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Design of Flat Slab with Matlab

S. P. Nirkhe, D. N. Kakade, A. G. Dahake
Department of Civil Engineering, Peoples Education Societyĝs College of Engineering, Aurangabad, Maharashtra State, 431003, India
saurabh.nirkhe@gmail.com deepak.kak06@gmail.com ajaydahake@gmail.com

Abstract-Flat slabs are highly versatile elements widely used in construction, providing minimum depth, fast construction and allowing flexible column grids. Common practice of design and construction is to support the slabs by beams and support the beams by columns. Here large Bending Moment & Shear Forces are developed close to the columns. These stresses brings about the cracks in concrete & may provoke the failure of slab, thus there is a need to provide a larger area at the top of column recognized as column head.MATLAB is a software package for high-performance numerical computation and visualization. It provides an interactive environment with hundreds of built-in functions for technical computation, graphics, and animation. Best of all, it also pro- vides easy extensibility with its own high-level programming language. The aim of this paper is to analyze the flat slab in India followed by a review of design methods for flat slab structure designs based on IS: 456-2000, NZ-3101-2006, Eurocode2-2004 and ACI-318-2008 design codes, with MATLAB Programming for the easy application for the design of flat slab

Keyword; Flat slab, IS 456-2000, NZ 3101-2006, Eurocode2 -2004, ACI-318-2008, MATLAB\

1. Introduction

A reinforced concrete flat slab, called as beamless slab also, is a slab supported directly by concrete columns without beams. A part of the slab bounded on each of its four sides by the center line of column is called panel. The flat slab is often thickened close to supporting columns to provide adequate strength in shear and to reduce the amount of negative reinforcement in the support regions. The thickened portion below the slab is called drop or drop panel shown in Fig.No.1. In some cases, the section of the column at top, as it meets the floor slab or a drop panel, is enlarged so as to increase primarily the perimeter of the critical section, for shear and hence, increasing the capacity of the slab for resisting two-way shear and to reduce negative bending moment at the support. Such enlarged or flared portion of column at their tops are called the column heads or column capitals shows in Fig. 2.

As a many other types of civil engineering structures, construction of flat slabs preceded its theory of analysis and design. C.A.P. Turner [1] constructed flat slabs in U.S.A. in 1906 mainly using intuitive and conceptual ideas, which was start of this type of construction. Many slabs were load-tested in USA in 1910-20.Nicholas [2] proposed a method of analysis of flat slabs based on simple statics. This method is used even today for the design of flat slabs and flat plates and is known as the direct design method.

Structural engineers commonly use the equivalent frame method with equivalent beams such as the one proposed by Deshpande et al [3] in practical engineering for the analysis of flat plate structures.

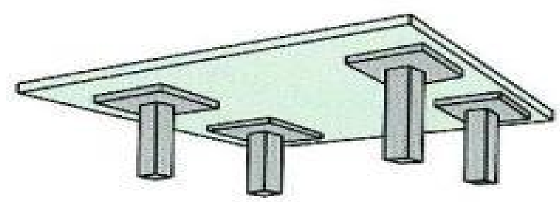

Fig. 1: Flat Slab

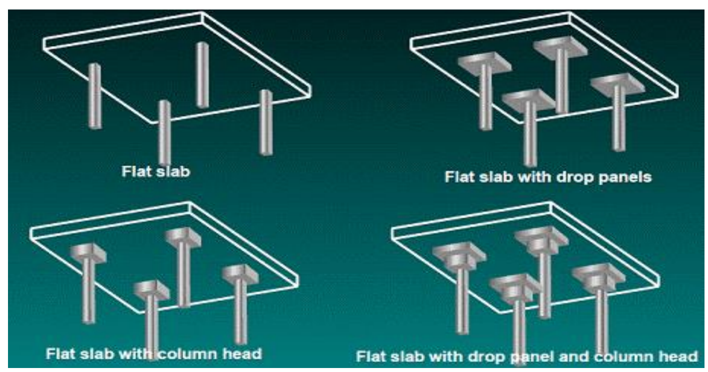

Fig. 2: Different Profile of Flat Slab

1.1 Objectives and scope

In present work, a flat slab system is a significant advancement in the building technology. It has been observed that to investigate the fragility of flat slab reinforced concrete systems. The main objective of the paper is to study method of analysis and design of flat slab by using IS: 456-2000, NZ-3101, EC2 Part I-2004 and ACI-318-08 design codes, with MATLAB Programming for the easy application (language) for the design of flat slab. Each code has specified the fixed coefficients for lateral and transverse distribution of moments as per direct design method and equivalent frame method. The paper aimed to check whether those moments are remain the same when we analyze the flat slab with use of MATLAB.

2. System Methodology

Flat slab may be analyzed and designed by any method as long as they satisfy the strength, stiffness and stability requirements of the IS: 456-2000, NZ-3101, EC2 Part-1 2004 and ACI-318-08. A typical flat slab can be analyzed by direct design method or equivalent frame method as prescribed by the code. However, if the flat slab is a typical one with unusual geometry, with irregular column spacing, or with big opening then the designer can use finite element method model analysis using various software. The design of flat slabs irrespective of the methodology used must first assume a minimum slab and drop thickness and a minimum column dimension to ensure adequate stiffness of the system to control deflection. The IS 456:2000 code is not clear on these minimum conditions. However NZ-3101, EC2 Part-I 2004, ACI-318-08 specifies empirical formulae to arrive at these minimums. Critical reactions for the load combinations are used for the design of the supporting columns and foundations.

2.1 Example formulation

Using IS 456-2000 [4] and using ACI 318 the distribution of moments across panels for slab as shown in Table 1 and 2 respectively, With NZ 3101-2006 the distribution of moments across panels for Slab as given in Table 3.The unbalanced slab moments at various supports are transmitted to respective columns. This unbalanced slab moment is shared by the column above and below in proportion to their relative stiffness. These moments are transferred by punching shear and flexure in the column. The punching shear produces cracks at the critical section close to the column faces. The shear stress is calculated as explained in the respective codes. The permissible shear stress is also calculated same as explained in respectivecodes. The shear reinforcement should be provided if the actual shear stress found to be greater than permissible shear stress.

For the simplicity and validation with different codes and MATLAB, we have considered the following dimensions of flat slab for numerical study.

Size of internal panel (room size) - 6.6 X 5.6 (in m)

Live load considered ï 7.5 kN/m2

Grade of concrete ï M20

Grade of steel ï Fe415

3.Result And Discussions

The results are presented in Table 4 and 5 and graphically illustrated in Fig. 3 through Fig. 5.

Table 1: Distribution of moments across panels for slab using IS 456-2000 [4]

Sr. No	Distributed moment	Column strip moment % (0.65)	Middle strip moment % (0.35)
1	Negative BM	0.49	0.16
2	Positive BM	0.21	0.14

Table 2: Distribution of moments across panels for Slab using Euro Code 2:Part1-2004 [6]

Particulars	End support/slab connection				First interior supports	Interior spans	Interior supports
	Pinned		Continuous				
	End support	End span	End support	End span			
Moment	0	0.086F1	-0.04 F1	0.075F 1	-0.086F 1	0.06 3F1	-0.063 F1

Table 3: Distribution of moments across panels for slab using ACI 318-2008 [7]

Particulars	Exterior edge unrestrained	Slab with beams between all supports	Slab without beams between interior supports		Exterior edge fully restrained
			Without edge beams	With edge beams	
Interior Negative moments	0.75	0.70	0.70	0.70	0.65
Positive moments	0.63	0.57	0.52	0.50	0.35
Exterior Negative moments	0	0.16	0.26	0.30	0.65

Table 4: Results of IS-456, ACI-318, NZS-3101 and Euro Code 2:Part1-2004

Code	IS ï 456 [4]	NZS ï 3101 [5]	EURO CODE [6]	ACI ï 318 [7]
Positive moment (KNm)	96.60	250	173.50	125.83
Negative moment (KNm)	225.40	297.29	350.25	292.09
Area of reinforcement (mm2)	2654	2601	2643	2274
Thickness of slab for serviceability criteria (mm)	140	210	350	185
Punching shear	Safe	Safe	Safe	Safe

Table 5: MATLAB Comparison

Moment and Code	IS ï 456 [4]	NZS ï 3101 [5]	EURO CODE2 [6]	ACI ï 318 [7]
Positive moment (KNm)	98.54	248.92	164.79	125.45
Negative moment (KNm)	229.92	296	337.43	291.22
Area of reinforcement (mm2)	2732	2586	2527	2253
Thickness of slab for serviceability criteria (mm)	138	208.3	349	183.3
Punching shear	Safe	Safe	Safe	Safe

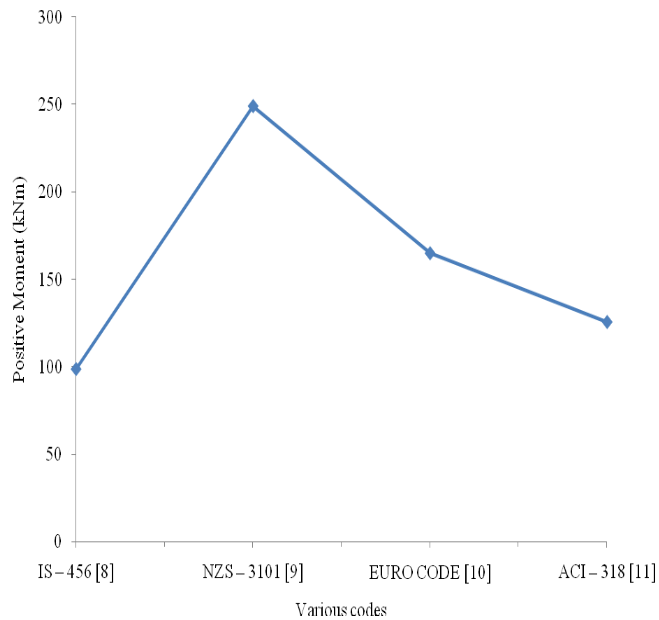

Fig. 3: Variation of Positive Bending Moment by various codes and with MATLAB

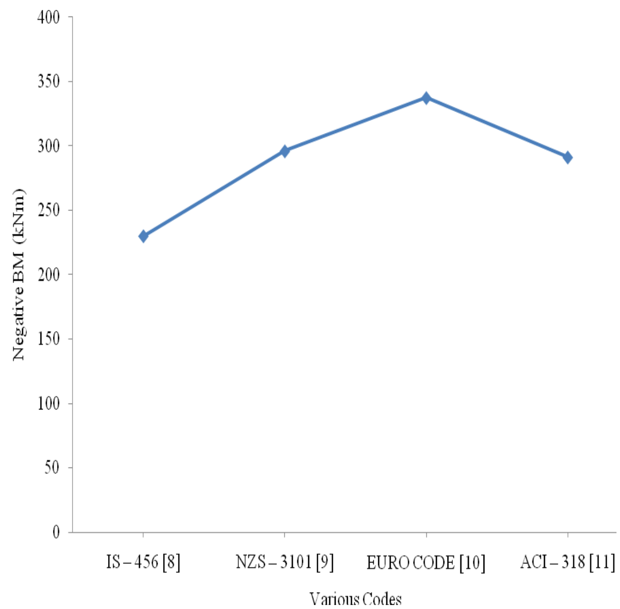

Fig. 4: Variation of Negative Bending Moment by various codes and with MATLAB

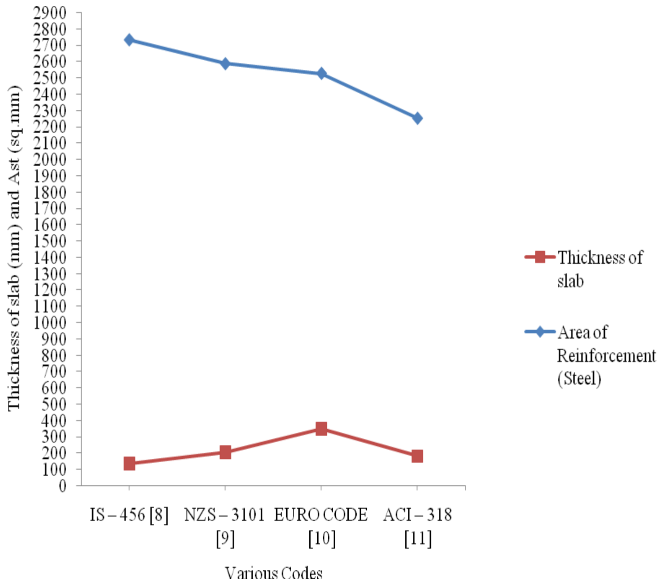

Fig. 5: Variation of Thickness of Slab (mm) and Area of reinforcement (mm2) by various codes and with MATLAB

Results

Bending moment: It is observed that, in case of IS 456 with MATLAB, it is slightly greater than manual design, but it is accurate one as compared to manual design. Using other codes the values are on high side.

Quantity of reinforcement: Area of reinforcement is in excellent agreement with each other.Thickness of slab: IS 456, using MATLAB and ACI 318 give somewhat same thickness whereas in EURO CODE and NZS-3101 it is on higher side.

Punching shear: It is safe in all codes.

Bending moment: It is observed that, in case of IS 456 with MATLAB, it is slightly greater than manual design; but it is accurate one as compared to manual design. Using other codes the values are on high side.Quantity of reinforcement: Area of reinforcement is in excellent agreement with each other.

Thickness of slab: IS 456, using MATLAB and ACI 318 give somewhat near about thickness whereas in Eurocode2 and NZS-3101 it is on higher side.Punching shear: It is safe in all codes.

By comparing with different codes we concluded that NZS 3101 and ACI 318 are most effective in designing of flat slabs.

As per Indian code we are using cube strength but in international standards cylindered are used which gives higher strength than cube.In the interior span, the total design moments (Mo) are same for IS, NZS.

5. Conclusions

It is observed that, the time required for manual design is much greater than in case of MATLAB which gives the results in micro seconds. Further it will conclude that by getting all the results of various codes with MATLAB to find the best way for practicing for analysis and design of flat sla

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