for columns using direct design method, Equivalent Frame Method with IS 456-2000, ACI 318-08, Euro code and NZ-3101.Analysis of flat slab with equivalent frame method using software ETABS. Preparation of excel worksheet for analysis and design of flat slab with and without column head as per IS 456-2000, ACI 318-08, Euro code and NZ-3101.

To compare RC flat slab by considering various aspects.For carrying out this study an interior panel of a flat slab with dimensions 6.6 x 5.6 m and super imposed load 7.75 KN /m^2 was designed using the above mentioned codal provisions.

II. Flat slab

RC slabs with long spans extended over several bays and only supported by columns, without beams known as flat slab. Flat slab system is very simple to construct and is efficient in that it requires the minimum building height for a given number of stories. Such structure contains large bending moment and vertical forces occur in a zone of supports. This gives a very efficient structure which minimizes material usages and decreases the economic span range when compared to reinforced concrete. Post-tensioning improves the structural behavior of flat slab structure considerably. This is more acceptable concept to many designers. It is
adopted in some office buildings. The flat slabs are plates that are stiffened near the column supports by means of ‘drop panels’ and/or ‘column capitals’ (which are generally concealed under ‘drop ceilings’). Compared to the flat plate system, the flat slab system is suitable for higher loads and larger spans, because of enhanced capacity in resisting shear and hogging moments near the supports. The slab thickness varies from 125 mm to 300 mm for spans of 4 to 9m. Among the various floor systems, the flat slab system is the one with the highest dead load per unit area. In general, in this type of system, 100 percent of the slab load has to be transmitted by the floor system in both directions (transverse and longitudinal) towards the columns. In such cases the entire floor system and the columns act integrally in a two- way frame action. Some terminologies involved

Drop Panels: The 'drop panel' is formed by the local thickening of the slab in the neighborhood of the supporting column. Drop panels or simply drops are provided mainly for the purpose of reducing shear stress around the column supports. They also help in reducing the steel requirements for the negative moments at the column supports. The code recommends that drops should be rectangular in plan, and have length in each direction not less than one third of the panel length in that direction. For exterior panels, the length measured perpendicular to the discontinuous edge from the column centerline should be taken as one half of the corresponding width of drop for the interior panel.

Column Capital: The column capital or column head provided at the top of a column is intended primarily to increase the capacity of the slab to resist punching shear. The flaring of the column at top is generally done such that the plan geometry at the column head is similar to that of the column. The code restricts the structurally useful portion of the column capital to that portion which lies within the largest (inverted) pyramid or right circular cone which has a vertex angle of 90°, and can be included entirely within the outlines of the column and the column head. This is based on the assumptions of a 45° failure plane, outside of which enlargement of the support is considered ineffective in transferring shear to the column. Some evident of flat slab failure:

a)In this new skeleton building with flat slabs and small structural columns designed to carry gravity loads, the only bracing against horizontal forces and displacements is a reinforced concrete elevator and stairway shaft, placed very asymmetrically at the corner of the building. There is a large eccentricity between the centers of mass and resistance or stiffness. Twisting in the plan, lead to large relative displacements in the columns furthest away from the shaft and, this implies the danger of punching shear failure.

b)Punching Shear Failure in the Main Roof at corner Column.

c)This multi-floor parking garage collapsed like a stack of cards while some of the neighboring buildings remained undamaged. Flat slab construction was the most vulnerable construction type with 85 total collapses during the 1985 quake at Germany.

d)In this building as in many others, the load-bearing column forced through the concrete floors as they collapsed around it. Severe resonance oscillations of the
buildings caused strain at the juncture between columns and ceiling slabs; the concrete structure was destroyed and the steel reinforcements were strained until they failed. The vertical columns were compressed or (as in this picture) punched through the heavy floors that collapsed around them.

Advantages of Flat Slab:

1. Increases speed of construction

2. The construction is simple and economical because of the simplified form work, the ease of placement of reinforcement.

3. The plain ceiling gives an attractive and pleasing appearance; in absence of beams, provision of acoustical treatment is easy.

4. In general flat slab construction is economical for spans up to 10m and relatively light loads.

5. Compare to the RCC less self-weight, which results in reduced dead load, which also has a beneficial effect upon the columns and foundations

6. Reduces the overall height of buildings or enables additional floors to be incorporated in buildings of a given height.

2.2 Major problems in flat slab:

1. Slab column connection does not possess the rigidity of the beam column joint.

2. Shear concentration around column is very high due to the possibility of the column punching through the slab.

3. Deflections tend to be very large due to lesser depth of slab.

III. Design 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 heads (see Fig. 1). 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.

Design of flat slabs as per NZS: 3101 Design Procedure:

First analysis the column strips & middle strips using 0.25L1/0.25l2.

Drop panel is used to reduce the amount of negative moment reinforcement over the column of the flat slab, the size of drop panel shall be 1/6 of the span length measured from center–to-center of support in that direction.

Estimate the depth of flat slabs from clauses 14.2.5 & 3.3.2.2.(b) Assume fy=300MPA.

The absolute sum for the span shall be determined in a strip bounded laterally by the center line of the panel on each side of center of the supports.

The absolute sum of positive and average negative moments in each direction at the
ultimate limit state shall??be? not less than:

M ? ? ? ??
? ?

Negative & positive design moments:

In an interior spans

Negative moments—0.65

Positive moments---0.35

SHEAR STRENGTH

1.Design of cross section of member subjected to shear shall be based on

$$v' \leq ¢Vn.$$

Where v´=shear force at that section. Vn=nominal shear strength of the section. ¢ =strength reduction factor.

2.The nominal shear stress Vn shall not exceed 0.2fc,1.1√fc or 9MPA.

3.Spacing limits for shear reinforcements shall be:
0.5d in non-prestressed member

0.75 h in prestressed member 600mm.
4.Design of slab for two way action shall be based on Vn ??

Where vn shall not be greater than Vc

$$V_c=0.17(1+2\beta c)\sqrt{fc}$$

βc=shorter side/long side of the concentrated load

5.Design the interior panel of flat slabs 6.6 x 5.6 m in size for a super imposed load of 7.75 KN/m^2provide two way reinforcement.

EUROCODE 2

1. Euro code 2 is generally laid out to give advice on the basis of phenomena (e.g. bending, shear etc.) rather than by member types as in BS 8110 (e.g. beams, slabs, columns etc.).

2. Design is based on characteristic cylinder strengths not cube strengths.

3. The Euro code does not provide derived formulae (e.g. for bending, only the details of the stress block are expressed). This is the traditional European approach, where the application of a Euro code expected to be provided in a textbook or similar publication.

4. Units for stress are mega Pascal’s, MPa (1 MPa = 1 N/m m2).

5.Higher strengths of concrete are covered by Euro code 2, up to class C90/105. However, because the characteristics of higher strength concrete are different, some Expressions in the Euro code are adjusted for classes above C50/60.

Design of flat slabsasper EUROCODE2

A procedure for carrying out the detailed design of flat slabs is given below.

1. Determine design life

2. Assess actions on the slab
3. Determine which combinations of actions apply

4. Determine loading arrangements

5. Assess durability requirements and determine concrete strength

6. Check cover requirements for appropriate fire resistance period

7. Calculate min. cover for durability, fire and bond requirements

8. Analyse structure to obtain critical moments and shear forces

9. Design flexural reinforcement

10. Check for deflection

11 .Check punching shear capacity

12 .Check spacing of bars

Design of flat slabs using ACI-318: Thickness of the slab :

For slabs without interior beams spanning between the supports and having a ratio of long to short span not greater than 2, the minimum thickness shall be in accordance with the provisions of Table below and shall not be less than the following values:

(a) Slabs without drop panels as 5 in.

(b) Slabs with drop panels as 4 in. Column strip is a design strip with a width on each side of a column center line equal to 0.25 l2 or 0.25 l1, whichever is less.

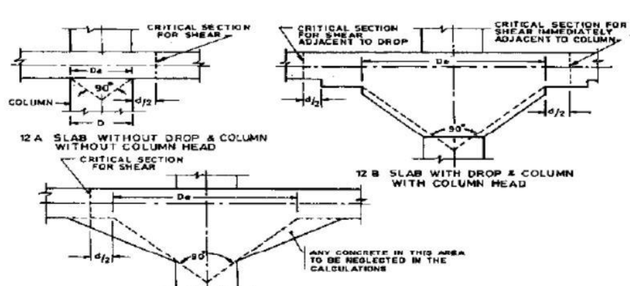
For Example: Design of flat slab by IS 456-2000

Characteristic strength of concrete=25 Minimum thickness of span required=span/28.8

Span length = 6.6 L2 = 5.6

Ln = 6.1
Fck = 20
B = 3300
D = 250
Fy = 415

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



MOMENTS:

panel moment Mo	390.705	kN.m
panel +ve moments	253.95825	kN.m
panel -ve moments	136.74675	kN.m

Distribution of moment into column strips and middle strips:

	column strips in kN/m	Middle strips in kN/m
negative moments	190.4687	63.48956
positive moments	82.04805	54.6987

Mu= 0.87 x fy x Ast x d {1 – (Ast x fy / bdfck)}

c = Mu = 90468688

Ast = 2285.903 mm^2

For, c = Mu = 82048050

Ast = 930.784mm^2

V : RESULT: CODAL COMPARISONS (ACI,NZS,IS)

CODE	IS-456	ACI-318	NZS 3101	Euro code
Grade of concrete(N/mm²)	20	20	30	20
Negative moment(KN-m)	288.5	308.89	392.14	292.6
Positive moments(KN -m)	110	213.22	247.37	235.5
Area of reinforcement(mm²)	4409	3029	3017	2715.5
Thickness of slab forServiceability criteria(mm)	170	150	210	315
Punching shear	Safe	Safe	Safe	Safe

VI .SUMMARY AND CONCLUSIONS:

The aim of this analytical study is to try and illustrate the methods used for flat slab Design using ACI-318,NZ- 3101part 1,Eurocode part 2 and IS: 456- 2000 design codes. For carrying out this study an interior panel of a flat slab with dimensions 6.6 x 5.6 m and super imposed load 7.75 KN/m^2 were adopted.

- By comparing with different codes we concluded that ACI 318, NZS 3101& euro codes are most effective in designing of flat slabs.
- Enhance resistance to punching failure at the junction of concrete slab & column.
- By incorporating heads in slab, we are increasing rigidity of slab.
- In the interior span, the total design Moments (Mo) are same for IS, NZS, ACI.

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.

- According to Indian standard (IS 456) For RCC code has recommended characteristic strength of concrete as 20, 25, and 30 and above 30 for high strength concrete. For design purpose strength of concrete is taken as 2/3 of actual strength this is to cube strength and actual strength of increasing the shear strength of the slab