Moisture loss from freshly laid concrete, depending on the temperature and humidity of the environment

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Abstract. The paper is devoted to the research of moisture loss from freshly laid concrete, depending on the temperature and humidity of the environment. Freshly laid concrete, hardening in a dry and hot climate, in the absence of care, under the influence of climatic conditions (high temperature, low humidity, solar radiation, dry winds). Significant moisture losses are observed, cement hydration is reduced, concrete hardening is slowed down (and may even stop), as a result, a decrease in strength is observed (sometimes up to 50%). Therefore, the study of the problems of caring for freshly laid concrete is very relevant.

1 Introduction

The construction industry is intensively developing in Uzbekistan, and concrete and reinforced concrete are the main building materials. The development of construction sets the most important task for the builders: improving the technology of construction work, improving quality, reducing the cost and labor intensity of construction and increasing the durability of products and structures made of concrete and reinforced concrete.

The solution to this problem is inextricably linked with the main issues of the theory and technology of concrete.

It is known that the durability of concrete and reinforced concrete structures and structures depends not only on the composition of concrete and the quality of the materials used for its preparation, but also on the conditions for the formation of its structure and basic properties (temperature and humidity of the environment, at which laying and subsequent aging occurs) [1,2].

Areas with high temperatures and low humidity are classified as dry and hot climates.

In the zone of dry and hot climate in summer, the outside air temperature reaches 35-42 °C with a relative humidity of 10-25%, intense solar radiation and frequent winds.

So, in Uzbekistan, the relative humidity of air during the day in the summer at temperatures above 45 °C is 10%. At night, the air temperature drops to 10-15 °C with a relative humidity of 40-60%. The surface temperature of concrete on sunny days reaches 70-80 °C. Due to the high air temperature and the initial temperature of the constituents of the

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concrete mixture, intensive evaporation of mixing water occurs, the processes of structure formation are accelerated, concrete mixtures quickly lose their plastic properties. In addition, high air temperature accelerates the hardening of concrete, and dry air and sharp drops between day and night temperatures cause the appearance of temperature and shrinkage stresses in the concrete structure. Intensive evaporation of mixing water from freshly laid concrete can significantly slow down or even completely stop the process of increasing its strength [3,4].

2 Methods and materials

The process of dewatering hardening concrete in a dry and hot climate at an early age is the most characteristic feature of keeping it in an environment with high temperatures and low humidity. Therefore, the question of studying the intensity of concrete dehydration and the time of stabilization of moisture loss, i.e. the study of the kinetics of moisture loss is important for the creation of favorable temperature and humidity conditions for the curing of concrete [5].

The main research was carried out on heavy concrete of class B 25 (corresponding to the M300 grade) of the following composition: 1: 2.25: 3.38. The water-cement ratio of the concrete mixture was 0.57; cone draft of 4-5 cm (concrete of such grades and composition is widely used in Central Asia for the construction of engineering structures and industrial buildings). And preliminary studies were carried out on samples prepared from a cement-sand mortar with W / C = 0.45. The composition of the sand-cement mortar was adopted 1: 3, since studies have shown that a change in the proportion of sand does not have a noticeable effect on the kinetics of moisture loss and this composition is most often used in construction.

Portland cement grade 400 of the Kuvasay cement plant with the following characteristics was used as a binder in the preparation of concretes and cement-sand mortars with the following characteristics: normal density 25.87; the beginning of setting - 2 hours 34 minutes, the end of setting - 3 hours 50 minutes. The mineralogical and chemical composition of the cement is shown in Tables 1 and 2.

Table 1. Mineralogical composition of Portland cement.

Manufacturing plant	**Content, in%**			
	C_3S	**C_2S**	**C_3A**	**C_3AF**
Kuvasay cement plant	56	16	7	16

Table 2. Chemical composition of Portland cement, %.

SiO_2	**Fe_2O_3**	**Al_2O_3**	**CaO**	**MgO**	**SO_3**	**K_2O**	**Na_2O**
227.62	3.07	6.88	53.11	5.07	3.46	0.70	0.41

As a coarse aggregate, we used crushed granite of a fraction of 5-20 mm, and as a fine aggregate, quartz river sand with a fineness modulus of 1.8-2.0.

The following compositions were taken as the main film-forming materials for research:

- water-soluble composition (WRC) based on acetone-formaldehyde resin;
- water-dispersed composition (WDC) based on styrene-butadiene latexes BS-85M and BS-60M;
- composition (CP) based on chlorosulfonated polyethylene varnish of the HP-734 brand;
- composition (OK) based on alkylphenolamine resin (octaphor).

3 Results and discussion

The research was carried out as follows. Samples were prepared from a cement-sand mortar. Film-forming materials (consumption 400 g/m^2) were applied to the surface of freshly prepared samples with a paint sprayer. The prepared figurines were placed in different conditions of storage - in a climatic chamber with с t=60°C и φ =30%; и с t=40°C φ=30%; into the normal hardening chamber (t=20°C; ϕ=95-98 %).

The kinetics of moisture loss in the samples was studied using the following procedure

This technique allows you to study the effect of film-forming materials on the kinetics of moisture loss and consists in determining moisture loss for a given time from samples of cement-sand mortar after applying film-forming materials to their surface.

To study the kinetics of moisture loss from a cement-sand mortar, the samples are weighed 1, 2, ..., 7 and 24 hours after applying the film-forming material and placing them in a holding chamber. Calculation of the kinetics of moisture loss is made according to the following formulas:

The loss of mixing water from samples of cement-sand mortar when using a film-forming material (VP) is determined by the following formula [6]:

$$B_n = \frac{m_n}{b+g} * 100\% \quad (1)$$

m_n- loss of mixing water from samples after applying a film-forming material, in g

$$m_n = a_1 - a_7 - g \quad (2)$$

a_1- the weight of the sample after applying the film-forming material, in g;

a_7-sample weight at the time of moisture loss determination, in g;

7-time for determining moisture loss, h;

g-the amount of water (solvent) contained in the film-forming material, in g;

b -the amount of mixing water in the sample, in g;

$$b = \frac{(a_0 - P - \Phi) * V}{100} \quad (3)$$

a_0 -the weight of the sample before applying the film-forming material, in g;

V - the amount of mixing water in the formulation of the cement-sand mortar, in%P- weight of paraffin embedded at the edges of the sample, in g;

Φ-mold weight, in g.

For control samples, the loss of mixing moisture (B) is determined by the formula:

$$B = \frac{m}{b} * 100 \quad (4)$$

Where: m- mixing water loss from samples (without film-forming material, in g)

$$m = a_{1 - a_7} \quad (5)$$

The calculation results were entered into a table and based on them a graph of moisture loss from a cement-sand mortar was plotted depending on the time and conditions of holding, as well as the type of film-forming material. The technique allows you to study the kinetics of moisture loss of a cement-sand mortar, using film-forming materials as moisture-protective coatings.

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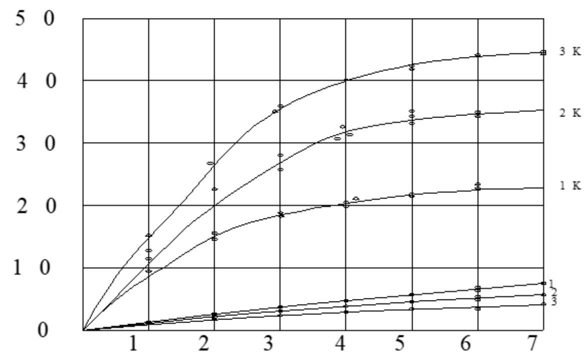

Fig. 1. Kinetics of moisture loss from concrete samples depending on the temperature and humidity conditions of aging.

1 k, 2 and 3k- uncoated samples;
1, 2 and 3- samples under VRK;
1 and 1 k- normal hardening chamber;
2 and 2 k- climate chamber /t=40°C; ϕ=30%/,
3 and 3 k- climate chamber /t=60°C; ϕ=30%/.

It can be seen from the graphs in Fig. 1 that the protective ability of the composition deteriorates somewhat with an increase in temperature and a decrease in environmental humidity. The amount of moisture loss from the samples was determined after 7 hours of exposure (Table 3).

Table 3. Influence of temperature and humidity conditions on the protective ability of film-forming materials.

№	**Compositions**	**Moisture loss, % after 7 hours of keeping in the chamber**		
		normal hardening t=20°C, ϕ=95-98%	**climatic**	
			t=40°C, ϕ=30%	**t=60°C, ϕ=30%**
1	VRK	3,00	4,60	6,71
2	VDK	3.49	5.02	6.60
3	OK	3.01	4.10	6.29
4	XP	2.20	2.91	5.44
5	Maintenance-free concrete	22.79	35.66	44.00

From the data given in the table, it can be seen that with an increase in the holding temperature, the protective ability of the film-forming materials deteriorates. However, this deterioration is within the acceptable rate of moisture loss (up to 10%). Lack of strength is observed in specimens aged under a layer of sand. At the same time, significant moisture loss is observed in concretes without maintenance: at normal hardening 22.79%, in a climatic chamber 33.66 and 44%. In the absence of care in concrete as a result of significant moisture loss, cement hydration decreases, as a result of which a decrease in strength is observed (sometimes up to 50%) [6,7].

The compressive strength of concrete was determined by testing cube specimens with dimensions of 150x150x150 mm. To prevent moisture loss through the cracks between the walls, a polyethylene film was placed inside the molds. Forms filled with concrete mixture were compacted on a vibrating table. Immediately after compaction, film-forming materials were applied to the surface of the samples with a CO-71A paint sprayer (Section 3.5). The consumption of materials was 300-400 g / m2. After the deposition of film-forming materials, one series of samples was placed for aging in a climatic chamber at t = 40 ° C and humidity = 30%, the other series was placed in a chamber under normal conditions. (t=20±1°C, ϕ =95-98%). The samples were tested after 1, 2, 3, 7, 28 and 90 days of keeping in the chamber [7].

The strength of M300 concrete, aged under a layer of moistened sand 3-4 cm thick (leaving-watering 4 times a day for 5 days) was taken as a standard.

Table 4. Concrete compressive strength depending on the method of curing (t=40°C, ϕ =30%,).

Care material	**Compressive strength of concrete, MPa, age, days**					
	1	**2**	**3**	**7**	**28**	**90**
Compositions:						
VRK	13.3	17.3	21.1	26.3	31.0	32.1
VDK	14.5	18.5	21.3	26.4	30.5	31.33
OK	14.2	19.1	20.96	25.0	30.2	30.7
XP	14.7	19.9	21.9	25.5	30.6	31.32
Wet sand layer	13.4	18.1	20.4	24.2	26.4	28.1
Maintenance-free concrete	13.3	16.3	18.1	20.9	23.7	24.2

As can be seen from the data given in Table 4, the compressive strength of concrete in samples hardened under film-forming materials is quite stable. And the samples, hardened, without leaving, gained only 79% of the design strength. Although the strength of concrete without maintenance is quite high, the study of its structure has shown that such concrete is prone to destruction during operation and, therefore, is not durable. Tests of concretes hardened under normal conditions showed that the design strength of the samples, cured under film-forming materials, was exceeded (Table 5).

Table 5. Influence of the temperature of holding concrete under film-forming compositions on its strength characteristics.

Care material	**Compressive strength of concrete, MPa, at a temperature**		**Flexural tensile strength of concrete, MPa, at temperature**	
	20°C	**40°C**	**20°C**	**40°C**
Compositions:				
VRK	31.2	31.0	3.8	3.6
VDK	31.0	30.5	3.6	3.5
OK	30.8	30.6	4.0	3.7
XP	31.0	30.6	3.5	3.3

Wet sand layer	30.3	26.4	3.1	2.8
Maintenance-free concrete	28.7	23.7	2.5	1.9

Analyzing the results of experimental studies, we can conclude that with an increase in the holding temperature, the protective ability of film-forming materials deteriorates, but the amount of moisture loss does not exceed the permissible value.

4 Conclusion

Based on the results of the studies carried out, it can be concluded that, with an increase in the holding temperature, the protective ability of film-forming materials deteriorates. However, this deterioration is within the acceptable rate of moisture loss (up to 10%). Lack of strength is observed in specimens aged under a layer of sand. At the same time, significant moisture loss is observed in concretes without maintenance.

When applied to a freshly laid surface of concrete, film-forming compounds and solar thermal treatment (comparable to dry and hot climates), moisture loss is prevented and the "soft" mode of hardening provides high strength indicators. The use of the investigated compositions (VRK and VDK) for the care of freshly laid concrete is very effective.

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