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Features of the Work of Monolithic Flat Floor Slabs Under Construction

V S Kuznetsov[1], Yu A Shaposhnikova[2]

[1]Moscow State University of Civil Engineering, Department of Architectural Construction Design, Yaroslavl highway, 26, Moscow, 129337, Russia
[2]Moscow State University of Civil Engineering, Department of Reinforced Concrete and Stone Structures, Yaroslavl highway, 26, Moscow, 129337, Russia

E-mail: [1]vitalik.kuznetsov2016@yandex.ru, [2]yuliatalyzova@yandex.ru

Abstract. The formwork for the construction of monolithic flat ceilings is traditionally carried out by installing supports in spans, in areas where the greatest deflections develop. The installation of temporary supports in the stage of erection changes the design scheme of the plates: zones of negative moments appear in the zone above the additional supports. When concrete reaches the ultimate tensile stresses in the upper zone, cracks appear that can significantly affect the strength and deformation properties of the structure in operation. This work is aimed at revealing the features of the work of plates in the manufacturing stage, their effect on the strength and deformability of the overlapping and the establishment of the optimal location of temporary formwork supports. The object of the study was a cell of a non-beam overlap, measuring 6×9m, the stress-strain state of which was analysed with the help of the Scad program for various arrangements of temporary supports. The plots of the dependence of the influence of the amount of reinforcement in the slab at the time of cracks formation are obtained, as well as the effect of the concrete transfer strength at the time of crack formation. According to the results of the research, the most acceptable options for installing temporary support elements are proposed, which cause the minimum values of negative moments. The results of the article can be used in practice in the construction of monolithic ceilings.

1. Introduction

In the construction of monolithic slabs, in order to accelerate the erection processes, part of the formwork is left in the form of separate racks or linear beam supports, so-called "temporary support elements", which allows faster release of the formwork material and use it in other areas of work [1-2] (‘Figure 1’).

As a rule, builders do not attach much importance to this operation, habitually having propping up in the middle zones, where the greatest deflections develop [3-4]. However, the device of the supports, their number and location in the plan, for some time changes the initial operational design scheme of the plates and causes the appearance of negative moments in the zones of temporary posts or beams [5-7].

Figure 1. Elements of temporary support.

When building monolithic structures, checking the strength of concrete in the stage of erection is a necessary condition for the possibility of further normal operation of buildings and structures [8-9]. However, in the case of tension stresses in the concrete equal to or exceeding the normative values of $R_{bt,ser}$ in the upper zone, cracks appear, which can significantly affect the strength and deformation properties of the structure during operation [10].

Calculations and basic provisions, the study of the stress-strain state of monolithic plates in the stage of erection are described in [11-19]. The problems arising in the construction of monolithic structures are covered in a wide range of works, for example [9, 20-25], in which the main attention is paid to the identification of defects in concrete at the stage of erection and their elimination, quality control of works and so on.

The presented work is aimed at revealing the features of the work of plates in the manufacturing stage, their effect on the strength and deformability of the overlaps and the establishment of the optimal location of the temporary support posts.

2. Methods

Let's consider some schemes of arrangement of temporary supports (security racks) before the decoupling: in the absence of intermediate supports, the stand in the center, the racks in the middle of the larger span, the temporary beams in the middle of the smaller and larger spans (‘Figure 2’).

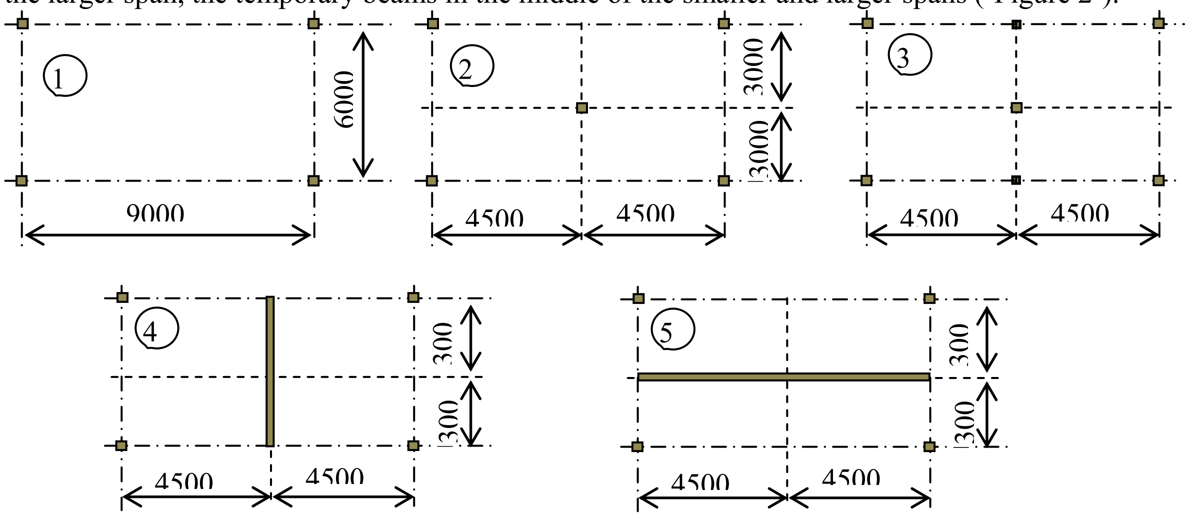

Figure 2. Some schemes for arranging temporary supports (security racks). 1-pillars are missing, 2-pillar in the center of the cell, 3-pillars in the middle of the larger span, 4-time beam in the middle of the larger span, 5-time beam in the middle of the smaller span.

As the object of investigation, a separate cell of non-beam overlapping with dimensions of 6×9m and a thickness of 200 mm was chosen. The dimensions of the design section $b \times h$=1000×200 mm ('Figure 3') the content of reinforcement (10Ø10; 10Ø12; 10Ø14; 10Ø16) class A500C [26-28]. The design load for testing the fracture toughness is g_n=5.0 kN/m^2. Fixing strength was taken (0.5; 0.67; 0.83)B30, which corresponds to the strength of concrete classes B15, B20, B25. The modulus of elasticity of concrete E_b corresponded to the strength of concrete at the time of tearing.

The stress-strain state of the slab was analyzed in the absence of temporary supports and their presence ('Figure 2'). Static calculation was performed in the Scad program, with a rigid connection of the plate with supports in the corners of the cell and a swivel connection with temporary supports. The bending moments M_x and M_y are shown in 'Figure 4' [29].

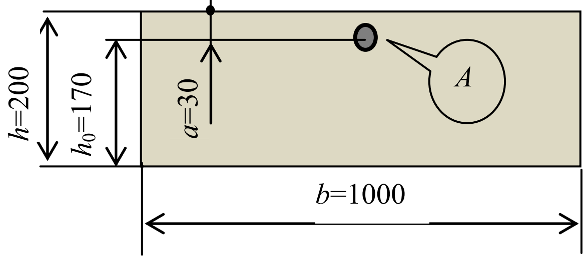

Figure 3. The calculated cross-section of the plate.

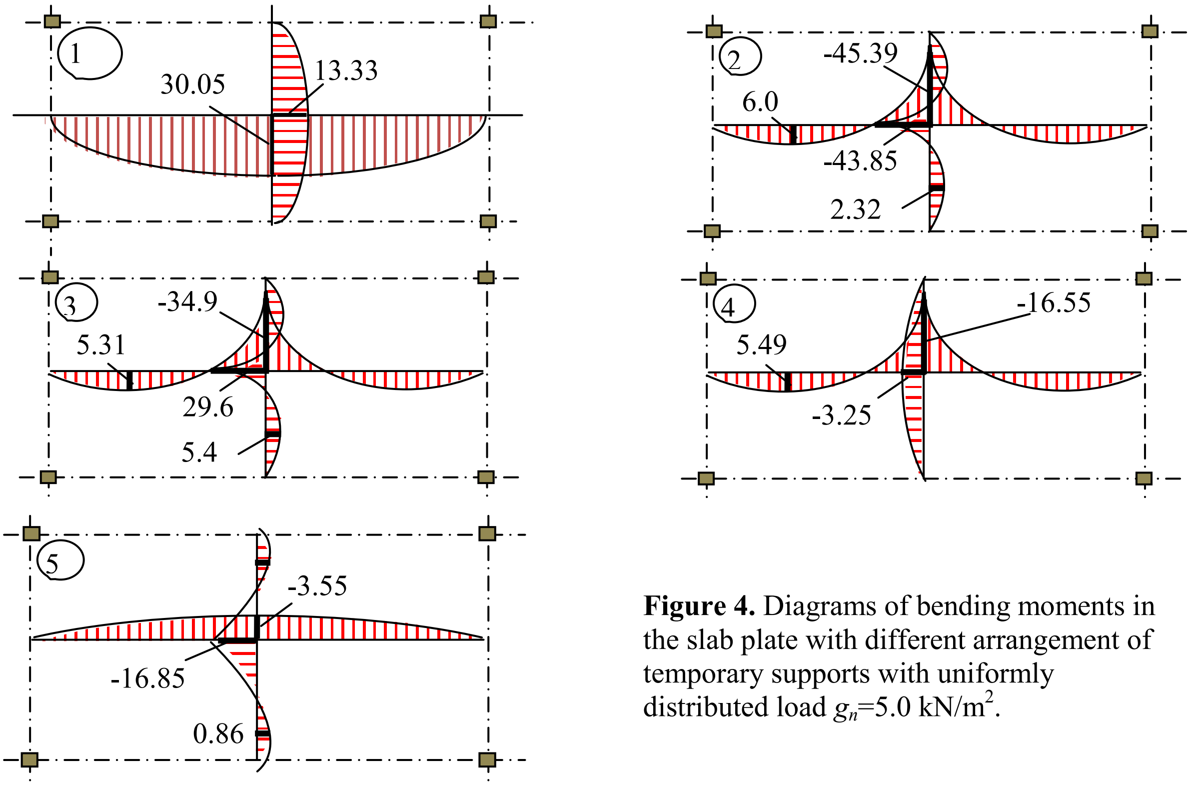

Figure 4. Diagrams of bending moments in the slab plate with different arrangement of temporary supports with uniformly distributed load g_n=5.0 kN/m^2.

Analysis of the bending moment diagrams ('Figure 4') shows that the most acceptable, from the point of view of the appearance of negative moments during the decoupling, are schemes 4 and 5. Schemes 2 and 3 are dangerous and can not be recommended for use.

The moment of formation of normal cracks was determined taking into account inelastic deformations of concrete in accordance with [11-12] by formula (1).

$$M_{crc}=R_{bt,ser} \cdot W_{pl} \text{ , где } W_{pl}=1{,}3W_{red}. \quad (1)$$

3. Results and discussion

The calculated moments of crack resistance at different levels of the form-fitting strength and percentages of the section reinforcement are shown in the graphs ('Figure 5').

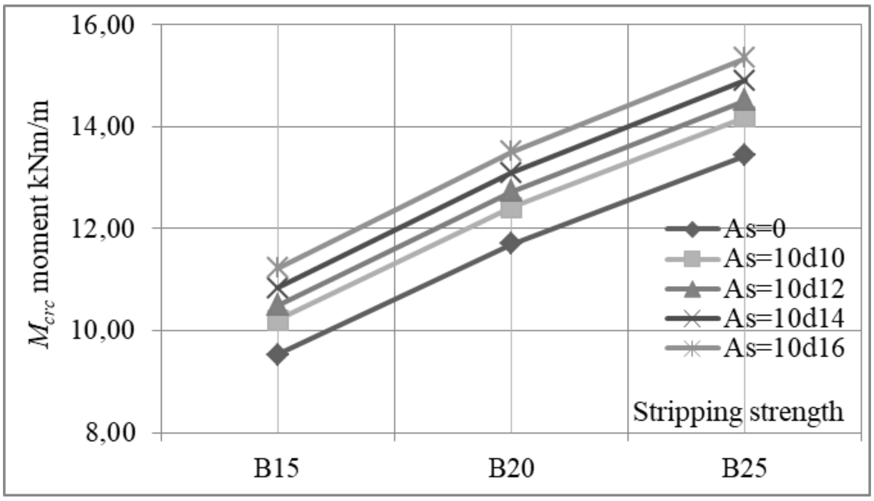

Figure 5. Crack resistance moments of M_{crc} at different transfer strength.

Obviously, the magnitude of the moments M_{crc} depends on the strength at the time of removal of the formwork and the number of reinforcement. Thus, the increase in the formwork strength from 0.5B30 to 0.83B30 (by 41%) within the reinforcement percentage μ=0.46% increases M_{crc} from 10.2 to 14.19 kNm/m (by 31.9%), and at μ=1.18% increases M_{crc} from 10.2 to 14.19 kNm/m (by 36.8%). 'Figure 6' shows the effect of reinforcement content % at the time of crack resistance M_{crc}.

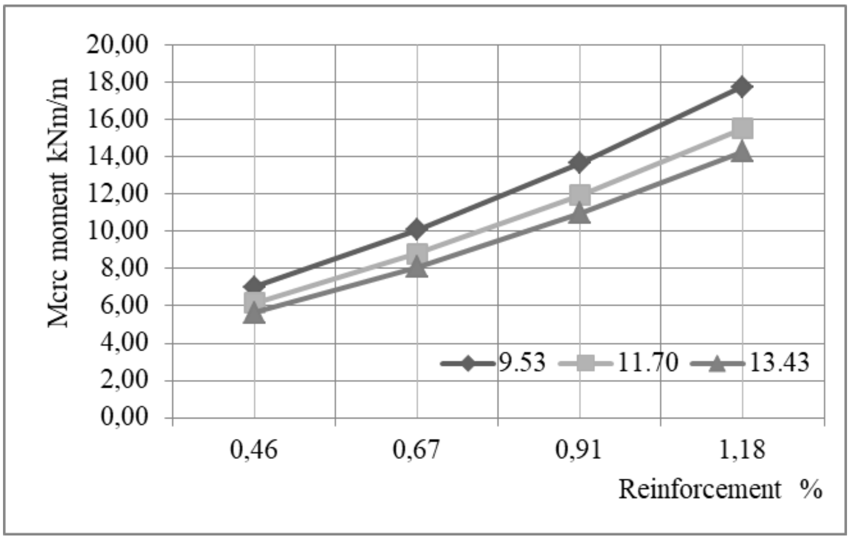

Figure 6. Influence of the content of reinforcement % at the moment of crack resistance M_{crc}.

With an increase in the reinforcement content from 0% (excluding the reinforcement) to 1.18% with the break-even strength of 0.5B30, M_{crc} increases from 9.53kNm / m to 11.22 kNm/m (17.73%), and at the stage The strength of 0.83B30 M_{crc} increases from 13.43 to 15.35 kNm/m (14.3%) ('Figure 6').

Thus, the calculation of the crack resistance of bent elements without taking into account longitudinal reinforcement [11-12] leads to an underestimation of the fracture toughness by 14-18%.

4. Conclusions

Comparison of diagrams moments ('Figure 3') with graphs ('Figure 6' and 'Figure 7') suggests the initial appearance of cracks in the upper area of the floor slab at the locations of temporary supports, as the maximum load points of the regulatory points exceed the formation fracture at M_{crc} all considered schemes of location of elements of temporary support. The most acceptable options for installations of temporary support elements are schemes Nos. 4 and 5, which cause the minimum values of negative moments on temporary supports.

The results of the work can be used in practical activities in the construction of monolithic ceilings.

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