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MODERN METHODS FOR CONTROLLING THE STRENGTH OF CONCRETE IN THE STRUCTURES OF MONOLITHIC BUILDINGS

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Annotation
The problematic link in the quality control system of monolithic construction is the control of the strength characteristics of concrete. As the analysis showed, at the moment there is no single universal method for controlling the strength of concrete at all stages of its hardening (stripping, critical, design, etc.). It is most rational in this situation to apply an integrated approach to controlling the strength of concrete, i.e. use in parallel several methods based on different physical principles. First of all, this applies to non-destructive testing methods, which make it possible to provide the required volume of measurements of a given parameter.

Introduction
Theoretical prerequisites for the creation of new methods for controlling the strength of concrete in the structures of monolithic buildings of all the existing methods, the most promising for controlling the strength of monolithic concrete at different ages is the ultrasonic pulse method. The disadvantages of the traditional ultrasonic pulse method do not allow the full use of this method for reliable control of the strength of monolithic concrete. In this regard, we propose the following ways to improve this method:
- To increase the accuracy of measurements by creating and using universal engineering methods of counting, adapted to the conditions of monolithic construction, i.e. taking into account all factors affecting the speed of ultrasound and the increase in the strength of concrete;
- Complex use of various measurement schemes, such as surface, through (diagonal and coaxial);
- Increase in the number of measurements;
- Improvement of measurement and statistical processing processes due to their automation.

To control the strength characteristics of concrete at an early age, it is necessary to install ultrasonic transducers with special devices in the shield deck to press them against the concrete surface after the mixture has been compacted. In this case, two important problems of the ultrasonic testing method will be solved. Firstly, tight contact of the transducers with the concrete surface will be ensured due to the hydrostatic pressure of the concrete mixture, compaction during its laying and pressing after it. This will allow to more accurately measure the speed of ultrasound in the structure without the use of special lubricants (plasticine, technical vaseline, etc.). Secondly, it will exclude the possibility of the appearance of a subjective error associated with the personality of the tester. While stripping the formwork, the ultrasonic sensors can remain in contact with the concrete until it reaches its design strength.

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It is enough to control the strength of monolithic concrete in several places, which is fully consistent with the principle of selective control. Such places can be a kind of “critical” points for reinforced concrete walls, for example, under window openings (or rather, under openings), at the junction of external and internal walls. It is in these places that underconsolidation of the concrete mixture is most likely. For columns made of monolithic reinforced concrete, the author recommends choosing the location of control points directly near the places of their joining with capitals, beams or monolithic ceilings. For monolithic floors, these points can be the areas of the middle part of the span, as the most critical and subject to deformation. The same condition is for monolithic beams. In each specific case, the acceptance of these sensor installation locations must be carried out individually.

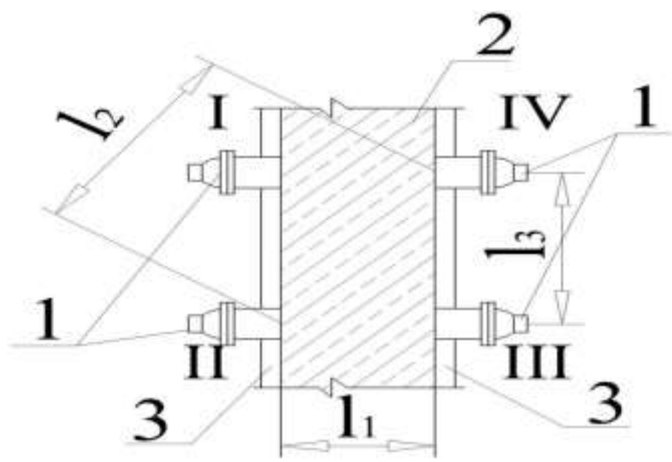
Installation of ultrasonic transducers in formwork panels is carried out as follows. In total, 4 (four) converters should be installed for each “critical” place, two on each side of the monolithic structure (Fig. 1.1). This arrangement of sensors will allow four measurements to be made. Thus, two end-to-end coaxial measurements I-IV and II-III on the base C, two end-to-end diagonal measurements I-III and II-IV on the base L are possible (two surface measurements I-II and III-IV on the base 13 are also possible).

Fig.1.1 Scheme of location of ultrasonic transducers on the formwork.1 Ультразвуковые преобразователи;

2- Concrete or reinforced concrete device;

3-Formwork.

It should be noted that this scheme has several significant drawbacks, which consist in the possibility of taking a limited number of measurements (four) in a given place of the structure, and also, its use contradicts the principle of "randomness" of the sample.



Another method that we single out as a priority is the method of determining the strength of concrete by the temperature-time factor.

SNiP [3] allow to control the strength of concrete based on the results of temperature control in the conditions of work at low temperatures. This method can also be used in the hardening of monolithic concrete of known composition at a known positive temperature from the moment of concreting the

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structure until the concrete reaches its design strength at a minimum of costs.
For its effective application, it is necessary to use an engineering method for calculating the strength parameters of monolithic concrete according to the temperature-time factor, taking into account the main conditions that affect its accuracy.
According to the results of the analysis, the most objective method for controlling the strength of monolithic concrete was the method of testing control samples taken from the body of concrete using special molds placed in the structure before concreting. The undoubted advantage of this method is its accuracy due to the identity of the conditions of molding and hardening of control samples and the main structure, as well as obtaining results directly in strength units. Compared to cutting core samples, the advantages are obtaining samples of the basic shape and high quality when removing concrete at any age after stripping the structure, does not require special expensive equipment for removal and preparation for testing.

Modern methods (ultrasonic, method of measuring instruments).
At present, the level of production of non-destructive testing devices has significantly increased, which is explained by the wide scope of their application: control of the strength of concrete and the quality of concreting, flaw detection, assessment of the depth of cracking, etc. [5].
In connection with the adoption in 2012 of a new edition of GOST 17624-2012 “Concrete. Ultrasonic Method for Determination of Strength”, which came into force on January 1, 2014 to replace the version of 1987 that has long lost its relevance, the requirements for instruments and methods for monitoring the strength of concrete by the ultrasonic method have changed [7].
The updated version of the standard has been developed in accordance with the requirements of international regulatory documents in the field of measurements, testing and control, and taking into account the current level of development of science and technology.

– The main positive differences of the new edition of GOST 17624-2012:
– For the first time, the permissible strength of concrete of classes B60 (ie, strength up to 75 MPa) was determined;
– For the first time it is allowed to determine the strength of concrete in monolithic structures by surface sounding method;
– A method was established for constructing calibration dependencies not only on control samples, but also on the results of testing by the tear-off method with shearing;

Concrete class assessments are clearly demarcated based on the results of ultrasonic testing according to GOST 18105-2010 (Appendix B)
Although the document is well developed, its shortcomings should also be noted. According to clause 5.4 of GOST 17624-2012, the sounding base of a non-destructive testing device must be at least 120 mm and not more than 200 mm, however, devices with a sounding base of 100 mm have been produced and successfully operated for a long time. The question arises about the possibility of using such devices as, for example, "Concrete-22" and "Concrete-32" (Fig. 1.2).

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Figure 1.2. Concrete-32 with a sound base of 100 mm.

However, in a number of studies it has been established that the error in the results of measurement by the ultrasonic method directly depends on the sounding base (Fig. 1.3). [eleven].

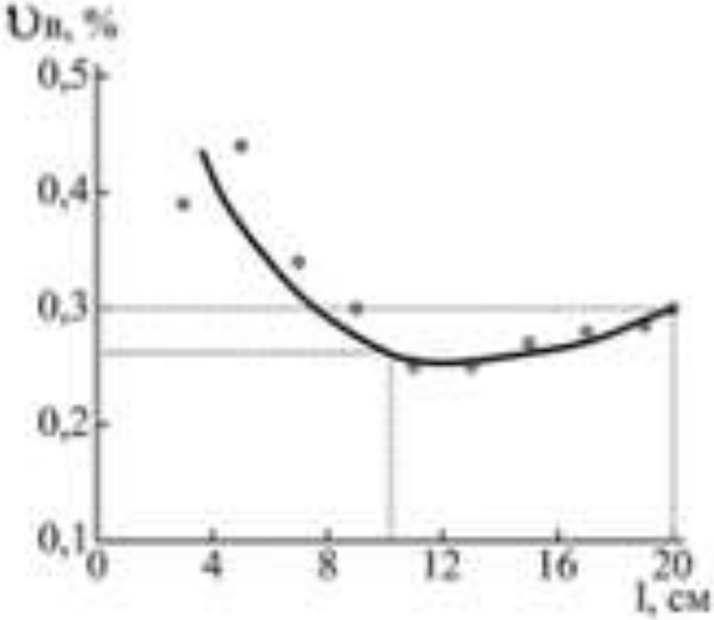

Figure 1.3. Dependence of the coefficient of variation of multiple measurements of the transit time of ultrasound on the sounding base.

On the basis of the above graph, it can be concluded that the sounding base of 20 cm established by GOST has a higher coefficient of variation than the forbidden one - 10 cm, which indicates the ambiguity of the established requirements for non-destructive testing devices.

Method according to temperature indicators during heating of concrete

The main parts of any concrete are crushed stone, sand, cement and water. The process of concreting is the process of transition of concrete from a liquid phase to a solid one. But certain conditions are necessary for a successful transition. Under normal conditions (temperature + 15 ° C in a humid

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environment), hydration of cement grains begins from their surface, forming cement glue in the form of hydrous calcium silicate. Then the reaction passes to the deeper layers of the cement grains due to the suction of water by them. The gel of the surface layers, gradually dehydrating, tightens more and more densely, reaches complete water tightness and turns into a solid gel - a cement stone. Thus, the grain of cement turns into a nut, as it were, with a hardened shell and an intact nucleolus, which did not participate in the hydration reaction.

The hydration process is exothermic. At 28 days of age at normal temperature, the hydrated part of the cement grain is 12% of the total volume. As the temperature rises, most of the cement grain hydrates, and the rate of hydration increases. The strength of concrete is noticeably increased, the period of time during which the concrete reaches the grade is reduced. (The brand of concrete is its average compressive strength in kg / cm2, achieved in 28 days during hardening under normal conditions). As a result of the hydration reaction, a large amount of heat is released. If, for any reason, the temperature rises above the permissible level (above 80 ° C), then free water will begin to evaporate intensively, leaving pores and reducing the density of concrete. If, during this process, the temperature drops below the permissible level (below 5°C), which is possible under winter concreting conditions, then unbound water will begin to freeze, i.e. create their structures and destroy the bonds of cement grains with their bonds. In both cases, the strength indicators are sharply reduced.

The need for warming up concrete during low temperatures is obvious, and since as the reaction temperature rises, its speed increases, concrete heating can be used at any time to achieve the concrete grade as soon as possible. The faster the concrete hardens, the sooner it is possible to free the formwork, heaters, insulation devices and materials, as well as reduce fuel or energy consumption, transfer technicians and workers to another site and start work that cannot be done before demoulding.

The release of heat during the hardening of concrete during winter concreting in some cases is of great practical importance. In conditions of winter concreting, the amount of heat released, the duration of heat release and its effect on the increase in the temperature of concrete are very significant (Fig. 1.4).

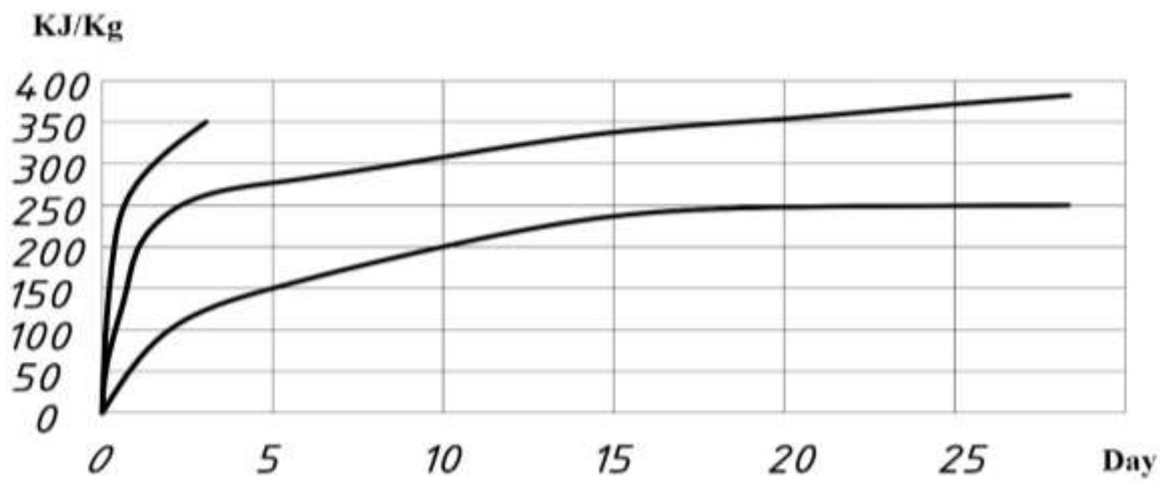

Figure 1.4 Heat dissipation of Portland cement.

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All this depends on [9]:
a) The chemical composition, grade and fineness of cement grinding - the higher the activity of the cement, the greater the heat release during its hardening;
b) Cement consumption per 1 m3 of concrete - since heat is released during cement hydration, its consumption per 1 m3 is essential;
c) The degree of massiveness (size and shape) of the structure - for a massive structure, the loss of heat through the surfaces is less, therefore, the temperature rise is higher, the cooling is longer; in medium-sized structures, the release of its own heat by concrete during hardening is of great practical importance, because. together with other measures, it often allows them to be kept in the winter in the way of a thermos without heating;
d) Temperature of the concrete mass (initial) and the environment;
e) Water-cement ratio. More often, the heat released is not enough to increase the temperature of concrete in the winter - it is only enough to slow down the cooling process.
But this heat must be taken into account when heating concrete.
To achieve the design strength of concrete, 28 days of exposure under normal conditions are required. But it is difficult to withstand concrete for such a long period in winter. When concrete freezes in the early stages (up to 4 days old), its hardening is interrupted, because. all water passes into a solid phase, and solids almost do not enter into a chemical compound. In addition, free water, upon freezing, expands by 10% of its original volume, creating a porous structure, and forms ice on crushed stone or gravel grains, which prevents further increase in strength after defrosting. This is the main reason for the decrease in the strength of concrete during its early freezing.
Depending on the water-cement ratio, when the concrete reaches the age of 6-7 days under normal conditions, almost all water hydrates, and besides, the concrete strength at this point is 40% of R28. After defrosting such concrete, its hardening will resume and when the concrete reaches 28 days of age (excluding freezing time), its strength will be 95-100% (depending on the brand) of the strength of the same concrete that has not been frozen (Fig. 1.5).
During winter work, concrete should be protected from freezing for a period that ensures that, at a given concrete curing temperature, it obtains strength, allowing it to be stripped and loaded with loads that it should take in winter, until the increase in strength in concrete resumes.

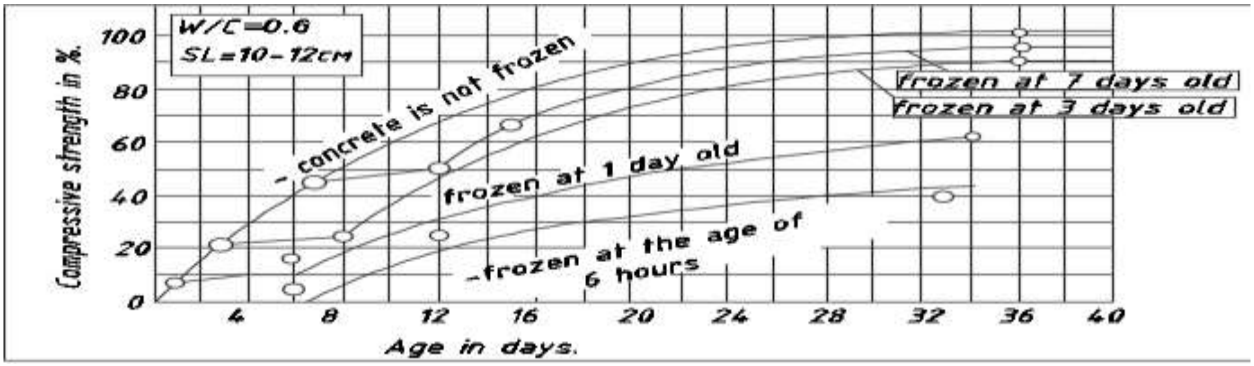

Figure 1.5. Loss of strength of concrete depending on its age at the time of freezing.

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The intensity of the processes of dissolution and combination of substances in water changes with temperature. It has already been mentioned that with an increase in temperature, the rate of hydration also increases, and with a decrease in temperature, it slows down. The setting time of cement paste is largely dependent on temperature. The timing of the onset of the beginning and end of the setting of cement accelerates with an increase in temperature, and slows down with a decrease

(Fig. 1.6).

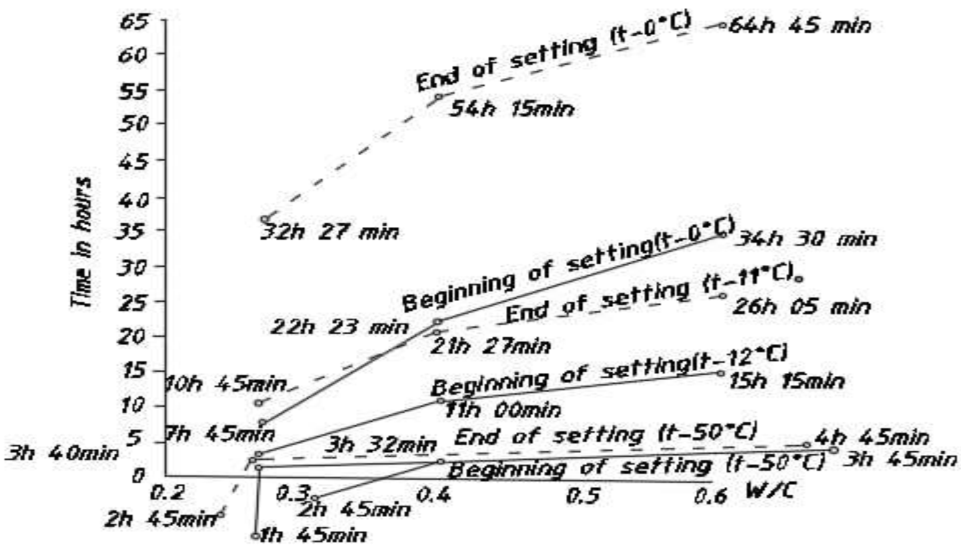

Figure 1.6. Influence of the water-cement factor on the setting time of Portland cement 400 at temperatures of 0o, +17o, +50o.

Because when the temperature rises, the hydrated part of the cement grain increases, then the amount of water required to obtain a test of normal consistency increases with an increase in its temperature. It is impossible to allow strong evaporation from the concrete surface, which will lead to its overdrying, a significant part will remain uninvolved in hardening. On the contrary, it is necessary to additionally moisten the concrete, which will even allow you to purchase a few in quality.

Conclusion

The objectivity of a complex system for monitoring the strength of monolithic concrete, consisting of an ultrasonic pulse method, a method for calculating strength by a temperature-time factor, a method for testing control samples-cubes extracted from a body of a monolithic structure, has been experimentally confirmed. The discrepancy between the results of strength control by the proposed methods during heat treatment was within 12%, in natural conditions - within 10%.

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