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HEAVY CONCRETE AND ITS STRENGTH AND PROPERTIES IN A DRY HOT CLIMATE

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Annotation
This article is devoted to the theoretical and experimental study of the strength and deformation characteristics of heavy concrete in a dry hot climate. Experimental research methods have been developed and the nature of the increase in strength and deformative properties of heavy concrete in a dry hot climate has been studied. Based on the conducted research, it was found that in a dry hot climate, the physical, mechanical and deformative properties of concrete change from the effect of temperature and humidity, which should be taken into account in the calculations. The creep deformation curves of concrete have a stepwise character and develop intensively mainly in the summer due to the effects of elevated temperature, low humidity and solar radiation of the environment.

Keywords: elastic-plastic state, deformations, initial modulus of elasticity, thermal expansion of concrete.

Further development of capital construction in the Republic of Uzbekistan provides for an increase in the production and use of precast and partially monolithic reinforced concrete. The climatic conditions of the Republic of Uzbekistan are sharply continental.

In summer, the air temperature can exceed + 400 C, while the relative humidity drops to 10-15% or lower. In such climatic conditions, the surface of reinforced concrete and concrete structures heats up to 70-800 C. Due to direct solar radiation. At the same time, significant deformations of concrete shrinkage appear, leading to the formation and opening of cracks on the surface of reinforced concrete and concrete structures.

Fluctuations in temperature and humidity during the day and season of the year (summer and winter) adversely affect the formation of the concrete structure. Intensive dehydration of concrete at elevated temperature and low relative humidity leads to a decrease in its strength and modulus of elasticity. A large daily temperature drop causes an uneven distribution of temperature stresses across the concrete sections. The design and construction of reinforced concrete structures for a dry, hot climate without taking into account deformations, forces caused by changes in elevated temperature and low humidity leads to early formation of cracks in concrete, excessive disclosure of them, as well as to large deformations of the structure.

One of the most important factors in improving the reliability and durability of structures of buildings and structures, especially for the Republic of Uzbekistan, is the further improvement of their calculation methods taking into account real operating conditions.

As the research results show, the properties of concrete in a dry hot climate have a number of features, without taking into account which significant errors can be made in the calculation and design of reinforced concrete structures [3,4].

According to the basic design requirements of the current SNiP 2.03.01-96, in terms of calculating the limiting states of the first and second groups, the reliability of structures must be ensured under the combined influence of force factors and adverse environmental conditions [12].

Such accounting follows mainly in connection with changes in the physical and mechanical properties of concrete and the behavior of structures in a dry hot climate, which are later incorporated into their calculation.

The available experimental data relate mainly to the calculation of bent reinforced concrete elements, and the influence of a dry hot climate on the stress–strain state of non-centrally compressed reinforced concrete elements has not been sufficiently studied and there are no recommendations on their calculation methodology. In addition, it would be necessary to clarify the values of the coefficients of the working conditions of concrete y_b7 and y_tt for the dry hot climate used for the manufacture of such structures.

To solve these problems, the main directions of this work and the program of upcoming experimental research were formulated.

Experimental studies were carried out in the conditions of the workshop

(relative humidity w = 60... 70% at a temperature t = 25...350C), as well as in natural conditions of dry hot climate (under direct solar radiation).

To prepare the concrete mixture, the Portland cement of the Navoi plant with an activity of 40.5 MPa was used. Granite crushed stone from the quarry of the floodplain of the Naryn River with a fraction of 5-20 mm was used as a large aggregate. Quartz sand of the same quarry with a size modulus of 2.1 was used as a fine aggregate. The composition of the concrete mixture corresponded to concrete in compressive strength of 16-18 MPa, in which the binder consumption was 250 кг/м3.

To study the strength and deformation characteristics of concrete, samples of a cube with a rib size of 10 cm and samples of a prism with dimensions of 10x10x40 cm were made. All samples were stored under wet sawdust for 7 days. Then one part of the samples was solidified in the workshop with a temperature of 25 ... 35 and relative humidity 60 ... 70%, and the other in a dry hot climate, outdoors under solar radiation. Samples of one series were tested at the ages of concrete 28,60,180 and 360 days. The study of shrinkage deformations and creep of concrete was carried out on samples of prisms with dimensions of 10x10x40 cm, which hardened under the same conditions.

The samples were loaded at the age of concrete for 28 days under both conditions under consideration. The level of constant stresses during the creep tests of concrete in all cases was assumed to be constant and amounted to approximately 40% of its prismatic strength. Along with loaded samples, unloaded prisms were also tested to determine the temperature–shrinkage deformations of concrete. The creep deformations of concrete were determined as the arithmetic mean obtained by measurements on two twin samples. The duration of observation was 340...360 days.

Based on the results of long-term tests, the average values for each loaded sample and shrinkage-temperature deformations for each unloaded sample were calculated.
To determine shrinkage deformations from the total temperature-shrinkage deformations of concrete, it is necessary to subtract the deformations of the temperature expansion of concrete depending on the temperature change[8].
To determine the deformation of the thermal expansion of concrete, 10x10x40 cm prisms were tested according to the following method: concrete prisms were dried to a constant weight for three hours in a Feitron climate chamber. The temperature in the chamber rose by 100 C and the temperature deformations of concrete were measured. The temperature in the chamber was brought up to 800 C, which made it possible to obtain temperature deformations of concrete expansion from temperature changes, which were calculated from the measured total temperature-shrinkage deformations of concrete prisms located in the workshop and outdoors.
During the experiments, it was found that changes in concrete temperature follow changes in air temperature and are sinusodial in nature
Analysis of the research results shows that the increase in the cubic strength of heavy concrete when stored in vivo for 180 and 360 days amounted to 6 and 8% and 8...11%, respectively, of the strength of concrete at 28 days of age. The increase in the prismatic strength of heavy concrete during 180 and 360 days compared to 28 days is also not the same for samples in natural conditions (4 and 6%) and under constant conditions in the workshop (7 and 8%).
Thus, there is a decrease in the growth of concrete compressive strength caused by unfavorable conditions of a dry hot climate. This must be taken into account when calculating reinforced concrete structures by the coefficient of the concrete working conditions for compression. This coefficient takes into account the influence of solar radiation, heating duration, low humidity and massiveness of structures on the compressive strength of concrete[3,4].
Processing of research data has shown that for the calculation of reinforced concrete elements made of heavy concrete operating in a dry hot climate, it is necessary to take the coefficient of concrete working conditions for compression $\gamma_{b7} = 0{,}75$ and the coefficient of concrete tensile work $\gamma_{tt} = 0{,}70$ when calculating for the first exposure to temperature and, respectively, $\gamma_{b7} = 0{,}70$ and $\gamma_{tt} = 0{,}65$ when calculating for a long alternating heating and cooling
Changes in air temperature and humidity also affect the initial modulus of elasticity of concrete.
According to the experimental data, the value of the coefficient β_b, which takes into account the decrease in the modulus of elasticity of concrete from the effects of temperature and humidity of a dry hot climate, can be taken equal to 0.70 when calculated for the first exposure to temperature and 0.65 when calculated for prolonged alternating heating and cooling[8]
The development of plastic deformations of concrete is estimated by the coefficient of elasticity of concrete ν, which is the ratio of elastic to total deformation. The values of the coefficient of elasticity of concrete $\bar{\nu}$, characterizing the elastic-plastic state of compressed concrete, when determining the reduced section of concrete and the stiffness of the section of the element without cracks for a relative humidity of 40% are assumed to be equal at short-term loading of 0.80 and at long-term loading of 0.30; the value of the coefficient of elasticity

of concrete characterizing the elastic-plastic state of the concrete of the compressed zone for a relative humidity of 40% is assumed at short-term loading of 0.40, and at long-term loading of 0.10

When exposed to a dry hot climate, an increase in elastic and plastic deformations of concrete is observed.[7,8]

The coefficient of elasticity of heavy concrete v, which characterizes the elastic-plastic state of compressed concrete in the sun, is less than for similar concrete under constant operation at all stages of short-term loading. At a voltage level of 0.5 Tr, the coefficient value for concrete in natural conditions is 0.75 for short-term loading and 0.25 for long-term loading. Studies have shown that the lowest value of v is observed in concrete under natural conditions.

Static processing has shown that the actual limiting deformations of concrete in a dry hot climate are greater and in comparison with the data obtained in the workshop and depend on the age of concrete at the time of application of the load. For concrete under the influence of solar radiation, the increase in the ultimate compressibility is equal to 1.05, 1.03, 1.12 and 1.15 and for concrete in the workshop 1.03,1,04,1,08 and 1.1, respectively, for 28, 60, 180 and 360 days. The analysis of experimental data allowed us to establish the nature of the relationship between the ultimate compressibility of concrete in a dry hot climate and its strength, which is described by the expression:

$$\varepsilon_b \cdot 10^{-5} = 24.1\sqrt[3]{R^2} \qquad (1)$$

where: R - is the strength of concrete at the time of application of the load, MPa

The results of the calculations (1) showed that the theoretical values are close to the experimental ones. At the same time, the average value of the ratio of experimental data to calculated data was 1.05 with a coefficient of variation of 14.4%, which gives reason to recommend expression (1) for practical application.

Shrinkage-temperature deformations of concrete under the influence of elevated temperature, low humidity and combined with solar radiation are quite complex. The effect of high temperature and low humidity accelerates the development of concrete shrinkage deformations and at the same time a relatively large amount of moisture is removed[9]. The average values of the coefficient of thermal expansion of concrete were obtained experimentally. The hardening of concrete in natural conditions leads to a more intensive accumulation of shrinkage deformations in the initial period due to the influence of low humidity, high climatic temperature and solar radiation. By 100 days, the deformation of concrete shrinkage is 65...75% of the observed by 360 days. The shrinkage of concrete also depends on the initial humidity and the intensity of moisture loss of concrete. The more intensive the removal of moisture from concrete in the first 4 months, the greater the shrinkage deformation. Then comes a period of some stabilization of the growth of shrinkage deformations and their reduction in the winter colder period. With the onset of spring, there is a further accumulation of shrinkage deformation. The maximum shrinkage deformation of concrete under the influence of solar radiation was equal to 68 • 10-5. In a dry, hot climate, shrinkage deformations for concrete unprotected from solar radiation are 1.4 times higher than similar shrinkage deformations observed in constant temperature and humidity conditions of the workshop.

The analysis of experimental data shows that the creep of concrete in natural conditions of a dry hot climate under the influence of solar radiation differs from creep deformations for concrete hardened under normal conditions and has a stepwise character [9,14]. At the same time, a significant increase in the creep deformations of concrete in the natural conditions of a dry hot climate occurs in the warm season and slows down in the cold period. The limiting values of the creep deformations of concrete under the influence of solar radiation of summer manufacture (loading) are on average 1.4...1.5 times higher than the creep deformations of concrete in the workshop.

GENERAL CONCLUSIONS

Due to the effect of temperature and humidity in a dry hot climate, the physicomechanical and deformative properties of concrete change, which must be taken into account in the calculations. When calculating off-center compressed elements designed to work in the dry hot climate of Central Asia, it is recommended to use the coefficients of concrete working conditions γ_{b7} and γ_{tt}. Concrete shrinkage deformations in dry hot climates have a pronounced periodic character depending on seasonal fluctuations in temperature and humidity. The creep deformation curves of concrete have a stepwise character and develop intensively mainly in the summer due to the effects of elevated temperature, low humidity and solar radiation of the environment.

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