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Methodology for Calculating a Slab of a Bridge Web of Reinforced Tensile Concrete with Free Boundary Conditions

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***Abstract**:In given work is designed methods of the calculation liberally lying plate of the bridge from use of stressing concrete . Herewith voltages is determined on upper galley proof of the concrete , on lower galley proof of the concrete and in armature.*

***Keywords** :Concrete, beams, bridges, slabs, structures, edges, fittings, tension.*

I. INTRODUCTION

The reliability and durability of railway and road bridges as a whole largely depends on the reliability and durability of individual structural elements, including the bridge of the roadway. The bridge canvas, in addition to perceiving pressures from a temporary load and transferring them to the main load-bearing structures, is also a kind of "roof" that protects the underlying elements from water and other factors that negatively affect the durability of the bridge.

The main function of the traditional design of the bridge fabric, consisting of a leveling, waterproofing and protective layers is the protection of the main load-bearing elements. At the same time, the dead weight of this "pie" is a forced constant load that acts on the main load-bearing elements and requires additional reinforcement consumption to absorb the forces arising from this load.

The rationality of the design of the bridge canvas could be achieved by arranging one ten-centimeter layer of self-stressed concrete, which acts as a leveling, waterproofing and protective layers [1,2,4].

II. MATERIALS AND METHODS

In accordance with the current requirements, the waterproofness of the concrete slab on tensile cement will be ensured with a value of self-stress (taking into account losses from shrinkage and creep) of at least 0,5 MPa. In connection with the above requirement, it is necessary to develop a methodology for calculating a free-lying slab of a bridge sheet of railway bridges from reinforced self-stressed concrete.

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In this case, stresses on the upper face of concrete σbв, on the lower face of concrete σbн and stress in reinforcement σs should be determined. It should be noted that the values of the determined stresses also depend on the location of the reinforcement along the height of the plate.

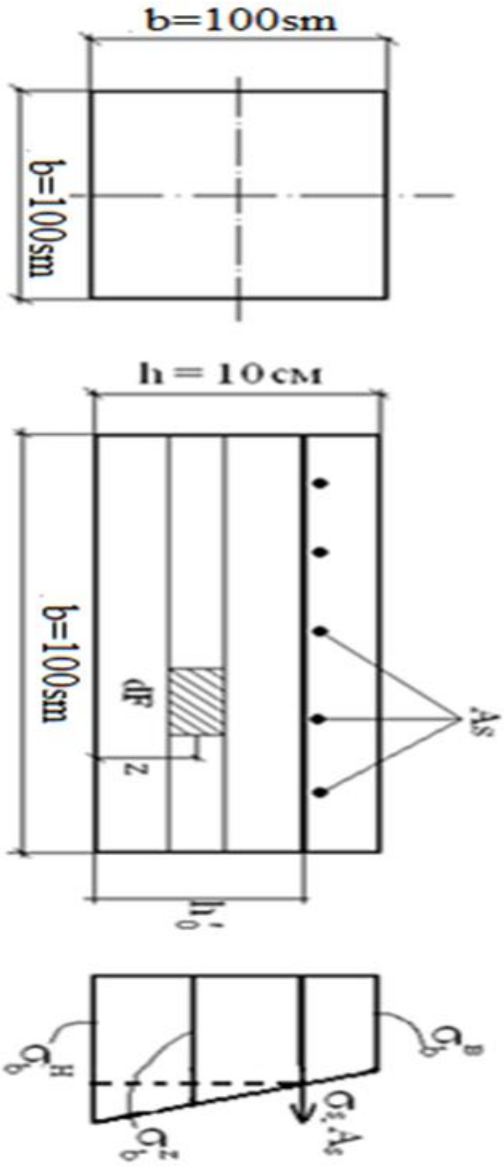

Figure 1. Schemes for calculating a slab of a bridge canvas made of reinforced self-stressed concrete

III. DISCUSSION OF RESEARCH RESULTS

To simplify the calculation, we consider a rectangular slab of tensile concrete with dimensions of 100 x 100 sm and a thickness of 10 sm reinforced (freely lying (with free boundary conditions, i.e., not having adhesion in contact with the underlying layer) on the surface of the main beams of the spans, reinforced five reinforcing bars with a diameter of 10 mm (Fig. 1).

1. The equation of compatibility of deformation of concrete and reinforcement has the form:

$$\varepsilon_0 + \left(\sigma_b^{в} - \mu\sigma_b^{в}\right)\frac{1}{E_b} = \frac{\sigma_s}{E_s}; \quad (1)$$

2. The equation of projection of forces on the axis of the plate:

$$\int_F \sigma_b^z dF + \sigma_a F_a = 0; \quad (2)$$

from: $dF=bdz$;

3. The equation of moments relative to the bottom of the plate:

$$\int_F \sigma_b^z z dF + \sigma_a F_a h_0^{'} = 0; \quad (3)$$

from: $$\sigma_b^z = \sigma_b^{в} + \frac{\sigma_b^{н} - \sigma_b^{в}}{h_0^{'}}\left(h_0^{'} - z\right);$$

from $$\sigma_b^z = \sigma_b^{н} - \frac{\sigma_b^{н} z}{h_0^{'}} + \frac{\sigma_b^{в} z}{h_0^{'}};$$

Then the equation of projections on the axis (2) will have the form:

$$\int_0^h \sigma_b^{н} bdz - \int_0^h \frac{\sigma_b^{н} z}{h_0^{'}} bdz + \int_0^h \frac{\sigma_b^{в} z}{h_0^{'}} bdz + \sigma_s A_s = 0;$$

or $$\sigma_b^{н} bdz /_0^h - \frac{\sigma_b^{н} z^2}{2h_0^{'}} b /_0^h + \frac{\sigma_b^{в} z^2}{2h_0^{'}} b /_0^h + \sigma_s A_s = 0;$$

Integrating over a variable height z, we obtain:

$$\sigma_b^{н} bh - \frac{\sigma_b^{н} z^2 bh^2}{2h_0^{'}} + \frac{\sigma_b^{в} bh^2}{2h_0^{'}} + \sigma_s A_s = 0;$$

from: $$2h_0^{'} bh\sigma_b^{н} - \sigma_b^{н} bh^2 + \sigma_b^{в} bh^2 + 2h_0^{'}\sigma_s A_s = 0;$$

After transformations, equation (2) takes the form:

$$bh\sigma_b^{н}\left(2h_0^{'} - h\right) + \sigma_b^{в} bh^2 + 2h_0^{'}\sigma_s A_s = 0; \quad (2)$$

Equation (3) after substitution will have the form:

$$\int_0^h \sigma_b^{н} bzdz - \int_0^h \frac{\sigma_b^{н} z^2}{h_0^{'}} bdz + \int_0^h \frac{\sigma_b^{в} z^2}{h_0^{'}} bdz + \sigma_s A_s h_0^{'} = 0;$$

or $$\frac{\sigma_b^{н} bz^2}{2} /_0^h - \frac{\sigma_b^{н} z^3}{3h_0^{'}} b /_0^h + \frac{\sigma_b^{в} z^3}{3h_0^{'}} b /_0^h + \sigma_s A_s h_0^{'} = 0;$$

Integrating the section over a variable height *z*, we obtain:

$$\frac{\sigma_b^{н} bh^2}{2} - \frac{\sigma_b^{н} bh^3}{3h_0^{'}} + \frac{\sigma_b^{в} bh^3}{3h_0^{'}} + \sigma_s A_s h_0^{'} = 0;$$

from

$$3h_0^{'} bh^2 \sigma_b^{н} - 2\sigma_b^{н} bh^3 + 2\sigma_b^{в} bh^3 + 6h_0^{'2} \sigma_s A_s = 0; \qquad (3)$$

After transformations, equation (3) takes the form:

$$bh^2 \sigma_b^{н} \left(3h_0^{'} - 2h\right) + 2\sigma_b^{в} bh^3 + 6h_0^{'2} \sigma_s A_s = 0;$$

So, the system of equations for determining the stresses on the upper face of concrete $\sigma_{bв}$, on the lower side of concrete $\sigma_{bн}$ and the stress in the reinforcement σ_s takes the form:

$$\begin{cases} \varepsilon_0 + \left(\sigma_b^{в} - \mu \sigma_b^{в}\right)\dfrac{1}{E_b} = \dfrac{\sigma_s}{E_s}; \\ bh\sigma_b^{н}\left(2h_0^{'} - h\right) + \sigma_b^{в} bh^2 + 2h_0^{'} \sigma_s A_s = 0; \\ bh^2 \sigma_b^{н}\left(3h_0^{'} - 2h\right) + 2\sigma_b^{в} bh^3 + 6h_0^{'2} \sigma_s A_s = 0; \end{cases}$$

Based on experimental data, the value of free expansion and the modulus of elasticity of concrete on tensile cement, ε_0 = 0,001; E_b = 35x10^{3}MPa.

Reinforcement coefficient μ = 0,2; The modulus of elasticity of the reinforcement is E_s = 2x10^5 MPa; The cross-sectional area of five reinforcing bars with a diameter of 10 mm As = 3,925 sm^2; Plate width b = 100 sm; Plate thickness h = 10 sm;

The calculations based on the developed calculation method with the adoption of the above values for a free-standing slab 10 sm thick made of reinforced concrete on tensile cement with values of working height = 3, 4, 5, 6 and 7 sm showed that the most rational, meeting the requirements of ensuring water resistance (i.e., the average value of self-stress taking into account losses from shrinkage and creep in the slab concrete should be at least 0,5 MPa), the value of the working height is = 5 sm. In this case, we obtain: $\sigma_{bв}$ = 0,77MPa;

b_n = 0,77 MPa; σ_s = 196,5 MPa.

Based on the obtained experimental data [1,3]. Self-stress losses from shrinkage and creep can be taken equal to 30% of the initial value. Therefore, the steady-state average self-stress in concrete is σ_{bt} = 0,7 x 0,77 = 0,54 MPa. This value of self-voltage provides the necessary water resistance

IV. CONCLUSION

As a result of calculating a slab of a bridge web made of reinforced tensile concrete with free boundary conditions, the stresses on the upper face of concrete σbв, on the lower side of concrete σbн and the stress in the reinforcement σs are determined by the above developed method. The value of self-voltage meets the requirements of the "Instructions for the design of self-reinforced concrete structures SN 511-78" and provides the necessary water resistance.

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