

On the definition deflections of monolithic slabs with the mixed reinforcing at the stage of limit equilibrium

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Abstract. The article considers innovative materials and structures for flat monolithic slabs. Overlapping mixed diagonal reinforcement where high strength is used as prestressing reinforcement in a flexible sheath type "Monostrend". The article discusses the theoretical solution to determine the deflection of a monolithic beamless slab without capitals in the process of limiting equilibrium. The formula based on the value of the limiting deflection cell, reinforcement class and plate thickness. Shows a plot of marginal values of deflections of different thickness slabs with reinforcement A500, for three cells to span 6, 7 and 9 m. These data set the initial stress in high-strength reinforcement and stress as a result acquired deflection in the slab floors with mixed diagonal reinforcement.

1 Introduction

In recent years, more attention is paid to monolithic slabs. Frame-monolithic is now one of the most popular types of construction [1].

To extend the range of span and loads for buildings of this type must be a more complete study of the work of monolithic slabs.

We present, developed by the authors, the theoretical solution to determine the deflection of a monolithic slab beamless floors without capitals in the stage of limit equilibrium [2, 3, 4, 5, 6].

Knowing the values of deflections beamless floors in the stage of limit equilibrium necessary in the calculations of overlap strength while using ordinary and high-strength reinforcement [7] to prevent constriction reinforcement and maximize its strength characteristics [8, 9, 10, 11].

Particular importance is the purpose of prestressing armature levels in the case of high-strength armature, such as "monostrend", without adhesion to the concrete, as damage or break a wire rope is not localized in the concrete, and leads to overstress the rest of the wires, a jumplike increase of deflections, excessive disclosure of cracks and destruction of all overlap [13, 14, 15, 16].

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2 Experimental section

As the object of study, the authors selected monolithic reinforced concrete slab beamless floors in an extreme condition. The dimensions of the cell «a» and «b», plate with prestressed reinforcement "Monostrend" without adhesion to concrete.

Traditional stress distribution scheme based on the compatibility of deformations of concrete and reinforcement, in this case, does not work, because the adhesion between the high-strength reinforcement and concrete missing.

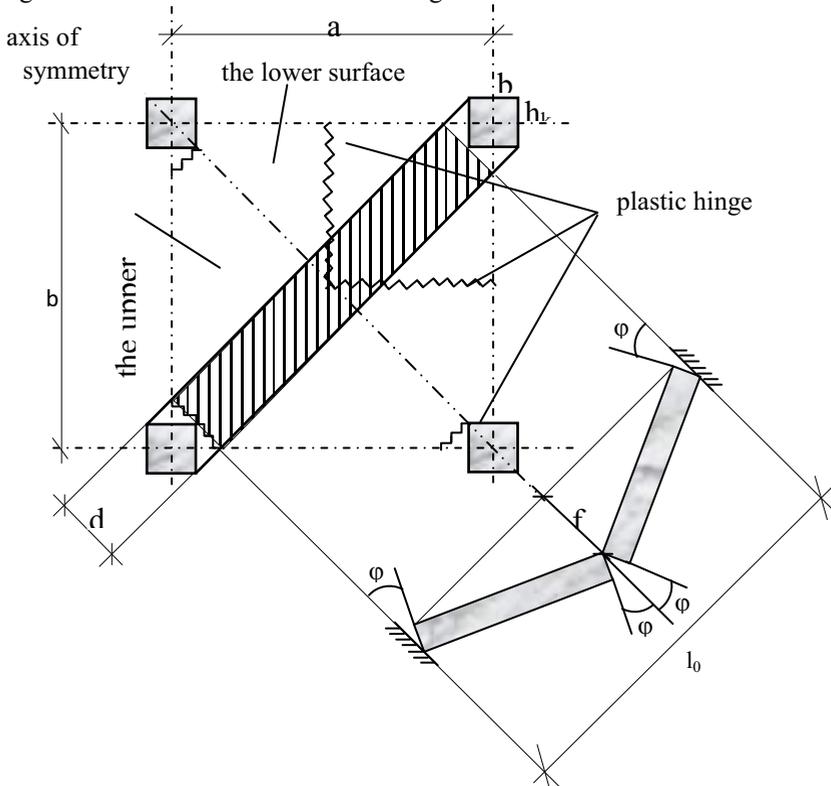


Fig.1. Scheme of the floor slab in a stage of limit equilibrium.

To display the calculated dependencies following assumptions adopted. Plate is in limiting equilibrium and consists of separate units, connected by a line hinges (Figure 1).

The diagram of stresses in the concrete compression zone is rectangular, the maximum stresses equal to the rated stresses - R_b . The maximum height of the compressed zone, which ensures the development of plastic deformations in the concrete and free of tension reinforcement $\xi \leq 0,3$ according to [5]. Free of tension stresses in the reinforcement equal to the rated voltage R_s , relevant to physical limit of elasticity (Figure 2). The initial stresses in high-strength reinforcement (excluding losses) is constitute 0.8 accounted for 80 percent of the conventional limit of elasticity R_{sn} .

So, under these conditions, the maximum positive moment M^+ (plate per unit width) in the center of the cell is determined only by the amount of the longitudinal lower reinforcement A_s in a predetermined section and plate height.

$$M^+ = R_s A_s z_b. \quad (1)$$

There z_b - is shoulder of internal force couple.

$$z_b = h_0 - x/2. \tag{2}$$

When the boundary value of $x = 0.3h_0$ shoulder couple of forces is

$$z_b = h_0 - 0.3h_0/2 = h_0(1 - 0.3/2) = 0.85h_0. \tag{3}$$

The value of the positive moment in the midspan is

$$M^+ = R_s A_s z_b = 0.85 R_s A_s h_0. \tag{4}$$

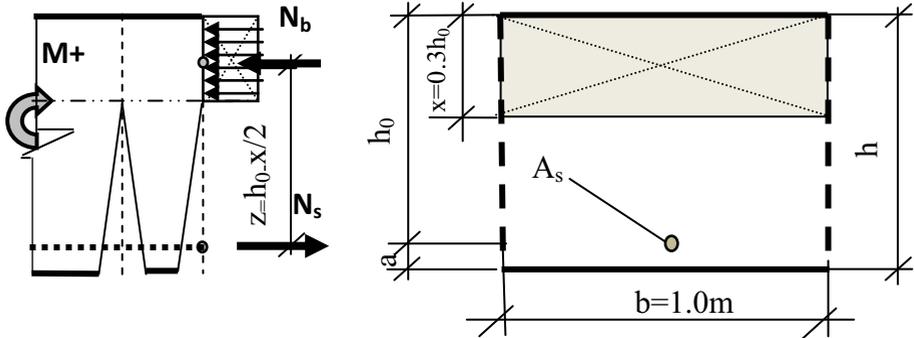


Fig. 2. The settlement scheme of the plate section in the span.

Similarly, the maximum negative moment on the supports-columns is determined by the amount of upper reinforcement A'_s , crossing the column contour (Figure 1).

$M^- = R_s A'_s z_b$ has a cross-section per unit width.

The amount of negative moment at the supports is

$$M^- = R_s A'_s z_b = 0.85 R_s A'_s h_0. \tag{5}$$

To determine the deflection method is used when the cut between the columns notional diagonal strip width equal to the diagonal of a square or rectangular column. The strip is seen as hingedly supported beam, with the calculated span equal to the distance between the supporting plastic hinges (Fig. 1).

In finding the deflections must first calculate the curvature of the conventional lane plate $1/\rho$

$$\frac{1}{\rho} = \frac{M}{D}, \tag{6}$$

here:

D - bending stiffness of the strip,

M - acting at the section moment. Stiffness concrete element section with cracks may be determined according to [3] by formula

$$D = E_{s,red} A_s z (h_0 - x_m), \tag{7}$$

where:

x_m - height of the compressed zone, taken for the element after the formation of plastic hinges equal $0.3h_0$, shoulder internal pair of forces $z = 0.85h_0$. Taking $z = 0.8h_0$, we obtain an expression for the stiffness

$$D = E_{s,red} A_s z (h_0 - x_m) \approx 0.7 E_{s,red} A_s h_0^2 \quad (8)$$

Using the expressions (2) and (3), and taking $E_{s,red} = E_s$ get expression of curvature

$$\frac{1}{\rho} = \frac{M}{D} = \frac{0.85 R_s A_s h_0}{0.7 E_s A_s h_0^2} = 1.21 \frac{R_s}{E_s h_0} \quad (9)$$

Given that, as free of tension reinforcement recommended armature A500 classes ($R_s = 435$ MPa) or A400 ($R_s = 350$ MPa) and the steel elastic modul is $E_s = 200000$ MPa, we obtain the following formulas.

When using reinforcement class A400

$$\frac{1}{\rho} = 1.21 \frac{R_s}{E_s h_0} = 1.21 \frac{350}{200000 h_0} = \frac{0.00212}{h_0} \quad (10)$$

When using reinforcement class A500

$$\frac{1}{\rho} = 1.21 \frac{R_s}{E_s h_0} = 1.21 \frac{435}{200000 h_0} = \frac{0.00263}{h_0} \quad (11)$$

Obviously, the curvature of element $1/\rho$ for limiting equilibrium depends on two variable parameters: the value of the physical limit of elasticity of reinforcement R_s and the section height h_0 .

Taking into account that for a square cell 6×6 m with columns 400×400 mm calculated span is equal to the distance between the inner corners of columns $l_0 = 7.92$ m, the deflection at the center of the cell (conditional beams) can be determined by well-known formula

$$f = S \frac{1}{\rho} l_0^2 = \frac{5}{48} \frac{0.00263}{h_0} 7.92^2 = \frac{0.0172}{h_0} \quad (12)$$

Then, at a thickness of plate 0.2 m, the reinforcement class A500 and the section column 400×400 mm, the deflection at the center of the cell is 10.12 sm ($1/78$), and if reinforcement class A400 deflection $f = 12.5$ cm ($1/63$).

When the reinforcement class is A500 and cell 7×7 m, formula becomes

$$f = S \frac{1}{\rho} l_0^2 = \frac{5}{48} \frac{0.00263}{h_0} 9.48^2 = \frac{0.0246}{h_0} \quad (13)$$

When the reinforcement class is A500 and cell 9×9 m, formula becomes

$$f = S \frac{1}{\rho} l_0^2 = \frac{5}{48} \frac{0.00263}{h_0} 12.16^2 = \frac{0.0405}{h_0} \quad (14)$$

3 Results section

Data limit deflections obtained from Eqs 12-14 for different sizes of cells and thickness of plates using background reinforcement A500 are summarized in Table 1.

Table 1. Deflection limits for different thicknesses of plates and cell sizes.

Cell size, [m]	Plate thickness, [m]				
	0.2	0.22	0,25	0.28	0.3
6x6	0.105	0.094	0.081	0.071	0.066
7x7	0.145	0.129	0.112	0.098	0.091
9x9	0.244	0.218	0.189	0.166	0.154
12x12	0.441	0.395	0.341	0.300	0.278

Fig. 3 shows graphs of limit values for deflections of the four cells with sizes 6, 7, 9 and 12 m, with different plate thicknesses overlap and the background reinforcement A500.

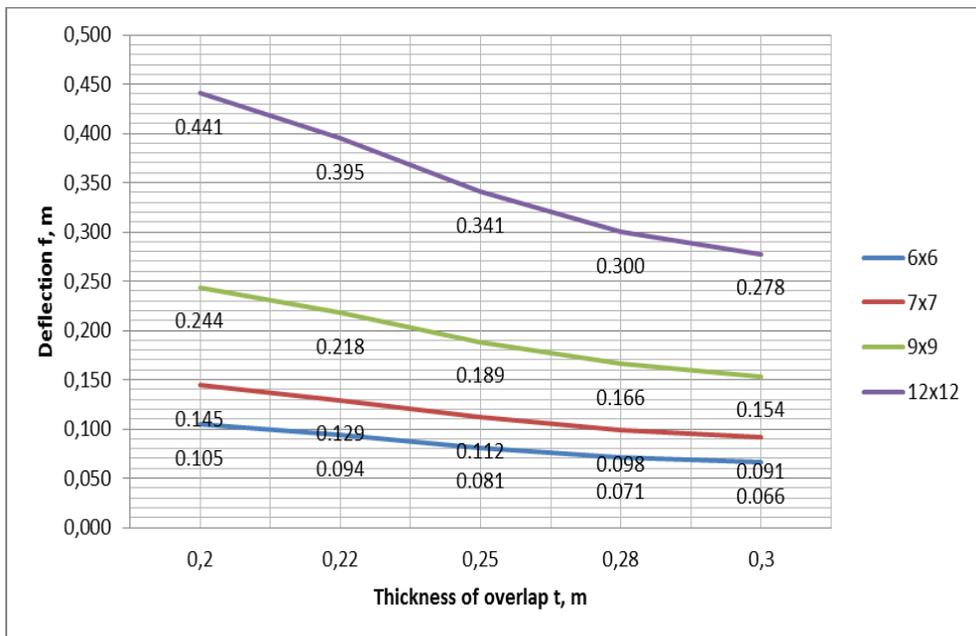


Fig. 3. Graphics of limit deflections to different cells.

Obviously and logically, that by decreasing plate thickness from 0.3 m to 0.2 m deflections increase significantly - for all the above cell size by 59%. Also, with the increase of cell size from 6×6m to 7×7m deflections increase - by 38%, with the increase of the cell to 9×9m deflections increase by 133%, to 12×12 - increased by 320%.

The graphs show that in the limiting state at least the thickness of the slab 0.2 m and the largest span of the cell plate 12×12m greatest deflections 0.441m.

Whereas at the lowest span 6×6m plate with a thickness of 0.2 m deflection is 0.105m in the limit state of the cell plate.

4 Conclusions

1. The proposed engineering method and presented graphics assess deflections slab beamless monolithic slab without capitals in the limiting state at different spans, slab thickness and classes free of tension reinforcement.
2. The proposed engineering method of calculation allows you to set the initial stresses in the high-strength reinforcement in the slab mixed diagonal reinforcement, and stresses as a result of the acquired deflection.

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