In Fig. 4, the temperature fields of the inhomogeneous system and the quasihomogeneous body are compared in the case of the boundary conditions in Eq. (34) when $\nu = 10^{-2}$, $\beta = 10^{-2}$, $\varepsilon = 0.5, 0.2, 0.1$ (the temperature distribution in the cross section $\overline{x} = 1$ is shown).

Thus, the temperature field of the inhomogeneous system may be approximately calculated from the quasi-homogeneous-body model in Eqs. (1)-(4); in this case, Eqs. (7)-(9) are satisfied with a certain degree of approximation. For the simplest inhomogeneous systems, estimates of the error in passing to a quasi-homogeneous body have been obtained. For more complex systems (e.g., a structure with mutually interpenetrating components [1]), the following estimate may be proposed

$$\sigma \leqslant \max\{\sigma_{\perp}, \sigma_{\parallel}\}. \tag{38}$$

NOTATION

t, t_I, t_i, temperature of quasi-homogeneous body inhomogeneous system, and i-th component of system; a, λ, $c\rho$, thermal diffusivity and conductivity and volume specific heat of quasi-homogeneous body; a_i, λ_i, $c\rho_i$, the same quantities for the i-th component; q, heat flux; S, V, system surface and volume; x, y, coordinates; l, macrodimension of system; Θ, dimensionless temperature; $Fo = a\tau/l^2$, $Bi = \alpha l/\lambda$, Fourier and Biot numbers; $\nu = \lambda_2/\lambda_1$; $\beta = a_2/a_1$; N, number of plates; $\varepsilon = h/l$, ratio of micro- and macrodimensions; $\Delta\Theta_V$, σ, volume-averaged and mean-square error of dimensionless-temperature determination; τ, time; m_i, i-th component concentration.

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DETERMINATION OF PARAMETERS OF ARTIFICIAL CONSTRUCTIONAL CONGLOMERATES USING CRITERIAL EQUATIONS

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Generalized similarity criteria and criterial equations are proposed for determining the physicomechanical and thermotechnical parameters of artificial constructional conglomerates and their mixtures.

The definition of artificial constructional conglomerates (ACC), nomenclature, and theoretical and experimental investigations of their properties are given in [1].

At present, considerable experience has been accumulated in determining the change in ACC parameters on the basis of experimental investigations. These parameters, as a rule, are expressed by empirical dependences. The result of this empirical approach, however, is that sometimes there is a large number of formulas for determining the same ACC parameters.

In the present work, an approach to the determination of ACC parameters is outlined involving the use of criterial equations which include both individual criteria and generalized similarity criteria obtained as a result of similarity theory and dimensional analysis of physical quantities characterizing the ACC properties.

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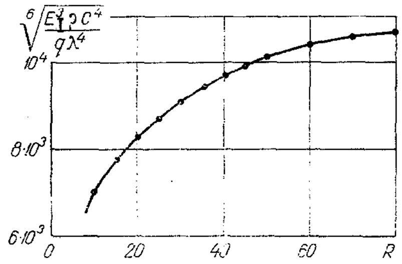

Fig. 1. Change in $\sqrt[6]{\frac{E_I^3\rho c^4}{q\lambda^4}}$ as a function of concrete strength R, MPa (10^5 kg/m·sec^2) under compression.

The similarity criteria comprise dimensionless complexes of quantities, in the form of products of these quantities (parameters) raised to different powers. They may be obtained from the defining equations of physical phenomena or by dimensional analysis. By means of similarity criteria and criterial equations, the physical phenomena of a system may be evaluated, and the change in individual physical quantities may be determined in terms of the other parameters.

The method of obtaining similarity criteria of physical quantities is outlined in [2], and individual similarity criteria characterizing the basic ACC properties are given in [3].

On the basis of the similarity criteria in [3], after certain mathematical operations, generalized similarity criteria may be obtained, and expressed in general form as follows

$$\Pi_i = \varphi(Z_1, Z_2, Z_3, \ldots, Z_m), \tag{1}$$

where Π_i are generalized similarity criteria; $i = 1, 2, 3, \ldots$; $Z_1, Z_2, Z_3, \ldots, Z_m$) are similarity criteria.

According to [3], the individual similarity criteria take the form

$$Z_1 = E\varepsilon\sqrt[3]{\rho c^2/\gamma^2\lambda^2};\ Z_2 = \frac{\sigma}{\sqrt{\gamma k}}. \tag{2}$$

These criteria were chosen because they include physical quantities characterizing the basic ACC properties, for which a large amount of experimental data is available; their values are given in SNiP II-21-75 and SNiP II-A.7-71.

Dividing Z_1 by Z_2, and replacing $\sqrt{F/L}$ by b yields the generalized criterion

$$\Pi_1 = b\sqrt[6]{E^3\rho c^4/q\lambda^4}, \tag{3}$$

or in general form

$$\Pi = b\sqrt[6]{K^3\rho c^4/q\lambda^4}. \tag{4}$$

Replacing K by E_I or $2G/(1+\mu)$, Eq. (4) yields the following generalized criteria

$$\Pi_2 = b\sqrt[6]{E_I^3\rho c^4/q\lambda^4};\ \Pi_3 = b\sqrt[6]{\left(\frac{2G}{1+\mu}\right)^3\rho c^4/q\lambda^4}. \tag{5}$$

The generalized criteria in Eq. (4) are conventionally divided into two factors including the physical-quantity complexes

$$\sqrt{F/L} = b \text{ and } \sqrt[6]{K^3\rho c^4/q\lambda^4}.$$

The first of these characterizes the geometric ACC parameters, and the second individual physicomechanical and thermotechnical ACC parameters.

In accordance with the data of SNiP II-21-75 and SNiP II-A.7-71 for heavy concrete with natural hardening of gravel or chippings of natural rock (State Standard GOST 13579-68, $\omega_A = 2\%$, $\omega_B = 3\%$), a curve of the change in $\sqrt[6]{E_I^3\rho c^4/q\lambda^4}$ against the strength of concrete under compression has been drawn (Fig. 1). The curve in Fig. 1 corresponds to the equation

$$a_1 R_I^{0,213} = \sqrt[6]{E_I^3 \rho c^4/q\lambda^4} \qquad (6)$$

or the equations

$$R_I^{0,213} = \frac{1}{a_1}\sqrt[6]{E_I^3 \rho c^4/q\lambda^4}; \qquad (7)$$

$$R_I^{0,213} = \frac{1}{a_1}\sqrt[6]{\left(\frac{2G}{1+\mu}\right)^3 \rho c^4/q\lambda^4} \qquad (8)$$

for the given concrete, $a_1 = 226$, and is of dimensionality $[M]^{-0.213}[L]^{-0.287}\times[T]^{0.426}$.

In general form for ACC, Eqs. (6)-(8) may be written as follows

$$aR^n = \sqrt[6]{K^3 \rho c^4/q\lambda^4}. \qquad (9)$$

From Eq. (9), the following dependence may be obtained

$$\lambda = c\left(\frac{K^4\rho}{q}\right)^{0,25} \Big/ (aR^n)^{1,5}. \qquad (10)$$

Denoting $\left(\frac{K^3\rho}{q}\right)^{0,25} \Big/ (aR^n)^{1,5}$ by α, Eq. (10) takes the form

$$\lambda = \alpha c. \qquad (11)$$

Substituting λ from Eq. (9) into the formula for the heat transfer in unit time, $Q = \lambda(F/\delta)(t_1 - t_2)$-gives

$$Q = c\,\frac{F}{\delta}\,(t_1 - t_2)\,(aR^n)^{-1,5}\left(\frac{K^3\rho}{q}\right)^{0,25}. \qquad (12)$$

For heavy concrete with the above parameters, Eq. (12) takes the form

$$Q = 3\cdot 10^{-3}\,\frac{cF}{R^{0,32}\delta}\,(t_1 - t_2)\left(\frac{E_I^3\rho}{q}\right)^{\frac{1}{4}}, \text{ J/sec}, \qquad (13)$$

or

$$Q = 0.71\cdot 10^{-3}\,\frac{cF}{R_I^{0,32}\delta}\,(t_1 - t_2)\left(\frac{E_I^3\rho}{q}\right)^{\frac{1}{4}}, \text{ cal/sec}. \qquad (14)$$

For other materials, Eqs. (9) and (12) are valid, but in this case the values of a and n may not correspond to the a and n for heavy concrete in Eqs. (6)-(8), (13), and (14).

If R in Eqs. (9) and (10) is replaced by $f(x_1, x_2, x_3, \ldots, x_m)$, where $x_1, x_2, x_3, \ldots, x_m$ are parameters characterizing the mixture (for concrete mixtures, the water–cement ratio, cement consumption, cement activity, etc.), Eqs. (9) and (12) may be written in the form

$$a\,[f(x_1, x_2, x_3, \ldots, x_m)]^n = \sqrt[6]{K^3\rho c^4/q\lambda^4}; \qquad (15)$$

$$Q = c\,\frac{F}{\delta}\,(t_1 - t_2)\,\{a\,[f(x_1, x_2, x_3, \ldots, x_m)]^n\}^{-1,5}\left(\frac{K^3\rho}{q}\right)^{0,25}. \qquad (16)$$

Thus, for example, if the formula $R_1 = (0.43\cdot 10^5)R_c(C/W + 0.5)$ from [4] for heavy concretes with $W/C \leq 0.4$ is substituted into Eq. (15) and (16), these equations take the form

$$226\left[0.43\cdot 10^5 R_c\left(\frac{C}{W} + 0.5\right)\right]^{0,213} = \sqrt[6]{E_I^3\rho c^4/q\lambda^4}; \qquad (17)$$

$$Q = c\,\frac{F}{\delta}\,(t_1 - t_2)\left\{226\left[0.43\cdot 10^5 R_c\left(\frac{C}{W} + 0.5\right)\right]^{0,213}\right\}^{-1,5}\left(\frac{E_I^3\rho}{q}\right)^{0,25}, \text{ J/sec}. \qquad (18)$$

The physical parameters appearing in the similarity criteria and the formulas have the following meaning and dimensions: c, specific heat, $[L]^2[T]^{-2}[\Theta]^{-1}$; R, stress, compressive or tensile strength, or shear stress, $[M][L]^{-1}[T]^{-2}$; G, shear modulus, $[M][L]^{-1}[T]^{-2}$; ρ, density, $[M][L]^{-3}$; λ, thermal conductivity, $[M][L][T]^{-3}[\Theta]^{-1}$; g, acceleration due to gravity, $[L][T]^{-2}$; K, elasticity coefficient, $[M][L]^{-1}[T]^{-2}$; E, Young's modulus, $[M][L]^{-1}[T]^{-2}$; μ, Poisson's ratio; b, a parameter, $[L]^{1/2}$; a, a coefficient, $[M]^{-n}[L]^{n-1/2}[T]^{2n}$; n, a power factor; σ, stress or pressure, $[M][L]^{-1}[T]^{-2}$; γ, specific weight, $[M][L]^{-2}[T]^{-2}$; ε, relative deformation; k, rigidity, $[M][T]^{-2}$; Q, heat transmitted through the surface normal to the wall in the direction of decrease per unit time, $[M][L]^2[T]^{-2}$; F, area, $[L]^2$; δ, wall thickness; [L]; $t_1 - t_2$, temperature difference between opposite surfaces of the wall; °C, $[\Theta]$; R_1, grade of concrete, $[M][L]^{-1}[T]^{-2}$; R_C, cement activity, $[M][L]^{-1}[T]^{-2}$; C, cement mass, [M]; W, water mass, [M]; E_I, initial elasticity modulus of concrete under compression and tension, $[M][L]^{-1}[T]^{-2}$; α, an index, $[M][L]^{-1}[T]^{-1}$. The symbols in square brackets denote dimensions in SI units: [M], mass, kg; [L], length, m; [T], time, sec; $[\Theta]$, temperature, deg.

Thus, the equations proposed—Eqs. (9), (12), (15), and (16) in general form and Eqs. (13), (14), (17), and (18) for heavy concretes—characterizing the functional relations between a series of physicomechanical parameters of both mixtures and artificial constructional conglomerates, may be used to determine the basic physicomechanical and thermotechnical parameters of ACC and their mixtures.

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USE OF FINITE-PENETRATION-DEPTH METHOD TO CALCULATE THE HEATING OF A PLANE PLATE UNDER THE ACTION OF A RADIANT HEAT FLUX

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Using the finite-penetration-depth method, a solution is obtained to the problem of plate heating a radiant flux. The results are compared with a numerical solution.

The heat-conduction problem with Stefan–Boltzmann boundary conditions is of considerable difficulty for analytic consideration, and requires linearization of the boundary conditions, or the use of numercial methods [1].

Below, the solution of one problem of this type by the finite-penetration-depth method [2, 3], an analog of the integral methods of boundary-linear theory, is considered. The basic idea is that it may be assumed, with sufficient accuracy for practical purposes, that heat penetrates into a heated body only to a finite depth, which is known as the heated layer. Following [2, 3], the heat-conduction equation for an infinite plane plate

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