V-70 DEFORMATIONAL MODEL OF SOLID PHASE IN FRESH CONCRETE FOR MIXTURE WITH MIXED GRADING

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1. INTRODUCTION

This paper introduces a model for obtaining the stress-strain relationship of the mixture with mixed grading, in other word mixture of coarse aggregate, fine aggregate and powder materials which is based on the model for single materials [1]. This information is important when dealing with the analysis of deformational behavior of fresh concrete in which fresh concrete is treated as multi-phased material, for example the analysis of dewatering of fresh concrete under pressure [2].

2. IDEA OF THE MODEL

The idea is introduced on the basis of the proposed model for single materials [1]. The total stress of the mixture is considered to be the summation of stress contributed from each single material. The stress of each material is dependent on its void ratio and the stress-void relationships of the single materials can be obtained from their stress-strain relationships by applying the relationship between volumetric and linear strains. Each material does not produce stress unless its particles come into contact, in other words, its void ratio approaches e_{max} of the material where e_{max} is the void ratio at the commencement of stress. Consequently, the general expression for computing the stress of mixtures of single materials can be written as (j indicates the direction of stress and subscripts g, s and p refers to coarse aggregate, fine aggregate and powder materials, respectively)

$$\sigma_j = \sigma_{jg}(e_g) + \sigma_{js}(e_s) + \sigma_{jp}(e_p) \qquad (1)$$

where e_g is void ratio of the coarse aggregate where void of coarse aggregate is considered as the volume other than that occupied by the coarse aggregate which can be written in the following expression

$$e_g = \frac{V_t - V_g}{V_t} \qquad (2)$$

e_s is void ratio of fine aggregate and the solid volume of coarse aggregate is not considered in the domain to compute void ratio of fine aggregate. e_p is void ratio of the powder material and it is calculated using the domain $V_t - V_g - V_s$. Then

$$e_s = \frac{V_t - V_g - V_s}{V_t - V_g} \qquad (3)$$

$$e_p = \frac{V_t - V_g - V_s - V_p}{V_t - V_g - V_s} \qquad (4)$$

where V_t is total volume of the mixture at any moment. V_g, V_s and V_p are volume of coarse aggregate, fine aggregate and powder materials, respectively. The void ratio of each phase can be computed when the initial volume of the mixture and strains are prescribed (using the relationship between linear strains and volumetric strain). Let subscript i indicate the initial condition, then $V_t = V_{ti} - \triangle V$ and V_g, V_s and V_p equal V_{gi}, V_{si} and V_{pi} respectively. $\triangle V$ is volume decrease due to deformation.

The lateral stress coefficient (K_o) for the uni-axial confined compression case can be calculated from ($\sigma_x = \sigma_y$ and subscript z denotes the loading direction)

$$K_o = \frac{\sigma_{yg} + \sigma_{ys} + \sigma_{yp}}{\sigma_{zg} + \sigma_{zs} + \sigma_{zp}} = \frac{K_{og} \cdot \sigma_{zg} + K_{os} \cdot \sigma_{zs} + K_{op} \cdot \sigma_{zp}}{\sigma_{zg} + \sigma_{zs} + \sigma_{zp}} \qquad (5)$$

3 VERIFICATION TESTS AND DISCUSSIONS

3.1 TESTING METHOD AND MATERIALS USED IN THE TEST

Uni-axial confined compression testing method was used for verifying the proposed model. Fig.1 shows the apparatus used for this test and the set-up. The materials used were given in Table.1 together with their properties. Samples of the materials were filled into the hollow steel cylinder with open top and bottom. Four strain gauges were attached to the outer side of the

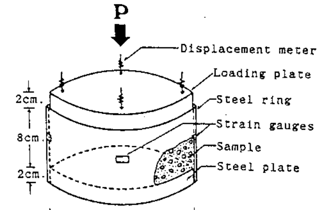

Fig.1 Apparatus

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Table.1 Properties of materials used in the test

Test	Material	Specific gravity(g/cc)	Finess (cm²/g)	K_o	e_{max} (%)
F	Fly ash	2.19	3000	0.63	43.2
S	River sand	2.62	(2.59)	0.52	40.2
G	River gravel	2.65	*	0.65	42.7

( ) Finess modulus * Size ranges from 5 to 15 mm

Table.2 Test condition

Test	Fly ash	Sand	Gravel
	(% by volume)		
FS	25.0	75.0	-
SG	-	75.0	25.0

steel ring for the purpose that lateral stress can be derived from the strain of the cylinder. Load was applied at the top of the cylinder and was measured with a load cell. Stress was derived by dividing the applied load with the cross-sectional area of the steel ring. To observe volume decrease during the test, four displacement transducers were set on the loading plate at the top of the cylinder. Initial void of the sample was calculated by subtracting solid volume of the sample from the volume of the cylinder. The solid volume of the sample was computed using specific gravity of the material to transform weight of the sample into its solid volume. Firstly, the tests for single materials were performed to obtain the stress-void relations for single materials which were utilized to predict the stress-strain relationships of their mixtures by utilizing the proposed model. Then the tests of mixtures of the single materials were carried on. The conditions of tested mixtures are given in Table.2.

3.2 ANALYTICAL AND TEST RESULTS

The results of stress-strain relationship and K_o for single materials in Table.1 are shown in Fig.2 with their corresponding best-fit curves. The result of gravel was fit at the low stress level since crushing took place at high stress level. Test and analytical results of the mixtures in Table.2 are plotted in Fig.3. The analysis were performed based on the best-fit of the test results of single materials since the paper is aimed to illustrate the idea of mixture (see ref.1 for analysis of single materials). It is seen from the figures that the analytical and test results are congruent.

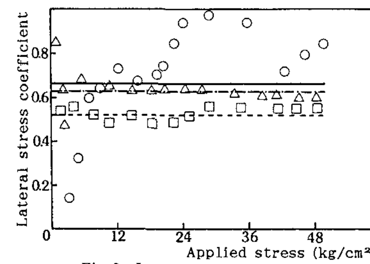

Fig.2a Lateral stress coefficient

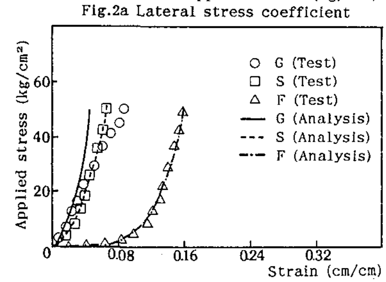

Fig.2b Stress-strain relationship

Fig.2 Test and analytical results of single materials

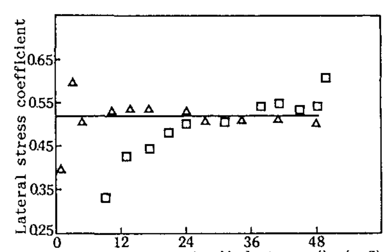

Fig.3a Lateral stress coefficient

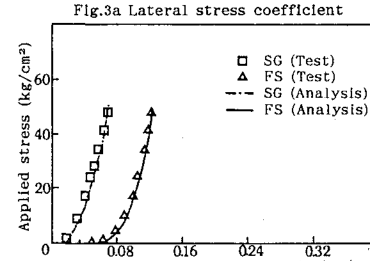

Fig.3b Stress-strain relationship

Fig.3 Test and analytical results of mixtures

4. CONCLUSIONS

Conclusions can be made as follows;

1) A model for obtaining stress-strain relationship of mixtures with mixed grading was introduced based on the model of single materials.

2) The uni-axial confined compression tests of various mixtures were conducted to verify the model and the comparison between the test and analytical results were proved satisfactory.

REFERENCES

1) Tangtermsirikul, S., Maekawa, K., "Deformational Model for Solid Phase in Fresh Concrete under Compression," Proc. of the annual conference of the JCI, 1989

2) Tangtermsirikul, S., Maekawa, K., et.al, "Mathematical Model for Dewatering of Fresh Concrete under Compression," Proc. of the 2nd East Asia-Pacific Conference on Structural Engineering and Construction, Vol.1, 1989, pp. 469-474