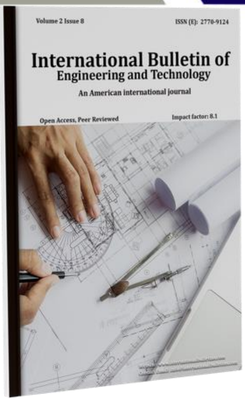

FEATURES OF STRESS-STRAIN STATE OF COMPRESSED REINFORCED CONCRETE ELEMENTS UNDER INFLUENCE OF LONG-TERM VARIABLE LOADS

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Annotation

In the article, having analyzed the experimental data obtained, as well as research, described in [3, 4, 5] showed that the creep deformations of concrete under variable loads are 15-20% less, than under constant load.

Keywords: Construction, strength, seismic, material, temperature, humidity, concrete, reinforced concrete, load, loading, cycle, building, element.

As is known, central compression in its "pure form" practically never occurs in structures, however, many elements of complex structural systems (elements of trusses, arches, columns of multi-story buildings with an incomplete frame, columns of loading ramps, tanks, bunkers, silos) in the cases specified in [1] it is calculated as centrally compressed elements with random eccentricity. In addition, consideration of this type of stress-strain state makes it possible to more clearly imagine the operation of structures under complex loading conditions due to a significantly smaller number of interacting factors than, for example, during eccentric compression or bending.

At any moment, temporary stress in concrete and compressed reinforcement reinforced concrete elements under the action of long-term constant load can be determined by formulas [2].

$$\sigma_s(t)=\frac{\alpha(t)}{\nu_{в}(t)}\sigma_{в} \qquad (1)$$

$$\sigma_{в}(t)=\frac{N(t)}{(1+\mu\frac{\alpha(t)}{\nu_{в}(t)})A_{в}} \qquad (2)$$

where $\mu=\frac{A_s}{A_{в}}$ - element longitudinal reinforcement coefficient;

$\alpha=\frac{E_s}{E_{в}(t)}$ - ratio of elastic moduli of reinforcing steel and concrete

$\nu_{в}(t)$ - elasticity coefficient of concrete, taking into account all its plastic deformations.

Taking into account expressions (1) and (2), it is possible to trace how stress in concrete changes over time $\sigma_{в}(t)$ and in $\sigma_s(t)$ fittings.

Calculations and experiments show that when operational loads are applied to structures due to concrete creep, the stress of the longitudinal reinforcement of compressed elements increases by 2-2.5 times, and in concrete it decreases.

Having analyzed the experimental data obtained, as well as research, described in [3,4, 5] showed, that the creep deformation of concrete under variable loads is 15-20% less, than under constant load. Currently accepted calculation methods (C) are capable of assessing concrete deformation processes under long-term variable loads with a certain accuracy. However, they have a rather cumbersome mathematical apparatus and require knowledge of numerous empirical parameters.

At the same time, with sufficient accuracy for design, it is possible to propose a variant of describing the change in the creep characteristics of concrete under various long-term loads.

$$\tilde{\varphi}(t) = \varphi(t) \cdot \tilde{k}(\rho, n) \quad (3)$$

where $\varphi(t)$ - characteristics of concrete creep under constant load;

Research to determine the creep deformation of concrete has made it possible to propose a simple relationship, reflecting the development of concrete creep deformations over time;

$$\varphi(t) = \varphi(\infty)\frac{t}{a+t} \quad (4)$$

$\varphi(\infty)$ - limit value of concrete creep characteristics [3]

t - time counted from the moment the load is offered, days;

a - coefficient that takes into account the influence of the reduced section size and the moment of application of the load on the rate of development of creep deformation in concrete.

For our experience a =100 [4]

- coefficient taking into account the reduction in concrete creep characteristics, $\tilde{k}(\rho, n) \le 1$;

$$\tilde{k}(\rho, n) = 1 - \sum_{i=1}^{n} B^i; \quad i = 1,2,3.....n \quad (5)$$

where n - the number of cycles

B - coefficient depending on cycle characteristics

$$B = f(\rho) = в\sqrt{1-\rho} \quad (6)$$

where ρ - cycle characteristics $\rho = \frac{\sigma_{\min}(t)}{\sigma_{\max}(t)}$;

$в$ - experienced parameter

For the described studies, a numerical value was selected, $в = 0{,}142$ [4]. The value of the coefficient can be obtained using a formula similar to that proposed [5|. taking into account the nature of the element loading.

$$\nu_в(t) = \frac{\nu_0}{1+\tilde{\varphi}(t)}; \quad (7)$$

Where; ν_0 - initial value of the elasticity coefficient

$\tilde{\varphi}(t)$ - the creep characteristic of concrete under constant loads is determined by the formula (4). Under variable loads according to the formula (3).

The value of the modulus of elasticity of concrete over time formula given in the work [3]

The most characteristic feature of the operation of compressed reinforced concrete elements is periodically unloaded, is the formation of transverse cracks due to the creep of concrete when the load is removed after a long period of loading. This effect was first described by A.A. Gvozdev. AND I. Barashikov and was subsequently observed in experiments [3.4.5].

Author of the work (5] an approximate relationship has been proposed linking the reinforcement coefficient with the strength and deformation properties of concrete.

$$\mu \le -\frac{l_n\left(1-\frac{R_{bt,ser}}{\sigma_{в0}}\right)}{\alpha\left[\varphi(t)+l_n\left(1-\frac{R_{bt,ser}}{\sigma_{в0}}\right)\right]} \qquad (8)$$

The dependence (8) proposed by the author [5] makes it possible to solve two problems. Given the known plastic properties of concrete, determine the maximum percentage of reinforcement in order to prevent the occurrence of cracks during unloading, and also, with known reinforcement, determine the permissible load level.

In the development of this problem, it is possible to determine the limiting reinforcement or the level of loading unloading during slow unloading, occurring according to the law of recovery of deformation of the elastic aftereffect. At initial voltages $\sigma_{в0} = 0,5R_b^n, E_s E_в$ and $R_{bt,ser}$ adopted by QMQ 2.03.01-96 equation (8) will be written;

for concrete class B15

$$\mu\% \le \frac{3,1}{\varphi(t)-0,25} \qquad (9)$$

for concrete class B30

$$\mu\% \le \frac{3,3}{\varphi(t)-0,2} \qquad (10)$$

Table 1 presents the values of the maximum reinforcement, depending on the plastic properties of concrete

Table 1

Class concrete	Creep characteristic $\varphi(t)$							
	0,5	1,0	1,5	2,0	2,5	3,0	3,5	4,0
	Limit percentage of reinforcement							
B15	12,4	4,13	2,48	1,78	1,38	1,13	0,82	0,65
B30	11,0	4,12	2,54	1,82	1,43	1,18	0,87	0,69

As can be seen from table. Class 1 concrete has little effect on the change $\mu = f\varphi(t)$ this is due to the relatively small difference $R_{bt,ser}$ when increasing the class of concrete.

For bending eccentrically compressed and eccentrically stretched elements, this issue is given in the work [4]

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