Influence of size factor on creep deformation of fine-grain foam concrete for repair

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Abstract. The work has studied the influence of carbonization of fine-grain foam concrete for repair on its plastic yield in case of compression depending on the size factor to provide seamless operation of new layer with the old after repair and renovation of concrete and reinforced concrete structures. It has been found that in choosing a composition for repair and renovation of foam concrete and reinforced concrete structures and in course of designing technologies and structures for renovation one should take into account the size factor and creep deformation of fine-grain carbonized and uncarbonized cell concrete.

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Introduction

One of the first to study influence of size or scale factor on lightweight concrete creep was K.S. Karapetyan [1]. His experiments showed that in drying compressed samples of lightweight concrete based on pumice, plastic flow decreases as cross section of the concrete element increases. In isolated samples, when evaporation is impossible, sample size has almost no effect on its plastic flow.

On the basis of these studies, K.S. Karapetyan proposed a method that makes it possible to assess concrete plastic flow in structures of all sizes by results of experiments with small isolated laboratory samples. This fact is important, since studying creep deformation is important to ensure seamless operation of several layers in course of repair and renovation of structures of all sizes made of fine-grain cell concrete [2].

Influence of size of unisolated samples on plastic flow autoclaved cell concretes was studied by F. Kruml [3] A.M. Krasnov [4] J.B. Solovei and V.A. Pinsker [5]. According to data of F. Kruml [3], influence on samples size on gas concrete plastic flow may be neglected if the size of samples cross section is between 10 and 30 cm.

A.M. Krasnov tested 7x7x21; 10x10x30 cm and 15x15x45 prisms of cell silicate concrete with density of 1,000 kg/m^3. Plastic flow for all tested samples was the same [4].

In the studies made by J.B. Solovei and V.A. Pinsker [5], the rate of creep deformation growth in smaller samples was higher. Thus, plastic flow in prisms of aerated concrete with 20x20 cm cross section was 5-15% lower than in 10x10 cm cross section prisms [6]. However, as the authors point out, after test duration of 5.5 years, creep deformation in samples of different sizes became the same.

Thus, in fine grain cell concrete, without taking into account carbonization factor, maximum creep deformations are the same regardless of sample size. [7]

The study was focused on the influence of carbonization of fine-grain foam concrete on its plastic yield in case of compression depending on the size factor to provide seamless operation of new layer with the old after repair and renovation of concrete and reinforced concrete structures.

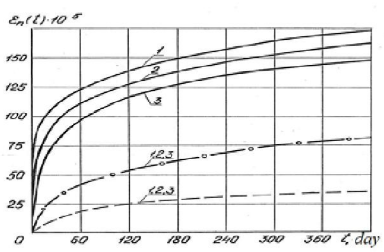
Methods

The experiments were performed using isolated 4x4x16, 7x7x28 and 10x10x40 cm samples of cell concrete with density of 600 kg/m^3 both with and without regard to concrete carbonation factor. Samples were carbonized with 10% concentration of carbon dioxide and atmospheric concentration of carbon dioxide. Strain for all prisms was 0.3 of prism strength of carbonized concrete.

Main part

As it is seen in Figure 1, plastic flow in samples of carbonized concrete of different sizes turned out virtually the same.

Influence of size factor on cell concrete plastic flow after carbonization of samples with atmospheric concentration of carbon dioxide is also insignificant [8]. This is due to the fact that the rate of concrete carbonation with atmospheric carbon dioxide in concentration of 0.03-0.05 % is very low [9]. Therefore, the probability of manifestations of relaxation processes in concrete are similar for samples of different sizes, which is very important in choosing fine grain cell concrete for repair [10].



——— - samples carbonized with 10% carbon dioxide; - samples carbonized with 10% carbon dioxide;

—○— - samples carbonized with atmospheric carbon dioxide by air sweeping;

— — - uncarbonized samples;

1, 2, 3 – samples with size 10x10x40, 7x7x28 and 4x4x16 cm accordingly

Figure 1. The effect of scale factor on fine grain gas concrete plastic flow.

At the same time, plastic flow in samples carbonated with 10% CO_2 slightly increased with increasing cross-sectional dimensions [11]. So, after 420 days of test, relative creep deformation in samples carbonized with 10% carbon dioxide was equal to 145, 160 and 174.10^{-5}, respectively, for samples with 4x4, 7x7 and 10x10 cm section. This circumstance should be considered in designing concrete footing.

Increase in plastic flow in specimens carbonated with 10% CO2 concentration with an increase in their size may be caused by different values of shrinkage that occurs in samples of various sizes in the process of their preliminary carbonization [12]. In our experiments it was found that with the same degree of gas concrete carbonation, its shrinkage was higher when sample size was smaller. As a result, the plastic flow value in larger samples was higher than in smaller samples, which is very important in ensuring seamless operation of several layers in concrete footing.

This consideration is confirmed by the data presented in the work of A.F. Milovanov and N.I. Tupov [13], according to which, if old conventionally hardening concrete is exposed to rising temperatures, its plastic flow decreases relative to the shrinkage of old and new concrete occurs prior to loading.

Conclusions

Thus, the results of our experiments showed that in studying cell concrete plastic flow with regard to its carbonization with carbon dioxide with increased concentrations, it is necessary to consider scale or size factors. If we take the plastic flow in a 10x10x40 cm sample carbonated with 10% CO2 for 100%, then for 7x7x28 cm samples it will be 92%, and for 4x4x16 cm samples - 83%. Since cell concrete plastic flow in case of carbonization with 10% carbon dioxide increases with the size of sample's cross section, the value of the transition coefficient k_1 between the plastic flow when concrete is subjected to carbon dioxide in 10% concentration and the plastic flow under natural carbon dioxide concentrations will also depend on the size of samples, which is important in planning of repair activities.

It is proposed to express the influence of sample size on the value of the transition coefficient k_1 as follows:

$$k_1 = 0{,}617 - 0{,}034\,r \text{ при } 2 \le r \le 10, \quad (2.1)$$

where $r = \frac{A}{0{,}5[pi]}$ – is the ratio of sample cross section area on its half-perimeter (reduced cross section radius).

Thus, in choosing composition for repair and renovation of foam concrete and reinforced concrete structures and in course of designing technologies and structures for renovation one should take into account size factor and creep deformation of fine-grain carbonized and uncarbonized cell concrete.

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