ANALYSIS OF THE EFFECT OF DRY HOT CLIMATE ON THE WORK OF REINFORCED CONCRETE ELEMENTS

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Abstract. *The article provides information on the influence of conditions on reinforced concrete elements in dry hot climates and their changes.*

Keywords: *Climate influence, dry conditions, reinforced concrete, construction.*

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Аннотация. *В статье приведены сведения о влиянии условий на железобетонные элементы в условиях сухого жаркого климата и их изменениях.*

Ключевые слова: *Влияние климата, сухие условия, железобетон, строительство.*

INTRODUCTION

The work of reinforced concrete structures, their strength and deformation characteristics in a dry hot climate differ from the strength and deformation characteristics in normal temperature and humidity conditions. In conditions of dry hot climate, the strength of concrete decreases, the deflection and the width of crack opening in reinforced concrete structures increases under long-acting loads. If the effects of these factors are not taken into account, the quality and durability of reinforced concrete structures significantly decreases due to prolonged cyclic exposure to elevated temperatures and low humidity. In this regard, in the chapter CMC2.03.01.-96 [1] it is indicated that for structures unprotected from solar radiation intended for operation in the climatic subdistrict IVA, the calculation should take into account the temperature climatic effects.

RESEARCH MATERIALS AND METHODOLOGY

According to [94], when calculating the strength, deformations and crack resistance of reinforced concrete structures, it is necessary to multiply the calculated concrete resistance to compression and stretching by the coefficient of working conditions $\gamma_{b7}= 0,85$ and the modulus of elasticity of concrete by the coefficient $\beta_b=0,85$, which take into account the adverse effects of climatic conditions.

Elevated temperature and low relative humidity of the environment lead to significant temperature-shrinkage deformations and stresses. Consequently, structures that are unprotected from solar radiation have increased cracking of a temperature-shrinkage nature. Therefore, the study of the influence of dry hot climate on crack resistance is of great importance.

RESEARCH RESULTS

In conditions of dry hot climate, cracking in reinforced concrete structures must be determined taking into account the combined cyclic changes in temperature and humidity of the environment, the season of manufacture and loading of structures. For example, in the work [2], the crack resistance of reinforced concrete beams made of light concrete was investigated in a dry hot climate. With short-term loading of experimental beams that are not exposed to the influence of a dry hot climate, the theoretical width of the opening of normal cracks determined by the method [94] approximately corresponds to the width of the opening of cracks determined by experience. For other beams tested in conditions of dry hot climate, the theoretical width of normal cracks opening turned out to be underestimated by 10-25%. At the same time, the samples were at the time of loading for 3 and 20 months under climatic influences. The more beams were in conditions of dry hot climate, the more cracks opened, and the theoretical width of crack opening according to [1] does not take into account these factors.

Temperature and humidity deformations of precast reinforced concrete elements operating in the climate of Central Asia are periodic in nature due to changes in temperature and relative humidity of the environment both during the day and throughout the year [2]. At the same time, the maximum of deformations during the day corresponds to 17 hours, and the minimum is about 4-6 hours in the morning. The maximum values of deformations during the year correspond to the summer period, and the minimum values correspond to winter. The conducted experimental studies show that when calculating reinforced concrete structures, it is necessary to take into account the change in strength, the increase in shrinkage and creep deformations of concrete, the manufacturing season and the operating conditions of the element. Experiments have established that the limiting values of shrinkage deformations of winter-made concrete are on average 10%, and creep is 25% less than that of summer-made concrete (loading) [8]. As a result of the analysis of numerous studies, it was found that the CMC 2.03.01.-96 technique underestimates the loss of prestress from shrinkage and creep by about 12% [3].

In a dry, hot climate, there are daily and seasonal fluctuations in the temperature and humidity of the outdoor air. When heated, temperature deformation consists of two types of deformations: reversible deformation - temperature expansion of concrete and irreversible deformation - temperature shrinkage of concrete. The temperature deformation of concrete expansion mainly depends on the type of aggregate and the humidity of concrete. When the temperature rises, the cement stone expands significantly less than the filler, and this expansion "disappears" when the adsorption-bound water is removed from the gel and the temperature deformation of shrinkage develops. With the effective humidity of concrete, approximately equal to 2 ... 3%, the gel has the maximum degree of moisture and there is no free water.

When heated with humidity less effective, the temperature shrinkage of concrete occurs even with a short-term rise in temperature. The temperature shrinkage of concrete on Portland cement is mainly due to the shrinkage of cement stone. When concrete is heated, deformations of thermal expansion and shrinkage are simultaneously manifested. The temperature deformation of concrete ε_{bt} will be less than the temperature expansion ε_{tt} by the amount of temperature shrinkage ε_{cs}

$$\varepsilon_{bt} = \varepsilon_{tt} - \varepsilon_{cs} = (\alpha_{tt} - \alpha_{cs}) \cdot t = \alpha_{bt} \cdot t \qquad (1)$$

When heating concrete with a humidity higher than effective or dry concrete, the temperature deformations ε_{bt} will be equal to the deformations of the temperature expansion of concrete $\varepsilon_{bt} = \varepsilon_{tt}$, since the temperature shrinkage in wet concrete has not yet manifested itself, but in dry concrete has already passed. The values of temperature deformations ε_{bt} in wet concrete will be greater than dry concrete. If the concrete is moistened during cooling, then temperature shrinkage will appear again during subsequent heating.

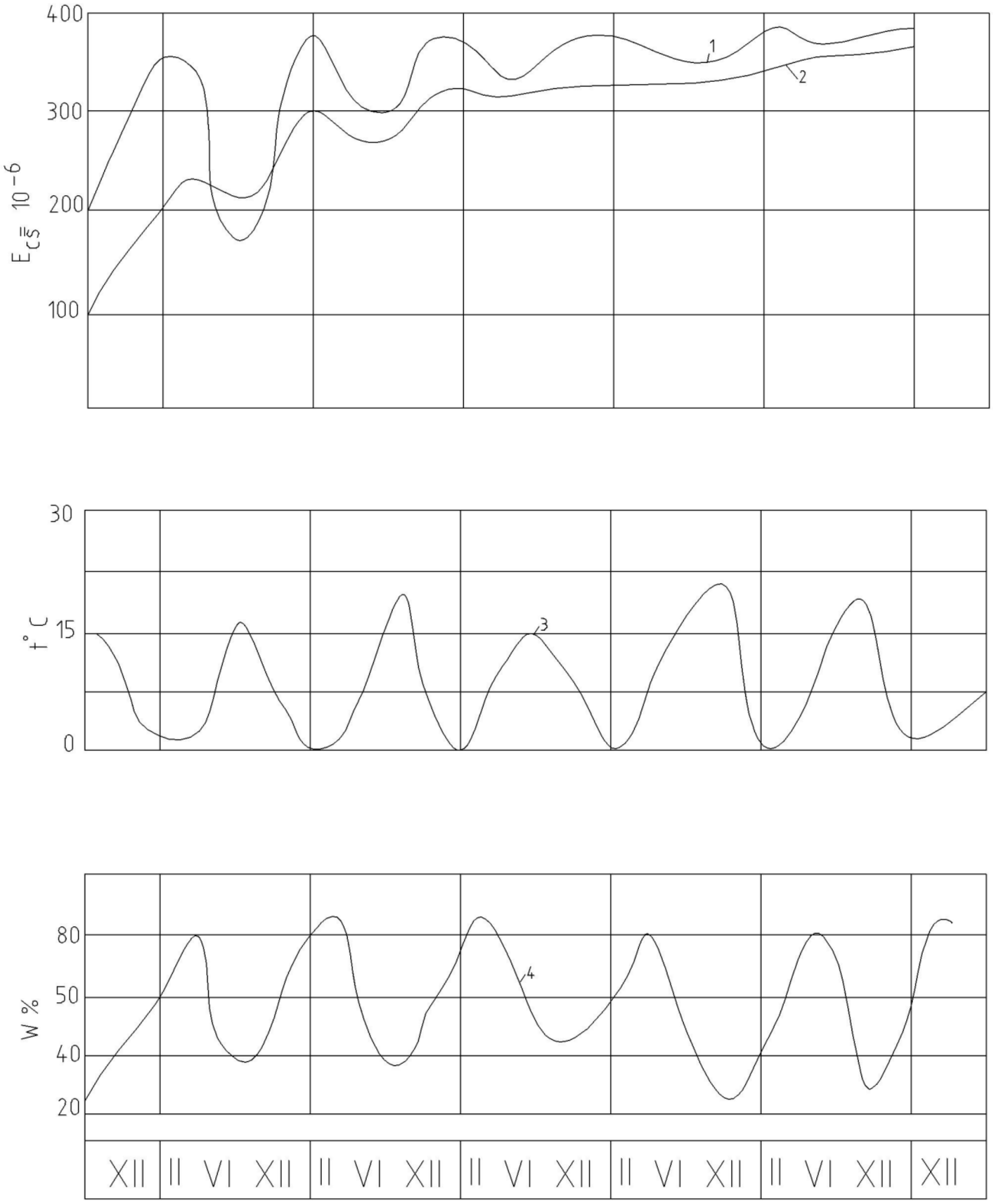

Fig.1. Deformations of moisture shrinkage of concrete in a dry hot climate [2]

1 - prisms with a cross section of 70x70 mm;
2 - призмы сечением 200x200 мм;
3 - temperature, °C; 4 - outdoor humidity.

The coefficient of linear temperature deformation of concrete α_{bt} of natural humidity at the first heating depends on the type of aggregate made of granite $11 \cdot 10^{-6} c^{-1}$, limestone $10 \cdot 10^{-6} c^{-1}$ and expanded clay $9 \cdot 10^{-6} c^{-1}$. The main climatic factors affecting the change in the temperature of structures are the outdoor temperature and solar radiation. In their changes, two periodic fluctuations can be distinguished with annual (winter-summer) and daily (day-night) periods. Under the influence of fluctuations in air temperature and the intensity of solar radiation, the temperature field of structures changes over time and is non-stationary. The temperature distribution over the cross section of the element at any given time is nonlinear.

CONCLUSION

In practical calculations of structures, the temperature field is considered during the period of the most unfavorable impact of climatic temperatures. At the same time, to simplify the calculation, a non-stationary temperature field leads to equivalent stationary ones. It is assumed that within any cross-section, the temperature is distributed according to a linear law.

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