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INFLUENCE OF SAND PERCENTAGE TO FRESH CONCRETE PROPERTIES

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In recent years, the target value of slump in general concrete construction is changed from 8 cm to 12 cm in Japan so that constructors will aim to improve workability and ensure quality. However, increasing the concrete slump may cause material separation. As one of the evaluation methods of material separation of fresh concrete, although TAISEI CORPORATION developed a "T-post slump test," this test result depends on the engineers' experience because this test is the qualitative evaluation, not the quantitative evaluation. Therefore, in order to propose the simple evaluation method of this test, we investigate the relationship between the result of the T-post slump test and bleeding amount of fresh concrete in each sand percentage. As a result, it shows that the material separation, which water exudes on the surface, in the T-post slump test occurs at the sand percentage of 40.0% and 50.0% and the final bleeding amount also obtains 0.39 cm^3/cm^2 and 0.53 cm^3/cm^2.

Keywords: Slump, Material separation, Bleeding, Quantitative evaluation, Qualitative evaluation, Evaluation method.

1 INTRODUCTION

In Japan, since the high aseismic capacity has been required after the Hanshin-Awaji earthquake, the density of the reinforcing bars in the concrete is increasing. With the conventional slump target value of 8 cm, since the fresh concrete placement efficiency into the densified reinforced concrete is lowered, and the quality of the hardened concrete is expected to deteriorate due to the insufficient filling of concrete, we aim to improve these problems by modifying the slump target value of the concrete construction from 8 cm to 12 cm. However, it is generally considered that material separation occurs by enlarging the concrete slump. Here, Figure 1 shows the situation of T-post slump test. This test is one of the simple evaluation methods for separation resistance.

Figure 1. T-post slump test situation.

T-post slump test is the test conducted after slump test. First, when the slump test is conducted, we put the Phenolphthalein solution on the top surface of the fresh concrete stuffed in a slump cone before pulling out a slump cone. Then, we hit the corner of slump board with a hammer until the fresh concrete spreads to 47 cm and 52 cm after measuring the slump value of fresh concrete and confirm the change of the circular shape of the top surface with the Phenolphthalein solution at that time. However, the many experiences are required in this test because it is a qualitative evaluation, not a quantitative evaluation. Therefore, in order to evaluate this test quantitatively, we conduct the T-post slump test and the bleeding test, which focus on the sand percentage, in this study. From the relationship between both tests results, we try the quantitative evaluation of T-post slump test.

2 EXPERIMENTAL OUTLINE

2.1 Experimental Factors

Table 1 shows the mix proportion and the required quantity of each material in the concrete using in this study. The water cement ratio was 0.55 at all mix proportions. The standard mix proportion was 45.5% of the sand percentage and we changed only the sand percentage at each mix proportion to investigate the relationship between the T-post slump test and the bleeding test.

Table 1. Concrete mix.

Composition	**W/C**	**s/a**	**Unit Weight (kg/㎥)**					**F**
	(%)	(%)	W	C	S	G1	G2	(C × %)
Base	55	45.5	185	336	815	402	599	0.25
Change s/a	55	50.0	185	336	896	369	550	0.25
	55	40.0	185	336	716	443	659	0.25

2.2 Employed Material

Table 2 shows the type and density of the employed material. Two kinds of coarse aggregate and one type of fine aggregate were used in this study. Normal Portland cement is used, and Air Entraining (AE) water reducing agent was used as the admixture.

Table 2. Material and density.

Code	**Type**	**Density (g/㎤)**
C	Normal Portland cement	3.15
S	Crushed Sand	2.7
G1	Crushed Stone (particle diameter : 5-15mm)	2.77
G2	Crushed Stone (particle diameter : 10-20mm)	2.78
F	AE Water Reducing Agent (normal type)	1.25

3 EXPERIMENTAL RESULT AND CONSIDERATION

3.1 Aggregate Dispersion Distance

In this study, the aggregate dispersion was calculated by Kennedy's thickness of excess paste theory (Kennedy 1940). In this theory, concrete is made as a two-phase material of aggregate and cement paste. The gaps between the aggregates are filled with gap paste and concrete flows due to excess paste as shown in Figure 2. Assuming that the excess paste covers the aggregate, twice the thickness of excess paste is the aggregate dispersion distance.

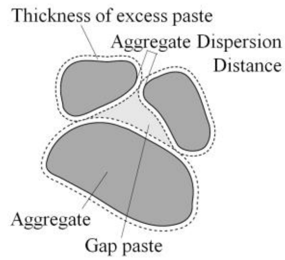

Figure 2. Aggregate dispersion distance.

The larger aggregate dispersion distance shows the higher the fluidity (Powers 1968). The aggregate dispersion distance is calculated by

$$D_{ep} = \left(\sqrt[3]{\frac{C_a}{V_a}} - 1\right) D_a \tag{1}$$

Where, D_{ep} is the aggregate dispersion distance (×10^3μm), C_a is the percentage of the absolute volume of aggregate (%), V_a is the aggregate volume ratio (%), and D_a is the mean size of aggregate (mm). C_a used in this study was a mixture value of fine aggregate and coarse aggregate. The mean size of aggregate is calculated by the following Eq. (2) (Tokumitsu 1965 and Teranishi *et al.* 2015).

$$D_a = \frac{1}{\sum_{n=1} \frac{(ln\, D_{n+1} - ln\, D_n)}{D_{n+1} - D_n} V_n} \tag{2}$$

In Eq. (2), n is the order of sieves counted from the smallest nominal size, D_n is the nominal dimension of nth sieve (mm), and V_n is the aggregate volume ratio staying at the nth sieve (%). Here, Figure 3 shows the relationships between the aggregate dispersion distance, the slump value and the sand percentage. In this figure, the horizontal axis is the sand percentage and the vertical axis on the left is the aggregate dispersion distance and the vertical axis on the right is the slump value. In general, when the sand percentage is increased, the aggregate dispersion distance decreases. This result is consistent with the past experimental results (Teranishi *et al.* 2015).

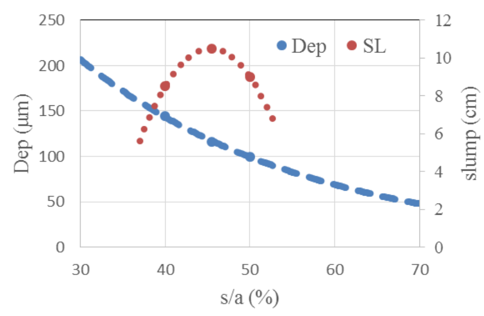

Figure 3. Aggregate dispersion distance and sand percentage.

However, there was no clear relationship between aggregate dispersion distance and slump value.

3.2 T-post Slump Test

For the determination of the material separation resistance in the T-post slump test, it is preferable that the colored circular shape of the top is kept circular at 47cm of the slump flow. When the colored circular shape collapses before 47 cm of the slump flow, it tends to separate. Also, the circular shape has to be lost at 52cm of the slump flow (Liang *et al.* 2012), and if a colored circle remains, it means that the separation resistance is too strong. Here, Figure 4 shows the condition of the slump flow at 47 cm for each sand percentage. Although the colored shape retained circular at 45.5% of the sand percentage, the circular shape collapsed at 40.0% and 50.0%. In addition, the material separation which water exudes on the surface was observed at 40.0% and 50.0%. In general, the viscosity and the material separation resistance of concrete with increasing the sand percentage. However, when the sand percentage is excessively increased and decreasing such as this result, material separation would occur. Also, Figure 5 shows the condition of the slump flow at 52cm of 45.5% of sand percentage. The colored circular shape showed the collapsed shape in this figure, so that separation resistance of the concrete in this study was appropriate at 45.5% of sand percentage in combination with the result at Figure 4.

Therefore, it is considered that the adequate design of the sand percentage is required to satisfy appropriate the material separation resistance for fresh concrete.

Figure 4. Result of T-post slump test.

Figure 5. Slump flow 52cm of 45.5% of sand percentage.

Figure 6 shows the relationship between the center height of the sample after the T-post slump test and the slump flow. The center height was examined at 47 cm and 52 cm of the slump flow. The sand percentage 40.0% and 50.0% changed the height from 8 cm to 6 cm. The sand percentage 45.5% changed from 11 cm to 6.5 cm. Considering the described above consideration, the center height of the fresh concrete, which was 45.5% of the sand percentage, with the appropriate material separation was higher than others at 47 cm of the slump flow. It is considered that the fresh concrete with the appropriate material separation resistance spreads its surround while keeping its center height due to its appropriate viscosity. On the other hand, all center height of 52 cm of the slump flow showed about 6 cm regardless of the sand percentage. From this result, it is effective to measure the center height at 47 cm of the slump flow after the T-post slump test to evaluate the material separation resistance.

Therefore, measuring the center height after the T-post slump test would be the effective method as a quantitative evaluation to investigate the material separation resistance of fresh concrete.

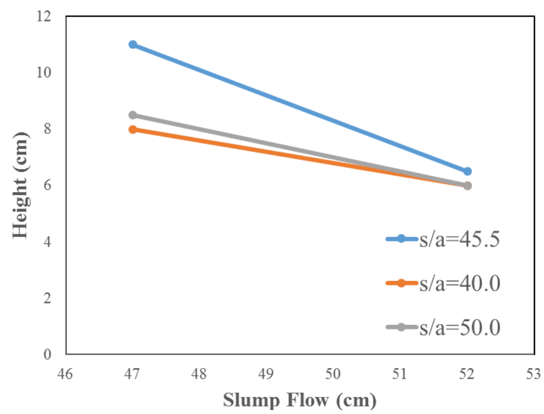

Figure 6. Aggregate dispersion distance and sand percentage.

3.3 Bleeding Test

The bleeding test was conducted by, a metallic cylindrical container with a diameter of 250 mm and a height of 285 mm. The concrete was filled in three layers. Measurement of bleeding was picked up by dropper on the surface. We measured every 10 minutes for the first hour and then measured every 30 minutes until there was no bleeding. Figure 7 shows the relationship between the elapsed time and the bleeding amount.

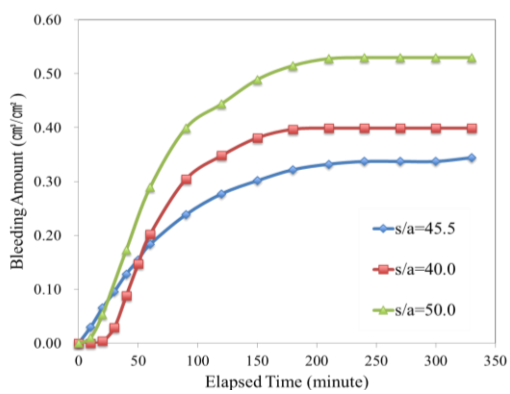

Figure 7. Aggregate dispersion distance and sand percentage.

It is considered from this figure that the bleeding amount occurs with the elapsed time even when the sand percentage is too small or too large. Also, when the sand percentage is at 45.5%, the bleeding amount is the smallest at 0.34 cm^3 / cm^2. From these results and the T-post slump test results, we find that there is a tendency of material separation when the bleeding amount is large.

4 CONCLUSIONS

In this study, we investigated the properties of concrete by the change of sand percentage. We obtained the aggregate dispersion distance and performed the T-post slump test and the bleeding test. From the experimental results, we can be concluded the following.

(1) There was no clear relationship between aggregate dispersion distance and slump.
(2) When the sand percentage is greatly changed from 45.5%, the material separation which water exudes on the surface occurs.
(3) The amount of bleeding of concrete in which material separation occurred in the T-post slump test tends to increase.
(4) The height of the slump flow 52 cm converges to approximately 6 cm.

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