Nexus : Journal of Innovative Studies of Engineering Science (JISES)
Volume: 02 Issue: 04 | 2023 ISSN: 2751-7578
http://innosci.org/

Strength Problems of Indirectly, Reinforced Compressed Elements of Spatial Structure

Tleubaeva T. A.
Junior researcher, Research and Production Laboratory of LLC Spatial Structures,seismic resistance of buildings and structures "Zhambay, Uzbekistan

Annotation: A universal method of strength of the diaphragms of eccentrically compressed spatial elements with conventional and indirect reinforcement is proposed. The method is based on the basic dependences of the mechanics of a deformable solid. It allows you to take into account the peculiarities of the stress-strain state of concrete, the clips of which are mesh or spiral reinforced elements of the diaphragms of shells of the “2P” type.

Key words: spatial structures, indirect reinforcement, strength problems, 2Π elements, optimal solution.

The analysis of the method for calculating the strength of compressed elements with indirect reinforcement, proposed by the building codes, indicates that it is based on experimental data on tests of plane deformed states, and therefore has a limited area of application. With the advent of new design solutions for the diaphragms of the shells, in each case, additional experimental verification is required, associated with the setting of experiments on numerous laboratory samples.

Therefore, it is urgent to develop a universal method for calculating the strength of compressed elements of shell diaphragms with indirect reinforcement, which adequately takes into account the main features of their stress-strain state and is based on the strength and deformation characteristics of concrete and steel [1, 2].

Let us consider the theoretical aspects of determining the breaking load for eccentrically compressed rod elements of shell diaphragms with mesh or spiral reinforcement. The peculiarities of their reinforcement in accordance with the current design standards for reinforced concrete structures imply the calculation of the strength of normal sections based on a nonlinear deformation model [3]. In this case, it is necessary to take into account the increase in the strength and deformability of the volumetric-stressed concrete core, as well as its joint work with longitudinal and indirect reinforcement.

With more complex deformations (oblique bending and oblique eccentric compressed), the compressed zone of the diaphragms of the shell structures has a shape that differs from a rectangle. This, naturally, is reflected in the stress-strain state of this zone and at its boundary height [2], and not only due to the variable width of the section, but also in connection with the different ultimate deformability of the extreme compressed fiber.

Since the height is inextricably linked with the ultimate elongation of the tensile reinforcement ε_{su} and with the maximum shortening of the concrete fiber farthest from the neutral line in the edge of the section ε_{su}, its mathematical expression can be written as:

$$\xi_R = \frac{x_R}{h_0} = \frac{\varepsilon_{bu}}{\varepsilon_{bu} + \varepsilon_{su}} = \frac{1}{1 + \frac{\varepsilon_{su}}{\varepsilon_{bu}}} \quad (1)$$

The main difficulty in using this formula lies in determining the ultimate deformations of materials, especially ε_su.

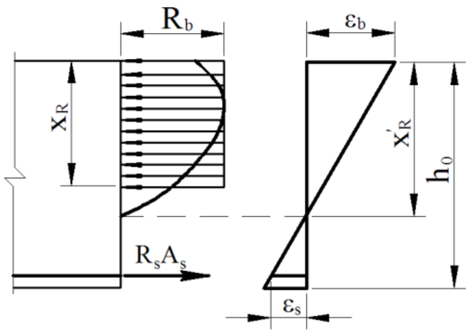

Fig. 1. Boundary height of the compressed zone of the diaphragm of shells and ribbed plates.

Since all stages of destruction give similar results, the secant modulus of concrete deformation in this state can be taken in accordance with the expression [1,4].

$$E_b' = E_b(0{,}03 + 0{,}0047B). \quad (2)$$

Then

$$\xi_R' = \frac{1}{1 + \frac{R_s}{\alpha R_b(0{,}03 + 0{,}0047B)}} \qquad (3)$$

where α is the ratio of the moduli of elasticity of reinforcement and concrete; B - class of concrete.

Here, attention should be paid to the need to take into account the change in the transverse deformation coefficients of materials with an increase in the stress level of elements with indirect reinforcement. In this case, it becomes possible to give an accurate analytical assessment of the joint work of concrete and steel, since the value of the lateral pressure of the volumetric-compressed concrete core depends on the ratio of the values of v_b and v_s, and this creates the so-called cage effect.

Parametric coordinates of the points of the diagram can be taken according to the recommendation [4]. For a concrete core diagram, these coordinates are unknown at the beginning of the calculation. They largely depend on the ratio of the main compressive stresses. In centrally compressed reinforced concrete elements with indirect reinforcement at any point, the ultimate stress σ_bzu can be calculated by the formula obtained theoretically [4]:

$$\sigma_{bzu} = R_{bu} + k\sigma_{bxu} \qquad (4)$$

where: R_bu is the strength of concrete under uniaxial compression; k - lateral pressure coefficient depending on the level of lateral compression m = σ_bxu / σ_bzu and determined by the formula (5):

$$k = \frac{1 + a - am}{b + (1 - b)m} \qquad (5)$$

a and b - material coefficients established from experiments.

The value of the relative deformation of concrete ε_bz0 for elements with indirect reinforcement is proposed to be determined by the following formula:

$$\varepsilon_{bz0} = \varepsilon_{b0\left(\frac{\sigma_{bzu}}{R_{bu}}\right)} \quad (6)$$

in which the exponent γ is calculated by the formula:

$$\gamma = 2 - \mu_{sz}\frac{E_s}{E_b} \qquad (7)$$

where: ε_bo is the value of the relative deformation of concrete at the top of the σ_b-ε_b diagram under axial compression (taken according to the current design standards); μ_sz - longitudinal reinforcement coefficient; E_s and E_b are the initial moduli of elasticity of steel and concrete.

The resolving equation relating the acting stresses and deformations of materials will be obtained using the generalized Hooke's law for the elastic and elastoplastic stages of work.

Let us consider the proposed method for calculating the strength of a compressed element using the example of a U-shaped section with spiral reinforcement.

When loading by a centrally applied compressive force of a reinforced concrete element of a U-shaped cross-section, reinforced with longitudinal reinforcement (reinforcement coefficient μ_sz) and a spiral diameter d_ (s, c) (Fig. 2.). compressive stresses σ_ (s, c) appear in the concrete core and longitudinal reinforcement, and tensile forces arise in the spiral bars with a cross-sectional area A_ (s, c).

From the equilibrium condition of the considered fragment of height s, taking into account the uneven compression, we obtain the equations:

$$\frac{\sigma_{br}}{\psi_b} d_{eff}\frac{s}{2} - 2\sigma_{s,c}A_{s,c} = 0, \qquad (8)$$

where: μ_ (s, c) - coefficient of indirect reinforcement with spirals; ψ_b is a coefficient that takes into account the unevenness of the lateral compression of the concrete core (for a U-shaped section it usually takes ψ_b = 0.7, for a rectangular - ψ_b = 0.75), for a box-shaped and I-section ψ_b = 0.8.

Taking into account the known dependence σ_ (s, c) = ε_s ν_s E_s for spiral reinforcement, equations (8) can be written in the following form

where: μ_ (s, c) - coefficient of indirect reinforcement with spirals; ψ_b is a coefficient that takes into account the unevenness of the lateral compression of the concrete core (for a U-shaped section it usually takes ψ_b = 0.7, for a rectangular - ψ_b = 0.75), for a box-shaped and I-section ψ_b = 0.8.

Taking into account the known dependence σ_ (s, c) = ε_s ν_s E_s for spiral reinforcement, equations (8) can be written in the following form

$$\sigma_{br} = 0{,}9\mu_{s,c}\varepsilon_{s,c}\nu_s E_s \qquad (9)$$

where E_s is the modulus of elasticity of steel; ε_ (s, c) - relative elongation strains of spiral reinforcement.

$$\rho_s = 0.375\mu_{xy}\frac{\sigma_y}{R_{bu}} \qquad (10)$$

The practical implementation of the proposed calculation method is based on the step-iterative method in two stages. At the first stage, a centrally compressed element with indirect reinforcement is considered. For this optimal section of the element, a diagram of the volumetric stressed concrete core is constructed by calculation.

In the calculations, it is recommended to gradually increase the axial deformation of the concrete. Further are determined (Fig. 2). stresses, as well as relative deformations of elongation of spiral reinforcement, after which the coefficients of elasticity and transverse deformations of concrete and steel are calculated for a given level of loading. Then, the iterative process is repeated until the specified computational accuracy is achieved.

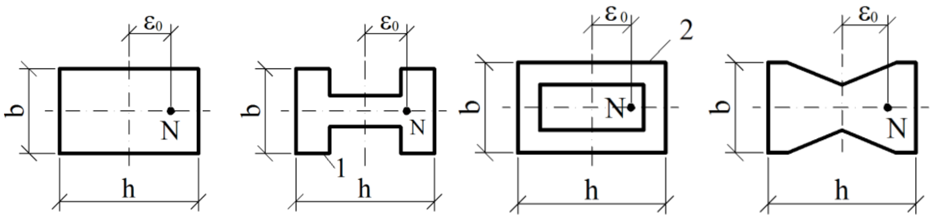

Fig. 2. Indirectly reinforced optimal sections of compressed reinforced concrete diaphragms of shells from elements "P" with eccentricities e_o> e_a 1,2 - I-beams and box sections from elements "P"

At the second stage, the strength of the eccentrically compressed element is directly calculated using the known dependences of the norms. Moreover, the calculated eccentricity is taken at least random, and the design flexibility is taken into account according to the deformed scheme.

Thus, a universal method for calculating the strength of compressed elements with indirect reinforcement of various types of optimal transverse of two "P" shaped sections has been obtained. Within the framework of this technique, on the basis of a nonlinear deformation model, an algorithm for calculating the strength was developed and an assessment of the stress-strain state of eccentrically compressed elements was performed.

Literature

1. Gushcha Yu.P. Influence of cross-sectional shapes of elements on strength, crack resistance and deformability [Text] / Yu.P. Gushcha I.Yu. Laricheva., K.T. Sakanov // Concrete and reinforced concrete. 1987. - No. 5 - P.19-20.
2. Vakhnenko P.F. About taking into account the plastic properties of concrete when calculating skew-compressible and skew-bending reinforced concrete elements [Text] / P.F. Vakhnenko, V.N. Condel // Izv. universities. Ser. Construction and architecture. 1989.-No.10.- P.6-9.
3. Karpenko N.I. General models of reinforced concrete mechanics. [Text] N.I. Karpenko. - M .: Stroyizdat, 1996. - 416 p.
4. Rzhanitsyn A.R. Composite rods and plates. [Text] / A.P. Rzhanitsyn. –M .: Stroyizdat, 1986. –316 p.
5. Razzakov SR, Composite reinforced concrete shells of building coverings in conditions of long-term operation and seismic impacts. [Text] / SR Razzakov-Tashkent.Fan, 2004.-380 p.
6. Razzokov NS Zhamoat binolari zallarida yangi tejamkor kobik yepmalar constructive echimlarining tadkkoti. [Text] / N.S. Razzokov // Modern problems of building structures. Materials of the International Scientific and Technical Conference - Samarkand. 2013.-B. 292-296.
7. Sanaeva, N. P., & Usmanov, V. F. Influence Of Step-by-step Rise And Loading On Stress-deformed State Structures Of Multi-storey Buildings In The Conditions Of Dry Hot Climate Of Central Asia. Journal NX, 148-151.
8. Sanaeva N.P. The Influence of the Central Asian Climate on the Strength Characteristics of brick masonry. "International journal on human computing studies" Volume: 04 Issue: 2 | Feb 2022. Journal /IJHCS e-ISSN: 2615-8159p-ISSN:2615-1898.
9. Maxmadaliyevich, A. R., & Payzullayevna, S. N. (2023). Experimental Studies of Brick Masonry on Climatic Action Impacts. Nexus: Journal of Advances Studies of Engineering Science, 2(4), 69-73.