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THE NEW METHOD OF PRODUCTION OF HIGH-DENSITY CONCRETES

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ABSTRACT

In numerous works by Soviet and foreign authors, a significant role is assigned to the density of concrete in the formation of its structure and physical and mechanical properties. It is noted that one of the important tasks of concrete technology is to find conditions that provide the possibility of obtaining the maximum density. As is known, it is POSSIBLE to solve this problem by reducing the W/C to values at which the mixing water completely interacts with cement, and at the same time, the maximum compaction of the concrete mixture is ensured, which practically excludes the presence of a gas phase in it.

KEYWORDS: *Concrete, Sand, Water, Mixture, Density, Plasticizers, Molecular Forces, Phase Density.*

INTRODUCTION

However, there is a contradiction between the W/C and the degree of compaction of the concrete mixture: with a decrease in W/C (especially in the range of its low values), the compaction of the mixture becomes very difficult. In order to provide the necessary workability of the mixture, much more water is introduced into it [2] than required, and, thus, a decrease in the concrete density is predetermined. On the other hand, when compacting a concrete mixture after mixing with water, air is trapped in it, and the more the mixture is stiffer, which also reduces the concrete density. The porosity of conventional concrete is 12–20% [3]. In the density classification [4], high-density concretes have a porosity of 15-20%, high-density concretes 10-15%, and extra-dense concretes up to 10%.

Methods

Existing ways to increase the density of concrete are based mainly on the use of plasticizers to reduce the water content and W/C concrete mixture or on the use of rigid mixtures with simultaneous intensification of their compaction. However, it is usually possible to reduce hair content with the help of plasticizers only by 10-15%. and the intensification of the compaction process is associated with an increase in energy costs. Therefore, the problem of increasing the density of concrete continues to be relevant. Research into the issue of obtaining high-density concretes, based on the compaction of the concrete mixture before mixing with earth, led to the development of the so-called "dry" concreting method. Its essence is that the preparation and compaction (molding) of the concrete mixture is carried out in a dry state, after which the mixture is impregnated with water.

It was assumed that the compaction of dry mixtures should provide a greater percentage of the solid phase in concrete, and their good gas and water permeability and acting outside of capillary and molecular forces during impregnation should contribute to the almost complete displacement of air and filling the intergranular space of the mixture with water. Experiments begun at the Institute of Physical Chemistry of the Academy of Sciences of the USSR and continued at the K. D. Panfilov Academy of Communal Services confirmed this assumption.

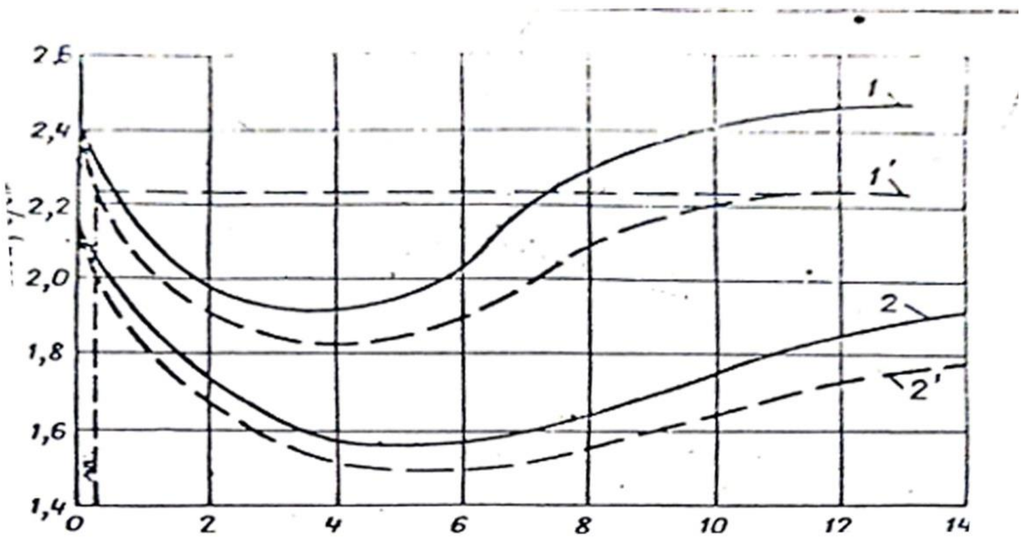

Fig. 1. Dependence of the volumetric mass of cement-sand (1) and cement (2) on humidity at the same compaction intensity (curves 1, 2 show the change in the density of the system; curves 1. 2. constructed by subtracting the volumetric mass of water, the change in the particle packing density solid phase)

Figure 1 shows a graph of the change in bulk density as an indicator of density for cement and cement-sand mixture, depending on moisture content at the same intensity of compaction.

As can be seen from the graph, the maximum solid phase density corresponds to the minimum moisture content when the cement and mixture were dried to constant weight. The bulk density of the dry mixture was 2.4 g/cm^3, the void content was 12.5%, and the concrete obtained by impregnating this mixture with water (with an initial B/L=0.18) had a strength at the age of 28 days of normal hardening of 1180 kgf/cm^2 and a porosity of 3.5%, which indicates its high density. The indicated value of V C approximately corresponds to the quantity. water, necessary for chemical interaction with cement, i.e., close to optimal. However, for a more complete hydration of the cement and a further increase in strength, in this case it is advisable to use water replenishment: water due to contraction, which occurs during water hardening. So, experiments show that during the first day of water hardening W/c increases up to 10%. Characteristically, with this method, the initial water content and water demand of the mixture are identical, depend on the degree of its compaction, and can be determined by the formula B = 1000e (l/m^3), where the porosity of the dry mixture after compaction is in fractions of 1. This corresponds to 11. A. Popov [5] came to the conclusion as early as 1933 that the water flow rate at which the highest density is achieved can practically be considered equal to the volume of voids in a compacted dry mixture of solid components. The same opinion is shared by M. Z. Simonov [1] and S. V. Shestoperov [6].

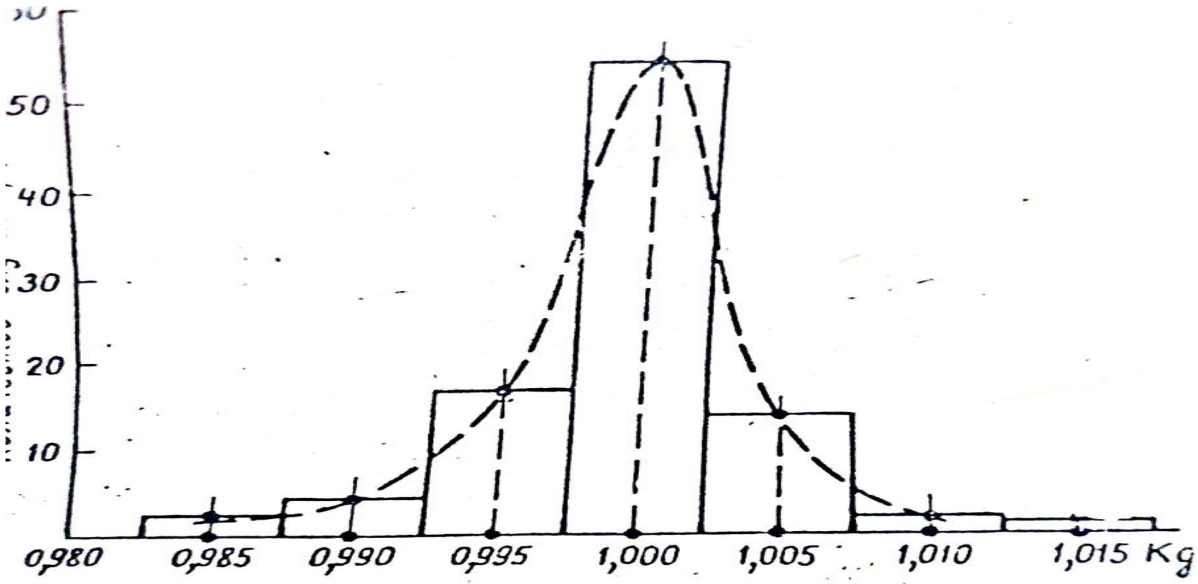

Fig. 2. Distribution of 196 obtained values of compaction coefficient of fresh concrete

Experimental determination of the compaction coefficient [7] of freshly prepared concrete, shown in the form of a graph (Fig. 2). indicates that k is practically equal to 1; this agrees with the above formula. Above. Some values of K above 1 are explained by the experimental error allowed by the existing technique. In this case, this error did not exceed 1.5%. The selection of the composition of the dry mixture is simplified, since there is no need to take into account the factors of workability and mobility of the mixture. The matter is reduced to the selection of such a ratio between cement and aggregate, when their most dense packing occurs. Due to the incoherence of dry mixes, their tendency to delamination, fine-grained mixes are the most acceptable for dry concreting.

Results

Indicators of density, strength and other characteristics of concrete were determined on sample cubes 10x10x10 cm from a cement-sand mixture of composition 1: 2.5 and cement-sand-crushed stone 1: 2.5: 1.5. Tuchkovskiy sand and cement or a mixed binder prepared by joint grinding of cement with sand in various ratios were used as starting materials. The specific surface area of cement and mixed binder in the experiments was about . 5000 cm^2/g [Belgorod cement brand 500 (Sy=2500 cm^2/g), crushed granite fraction 5-10 mm]. The residual moisture content of the dry mix did not exceed 0.3%.

The mixtures were tested for stratification by free vibrating with a CHTO load, vibrating at 100 g/cm^2. Experiments with at have shown that when vibrating with a load, the separation of the mixture practically does not occur. vibrating mill M-10 without balls for 1 min, Nyali compaction on a vibrating platform with a weight of about 100 g/cm^2. The degree of compaction of the dry mixture was characterized by a void content of 15-16% for cement-sand and 13% for a mixture with crushed stone. After compaction of the mixture, its volume was fixed (by installing a clamping cover on its surface). This was done in order to prevent swelling of the mixture as a result of the wedging action [8] of water during the impregnation process. The impregnation of the mixture with water was carried out through the perforated bottom of the form under a pressure of 0.15 atm. The impregnation time of the samples was 55–68 min.

With an increase in the thickness of the mixture layer, the time increases. This was done in order to prevent swelling of the mixture. As a result of the wedging action [8-11] of water during the impregnation process.

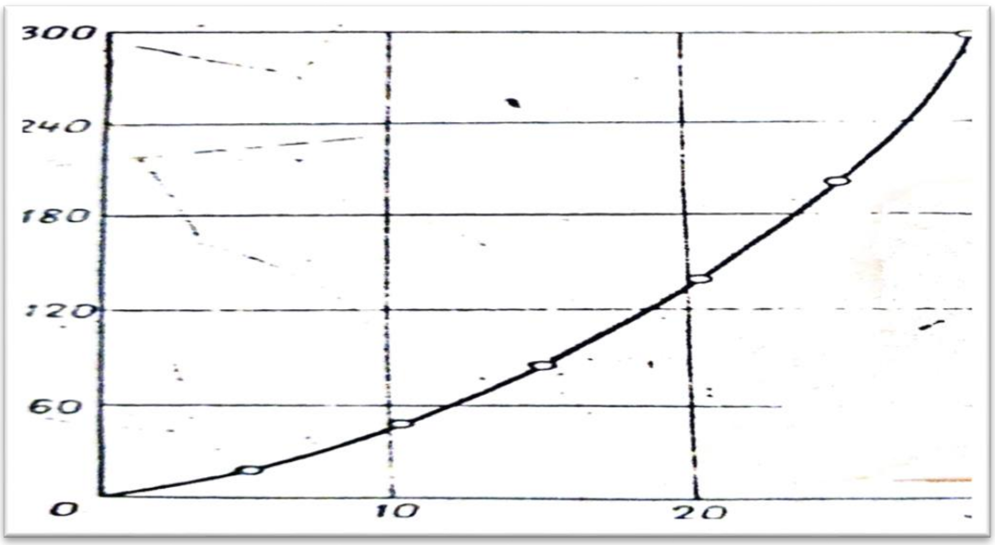

Fig.3.The dependence of the impregnation time of concrete under the mixture on its thickness

The mixture was impregnated with water through a perforated diish mold under a pressure of 0.15 atm. The impregnation time of the samples was 55–68 min. As the layer thickness of the mixture increases, the time increases. Thus, the impregnation of 10x10x30 cm prisms in the vertical direction lasted about 5 hours. The dependence of the impregnation time on the layer thickness is shown in Fig. 3. As experiments have shown, the duration of impregnation can be halved by the use of surface-active additives to water, in particular 0.1-0.2% PRS.

TABLE 1.

Type and composition of mixture		***The ratio of cement and sand in a mix binder***	***Cement consumption***	***W/C***	***Density of concrete in g/cm^3***	***The total porosity on day 28 in %***	***The chemical bound water on the 28th day in %***
Cement-sand	**I**	**100:0**	**660**	**0.23**	**2.474**	**6.1**	**13.8**
	II	**80:20**	**525**	**0.30**	**2.458**	**6.8**	**15.6**
	III	**60:40**	**385**	**0.44**	**2.431**	**7.4**	**19.3**
	IV	**40:60**	**260**	**0.61**	**2.412**	**8.2**	**26.0**
	V	**20:80**	**130**	**1.20**	**2.405**	**9.8**	**26.4**
Gravel mixture		**80.20**	**360**	**0.35**	**2.490**	**5.5**	**16.4**

After stripping, the samples are kept in a wet storage chamber. The resulting concrete was distinguished by high values of bulk density, low porosity and should be classified as especially dense (Table 1). The amount of chemically bound water (CBW) in it is within the same limits as in conventional concrete.It should only be noted an increase in CBW with an increase in the proportion of sand in the mixed binder, which is apparently associated with an increase in W/C.

The density of concrete was also checked by water and gas permeability of the samples. When testing cement-sand concrete of composition II for water permeability with a sample thickness of 3 cm and a hydrostatic pressure of up to 20 atm for 300 h, no signs of water penetration were found.

TABLE 2.

Type and composition of mixture		***R_{sqz}, kg/cm^2 in period of a day***				***R_{sqz}/C***
		1	**3**	**7**	**28**	
Cement-sand	**I**	**615**	**790**	**885**	**1064**	**1.61**
	II	**510**	**695**	**760**	**918**	**1.75**
	III	**300**	**536**	**648**	**714**	**1.86**
	IV	**148**	**320**	**435**	**496**	**1.95**
	V	**__**	**151**	**236**	**261**	**2.01**
Gravel mixture		**358**	**560**	**656**	**758**	**2.10**

To test the gas permeability, samples were made in the form of a truncated cone with a diameter of 102/107 mm Bb with a hundredth of 100 mm, normal hardening, 2 months old. The gas filtration coefficient at a pressure of 50 atm for concrete with crushed stone turned out to be within

$8*10^{-7}$__$4x10^{-5}(\frac{cm^3*cm}{cm^2*atm*sec})$

for concrete without crushed stone on Tuchkov sand _$1.2*10^{-6}$_$5*10^{-5}$, on Juminsky sand - $4.2x10^{-5}$__$1.1*10^{-4}$ Data on the compressive strength of concrete at different ages are given in Table 2.

From the data in Table. 2 it can be seen that the high density of concrete provides high rates of its absolute and, especially, relative (R_{sqz} /c) strength. The use of a mixed binder with different consumption of cement makes it possible to obtain concrete with a strength of 260 to 1060 kg/cm^2.

The highest relative strength was obtained for concrete with crushed stone, it is 30% higher than the relative strength of cement-sand concrete, although the absolute strength of the latter is much higher. This indicates a more complete use of the properties of cement in crushed stone concrete (although the content of crushed stone in concrete during “dry” concreting usually does not exceed 30-35% of the mass of the entire mixture, since a significant expansion of crushed stone grains is necessary for good compaction of a dry concrete mixture). Concrete samples of compositions II and III were tested for frost resistance and withstood 1000 cycles of alternate freezing and thawing: in this case, the loss in mass of the samples a was 1.6–2.6%, and the strength was -0-20%.

An interesting question is about the homogeneity of the resulting concrete in terms of the height of the product with the technology of "dry" concreting. To assess the homogeneity of cement–sand concrete, the volumetric mass, the amount of chemically bound water, compressive strength, and the propagation velocity of an ultrasonic pulse along the height of the samples were determined.

In the experiments, 10x10x30 cm prisms were used, which were molded in a vertical position, in the direction of impregnation from bottom to top. The composition of the cement-sand mixture is 1: 2.5: Belgorod cement grade 500, Tuchkovsky sand, W/C of the resulting concrete 0.28. Samples of normal hardening were tested at the age of one month.

TABLE 3.

N. of prisms from down to up	*Prism 1*			*Prism 2*			*Prism 3*		
	γ g/cm^2	CBW %	R_{sqz} kg/cm^2	γ g/cm^2	CBW %	R_{sqz} kg/cm^2	γ g/cm^2	CBW %	R_{sqz} kg/cm^2
1	2.42	14.5	810	2.40	13.7	790	2.40	14.6	748
2	2.41	13.9	784	2.42	14.4	740	2.41	13.6	786
3	2.43	14.2	726	2.42	14.0	805	239	13.4	738

The prisms were split in the transverse direction into 3 parts, from which, after the strength test, 3 samples were taken to determine chemically bound water in concrete. The propagation velocity of an ultrasonic pulse was measured with a UKB-1 portable pulsed ultrasonic device at 9 points every 3 cm along the height of the prism. The test results are given in Table 3 and 4.

TABLE 4.

N. of points from down to up	***The velocity of an ultrasonic pulse***		
	Prism 1	**Prism 1**	**Prism 1**
1	**4.95**	**4.89**	**4.94**
2	**4.94**	**4.96**	**5.03**
3	**5.03**	**4.98**	**5.05**
4	**5.03**	**4.91**	**5.05**
5	**5.05**	**4.92**	**5.05**
6	**5.03**	**4.91**	**5.05**
7	**5.03**	**4.98**	**4.86**
8	**5.05**	**5.13**	**4.91**
9	**5.07**	**5.13**	**4.94**

The data show a good uniformity of concrete, the largest deviation of the ultrasonic velocity values does not exceed 3%. Some decrease in the speed of ultrasound (within 2.2-4.7%) is noted in the direction to the place of water injection.

CONLUSION

Thus, the method of dry concreting makes it possible to obtain, from fine-grained mixtures, particularly dense concrete of high uniformity, strength, with a good degree of use of the cement's binding properties. The method can be used primarily for the manufacture of concrete products intended for work in harsh operating conditions, where increased resistance and, at the same time, high concrete strength are required.

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