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STUDY ON EVALUATION OF BOND CHARACTERISTIC FOR SPRAYING MATERIAL WITH BAMBOO

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In this study, bamboo and solidification material are used as spraying materials and their bond characteristic with the mortar as the base material is evaluated. Four different proportions of specimens are prepared as the spraying material. The types of fine aggregate, the mixing ratio, and the bamboo content are applied as the different parameters. The box shear test is used in this study to investigate these characteristics. As a result, under the same mixing ratio, the bond strength of the spraying material mixed with flying sand is greater than that of the splayed material mixed with decomposed granite soil. Also, the strength of the spraying material using flying sand decreases with increasing the bamboo fiber amount, while the strength of the spraying material using decomposed granite soil increases. Therefore, it is clarified that although using flying sand is effective as the spraying material, in the case of using decomposed granite soil, increasing the bamboo fiber amount is required.

Keywords: Mortar, Construction materials, Box shear test, Adhesion strength.

1 INTRODUCTION

Bamboo grows about 3 meters of underground stem every year and produces bamboo shoots from it. Bamboo grows very fast. Once above ground, they can grow to 10 to 20 meters in a few months (Suntory Holdings Limited 2022). If there is an abandoned bamboo grove next to a wooded area, bamboo expands the underground stems into a wooded area and expropriates the sunlight of a wooded area. Therefore, a wooded area dies due to bamboo growth. However, if bamboo can be effectively utilized, it can be used as an environmentally friendly material (Takex Labo Corporation 2022). Currently, in Japan, the slope splaying construction method using waste bamboo material is used as one of the projects to contribute to environmental regeneration (Green Organic Materials Corporation 2022). Also, this construction method is applied to the creation of seaweed beds and fishing grounds. However, when this method is used in the sea, environmental issues, such as the microplastics problem, occur due to plastic bags. It is important to prevent the microplastics problem if this method applies to the sea. For the prevention example, it is considered that directly spraying the material on the base materials, such as tetrapod, does not require plastic bags. Therefore, it is crucial to evaluate the adhesion strength between the base part and the spraying material. This study establishes a test method to measure the adhesion characteristics of the spraying material on the mortar, which assumes the base material and investigates whether the spraying material has enough adhesion strength to the mortar.

2 EXPERIMENT SUMMARY

2.1 Materials Used and Mix Proportions

All the materials used in this study were produced in Japan. The spraying materials were prepared by mixing the magnesium oxide of 80% purity, magnesium chloride, flying sand or decomposed granite soil, bamboo, water, and inorganic granules. Table 1 shows the mixed proportions. Here, bamboo fiber was used in this study, as shown in Figure 1.

Table 1. Mix proportions.

Mix Proportion	Magnesium oxide of 80% purity (kg)	Magnesium chloride (kg)	Flying sand (kg)	Decomposed granite soil (kg)	Bamboo fiber (L)	Water (L)	Inorganic granules (kg)
1	20	25	128	-	40	30	0.1
2	20	25	77	-	80	30	0.1
3	20	25	-	133	40	30	0.1
4	20	25	-	80	80	30	0.1

Figure 1. Bamboo fiber.

2.2 Test Method

The box shear test was performed in this study. A cylindrical formwork with inner diameter D = 60 mm and height H = 10 mm was used for producing the specimens. Mortar was assumed as the base material in this study. The mixed ratio of the ordinary Portland cement, sand, and water is 1:3:0.6. First, the mortar as the base material was filled into the formwork and left to cure in the air at room temperature for 48 hours (Figure 2). Secondly, the same formwork was piled up and the spraying material was filled to a height of 10 mm above the base material. After that, the specimens were cured for two weeks at a constant temperature and humidity of 20°C and 60% (Figure 3). The adhesive characteristic was defined as the shear strength gained from the bonded surfaces of the mortar and the spraying material at the box shear test (Figure 4). Here, the shear strength was calculated by Eq. (1).

$$\tau = \frac{S}{A} \tag{1}$$

where τ is the shear stress (N/mm^2), S is the shear force (N), A is the cross section (mm^2). At least three specimens were tested, and the average value was used as the shear strength. Also, mortar, which has the same proportion as the base material, as the spray material was used on the base material for comparison with other specimens.

Figure 2. Preparation of the base material.

Figure 3. Filled with the spraying material.

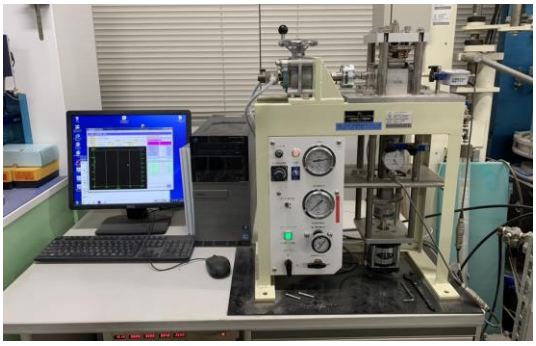

Figure 4. The box shear tester.

3 RESULTS AND DISCUSSION

3.1 Strength Variation with Different Types of Fine Aggregate

This section investigates the influence of the types of fine aggregates in the spraying material on the adhesive characteristic. The types of fine aggregate are flying sand and decomposed granite sand. The mix proportions considered here are the Mix proportion 1 and the Mix proportion 3 in Table 1. Also, the bamboo fiber amount is the same. Figure 5 shows the average strength of the maximum shear strength of the specimens with flying sand and decomposed granite soil. The mortar used as the spraying material on the base material is also shown in this figure for comparison. As a result, the shear strength of the specimens with flying sand is greater than that

of the specimens with decomposed granite soil. Therefore, using flying sand as fine aggregate is more effective for shear strength than decomposed granite soil.

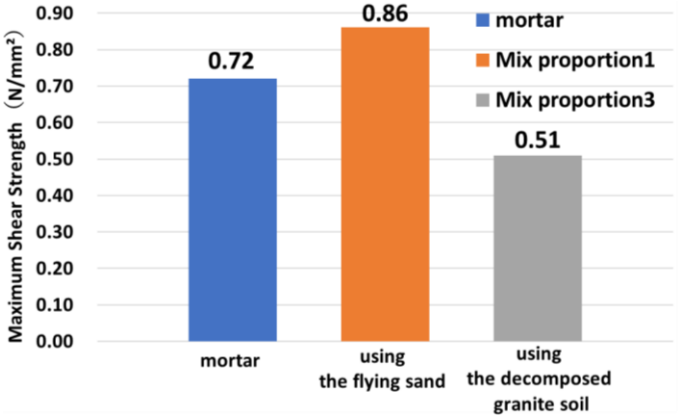

Figure 5. Strength comparison of different types of fine aggregate.

3.2 Change in Strength due to Different Mix Proportions of the Bamboo Material

The shear strengths of spraying materials are compared by varying the proportion of bamboo fiber in this section. The mix proportions considered here are from the Mix proportion 1 to the Mix proportion 4 in Table 1. Figure 6 shows the change in the average strength of the maximum shear strength for different proportions of bamboo fiber. As a result, when decodeco sand is used, the shear strength decreases as the bamboo fiber amount increases. On the other hand, in the case of decomposed granite soil, the strength increases as the bamboo fiber amount increases. In the previous session, using flying sand was effective for adhesive characteristics. However, the strength of decomposed granite soil is increased by replacing this soil with bamboo fiber. Therefore, it shows that bamboo fiber is an effective material for the adhesive characteristics of decomposed granite sand.

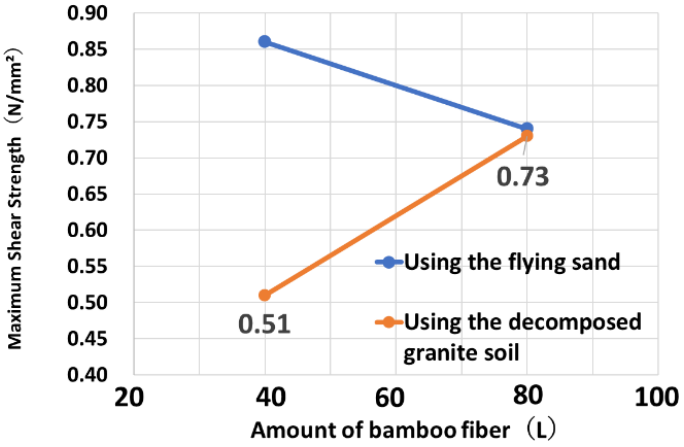

Figure 6. Change in strength due to different proportions of the bamboo material.

Micrographs were taken of the adhesion surfaces between the mortar and the spraying material after the shear tests. Figure 7 shows a specimen with a small bamboo fiber amount. Figure 8 shows

a specimen with a large bamboo fiber amount. When the bamboo fiber amount is large, more spraying material remains on the surface. The red circles in Figure 8 show the areas of the spraying material where the bamboo material is entangled. Therefore, it can be confirmed that the spraying material adhering to the mortar in Figure 8 contains more bamboo material than in Figure 7. It is also considered from these figures that the bamboo fiber works to increase the adhesion to decomposed granite soil than flying sand.

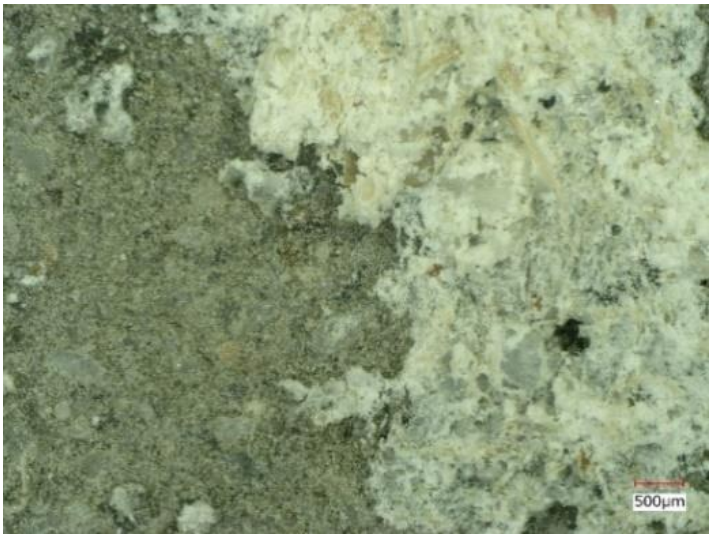

Figure 7. Mix proportion 3.

Figure 8. Mix proportion 4.

4 CONCLUSIONS

This study measured the adhesion strengths of spraying materials by using the shear strengths for four different mix proportions. From the obtained results, the following conclusions are drawn. The adhesion strength is greater and more effective when flying sand is used. However, even with

the use of decomposed granite soil, the adhesion strengths of spraying materials can be increased by increasing the bamboo fiber amount. Also, it is possible to close to the adhesion strength of flying sand.

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