ACADEMICIA

ISSN: 2249-7137 Vol. 11, Issue 5, MAY, 2021 Impact Factor: SJIF 2021 = 7.492

ACADEMICIA
An International Multidisciplinary Research Journal
(Double Blind Refereed & Peer Reviewed Journal)

DOI: 10.5958/2249-7137.2021.01503.2

ANALYSIS OF THE INFLUENCE OF A DRY HOT CLIMATE ON THE OPERATION OF REINFORCED CONCRETE ELEMENTS

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ABSTRACT

This article is devoted to the theoretical and experimental study of the deformation characteristics of heavy concrete in a dry hot climate. The methods of experimental research have been developed and the nature of the temperature distribution of the concrete of the column in a dry hot climate has been studied.

KEYWORDS: *Reliability, Operating Conditions Coefficients, Strength, Deformability, Shrinkage, Opening Width, Stiffness, Curvature, Axial Thermal Elongation, Concrete Shrinkage Deformations, Sinusoidal Character.*

INTRODUCTION

According to the basic design requirements of SNiP 2.03.01.-84 in terms of the calculation for the limiting states of the first and second groups, it is written that this calculation, among other things, should ensure the reliability of the structure under the combined influence of force factors and unfavorable environmental conditions. Such an account follows mainly from changes in the physical and mechanical properties of concrete in a dry hot climate, which are later included in the design calculation. In this case, the influence of a dry hot climate is taken into account by multiplying the design resistance of concrete to compression and tension, respectively, by the coefficients of working conditions γ_{b7} and γ_{tt}, which are taken according to table. 1.8 and 1.9 /4.9/.

The need to take into account the impact on reinforced concrete structures of a dry hot climate is noted in the works of many researchers / 5,6,8 /.

In the studies of A.F. Milovanova, A.V. Nifontova, E.A. Mazo / 2,3 / it is noted that the effect of elevated temperature causes early formation of cracks, and also reduces the stiffness of bent reinforced concrete elements.

Experimental studies have shown that the operation of reinforced concrete structures in a dry hot climate leads to an additional increase in the width of the opening of normal and inclined cracks. The crack opening width in bent reinforced concrete elements in a dry hot climate turned out to be 1,2 times greater than under normal conditions. The experience of operating ribbed slabs in hot dry climates shows that structures unprotected from solar radiation have early cracking.

The calculated deflections of the coatings, determined according to the standards, were less than the experimental ones from 20 to 40% / 25 /.

The research results of MM Selimov, Sh. Nizamov / 7 / showed that in bent reinforced concrete elements made in a dry hot period of the year, reduced rigidity and insufficient crack resistance are observed. Actual cracking loads for slabs were 12.3 ... 25.4% lower than the control ones. In reinforced concrete beams made of agglоporite concrete, loaded with a long-term load of 0.8 $M_{счс}$, cracks appeared after 6 ... 7 months in the summer. In reinforced concrete beams made of agglоporite concrete, which were for 20 months under solar radiation in an unloaded state, the moment of cracking under short-term loading turned out to be less on average by 36%.

With an increase in the temperature of the element and a decrease in the humidity of the outside air, the curvature and width of the crack opening increase, the rigidity of reinforced concrete beams decreases / 7 /. In work / 9 / the results of studying the strength of columns made of fine-grained high-strength slag concrete under eccentric compression with a large eccentricity are presented.

The author came to the conclusion that when calculating the formation of cracks in eccentrically compressed elements made of fine-grained cinder concrete, it is necessary to take into account the stresses in the reinforcement caused by increased shrinkage of cinder concrete, which becomes important under conditions of a dry hot climate.

The increased shrinkage of cinder concrete reduces the forces of cracking of the columns and leads to an increased width of crack opening. When calculating columns for cracking must be entered into the design formulas of stress in tensile reinforcement caused by shrinkage of slag concrete. In turn, as it was revealed in the study of the completeness of the stress diagram of the compressed zone of reinforced cinder concrete, shrinkage increases the deformability of concrete due to the creation of tensile stresses in it. Increased values of the initial modulus of elasticity and coefficient \) characterizing the elastoplastic state of concrete in the compressed zone, the deflections of slag concrete columns increased in comparison with the calculation according to SNiP 02.03.01-84 by an average of 20%.

With an increase in temperature, reinforcing steel expands and its temperature deformations are close to the temperature deformations of concrete, and its linear thermal elongation coefficient is:

for fittings of classes A-1, A-II, B-1, B-II, K-7, grades ВСт3Гпс5, ВСт3кп2-11,510^{-60}C^{-1}

for fittings of classes A-III, A-IIIv, A-IV, A-V, A-VI, At-IV,At-V, AT-VI, 12 10^{-60}C^{-1}.

The reinforced concrete element is lengthened by the amount of greater concrete elongation and less reinforcement elongation. Before the formation of cracks, the temperature deformations of the reinforced concrete element are close to the temperature deformations of concrete. In a reinforced concrete element, thermal expansion creates tensile stresses in concrete and compression stresses in reinforcement. Expanding more than concrete, reinforcement sometimes breaks it. Cracks appear in the concrete. When cracks appear, the stresses in concrete and reinforcement fall, and the reinforced concrete element begins to lengthen more and its elongations approach the elongation of the reinforcement.

It is recommended to calculate reinforced concrete members for cracking on forces caused by temperature when the temperature of concrete along the height of the element between the section edges differs by more than 30^0 C in the elements of statically indeterminate structures and by more than **50^0 C** in the elements of statically definable structures. Such temperatures are unlikely in dry, hot climates.

Therefore, the calculation of temperature deformations of reinforced concrete elements in a dry hot climate can be performed as for concrete elements.

When calculating concrete and reinforced concrete elements for the first heating, the temperature elongation of the element axis ε_t and its temperature $\left(\frac{1}{r}\right)$ curvature in the warm season are determined by the formulas:

$$\varepsilon_t = \Delta t_w \cdot \propto_{bt} \cdot \gamma_{tt} \quad (1.14)$$

$$\left(\frac{1}{r}\right)_t = \frac{\vartheta_{w \cdot \propto_{bt}}}{h_{red}} \cdot \gamma_t \quad (1.15)$$

When calculating concrete and reinforced concrete elements $\varepsilon_{t,cs}$ for long-term alternating heating and cooling, the change in the length of the element axis and its curvature $\left(\frac{1}{r}\right)_{t,cs}$ under the influence of temperature from the joint manifestation of thermal deformation and shrinkage of concrete is determined by the formulas:

for the warm season

$$\varepsilon_{t,cs} = (\Delta t_w \cdot \propto_{bt} - \varepsilon_{cs}) \cdot \gamma_t \quad \mathbf{(1.16)}$$

$$\left(\frac{1}{r}\right)_{t,cs} = [\frac{\vartheta_{w \cdot \propto_{bt}}}{h_{red}} \pm \left(\frac{1}{r}\right)_{cs}] \cdot \gamma_t \quad (1.17)$$

During the cold season

$$\varepsilon_{t,cs} = (\Delta t_c \cdot \propto_{bt} - \varepsilon_{cs}) \cdot \gamma_t \qquad (1.16)$$

$$\left(\frac{1}{r}\right)_{t,cs} = [\frac{\vartheta_{c \cdot \propto_{bt}}}{h_{red}} \pm \left(\frac{1}{r}\right)_{cs}] \cdot \gamma_t \quad (1.17)$$

In formulas **(1.16-1.17)**

$\Delta t_w, \Delta t_c$ -is the average temperature over the section of the element, respectively, in the warm and cold seasons, $\vartheta_{w,}$ ϑ_c is the temperature difference, respectively, in the warm and cold seasons.

It has been found that structures operating in a dry, hot climate are subject to periodic heating and cooling both throughout the year and throughout the day. The distribution of temperature in reinforced concrete structures from temperature climatic influences under non-stationary conditions of heat transfer and taking into account the variable moisture content of concrete should be determined by methods of theories of heat and mass transfer or on the basis of experimental data.

To determine the temperature distribution in reinforced concrete structures from temperature climatic influences, the columns of the 1st series in the amount of 6 pieces after 7 days of wet storage were demounted and installed on the landfill in the open air. These columns were exposed to outside air temperature, scattered and directed solar radiation for 1 year.

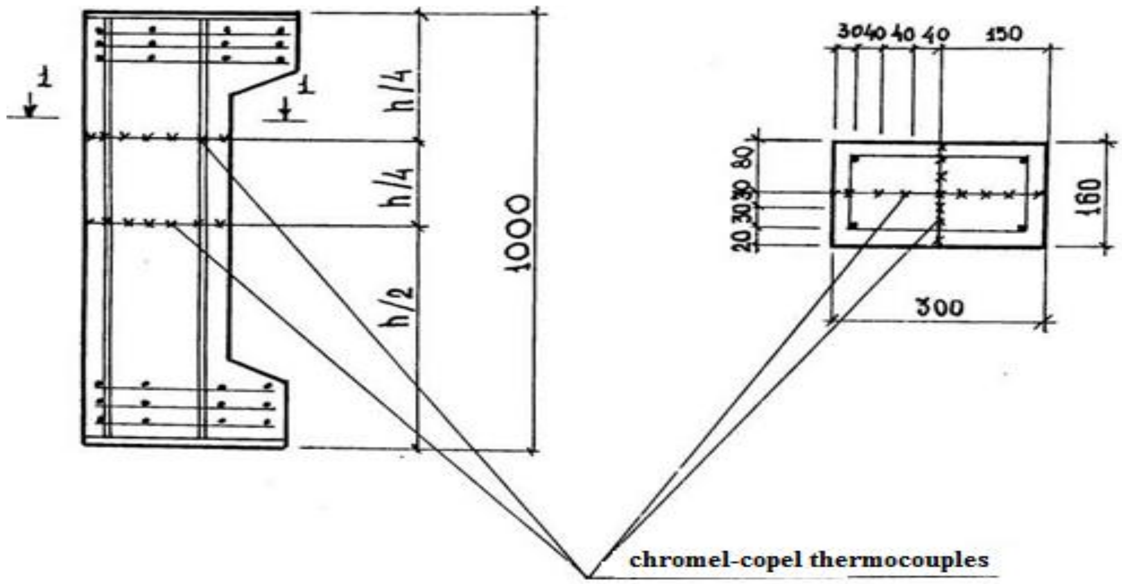

Fig. 1. Layout of thermocouples in columns

In order to establish the effect of directed solar radiation on concrete heating, the columns were positioned so that in some columns there was a stretched zone; in other columns, the compressed zone and the side surface would be exposed to its greatest effect. For this, the columns were oriented to the south by a stretched or compressed zone or lateral surface (Fig. 1).

To establish the change in the temperature of concrete over the cross section of the column, depending on the daily and seasonal fluctuations in the outside air temperature, the concrete temperature was measured in the morning 2 hours before sunrise, in the afternoon at 14-17 hours and in the evening 2 hours after sunset. The temperature of the concrete was measured with a chromel using Copel thermocouples. Thermocouples were connected to a portable potentiometer. At the moment of temperature change in concrete, the cold junction of thermocouples was in thawed ice with zero temperature. According to the potentiometer readings E. D.S. thermocouples in millivolts were converted to degrees Celsius. [nine].

Analysis of experimental data shows that in a dry hot climate, reinforced concrete elements heat up unevenly. Under the influence of fluctuations in air temperature and the intensity of solar radiation, the temperature field of structures continuously changes over the section of the element at any time nonlinearly. Changes in concrete temperature follow changes in ambient temperature and are sinusoidal. [10].

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