Crushability of Pumice Particle Based on Statistical Approach

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1. Introduction

On April 14, 2016, a magnitude 6.5 earthquake occurred at an epicentre depth of approximately 10 km in Kumamoto Prefecture. This quake was followed by a second strong earthquake (M7.3) with a depth of 10 km on April 16, 2016, whose epicentre was near the first one. These earthquakes were caused by two active faults Futagawa and Hinagu fault. These two consecutive seismic events are known as the 2016 Kumamoto earthquake. An earthquake with a seismic intensity of 7 was the fourth in Japan. The second earthquake triggered landslides, rock falls, widespread liquefaction, and ground fissures and makes Kumamoto prefecture suffer significant damage. Kasama et al., (2021) study about the landslide in Kumamoto Prefecture and find out the pumice fall deposit layer has enough stability under normal conditions, and the strength reduction induced by the soil particle crushing is considered to be one of the factors that caused a long runout landslide. Pumice is found where volcanic rocks and pyroclastic flows occur. When lava or magma rises to the surface under high pressure and contains dissolved gases and vapors (the terminology is "lava"), the gases quickly escape as the lava cools rapidly to a solid state (Carver, 2020). Therefore in this study, a single particle crushability test was carried out with a statistical approach to predict the crushability behavior of pumice.

2. Experimental Procedure

Pumice samples were obtained from the area around Mount Aso. The sample of pumice sand was dried in the oven and then sieved. Based on the results of the sieve test in Table 1, three dominant sizes of pumice sand were selected, namely 4.75 mm – 2.00 mm (S1 = Large Particle), 2.00 mm – 0.850 mm (S2 = Medium Particle), and 0.850 mm – 0.425 mm (S3 = Small Particle).

Table 1. Sieving test result

Sieve Opening (mm)	Mass Retained (gr)	Mass Passing (gr)	% Finer by Mass
4.750	0.00	201.38	100.00
2.000	7.71	193.67	96.17
0.850	133.84	59.83	29.71
0.425	39.56	20.27	10.07
0.250	4.74	15.53	7.71
0.106	1.90	13.63	6.77
0.075	0.58	13.05	6.48
Pan	13.05	-	-

A total of 5 particles of each size were carried out for a crushability test with a loading speed of 0.50 mm/min. The crushability test apparatus is as shown in Figure 1, the particle pumice is compressed, and then the load force and displacement are read using a data logger.

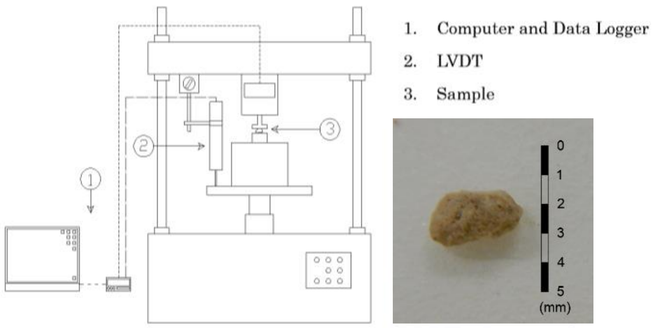

Figure 1. Apparatus setup and pumice sample

The results of the particle compressive strength test are then processed using the Weibull distribution as in Eq. (1).

$$F(t) = 1 - e^{-\frac{t}{\hat{\eta}}^{\hat{\beta}}} \quad (1)$$

Where: $F(t)$ is the cumulative density function, $\hat{\beta}$ is the shape parameter, $\hat{\eta}$ is the scale parameter, t is the limit.

3. Result

Tested 15 particles of pumice sand, and the first load peak (σ_s) was recorded, as shown in Figure 2. The results of the crushability test and regression line can be seen in Figure 3.

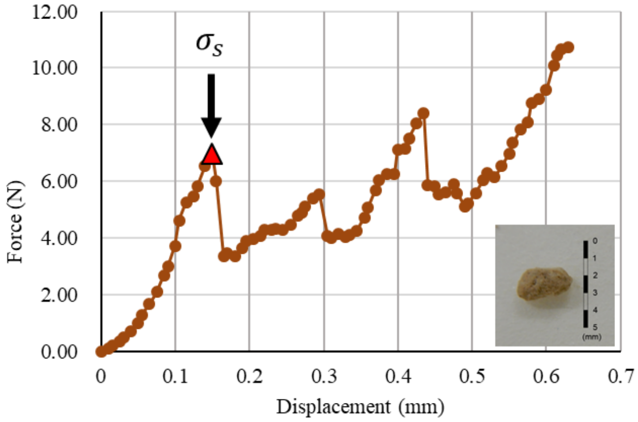

Figure 2. Crushability test result

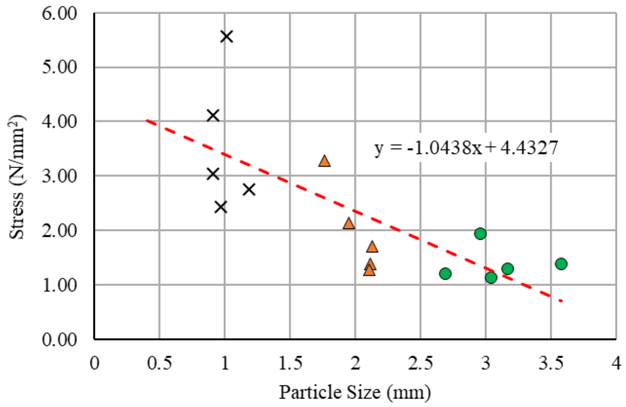

Figure 3. Pumice particles crushability

4. Discussion

The results of the crushability test on the pumice show that the reduced particle size increases the strength of the pumice particles. In other words, smaller particles are stronger can be seen in Figure 4. Based on the statistical approach with Weibull parameters, the results are shown in Figure 5.

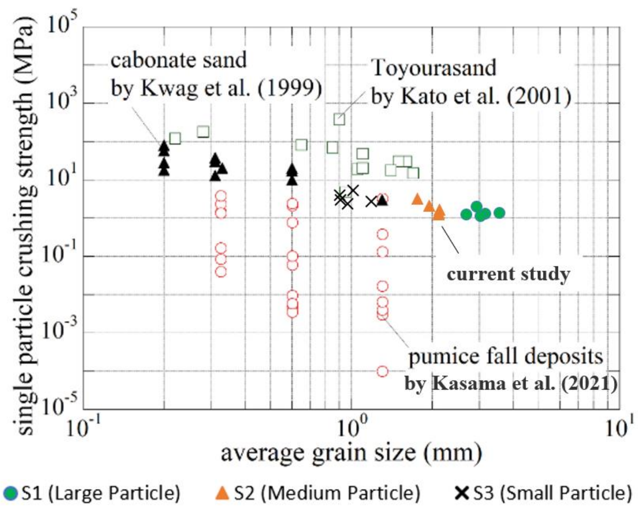

Figure 4. Comparison of pumice particles crushability

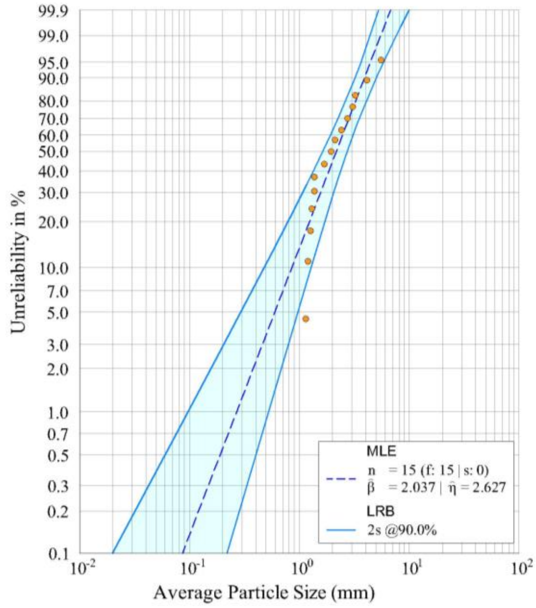

Figure 5. Weibull distribution of pumice particles

Figure 5 shows the relationship between the size of the pumice on the x-axis and the unreliability on the y-axis. With this relationship and including scale and shape parameters, it can predict the durability of pumice particles of different sizes, which are represented by unreliability values. In this study obtained the value of the scale parameter is 2.627, and the value of the shape parameter is 2.037 with a likelihood ratio bounds (LRB) is 90.0%.

5. Conclusions

Based on the experimental test can be obtained the smaller the pumice particle, the greater the compressive strength. The strength of the pumice is slightly different from previous studies because of the different source locations of taking the pumice samples. Weibull distribution can be used to predict the durability of pumice particles of different sizes, which are represented by unreliability values.

References

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