

**DEFORMATION SHRINKAGE AND CREEP OF CONCRETE IN NATURAL CONDITIONS OF DRY HOT CLIMATE**

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**Abstract**

This article presents the experimental value of the coefficient of thermal expansion of concrete, shrinkage deformations and creep deformations of concrete in dry and hot climates.

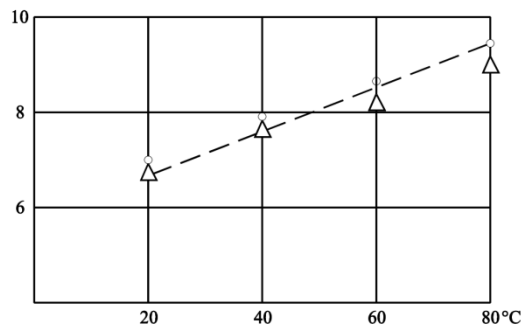
**Keywords:** shrinkage, creep, stresses, deformation, humidity, temperature, temperature expansion, wet storage, solar radiation, concrete moisture loss, seasonal change, normal conditions

This effect can be significant, especially for iron-concrete elements manufactured and operated in dry hot climates, since at the same time daily and seasonal fluctuations in temperature and humidity cause greater removal of moisture from concrete.

As a result, shrinkage stresses develop in the concrete, leading to the formation of cracks in the concrete. The correct assessment of shrinkage deformations and creep of structures has an important role. Shrinkage-temperature deformations of concrete under the influence of high temperature and low humidity in combination with solar radiation are quite complex. The following main features of these deformations can be distinguished: temperature deformations of concrete from heating and the development of additional shrinkage compared to normal conditions from changes in humidity of a dry hot climate. The effect of elevated temperature ( $t_{cp} > 30\text{ c}$ ) accelerates the development of concrete shrinkage deformations and at the same time a relatively large amount of moisture is given. The regularities of the development of shrinkage deformations and creep of heavy concrete in natural conditions of dry hot climate were previously studied in detail in the works of E.E.Shcherbakov, R.Mamadzhanov and R.R.Yusupov.

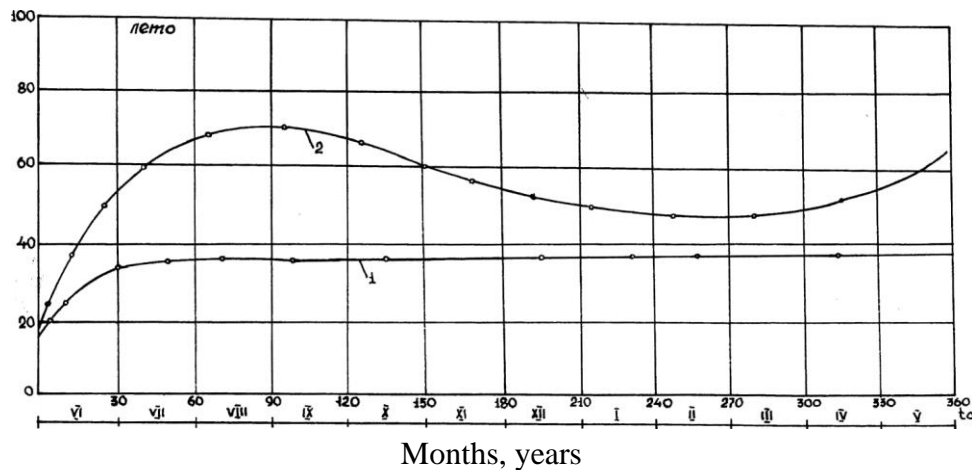
The study of temperature-shrinkage deformations of concrete in a dry hot climate included the following stages:

- determination of the coefficient of thermal expansion of concrete;
- study of shrinkage deformations and the nature of their development over time.



**Fig. 1. Coefficient of thermal expansion of concrete depending on temperature.**

Figure IMG 1 shows the average values of the coefficient of thermal expansion of concrete. The study of concrete shrinkage deformations was carried out after 7 days of wet storage, under sawdust. Zero measurements were carried out 2 hours after the samples were stripped.



**Fig. 2. Development of concrete shrinkage during deformations in a dry hot climate.**

Figure IMG 2 shows the development curves of shrinkage deformations of concrete made in the summer (June) and hardened under the influence of solar radiation and protected from the effects of solar radiation in the workshop.

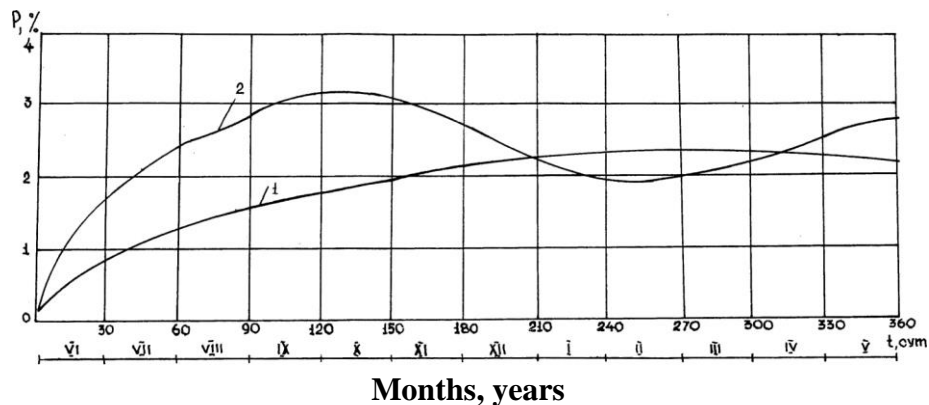
Analysis of the deformation curves of shrinkage of samples in natural conditions of dry hot climate shows that the main patterns of their development are observed in hot months compared to concrete that is not affected by solar radiation.[1],[2]

Unlike curves for concrete hardened in laboratory conditions, hardening in natural conditions leads to a more intensive accumulation of shrinkage deformations in the initial period due to the influence of low humidity, climatic temperature and solar radiation.

For example, by 100 days, concrete shrinkage deformations are 65-75% of those observed by 180 days. The shrinkage of concrete also depended on the amount of initial moisture and the intensity of moisture loss of concrete. The intensity of concrete moisture loss is a variable value ( $t=25...35\text{ }^{\circ}\text{C}$ ,  $W=65...70\%$ ) moisture loss of concrete in the first 3-4 months after concreting occurs most intensively, but in the next 2-3 months it occurs almost linearly, less intensively, and then stabilizes until the end of the year. The moisture loss of concrete during the summer production season in the first 2-3 months is almost twice as much as in the



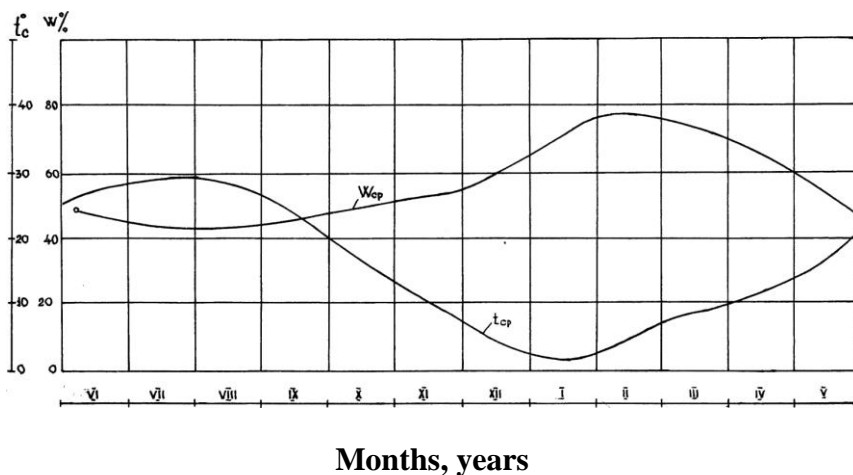
workshop (Fig. 3).[4]



**Fig. 3. Change in the amount of moisture loss over time in a dry hot climate.**

Then there is some suspension and decrease (swelling), in the winter season, caused by higher relative humidity and low air temperature. At the same time, the humidity of concrete increases slightly, but remains smaller in magnitude than the initial one. With the beginning of an increase in temperature and a decrease in air humidity, the removal of moisture from concrete is again observed.[4]

Analysis of the results of determining the shrinkage deformations of concrete over time revealed that the intensity of moisture loss has a significant effect on the shrinkage of concrete. The more intensive the removal of moisture from concrete (under the age of 4 months), the greater the shrinkage. The shrinkage of concrete at the age of 3-4 months under the influence of solar radiation is almost 1.8 times greater than in the workshop. Then comes a period of some stability in the growth of deformations and their reduction (in winter).



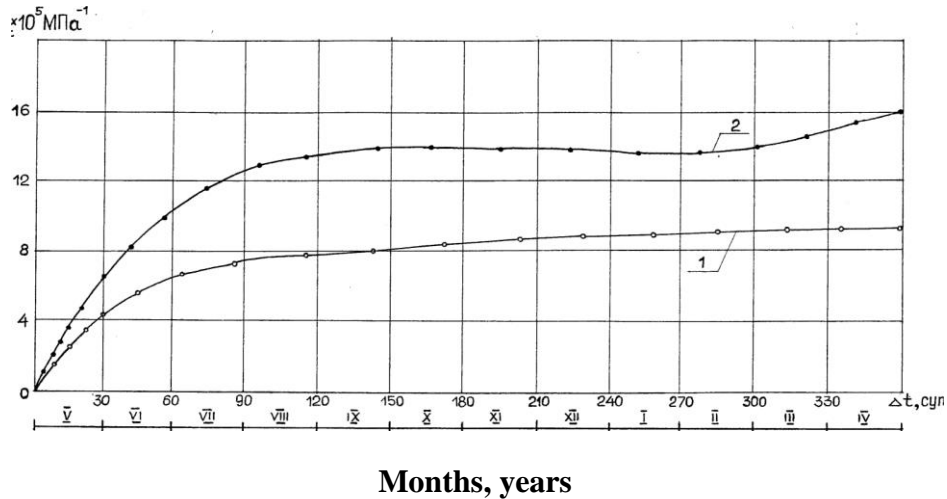
**Fig. 4. Change in average monthly humidity and air temperature during the test period in a dry hot climate**

Figure IMG 4 shows measurements of the average monthly relative humidity and outdoor temperature during the entire test period. Attention is drawn to the significant scale of seasonal changes in these parameters (respectively from 30 to 85% and from 3 to +35 ° C). In this



sense, the test conditions were extremely harsh.[3]

With the onset of spring, there is a further accumulation of deformations. The maximum shrinkage deformation of concrete under the influence of solar radiation was equal to  $68 \cdot 10^{-5}$ . Thus, the curves of shrinkage deformations of concrete in natural conditions of dry hot climate have a periodic character.



**Fig. 5. The development over time of creep deformations of concrete in a dry hot climate**

Creep deformation. Figure 5 shows the creep deformation curves (creep measures) when loading concrete that has hardened in a dry hot climate under the influence of solar radiation and protected from the effects of solar radiation in the workshop. The creep curves of concrete in the natural conditions of a dry hot climate hardened under the influence of solar radiation differ from similar curves for samples hardened under normal laboratory conditions by a pronounced stepwise character. At the same time, a significant increase in the creep deformations of concrete in a dry hot climate occurs only in the warm season and stabilizes in the cold period. To obtain numerical parameters of long-term deformations, the results of their measurement are shown in Fig. 2 and 5 were processed. The data obtained are presented in Table 1.

Table. 1.

Hardening conditions	Numerical values of long-term shrinkage deformations : creep			
	$\alpha_s$ , day	$\epsilon_s \times 10^6$	An day	$C \times 10^5 \text{ MПа}^{-1}$
In the workshop, protected from the effects of solar radiation				
/ t= 25... 35 C				
/w/= 65... 70 %	71	356	49	96
Under the influence of solar radiation / summer/	45	532	34	145

Consideration and analysis of the data in Table 1 allow us to draw some conclusions on long-term deformations of shrinkage and creep in a dry hot climate:

- the limiting values of shrinkage and creep deformations of concrete under the influence of



solar radiation of summer manufacture (loading) are on average 1.4 and 1.5 times higher, respectively, than similar values of deformations obtained in the shade in the workshop, protected from the effects of solar radiation;

-the rate of increase of shrinkage deformations and creep of summer-made concrete (loading) is on average 1.55 and 1.45 times higher than similar deformations in the shade in the workshop, protected from the effects of solar radiation;

-the difference in the values of the ultimate deformations of shrinkage and creep, as well as the rate of their growth over time, is due to the difference in the relative humidity of the test conditions and the effect of solar radiation in the natural conditions of a dry hot climate.

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