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Relaxation of Compression Stresses in Fine-Grained Cellular Concrete

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ABSTRACT

Constructions and concrete are the most durable in practice of building construction. Each such facility allows you to fully determine how much durable it will be. In this article concrete is defined as invariant material for permanent structures. We investigate degree of shrinkage and reaction of concrete against various influences, and also we investigate durability in reference to building operation. It was performed a brief review of investigations of problem of relaxation of compression stresses in different types of concrete. It was established that in response to the carbonation relaxation ability of fine-grained concrete increases. The stress relaxation in the fine-grained cellular concrete of autoclave and non-autoclave curing was investigated. It was concluded that carbonation of fine-grained concrete affects speed of the process of the stress relaxation. It was analyzed various types of concrete, including certain fractions. It was investigated forms of carbonation of not only concrete, but it's also given recommendations for investigation in other materials. There was provided a view of technological type of system of stabilization, establishment and, if it's necessary, regeneration of concrete base. Further line of investigation is defined on the basis of investigation of process of relaxation of fine-grained concrete. Investigations of construction industry of western engineering thoughts were trended.

KEYWORDS
Relaxation; compression stress; autoclave; fine-grained concrete; cellular concrete; carbonation of concrete; durability; operation.

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Introduction

Ability to fine-grained concrete to stress relaxation under forced deformations, reported to it, is in close relation to its creep and is a very valuable property of fine-grained concrete, especially repair fine-grained concrete (Bazhenov & Mazhyev, 2011; Bazhenov & Murtazayev, 2006; Batayev & Betilgiriev, 2012; Murtazaev et al., 2015a; 2015b). Therefore stress relaxation, for example, caused by forced deformation, can be significantly reduced in comparison with calculated ones on the assumption of elastic work fine-grained concrete (Aizenberg et al., 2009).

At the same time, relaxation process in fine-grained concrete also may play a negative role, causing, for example, losses of pretention of reinforcement, thereby reducing crack resistance of post-tensioned constructions (Awwad & Donia, 2016;

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Erzar et al., 2016; Farshbaf Aghajani et al., 2016; Feng et al., 2016; Garrabos et al., 2016; Ghazavi Baghini, 2016; Kumar et al., 2016; Ulitskiy, 1967). According to S.V. Alexandrovskiy (1979) when the voltage is equal to 0.3-0.5 Rb, relaxation process of normal-weight concrete can reduce initial voltage to 66%, and relaxation process of fine-grained concrete isn't yet investigated.

Materials and methods

Relaxation of compression stresses in autoclave silicate concrete, density of which is 1900 kg/m3 at initial voltage, equal to 0.3 prism strength, was investigated by V.I. Skatynskiy (1974). Duration of the experiments was 150 days. According to his experimental data, stress relaxation process in silicate concrete is most intensive within first 30-40 days, after which it decays rapidly. By the end of the test voltage reduction was 45-57% in concrete samples.

Comparison of experimental data on relaxation of stresses in both silicate and conventional concretes suggests that relaxation process in autoclave silicate concrete happens with less activity than in conventional concrete (Lei et al., 2016; Lin et al., 2016; Lombardi et al., 2016; Pesavento et al., 2016). Thus, degree of stress relaxation in silicate concrete is approximately 9-19% lower than in conventional concrete.

It was broached a question of stress relaxation in cellular silicate concrete, density of which is 800kg/m3, in the work. According to this work, initial force, equal to 0.5 prism strength, in cellular concrete samples has decreased by approximately 33-38% within 120 days.

Relaxation processes in fine-grained cellular concrete weren't exposed to special investigation. This work presents data on stress relaxation in the fine-grained cellular concrete, taking into account their carbonation. Carbonized and uncarbonized gas concrete prismoidal specimens and gas-ash ones, sizes of which are 10x10x40 cm, were experienced. Each series consisted of six isolated twin samples, loaded by compressive force, equal to 0.3 prism strength (Seo & Kim, 2016; Zheng et al., 2016; Zingg et al., 2016).

Constancy of initial deformation of the samples was achieved by periodic load reduction, taking into account allowance for shrinkage. Force in the samples was fixed, using a reference dynamometer, type of which is DOSM-3-1.

Figure 1 shows a general view of test setup, in which stress relaxation in fine-grained cellular concrete was investigated.

Decrease of force in central compressed specimens in consequence of relaxation was estimated by coefficient of its decay:

$$H(t) = \frac{N(t)}{N_0}, \tag{1}$$

where $N(t)$ – loading at the moment of time and N_0 – initial loading.

Results of our experiments, shown in fig. 2, indicate that in consequence of the carbonation relaxation ability of fine-grained concrete increases.

So, within 720 days of experience voltage of carbonized gas-ash concrete decreased by 88%, and voltage of uncarbonized one decreased only by 59%.

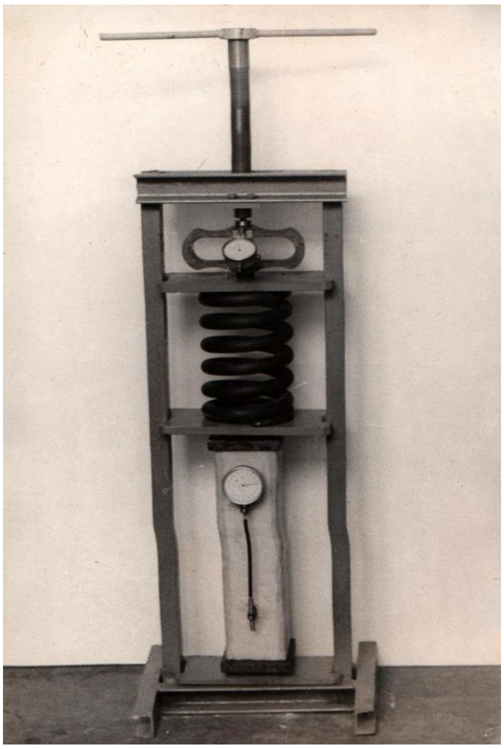
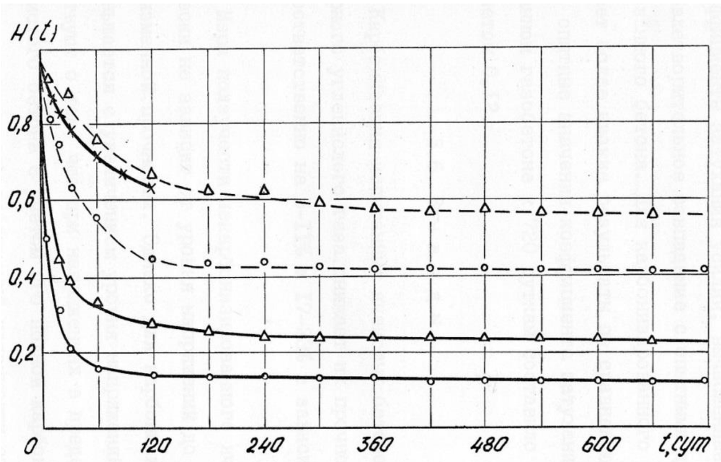


Figure 1. Spring-loaded installation for investigation of relaxation of stresses in fine-grained cellular concrete



- carbonized concrete
- uncarbonized concrete
- uncarbonized gas silicate (according to data of V.I. Skatynskiy (1964))

o - gas-ash concrete

Δ - gas concrete

Figure 2. Relaxation of stresses in fine-grained cellular concretes

Results and Discussion

Carbonation of concrete affects the speed of the process of stress relaxation. So, intense stress decrease in uncarbonized gas-ash concrete is observed for 60-80 days, and intense the same one in carbonized one is observed for 20-35 days.

Voltage of stress decrease in gas-ash concrete is 1.15 and 1.34 times less than in gas concrete consequently taking into account or not taking into account carbonation factor (table).

Experimental values of force decay coefficients for gas concrete samples were compared with ones, calculated according to the formula of theory of deterioration (Skatynskiy, 1964):

$$H(t) = e{-}\varphi(t), \qquad (2)$$

where φ(t) – concrete creep characteristic; e – base of natural logarithms.

Herewith module of elasticity of isolated uncarbonized gas concrete samples, and also carbonized samples from the moment of the end of the process of their full carbonation was considered to be constant over time.

Creep characteristics φ (t), necessary to calculate theoretical values of H (t), is obtained from experiments on investigation of creep on twin prisms, added along with prisms, on which the relaxation process was investigated.

Table 1. Comparison of the calculated and experimental values of force H(t) decay coefficient in samples of carbonized and uncarbonized fine-grained cellular concrete

Type of concrete	Carbonized			Uncarbonized		
Magnitudes / Time of day	φ(t) (experimental)	Experimental values $H(t)$	Calculated values $H(t)$	φ(t) (experimental)	Experimental values $H(t)$	Calculated values $H(t)$
10	0.92	0.46	0.40	0.20	0.85	0.81
20	1.08	0.43	0.34	0.28	0.80	0.76
30	1.15	0.38	0.32	0.33	0.78	0.72
60	1.40	0.33	0.25	0.42	0.76	0.66
90	1.55	0.32	0.21	0.48	0.72	0.62
120	1.69	0.30	0.21	0.51	0.70	0.60
360	1.89	0.26	0.26	0.61	0.59	0.54
420	1.93	0.38	0.38	0.63	0.58	0.53
480	1.96	0.25	0.25	0.66	0.575	0.517
540	1.98	0.24	0.24	0.68	0.57	0.507
600	2.0	0.235	0.235	0.70	0.564	0.497
660	2.05	0.23	0.23	0.71	0.562	0.492
720	2.12	0.22	0.22	0.72	0.56	0.487

Values, average by series, of experimental magnitudes of decay coefficients, and values, obtained by calculation, are shown in the table.

Force decay coefficients, calculated using the formula (2), give satisfactory agreement with the experimental data for fine-grained uncarbonized cellular concrete. Theory of deterioration gives lower results for fine-grained carbonized cellular concrete in comparison with the experimental data. Thus, experimental values of force decay coefficient was 0.22 in carbonized gas concrete within 720 days, and values, defined by calculation, was 0.12.

Conclusion

Thus, the degree of relaxation of compression stresses, as well as relaxation process reaction rate in carbonized cellular concrete carbonized is higher than in uncarbonized concrete. Fine-grained cellular concrete, taking into account and not taking into account carbonation factor, has a greater ability to stress relaxation than conventional concrete. It means that differentiated approach to assessment of relaxation processes depending, on the type of concrete, is necessary when calculating constructions of fine-grained cellular concrete.

Disclosure statement

No potential conflict of interest was reported by the authors.

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