FEATURES OF HEAT TREATMENT OF CONCRETE IN DRY HOT CLIMATES

A. M.Rakhimov
M. M. Turgunpulatov
Namangan Engineering Construction Institute

ABSTRACT

The article presents the results of studies of the influence of ambient temperature on the thermal treatment of concrete. A method for assigning heat treatment modes to concrete taking into account the ambient temperature of a hot climate is proposed.

Keywords: hot climate, concrete, method of heat treatment of concrete, concrete hardening, temperature gradient

INTRODUCTION

The Republic of Uzbekistan has adopted a number of key resolutions aimed at increasing energy efficiency in sectors of the economy and social sphere, introducing energy-efficient and energy-saving technologies, further developing renewable energy, and ensuring the rational use of energy resources.

The precast concrete industry is one of the largest consumers of energy among other sectors of the national economy.

Currently, heat treatment is an integral and at the same time the longest process in the production of precast concrete.

Despite certain successes, heat treatment has been and remains the longest technological process in the production of prefabricated reinforced concrete, occupying 80-90% of the total time required for the manufacture of products.

The main advantage of steam heating is the ability to provide favorable humidity conditions for concrete hardening, when the steam is in direct contact with the unformed surface of the products. The widespread use of steam heating in the production of prefabricated reinforced concrete in our country and abroad is explained not so much by the advantages of the method, but by its thorough study and extensive practical experience.

To accelerate the hardening of concrete in prefabricated structures, steam heat treatment has been used since the beginning of the last century.

Numerous studies have been and are being carried out on this issue and the method is well described in a number of works by S.A. Mironov, L.A. Malinina and B.A. Krylov [6,9,10,11].

Depending on the adopted manufacturing technology, the conditions for heat treatment of products change: concrete is heated either through the metal of the mold, or through direct contact of the product with the coolant. In this regard, the question arose about processing optimal steaming modes in relation to specific production conditions. Starting from the mid-50s of the last century to the present day, extensive research has been and is being carried out on the effect of elevated hardening temperatures on the phase composition, structure of new formations, degree of hydration of the binder, and exotherm of cement.

The international conference RILEM, held in 1964 in Moscow, made a great contribution to the problem. A number of reports were made at it on the issue of choosing cement for heat treatment

[4,13], hydration processes of Portland cement during heat treatment [2,12,16], reducing concrete hardening time [3,8,14], temperature gradients in concrete subjected to steaming [19] and concrete hardening in Central Asia [15].

In hot climates, high outside air temperatures (30...35 ¬o C) are observed 6...7 months a year. In such conditions, the temperature of the concrete mixture at the time of molding reaches 25...30 o C. However, at present, these factors are not taken into account when assigning heat treatment modes for concrete, as a result, the duration of heat treatment and energy consumption at enterprises in the southern and northern regions remain the same.

In order to study the influence of the initial temperature of the concrete mixture and the ambient temperature on the heat treatment of concrete, we conducted a number of studies.

The research results showed that the initial temperature of the concrete mixture significantly affects the nature of the increase in strength of concrete prepared with Portland cement (table).

Strength of concrete based on Portland cement under various heat treatment conditions

Options	No. Series	Parameters of the environment in the chamber during preliminary exposure		Initial temperature of the concrete mixture $T_{b.s.}$, °C	V/C	Cone draft , cm	Steaming mode, hour	Strength of concrete at compression , MPa _ _ through			
		t , °C	φ, %					4 hours after TVO	3 days	28 days	28 days of normal hardening
1	2	3	4	5	6	7	8	9	10	eleven	12
I	**1**	**15-16**	**70-75**	15	**0.65**	**2-2.5**	2+3+6+4	17, 4 61	20.3 71	26.8 94	28.5 100
	2	**20-21**	**70-75**	**20**	**0.65**	**2-2.5**	2+3+6+4	18 , 6 60	22.2 72	29.1 94	31.1 100
II	**3**	**26-28**	**48-50**	**22-25**	**0.65**	**2-2.5**	2+3+6+4	20.5 65	22 , 1 70	29 , 4 94	31.4 100
	4	**26-28**	**48-50**	**22-25**	**0.65**	**2-2.5**	2+3+4+4	17.6 57	21.8 69	30.1 95	31.6 100
	5	**26-28**	**48-50**	**22-25**	**0.65**	**2-2.5**	2+3+2+4	*15.5* 49	20.1 14	28.5 91	31.4 100
	6	**26-28**	**48-50**	**22-25**	**0.65**	**2-2.5**	2+3+2+6*	15.1 60	18.2 72	24.8 98	25.3 100
	7	**26-28**	**48-50**	**22-25**	**0.65**	**2-2.5**	2+3+2+6*	*17.4* 55	21.5 72	29.5 93	31.8 100
III	**8**	**32-34**	**44-46**	**28-30**	**0.65**	**1.5-2**	**2+3+4+4**	19.7 54	22.5 70	30.1 94	32.0 100
	9	**32-34**	**44-46**	**28-30**	**0.65**	**1.5-2**	**2+3+2+4**	17.4 54	22.2 69	31.0 96	32.2 100
	10	**32-34**	**44-46**	**28-30**	**0.65**	**1.5-2**	2+3+6+4	23.2 70	25.5 77	31.5 95	33.0 100
	eleven	**32-34**	**44-46**	**28-30**	**0.65**	**1.5-2**	**2+3+4+6 ***	21.0 68	22.5 73	29.8 96	31.0 100

Notes 1). Above the line - concrete strength, MPa , below the line - % of R_28^(H.T.)2). 6* cooling of the concrete at an average rate of 3-4°C/hour for 6 hours was carried out with the control valve of the chamber ventilation duct open. 3). Concrete in series No. 1 and 2 was prepared without heating water, i.e. using conventional technology and pre-conditioned in the workshop for 2 hours under the conditions specified in the table.

The higher the initial temperature of concrete, the greater strength it gains after heat treatment. However, after 3 days the strength of concrete with different initial temperatures levels out, and after 28 days the concrete gained the same strength regardless of the initial temperature. This is apparently explained by the fact that in concrete with greater strength after heat treatment, its further growth occurs more slowly than in concrete with less strength. This is consistent with the kinetics of cement hydration. In concretes with greater strength, after heat treatment, a significant part of the cement grains are hydrated and denser shells of cement hydration products are formed around the non-hydrated grains. During further hardening, these shells make it difficult for moisture to penetrate to the non-hydrated parts of the cement grains, slowing down the hardening process. It follows that the greater the strength of concrete after heat treatment, the less its further growth.

From Table 1. It can be seen that for all series of experiments, the 28-day strength of Portland cement concrete after heat treatment is 5-9% less than normal-hardening concrete. The reason for the lack of strength may be two factors. Firstly, heat treatment at high (80 o C) temperature. It is known that heat is a powerful factor in accelerating the hardening of concrete, but it also, to a certain extent, disrupts its structure due to the uneven expansion of its components. This leads to the appearance of stress in the heterophase system, the appearance of cracks and other microdefects [7]. Secondly, preliminary curing of concrete at a relatively high ambient temperature (25-35 o C). It was found [10] that the most favorable results are obtained after preliminary conditioning of freshly molded products using Portland cement at a low temperature. Keeping concrete before heat treatment at a low temperature promotes greater dissolution of silicate phases [11] and the formation of a smaller number of crystal nuclei but with a well-ordered structure and a high degree of solution saturation [1].

Thus, preliminary curing of concrete using Portland cement at a relatively high ambient temperature, on the one hand, leads to a reduction in the pre-curing time, an increase in the strength of concrete immediately after heat treatment, and on the other hand, a slowdown in further hydration of Portland cement after heat treatment.

From the table it is clear that for series 1 and 10, the heating mode, isothermal holding temperature and duration of heat treatment are the same, but the strength indicators after heat treatment are different. In this case, the difference in strength indicators can be explained by the degree of maturity of the concrete, since its initial temperature was different and the time of heating to the isothermal holding temperature was different.

Concrete with an initial temperature of 30 o C (series 10) is heated to an isothermal holding temperature for 4 hours, and with an initial temperature of 15 o C (series 1) for 5.5 hours. Accordingly, by the 4th hour of heat treatment, the number of degree-hours is 272 (series 10) and 162 (series 1).

As a result, by the end of the heat treatment, concrete with a higher initial temperature gains a greater amount of degree-hours (series 10) compared to concrete with a lower initial temperature (series 1) and, accordingly, the strength indicators are 70 and 61% of R 28 nt .

From the test results (table) it is clear that the strength of concrete after heat treatment is significantly influenced by the nature of cooling. Portland cement concretes under heat treatment conditions of 2+3+4+4=13 hours (series 4, table 1) and 2+3+2+6*=13 hours (series 6 and 7, table 1) after heat treatment gain almost the same strength.

From the above it follows that increased ambient temperature has a beneficial effect on individual stages of heat treatment. With an increase in ambient temperature, the initial temperature of the concrete mixture increases, which, at the same rate of temperature rise, helps to reduce the time of this stage compared to concrete having a lower initial temperature. Cooling of concrete occurs more slowly due to a decrease in the temperature gradient between concrete and the environment, thereby making it possible to reduce the isothermal holding time. Thus, the results of experimental studies prove the correctness of the assumptions regarding the reduction of isothermal holding time during the heat treatment of concrete in hot climates.

The assignment of heat treatment modes for each specific case, depending on the initial temperature of the concrete and the environment, requires special study. This is a labor-intensive process, takes considerable time and is extremely inconvenient (and in many cases completely unacceptable) for production workers.

Therefore, we have proposed an analytical method for optimizing the conditions of holding products during heat treatment, taking into account the temperature of the environment, which consists of the following.

The sum of degree hours is determined for the adopted factory mode, where the temperature of the concrete mixture (tδ1) entering the heat treatment unit, according to current standards, is +15 o C:

S 1 = (t from - t δ 1) (τ under 1 / 2 + τ from 1), deg-hour;

Then the sum of degree-hours of the same mode is determined, but with the actual initial temperature of the concrete (t δ 2):

S 2 = (t from - t δ 2) (τ under 2 /2+τ from 2), degree-hour;

The ratio of the latter to the former is the optimization factor:

K op = S 2 / S 1 ;

Duration of the active cycle of heat treatment of concrete, taking into account Kop:

T op = T 1 . K op = (τ under 1 +τ from 1) . K op, hour

The results of a study of heat treatment modes for concrete with different initial temperatures of the concrete mixture and the resulting strength indicators of concrete after heat treatment confirmed the correctness of the proposed methodology for optimizing heat treatment modes in the manufacture of prefabricated reinforced concrete products in hot climates.

An increased initial temperature (25...30 o C) before heat treatment contributes to a more intensive increase in the strength of concrete prepared with Portland cement during heat treatment.

The strength of concrete prepared with Portland cement is significantly influenced by the nature of cooling; cooling at elevated temperatures (35-40 o C) of the environment proceeds more slowly, reduces temperature gradients in the product, and helps to increase the strength of concrete immediately after heat treatment.

The assignment of heat treatment modes for prefabricated reinforced concrete products, taking into account the ambient temperature of a hot climate, makes it possible to reduce the time of the active cycle (temperature rise + isothermal heating) by 2...3 hours. The reduction in energy costs is 20...22%.

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