AJEMA GLOBAL RESEARCH NETWORK

AMERICAN Journal of Engineering, Mechanics and Architecture
Volume 01, Issue 10, 2023 ISSN (E): 2993-2637

Hardening of Concrete on Portland Cement During Heat Treatment

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Abstract: This article presents the results of experiments on the physical processes that occur during the hardening process of concrete in dry hot-climatic seasons and the reduction of their negative effects - as well as on the physical and mechanical properties.

Keywords: dry hot climate, evaporation, plastic sinking, concrete care, ambient temperature, continuous evaporation, heat treatment, temperature gradient, surface modulus, environmental heat.

INTRODUCTION

At outside air temperature 35-45°C, relative humidity 10-25%, intense solar radiation and frequent winds cause rapid dehydration of concrete, which leads to a slowdown and even cessation of concrete hardening. Such solar radiation is observed for 6-7 months a year in regions of the country south of 50°C , and the manufacture of products during this period of time is possible without additional heat input obtained through traditional heating methods. In dry, hot climates, the mixing time of the mixture should be approximately 1.5 times increased, transportation in closed containers should be ensured, transportation time should be limited, and overloads should be minimized. It should be borne in mind that even at 30...35 °C at W/C =0.83 the mixture completely loses its mobility after 40 minutes. Heat treatment of concrete and reinforced concrete products is carried out until stripping, tempering, and, for prestressed products, transfer strength is achieved [1.2.3.11.12].

The heat treatment method may be the most effective, since it allows not only to reduce the risk of dehydration, but also to obtain the necessary strength of concrete in the shortest possible time. It should be borne in mind that after concrete has acquired 70...80% of its design strength, it does not require any special care in dry and hot climates. Thermal treatment of concrete and reinforced concrete products is one of the most lengthy and critical processes in the technology of their production. In cases where the amount of incoming solar energy is less than these values, it is necessary to supply additional thermal energy to the products from duplicate heat sources, i.e. move on to combined solar thermal treatment of concrete (CGTP).

Types such as steam, electricity, hot water, mineral oils, air, natural gas combustion products, etc. can be used as backup energy sources during CGTO. Heat transfer to concrete with the help of such coolants can be carried out in two ways: by external influence when it is supplied from the outside and by its formation inside the concrete itself.

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

Table 1

Parties	Series No	Environmental and chamber parameters		Initial tempera Tour concrete mixture Tb.s, °C	W/C	Cone draft, cm	Steaming mode in the chamber	Compressive strength of concrete, MPa			
		t, °C	n, %					4 hours after TVO	3 days	28 days	28 days normal hard
1	2	3	4	5	6	7	8	9	10	11	12
I	1	15-16	70-75	15	0,65	2-2,5	2+3+5+4	16,4	19,3	25,8	28,5
								60	71	93	100
	2	20-21	70-75	20	0,65	2-2,5	2+3+6+4	17,6	21,2	28,1	30,1
								60	71	93	100
II	3	26-28	48-50	22-25	0,65	2-2,5	2+3+6+4	19,5	21,1	29,4	31,1
								64	71	94	100
	4	26-28	48-50	22-25	0,65	2-2,5	2+3+5+4	16,6	20,8	29,1	31,2
								58	70	94	100
	5	26-28	48-50	22-25	0,65	2-2,5	2+3+4+4	14,5	20,1	28,5	31,3
								57	16	90	100

In accordance with this, all of the listed types of traditional coolants form a separate group, united by the fact that heat from them is transferred to concrete by contact. True, electrical energy, in addition, can generate heat inside concrete if the latter acts as resistance when current passes through it. Contact of the coolant with concrete occurs through a dividing partition, due to which, from the standpoint of heat transfer processes, all considered coolants are in the same position from the point of view of their use in the HTHT of concrete.

During the warm-up process, the modes are structured in such a way as to minimize energy consumption from redundant sources. At the same time, saving energy resources should also take into account the exothermia of cement, which occurs quite intensely during heating. When designing heating devices, one should strive to reduce heat losses to the environment both from the heater itself and from the parts of mold boards and concrete heated by it. The studies were carried out on an experimental stand, which is an unshaded area with plan dimensions of 3x6 m, covered with expanded clay gravel 15 cm thick [9.10.11.12].

In this series of experiments, a concrete mixture with W/C = 0.54 and O.K = 6-8 cm was used using Portland cement M 400 from the Kuvasai cement plant, quartz sand with Mk = 1.8 and dense gravel fr.5-20 mm Aktash quarry. At 9:30 a.m. the finished mixture was placed in pre-prepared molds.

To maintain the mobility of the concrete mixture, chemical additives of a hydrophilic nature were introduced into its composition, increasing the wettability of the mixture. The effect of mixing speed on the rate of hardening of the concrete mixture (strength gain) was determined by testing cube samples with dimensions of 15x15x15 cm, different hardening periods under normal hardening conditions (temperature 20+ 20C, humidity more than 95%). Brand strength 10 MPa. For all batches (with the same selection of composition), the volume of the concrete mixture is the same - 100 liters. Cement grade 400 (Kuvasay cement plant, Fergana region).

The duration of mixing the concrete mixture in conventional concrete mixers is 2 minutes. The test results are shown in the table. As can be seen from the table, with an increase in the mixing speed of the concrete mixture, the rate of concrete strength gain increases. For products of the same type, the greatest interest is the KGETO method, in which the mold is not equipped with heating devices, but they are concentrated in one place on the territory of the landfill, thereby forming an independent heating platform or stand, which is put into operation as reinforced concrete products are prepared.

The influence of chemical additives introduced into concrete mixture on the speed of concrete strength gain.

№	Chemical additives	Strength of sample cubes in MPa, days			
		1	3	7	28
1	Resin Wood Barge	2,9	5,6	7,5	10,1
2	S-3	3,1	6,2	8,1	10,4
3	No additive	2,8	5,3	7,2	10

table 2.

As can be seen from the table, the use of chemical additives in a concrete mixture significantly increases the rate of concrete strength gain. The use of chemical additives not only leads to a reduction in cement consumption, but also increases the density, water permeability and frost resistance of concrete (as a result of an increase in the volume of air entrainment, the volume of cement paste per unit of cement increases, which leads to a decrease in voids in concrete), which is very important in the preparation of hydraulic concrete .

Numerous studies show that all studied methods of care can be classified into the following conditional groups:

1. The first conditional group includes, for example, covering concrete with a layer of sand and keeping it in a covering water basin (PVB). In this case, the temperature of concrete is characterized by a relatively slow rate of solar heating. For example, heating at a rate of 1 degree/hour in sunny time;

During non-sunny times, cooling occurs at a rate of 0.7 degrees/hour. The change in concrete temperature during one day of curing is 8-10 degrees, with ambient temperatures fluctuating up to 18 °C. In this case, maturity (8) - the relative heat content of concrete is 740-765 degrees hours. Concrete hardening under these conditions, as well as due to the exotherm of cement, was heated to 36 °C.

2. The second group includes such methods of care as covering concrete, “ITVP” and metallized film. Due to the partial use of environmental heat, the concrete is heated to 40 °C, which is slightly higher than when using the first group of treatment methods. In this case, the rate of temperature rise is approximately 2 degrees/hour, and the rate of decrease is 1 degree/hour. The maturity of concrete during one day of hardening under these conditions is 10% greater and amounts to 825-835 deg.h.

3. The third conditional group includes such types of care as tightly covering the concrete surface with a polyethylene sheet, a combination of burlap, dark and transparent polyethylene film, glassine and applying film-forming materials of dark and light tones to its surface. Experiments showed that due to the heating of monolithic concrete directly under the influence of solar radiation in one case, due to the heat transferred by a heated film in another, the temperature conditions of the structures turned out to be almost the same.

The rate of heating and cooling of concrete is equal to 3.4 and 1.4 degrees/h, respectively. Fluctuations in the temperature of concrete during the first day of hardening under curing conditions amounted to 18-19 0C, with a change in the temperature of the environment 19 0C. In this case, the temperature of the concrete was 12-130C higher than the temperature of the environment and amounted to 45-460C. The maturity of the concrete was 855-875 degrees/hour, which is 2-3 and 12-13% more than the same indicators for concrete hardened under the conditions of the second and first conditional curing groups.

The main reason for the cessation of hardening of concrete mixtures in winter conditions is when exposed to low temperatures - freezing of water in them. It is known that the salt content of water sharply reduces its freezing point. If during the preparation process a certain amount of dissolved salts is introduced into the concrete mixture, the hardening process will also occur at temperatures below 0 0C.

When choosing the type of additive, take into account the area of application of concrete with chemical additives and the existing restrictions. The optimal amount of additives usually does not exceed 16% by weight of cement. The mixture with antifreeze additives is placed in structures and compacted in compliance with the general rules for laying concrete [1.2.6].

The influence of the speed of mixing the concrete mixture on the rate of strength gain of concrete.

table-3.

No	Concrete mix mixing speed, rpm	Strength of sample cubes in MPa, days			
		1	3	7	28
1	20	1,2	1,6	2,8	9,8
2	50	1,3	1,8	3,1	10
3	600	2,8	5,3	7,2	10
4	700	3,1	5,4	7,2	10

Table-3 shows the results of testing cube samples to determine the effect of chemical additives on the rate of hardening of the concrete mixture (strength gain), with separate technology for preparing the concrete mixture, mixing speed 600-700 rpm. The materials and hardening conditions are the same as in the previous test. Sulfite-yeast mash (SYB) and superplasticizer (S-3) were used as chemical additives, with the same consumption of 0.20 (calculated on dry matter, % by weight of cement).

An analysis of existing and currently possible technical solutions that are optimal for such technology provides grounds for somewhat limiting the scientific and technical search for the design of new types of electric heaters for CHHETO concrete and concentrating efforts on work in two practical directions [1.3. 4.5.8.9]:

- temporary, until the end of vibration compaction of concrete, separation of forms from electric heaters, followed by connection with them into a separate autonomous thermal unit;
- constant separation of molds from individual electric heaters, with the latter placed outside the molds at separate stations for carrying out the heat treatment of concrete. Technical and economic calculations of the use of separate backup devices for heat treatment of concrete show that the average annual savings of the heat sources themselves can be 60%, including when using them in the autumn-winter-spring periods of the year up to 25-40%, with a complete abandonment of them in the summer season [8.9.10.11.12].

CONCLUSION

The application of curtain-forming compositions for the care of freshly laid concrete is very effective, because the technology of application of this method is simple, relatively inexpensive compared to other methods, the raw material is sufficient. Under the curtain-forming coatings, favorable moisture conditions are created for the concrete to harden.

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