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Selection of the Calculation Model for Multi-Component Building Systems During Winter Concreting

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The article analyzes cement hydration minerals and identifies ways of increasing the initial strength of concrete. The results of experimental studies and the results of monitoring technology of concreting are also presented.

Keywords: *cement minerals, cement clinkers, cement humidification, concrete, concrete deformation device, load size.*

A multicomponent construction system is an artificially created structure of a chain of minerals 3CaO * Si02, 2CaO * SiO2, 3Cao * Al20z, 4CaO * Al2O3 * Fe2O2, which do not appear in industrial clinker but in solid solution of Mg, Al, Na, Ca (Golovnev: 1999).

There are quite a few elements in nature whose structures do not form from tightly surrounded planes. These include volume-centered cubic structures. Usually, clinker minerals have a combined structure in which one mesh is placed within another. Many specific structural heterogeneous bodies do not have the same mechanical properties. Their deformation and fracture processes are complex, as they occupy an intermediate place between viscous liquids and specific solids (Golovnev: 1999).

In order to determine the qualitative and quantitative characteristics of concrete, it is proposed to consider a multi-component system (cement clinkers) as a two-component system consisting of unadhered cement seeds and surrounding neoplasms. As a result, the properties of concrete are established as a function of the strength of this system, the amount of adhesion between them, and the strength and mineralogical composition of the aggregates, the adhesion between aggregates bonded by neoplasms. Very conventional structural models are proposed, reflecting very closely the properties of concrete materials.

The hydration mechanism of cement and its components is very complex. In his first theory, Le Chatel introduced the hydration of cement due to the products of adhesion and dissolution of precipitated anhydrous compounds. Michaelis believed that the precipitation and subsequent drying of cement-forming mortars imparted strength to them. More recently, the idea of a topochemical and solid-phase mechanism has emerged.

Despite numerous works in this field, the understanding of the wetting mechanism of alite (C3S) still remains unclear. To clarify the situation, it is necessary to take into account some stages of the wetting process. Researchers note five stages. In the first stage, called the pre-induction period, there is an increase in the rate of heat release and then a decrease. In the second stage, the reaction rate is very low - the induction period. It can last for several hours, while the cement dough retains its elasticity. In the third stage, the reaction rate decreases, reaching its maximum rate towards the end of this period. The beginning of tentative setting coincides with a strong increase in reaction rate and the end of setting coincides with the end of the third stage.

In the fourth stage, the heat release rate of C3S gradually decreases, and humidification continues. In the fifth stage, a small amount of humidification products is formed. This period is characterized by diffusion.

Materials and methods. C3S containing other inclusions are attempted to explain the observed hydration of (C2S) belite in the same way. The heat release rate curve for the hydration of (C2S) has no obvious peaks.

The study of multicomponent (more than 4) systems is difficult due to the impossibility of visualizing them in 3-dimensional space. To solve this problem, the generalized “center of gravity” rule is used (Mironov: 1975, Brzhanov: 2010). This approach requires a large mathematical apparatus. A simple method for calculating the phase composition, called balance, has been proposed. This method is based on the balance of distribution of initial components between secondary (formed) phases (Ismailov: 2016, Volzhenskij:1976).

However, these methods do not take into account the technological peculiarities of manufactured structures, dimensions of structures, environmental parameters, as well as the kinetics of cement dough setting. In addition, initial reaction products are formed on the surface of $3CaO * SiO_2$ (C3S), which further slows down the reaction. The reaction resumes due to the destruction of the newly formed layer.

Partial pressure diagrams are presented to investigate heterogeneous equilibrium. When production structures are revised under rapidly changing economic, social, and environmental conditions, process flow diagrams will be necessary to master new processes and materials based on fundamental knowledge of scientific advances. The description of these numerous applied thermodynamic methods is limited by the fact that they are given only in special textbooks, and many applied methods for calculating thermodynamic quantities are not given in specific examples, which makes it difficult to use them to solve applied problems (Catharin: 1978, Brzhanov: 2010).

Studies have shown that the quality of winter concreting depends on a combination of many factors. Among these factors, both the results of technological process regulation and, if possible, concrete temperature, process time and concrete strength at different stages of the technological limit are important (Agarwal ... 2007).

The properties of concrete, which is a complex system, are largely determined by its structure. The structure of concrete is formed by the choice of composition, physical effects on the concrete, which are constantly changing in the process of concrete curing under the influence of physical, physical-chemical, mechanical effects, physical-chemical effects are reduced to thermal effects and the introduction of various mixtures. When the temperature of the medium rises, wetting processes are strengthened, when the temperature falls, they are weakened. Mechanical effects are based on the compaction of concrete and changes in its structure under the action of external forces applied at different stages of curing (Rosenqvist: 2017).

At the same time, the conditions of concrete storage have a great influence on the degree of hydration, as there is a decrease in the final strength of concrete due to significant moisture loss in the cold. The phase composition of new formations in frozen concrete does not differ from normal, irreversible structural changes are caused only by early freezing. At positive temperature, structural changes with increasing time of concrete strength gain are slightly noticeable, no strength reduction is observed.

When concrete is frozen (Krentowski: 2021, Wei: 2021) at an early age, its deformability increases. The relative deformation of the frozen mass immediately after concrete production is 15-20 times higher than that of concrete with grade strength. When the temperature drops below zero, the specimen first decreases in volume, then elongates and after some time its dimensions stabilize. The initial reduction is due to the increase in water density, compression of solid components and moisture loss. Due to the decreased rate of cement hydration, water is in a non-contact state before turning into ice, so its evaporation rate increases. Expansion (elongation) of freshly prepared concrete is a consequence of water conversion to ice. When the concrete thaws, a significant increase is observed and when the ice melts, a subsidence is formed. The magnitude of the deformation depends on the pre-curing time of the concrete.

Early loads lead to certain changes in the stress state of structures, as plastic deformation of concrete weakens the stresses and redistributes them throughout the concrete. The effects of this type of loading are expressed in terms of changes in the mutual arrangement of cement components in the concrete, strengthening of the bond between cement stone and aggregate, mechanical change in the structure and self-healing of cracks. All these factors act together and manifest themselves in specific processes of deformation behavior of concrete: weakening due to the formation of microcracks under load and strengthening due to changes in the density and structure of concrete (Mehta: 2014, Stradanchenko: 2019)

In axial compression, the density of concrete increases with time, but the intensity of the process decreases. The strength of the concrete increases faster than the density and increases until the maximum transverse strain of the curing curve is reached. Whereas in compression, the densification of concrete under load occurs naturally, in tension we can expect a decrease in concrete density and delamination of the parts at the joints. However, in tension, in addition to longitudinal deformations, transverse deformations occur which, at a certain load intensity, lead to compaction of the grout in that direction. Concrete movement leads to stress relaxation and elimination of the harmful effects of design stresses. Reorientation of details, change in the shape of microdefects is of great importance (Yang: 2010).

The strength increase depends on the duration and intensity of loading. The greatest strength gain is observed at intensities of 0.3-0.4 of the ultimate load strength of concrete. The early loading strength gain is taken to be 20 to 40 per cent in compression, 30 to 70 per cent in tension, 25 to 55 per cent of the loading strength of concrete in flexibility. It is also found that the earlier the curing effect occurs under dynamic loading, the higher it is, and the optimum time for loading concrete is the period between the beginning and end of setting (Brzhanov… 2018, Mendibaeva: 2015).

Results and discussion. In order to realize and confirm the effect of early loading of concrete on its final strength (Brzhanov… 2011), we carried out the following experimental study.

The problem is solved by the method of winter concreting, which includes vibrating the mixture, with simultaneous vibrating with loading the mixture with a force of 12 kg/m3 before vibrating, including molding and subsequent vibration damping. During loading, the concrete mixture is in an elastic-plastic state and enters a complex stress situation. The concrete loading zone and the surfaces in contact with the concrete are the most pressurized. In the zones of maximum pressure, the setting temperature of the concrete mixture decreases. According to the Mendeleev-Clapeyron law PV = p. As the RT pressure increases, the setting temperature of the concrete mixture decreases. The difficulty lies in determining the pressure ensuring non-freezing of concrete mixture at different negative temperatures - minus 5,10,15,20. We have experimentally determined the pressure values that ensure the hardening of the concrete mixture made by the thermos method at these negative temperatures.

The tests were carried out as follows. The following materials were used in the experiments: cement grade PC-400D, granite crushed stone 10-20 mm, river sand of medium modulus of elasticity. Consumption of materials per 1 m3 of concrete mixture: cement - 300 kg; sand-780 kg; crushed stone-1285 kg; B/C = 0.5.

The concrete mixture was made for the whole volume of the experiment. In each series, 3 series of 3 specimens were made. All samples were vibrated on the laboratory vibration platform for 20 seconds, then 1 series of samples were placed in the chamber of normal curing, 2 series - in the cold chamber at a temperature of minus 20 ° C, 3 series of samples were subjected to compression pressure, the pressure of which was measured by dynamometer and was 12 kg/cm2, and also placed in the cold chamber.

The concrete strength test was carried out 28 days after normal curing. The frozen specimens were stored in good condition for 1 day before testing. The results of these experiments are presented in Table 1.

Table 1. Results of comparative tests

№	Age (day)	Strength MPa (kg/cm2)		
		1 Regular tightening	2 Unpressurised frozen	3 Pressurized frozen
1	3	13.4(134)	4.1(41)	10.4(104)
2		13.6(136)	4.3 (43)	10.6(106)
3		13 2(132)	4.7 (47)	10.2(102)
4	7	15.2(152)	6.8(68)	13.2(132)
5		16.0(160)	6.5 (65)	14.0(140)
6		14.8(148)	6.5 (65)	14.8(148)
7	28	27.7 (277)	14(140)	26 7 (267)
8		28,4 (284)	14,7(147)	27,4 (274)
9		28,7 (287)	16,8 (168)	27,7 (277)

The analysis of these data shows that the strength of unstressed concrete specimens during early curing of concrete (3 days) is 30.5% and the strength of normal curing concrete is 77.6%. During the late curing period (28 days), the strength of unstressed concrete specimens is 58.53% and the strength of normal curing concrete is 96.51.6% (Brzhanov: 2018).

Conclusion: 1. Early freezing of concrete may not cause destructive processes and even contribute to its strength if all the water in the cement gel is in a bound state. Such a state means the end of the induction period of cement hydration, since the liquid phase is bound with intensely saturated and dissociated ions. This is accompanied by the formation of a nucleated crystalline hydrate structure of the cement stone. At the end of the induction period, the freezing of the liquid phase is accompanied by the transition of some water to free water, turning it into ice. The less water in the cement gel before freezing, the faster the saturation occurs, and after thawing, the strength of concrete increases significantly.

2. Vibrating with concrete mix loading increases the strength gain efficiency of winter concrete when other methods of winter concreting are used separately.

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სამოქალაქო მშენებლობა და სამშენებლო დაპროექტება

ზამთრის პირობებში ბეტონირებისას მრავალკომპონენტიანი სამშენებლო სისტემის საანგარიშო მოდელის შერჩევა

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ნაშრომში მოცემულია ცემენტის ჰიდრატაციის მინერალების ანალიზი და განსაზღვრულია ბეტონის საწყისი სიმტკიცის გაზრდის გზები. წარმოდგენილია ექსპერიმენტალური კვლევის შედეგები და ბეტონირების ტექნოლოგიის კვლევის შედეგები.

საკვანძო სიტყვები: *ცემენტის მინერალები, ცემენტის კლინკერები, ცემენტის დატენიანება, ბეტონი, მოწყობილობა ბეტონის დეფორმირებისათვის.*

მრავალკომპონენტიანი სამშენებლო სისტემა - სასარგებლო წიაღისეულის ჯაჭვის 3CaO* Si02, 2CaO* SiO2, 3Cao* Al20z, 4CaO* Al2O3* Fe2O2 ხელოვნურად შექმნილი სტრუქტურაა, რომლებიც არ ჩნდებიან სამრეწველო წიდაში.

ხშირად კლინკერულ მინერალებს აქვთ კომბინირებული სტრუქტურა, რომელშიც ერთი ბადე ჩართულია მეორეში. ბევრ, სპეციფიკური სტრუქტურის ჰეტეროგენულ სხეულებს არ აქვთ ერთნაირი მექანიკური თვისებები. მათი დეფორმაცია და რღვევის პროცესი რთულია, რადგანაც უჭირავთ შუალედური მდგომარეობა ბლანტ სითხეებსა და მყარ სხეულებს შორის.

ბეტონის ხარისხობრივი და რაოდენობრივი მახასიათებლების განსაზღვრისათვის შემოთავაზებულია მრავალკომპონენტიანი (ცემენტური კლინკერები) სისტემების განხილვა როგორც ორკომპონენტიანი სისტემა, შედგენილი არა ადგეზირებული ცემენტის მარცვლებისა და გარემოცული ახლადწარმონაქმნებისგან. შედეგად, ბეტონის თვისებები დგინდება ამ სისტემის სიმტკიცეზე დამოკიდებულებით, ადგეზიის ხარისხით, ასევე შემავსებლის სიმტკიცით

და მინერალური შედგენილობით, შემავსებელსა და ახალწარმონაქმნებს შორის ადგეზიით.

მრავალკომპონენტიანი (4-ზე მეტი) სისტემის კვლევა რთულია მათი ვიზუალიზაციის შეუძლებლობის გამო 3 განზომილებიან სივრცეში. ამ ამოცანის ამოხსნისათვის გამოიყენება „სიმძიმის ცენტრის“ განზოგადებული წესი. ასეთი მიდგომა მოითხოვს რთულ მათემატიკურ აპარატს. შემოთავაზებულია ფაზური შედგენილობის გაანგარიშების მარტივი მეთოდი-ბალანსის მეთოდი. ეს მეთოდი ეფუძნება საწყისი კომპონენტების განაწილების ბალანსს მეორად (ფორმირებულ) ფაზებს შორის.

იმისათვის, რომ დადგენილიყო ადრეული დატვირთვის გავლენა ბეტონის საბოლოო სიმტკიცეზე ჩვენ მიერ ჩატარებულია ექსპერიმენტალური კვლევა. პრობლემა იხსნება ზამთრის ბეტონირების მეთოდით ხსნარის ვიბრირების ჩართულობით. ვიბრირებამდე ხსნარი დატვირთულია 12 კგ/მ^3-ით. ჩატვირთვისას ბეტონის ხსნარი იმყოფება დრეკად-პლასტიკურ, რთული დაძაბული მდგომარეობის პირობებში.

ბეტონის სიმტკიცეზე გამოცდა ჩატარდა ნორმალური გამყარებიდან 28 დღის შემდეგ. გაყინული ნიმუშები კარგ მდგომარეობაში ინახებოდა გამოცდამდე 1 დღის განმავლობაში. ნიმუშების გამოცდის შედეგები მოცემულია ცხრილი 1.-ში. ამ მონაცემების ანალიზი აჩვენებს, რომ დაუძაბავი ბეტონის ნიმუშების სიმტკიცე ბეტონის ადრეული (3 დღე) გამყარებისას შეადგენს 30,5%, ხოლო ნორმალური გამყარების ბეტონის სიმტკიცე - 77,6%. გვიანი გამყარების (28 დღე) პერიოდში თავისუფალი (დაუძაბავი) ბეტონის ნიმუშების სიმტკიცე შეადგენს 58,53%, ხოლო ნორმალური გამყარების ბეტონის სიმტკიცე - 96,51%.