V－158 SIMULATION OF DEWATERING OF FRESH CONCRETE UNDER MECHANICAL PRESSURE

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1. INTRODUCTION

This paper introduces the idea to simulate dewatering behavior of fresh concrete which is loaded under mechanical pressure. One-dimensional analysis of mixture with insignificant amount of air void is carried out to demonstrate simply the concept of mathematical simulation. The method can be applied to, for example, the tunnel lining process where water is squeezed out from the fresh concrete to obtain high strength as well as to pressure bleeding test which is done to check degree of blocking susceptibility of fresh concrete in pipe flow.

2. MATHEMATICAL SIMULATION

Considering an element of fresh concrete mixture with impermeable wall loaded with mechanical pressure as shown in Fig.1, mechanical pressure means pressure which is not applied to only solid or liquid phase but to both, pressure through a piston for example. We can obtain dewatering curve which is volume of water emitted from the mixture versus time. This dewatering curve changes with various factors such as applied pressure or mix design. In this paper the dewatering behavior is simulated mathematically by firstly, equation for one-dimensional flow of permeant in a porous media(2), assuming unvaried permeability in the flow direction, is introduced as

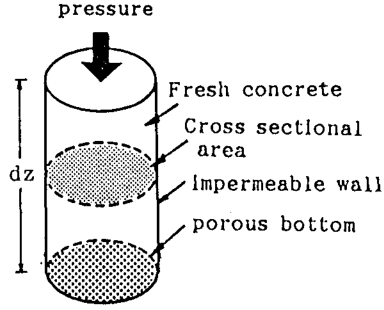

Fig.1 1-D dewatering element

$$k_z \frac{\partial^2 u}{\partial z^2} = S \frac{\partial e}{\partial t} + e \frac{\partial S}{\partial t} \qquad (1)$$

For mixture with insignificant amount of air void (S=1.0), flow equation in eq(1) can be rewritten as

$$k_z \frac{\partial^2 u}{\partial z^2} = \frac{\partial e}{\partial t} \qquad (2)$$

where k_z is permeability coefficient in z direction and u is pore water pressure. Saturation degree(S) is defined as ratio of volume occupied by water to the the total volume of void (water+air). Void ratio(e) is defined as ratio of volume occupied by water and air to the total volume of the mixture.

To derive u, the following equilibrium equation and the drained constitutive law of the solid in the mixture are essential and they are given as

$$p_z = \sigma_{ze} + u + f_z \Phi dz/A \qquad (3)$$

$$\sigma_{ze} = \sigma_{ze}(e) \qquad (4)$$

where p_z is the applied mechanical pressure, σ_{ze} is effective stress in z direction or stress transferred through structure of solid particles (coarse aggregate, sand and cement), u is pore water pressure. Φ and A are circumferential length, and sectional area of the element. dz is element height. f_z is friction stress between wall and solid particles and can be computed from

$$f_z = \mu K_o \sigma_{ze} \qquad (5)$$

where μ is coefficient of friction between wall and solid particles. K_o is lateral stress coefficient.

Solving eq.(2) to eq.(5) dewatering curve can be obtained. Dewatering volume is computed from reduction of void in the mixture neglecting air void (S=1.0).

k_z, μ, K_o and the constitutive equation are, in this paper, assumed in order to get qualitative results of dewatering as follows

μ = 0.58 K_o = 0.50

$k_z = k_z(\nu, e)$ $\sigma_{ze} = \sigma_{ze}(e)$

where ν is viscosity of the permeant. The form of function for σ_{ze} and k_z are illustrated in Fig.2 and Fig.3, respectively.

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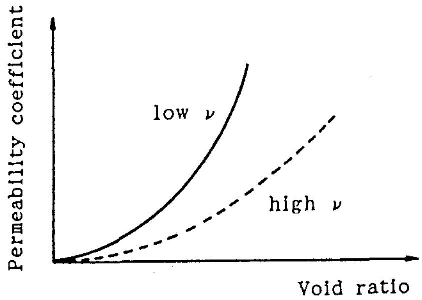

Fig.2 Assumed k_z curve

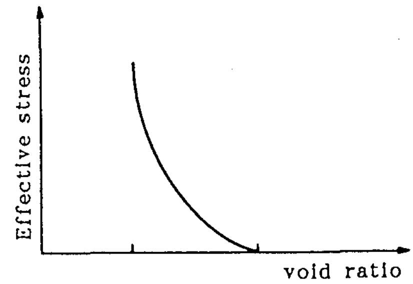

Fig.3 Assumed σ_{ze} curve

3. ANALYTICAL RESULTS AND DISCUSSION

The example of analytical results were obtained by analyzing fresh concrete mixture having initial total volume of 2000 cm^3 being filled in a cylindrical porous-bottomed vessel with 10 cm in diameter. Table.1 shows the analytical conditions used in each no. of analysis. The analytical dewatering curves are given in Fig.4. It can be observed that the dewatering rate and total dewatering volume are greater when initial void and the pressure are higher and when the viscosity of water is lower. The meaning of changing the parameters in Table.1 in sense of fresh concrete is, for examples, as follows; increasing initial void means increasing w/c ratio without changing mix proportion of cement, sand and coarse aggregate. Viscosity of the mixing water can be increased by adding some kinds of admixture. Pressure can be varied arbitrarily. Different proportion of cement, sand and coarse aggregate leads to different curve of σ_{ze}. Therefore, mix design can be taken into consideration in the analysis.

Table.1 Analysis conditions

Analysis No.	Initial Void (%)	Viscosity (g/sec・cm)	Pressure (kg/cm²)
1	17.5	1.0	5
2	18.7	1.0	5
3	17.5	1.0	15
4	17.5	4.0	5

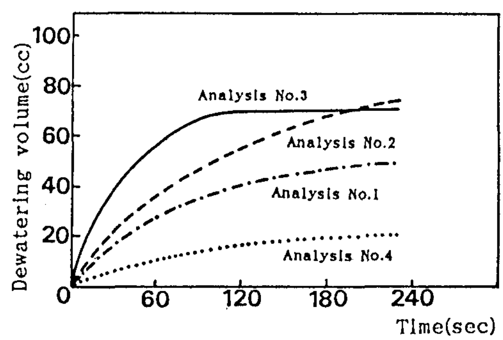

Fig.4 Analytical result

5. CONCLUSIONS

On the basis of this study, conclusions can be written as follows;

1) The idea for mathematical simulation of dewatering behavior of fresh concrete under mechanical pressure was introduced and the one-dimensional analysis of mixture with insignificant amount of air void is performed.

2) Mix design can be taken into account by means of parameters varied in the permeability coefficient, effective stress-void relationship, friction and lateral stress coefficient.

3) The amount and rate of dewatering are larger when applied pressure and initial void ratio are higher and when viscosity of mixing water is lower.

4) To simulate the dewatering quantitatively, the model for effective stress-void relationship, lateral stress, permeability coefficient and the concept which consider effect of air void are necessary.

REFERENCES

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