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RESEARCH OF PRESSING PROCESS CONCRETE MIXTURES

On the basis of thermal, dynamic analogy, the article suggests determining the speed of pressure distribution in concrete mixture by solving the differential equation of heat conductivity. It is suggested to characterize the speed of distribution of pressure in concrete mixture by the coefficient of barotropic. The influence of concrete property mixture on the value of parameter of barotropic was estimated.

Keywords: principle of impulse saving, liquid phase, theory of soil compression, closeness of water, coefficient of barotropic.

Until recently there hasn't been an accurate analytical decision and mathematical description of the pressing process and pushing back of moisture during filtration consolidation of concrete mixture processed by external technological pressure. There researches exist no on determination of the pressure distribution dynamics in the array of concrete mixture under the action of seal pressure, that is important for the choice of the pressing mode, duration and intensity of its use.

Developing the theoretical bases of concrete mixture compression under the action of external pressure the basic theoretical principles of filtration consolidation and hydrodynamics have been used.

Using the well known principle of impulse saving (theorems of motion amount), it is possible to show out equation of liquid phase deleted by pressure from concrete mixtures [1]:

$$\frac{d}{dt}\iiint_{\upsilon}\overline{W}\rho dV = \iint_{s}\overline{P}dS + \iiint_{\upsilon}\overline{F}\rho dV \tag{1}$$

Converting the integral of superficial forces taken for surfaces in a triple integral and taking into account that a volume is taken arbitrarily, we get:

$$\frac{d(\overline{W}\rho)}{dt} = div\overline{P} + \rho\overline{F} \tag{2}$$

Mass forces can be defined by the formula:

$$\overline{F} = \frac{\mu\overline{W}}{K_p} = \frac{\overline{W}}{\frac{K}{\mu}\rho} = \frac{\overline{W}}{\frac{K_f}{\rho}\rho} = \frac{\overline{W}}{K_f} \tag{3}$$

Finally equation of motion in a vectorial form is possible to present in the form:

$$div\overline{P} + \frac{\rho\overline{W}}{K_f} = \frac{d(\overline{W}\rho)}{dt} \tag{4}$$

where μ, K – is viscidity of water and coefficient of the theoretical penetrating; ρ – is a volume mass of liquid phase; K_f – *is* a coefficient of filtration of concrete mixture.

For the elementary layer of dx on depth x on the thickness of concrete mixture the diminishing of water amount approximately equals the diminishing of porosity:

$$\iint_{s}\rho\overline{W}dS \approx -\frac{\partial(\rho\Pi)}{dt} \tag{5}$$

or

$$div(\rho\overline{W}) + \frac{\partial(\rho\Pi)}{dt} = 0 \qquad (6)$$

Porosity is known to be related to the coefficient of porosity ε with dependence of Π= *of ε/1+ε*, thus it is possible to write down:

$$\frac{\partial\Pi}{\partial t} = \frac{d\varepsilon}{(1+\varepsilon)dt} \qquad (7)$$

From the theory of soil compression it follows that

$$\frac{d\varepsilon}{dt} = e_o\frac{\partial P}{\partial t} \qquad (8)$$

where e_o *is* an aspect ratio, that equals:

$$e_o = (\varepsilon_1 - \varepsilon_2)(P_2 - P_1) \qquad (9)$$

then we get

$$\frac{\partial\Pi}{\partial t} = -\frac{e_o\partial P}{(1+\varepsilon)dt} = -e_\upsilon\frac{\partial P}{\partial t} \qquad (10)$$

If to put the expression got (10) in equation (6), we get:

$$div(\rho\overline{W}) + \Pi\frac{\partial\rho}{\partial t} - \rho e_\upsilon\frac{\partial\overline{P}}{\partial t} = 0 \qquad (11)$$

or

$$div(\rho W) + (\Pi\frac{\partial\rho}{\partial\overline{P}} - \rho e_\upsilon)\frac{\partial\overline{P}}{\partial t} = 0 \qquad (12)$$

Taking into account the insignificant changes of water closeness under pressure is possible write down:

$$\frac{\partial\rho}{\partial\overline{P}} \approx \rho_0\alpha_з \qquad (13)$$

Thus finally we get:

$$div(\rho\overline{W}) + \rho_o(\Pi\alpha_3 - e_\upsilon)\frac{\partial P}{\partial t} = 0 \qquad (14)$$

From equation (4), if to ignore the forces inertia, we write down:

$$\rho\frac{\overline{W}}{K_f} + div\overline{P} = 0 \qquad (15)$$

Hence it follows:

$$div(\rho\overline{W}) = -div(K_f div\overline{P}) = 0 \qquad (16)$$

We put expression (16) in (14):

$$-K_f div(divP) + \rho_0(\Pi\alpha_g - e_\upsilon)\frac{dP}{dt} = 0 \qquad (17)$$

$$\nabla^2 P = \frac{\rho}{K_f}(\Pi\alpha_g - e_\upsilon)\frac{\partial P}{\partial t}$$

or

$$\frac{\partial P}{\partial t} = \nabla^2 P \frac{K_f}{\rho(\Pi\alpha_g - e_\upsilon)} = \bar{a}_p \nabla_2 P \tag{18}$$

In equation (18) a relative condensability e_υ of concrete mixture is easy to define experimentally, knowing its module of deformation of *E:*

$$e_\upsilon = \frac{\Delta h\beta}{h(P_2 - P_1)} = \frac{\varepsilon_\upsilon\beta}{\Delta P} = \frac{\sigma_c\beta}{E\Delta P} = \frac{\beta}{E} \tag{19}$$

where β - is a coefficient which depends on the mode of pressing.

Equation of concrete mixture pressing (18) is similar to equations of water motion got in [2] and to the one of at pumping of concrete mixture selected in [3] equations of indissolubility, has expressions which differ in form and contents, for the coefficient a_p at an operator Laplasa.

In equation (18) the coefficient a_p is a coefficient of bar conductivity.

On the following example, it is worth defining a_p using set properties of concrete mixture: by the coefficient of filtration $K_f=0,00063$ cm/s; by porosity Π=0,2; by the coefficient of volume clench of water of $a_g=4\bullet10^{-5}\,1/kgs/cm^2=4\bullet10^{-4}\,1/MPa$; by the module of deformation of concrete mixture of $E\approx10,0$ MPa; $\beta=0,71$ [6] – at the clench of environment in the conditions of impossibility of lateral expansion.

The absolute value of coefficient of bar conductivity for this case is:

$$\alpha_p = \frac{K_f}{\rho\left|(\Pi\alpha_g - \frac{\beta}{E}\right|} = \frac{0,00063}{0,001\left|(0,2\cdot4\cdot10^{-5} - \frac{0,71}{100})\right|} = 88,7cm^2/s = 0,89\cdot10^{-2}m^2/s \tag{20}$$

The size of parameter a_p is determined mainly by the values of coefficient of filtration K_f and module of concrete deformation mixture *E* (Fig.1).

Thus to simplify the calculations the expression for defining within 1...1,5% is possible to present in the following form:

$$\alpha_p = \frac{K_f}{\rho e_\upsilon} = \frac{K_f E}{\rho\beta} \tag{21}$$

Let’s find distribution of effective pressures in concrete mixture of unlimited plate with a thickness δ=60 cm, pressed one-side by pressure of *P*=5,0 MPa.

To find of relative clench of concrete mixture we use the compression curves built for every particular value of concrete mixture composition (W/C) in the set range of pressure (Fig.2) [6].

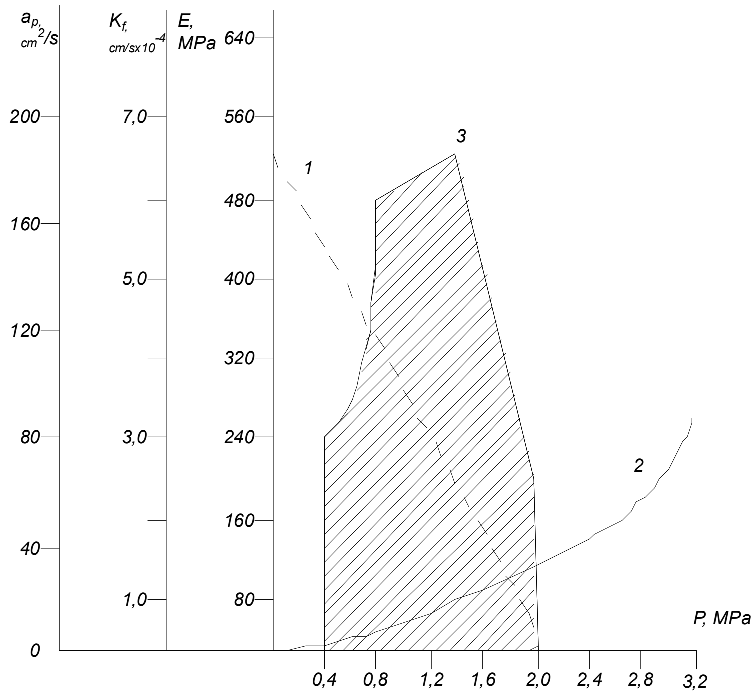

Fig.1 Change of bar conductivity coefficient depending on the coefficient of filtration (1) and module of concrete mixture deformation (2).

Since the coefficient of filtration K_f and relative condensability depend on pressing pressure $K_f = f(P)$, the value of bar conductivity coefficient a_p in the process of pressing will also change.

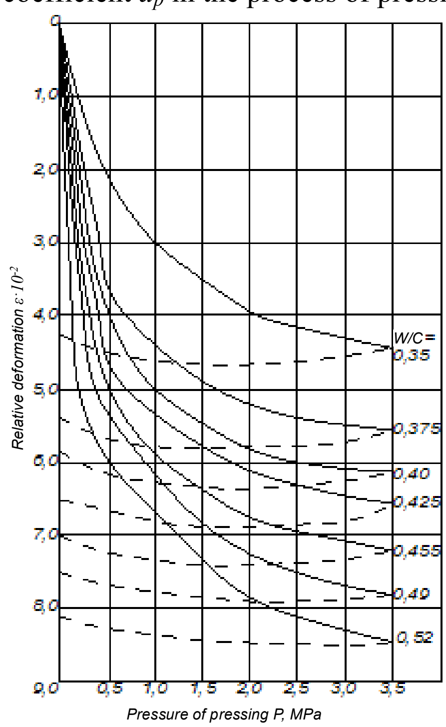

Fig.2 Dependence of relative deformation of concrete mixture clench from the size of water-and-cement ration and pressing pressure.

We can get more exact solution of one-dimensional task of concrete mixture pressing if take into account the change in time of bar conductivity coefficient in equation (18):

$$\frac{\partial P}{\partial t} = \frac{\partial\left(\alpha_p \frac{\partial P}{\partial x}\right)}{\partial x} = \frac{1}{\beta_\rho}\frac{\partial}{\partial x}\left(K_f E \ \frac{\partial P}{\partial x}\right) \tag{22}$$

The researches have shown that approximately the law of change of concrete mixture resiliency module in the process of pressing is possible to express by the equations:

$$E \ \approx 50K \ \sqrt{P^3} \tag{23}$$

where K – changes depending on the size of pressing pressure and concrete mixture composition.

If to be used in conditions of concrete mixture pressing the coefficient of filtration can be expressed by the formula [4]:

$$K_f = 0{,}03\left(\frac{P_n}{h_c}\right)^{1/aP_n} \frac{m_r^2}{\left(1-m_r\right)^{3/2}} \tag{24}$$

where h_c - is a height of standard; m_r - is concrete mixture porosity after compression; a - is a coefficient which takes into account the composition of concrete mixture.

Let's determine the value of a_p at the beginning of concrete mixture pressing W/C=0,375. From data of Fig.1 we find a value e_υ^l at growth of pressure to 1,0 MPa:

$$e_\upsilon^l = \frac{\varepsilon_\upsilon^l}{\rho_в^l}\frac{0{,}043}{10} = 0{,}0043\frac{1}{kgs/cm^2} = 0{,}043 \ \text{1/MPa.}$$

At the end of pressing that is at the change of pressure from 1,0 to 3,0 MPa

$$e_\upsilon^f = \frac{\varepsilon_\upsilon^f - \varepsilon_\upsilon^l}{P_f - P_l} = \frac{0{,}055-0{,}43}{\left[(30-10)\right]10^{-1}} = 0{,}006 \ \text{1/MPa.}$$

We calculate the value of coefficient of bar conductivity at the beginning and at the end of pressing. For this purpose we set the coefficient of filtration K_f=*0,00063* cm/s and K_f^f=0,00005 cm/s accordingly at the beginning and at the end of pressing [4], then:

$$a_p^l = \frac{K_f^l}{\rho e_\upsilon^l} = \frac{0{,}00063}{0{,}001\cdot 0{,}0043} = 146cm^2/s,$$

$$a_p^f = \frac{K_f}{\rho e_\upsilon^f} = \frac{0{,}00005}{0{,}001\cdot 0{,}0006} = 83cm^2/s.$$

The average value of coefficient a_p for pressing period equals:

$$a_p^{av} = \frac{a_p^l + a_p^f}{2} = 115cm^2/s = 115\cdot 10^{-4}m^2/s.$$

The speed of pressing pressure distribution in the array of concrete mixture can be calculated after the method of final differences.

For firmness of obvious approximation the limit on a step at times [5] must be adjusted:

$$\Delta\tau \le \frac{\Delta x_i^2}{2a_p}.$$

Set the layer thickness Δx_i =10 cm, then:

$$\Delta\tau = \frac{0{,}5\Delta x_i^2}{a_p} = \frac{0{,}5 \cdot 10^2}{115} = 0{,}434s.$$

The results of calculations show that during all pressing process of concrete mixture there is a substantial differential pressure on the thickness of flag. Gradually differential pressure for the layers of flag goes down (Fig.3).

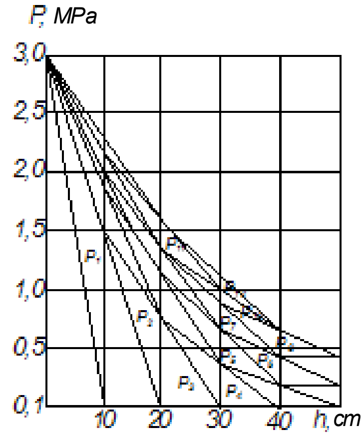

Fig.3 The dynamic of pressure change in a concrete standard at the one-sided pressing by pressure of 3,0 MPa in 0,43s time intervals.

On the basis of thermo-hidrodynamical analogy there has been suggested determining speed of pressure distribution in concrete mixture by solving differential equation of heat conductivity.

It is suggested to characterize the speed of pressure distribution in concrete mixture by the coefficient of bar conductivity. The influence of concrete mixture property (Fig.2) on the value of bar conductivity parameter was estimated.

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