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EFFECTS OF BAMBOO ON FRACTURE CHARACTERISTICS OF BAMBOO REINFORCED CALCIUM CONCRETE MEMBER

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The calcium-based solidification material enables us to expect the reduction of environmental burdens because it is near-neutral. We defined the concrete using this material as Calcium (Ca) concrete, and we have performed some experiments to investigate the properties of this concrete. From these results of previous experiments, we think that Ca concrete will be effective material on strength as a new civil engineering material. However, it is difficult to use steel as reinforcement material in Ca concrete due to near-neutral. Therefore, the bamboo is used as reinforcement material in this paper. And, the effect of bamboo as reinforcement material in Ca concrete is examined by investigating the fracture properties of Ca concrete reinforced by bamboo from four-point bending test. In particular, this investigation pays attention to the effect of the number of reinforcing bamboo. As a result, it becomes clear that the bending strength of Ca concrete with reinforcing bamboo is stronger than the strength of Ca concrete without reinforcing bamboo.

Keywords: Number of bamboo, Bending strength, Fracture condition, Covering, Slip.

1 INTRODUCTION

The cement concrete, the one of the most important construction material in recent construction project, has some problems. For example, because the cement is alkaline, the cement may have harmful influence on nature environment and the disposal of concrete is also difficult when the concrete is discarded at the field of construction work. So, this study pays attention to the calcium-based solidification material to consider the construction material for environment and landscape instead of cement. In our previous research, we made the concrete using this solidification material and defined it as Ca concrete. Then, we have performed some experiments to investigate the properties of this concrete. As the experimental results, we have thought that Ca concrete will be effective material on strength as a new civil engineering material (Shimabukuro 2009, Shimabukuro 2013). However, it is difficult to use steel as reinforcement material in Ca concrete because this solidification material is near-neutral. Therefore, the bamboo is used as reinforcement material in this paper. From the above, the purpose of this study is to investigate from four-point bending test about the fracture condition of Ca concrete with reinforcing bamboo and bending strength of Ca concrete with reinforcing

Table 1. Mix proportion quantity of Ca concrete.

W (kg/m^3)	Ca (kg/m^3)	S (kg/m^3)	G (kg/m^3)
165	275	803	1005

W: Water, Ca: Calcium-based solidification material, S: Fine aggregate, G: Coarse aggregate

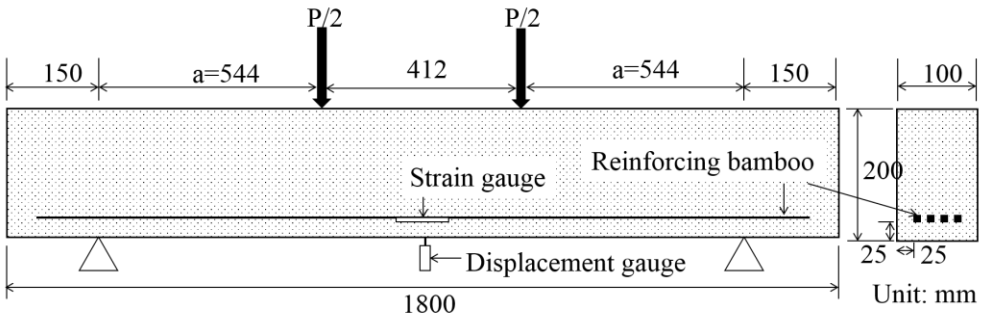


Figure 1. Size of specimen and detail of four-point bending test.

bamboo. We consider the effect of bamboo as reinforcement material in Ca concrete from the test results.

2 CALCIUM BASED SOLIDIFICATION MATERIAL

The calcium based solidification material (Japan Conservation Engineers Co., Ltd. 2002) has brown color like natural soil and is composed from mineral component. The main purpose to use this material is application to recreation trail and grass proofing at slope. The following shows the typical characteristics examples of this material.

(1) The pH at the time of the spraying is near-neutral.

(2) This material has water permeability and water retentively.

Thus, the calcium based solidification material is an attractive material for the environment and the landscape instead of cement.

3 EXPERIMENTAL OVERVIEW

The requisite quantity of the each material for Ca concrete in this study is shown in Table 1. The specimen of the bamboo reinforced concrete member which is locating four reinforcing bamboo and the detail of four-point bending test are shown in Figure 1, as example. The size of the reinforcing bamboo is 1700mm long, 10mm wide, and approximately 10mm thick. The kinds of the specimen are three kinds that the number of reinforcing bamboo is different. The number of the reinforcing bamboo located in Ca concrete is 1, 2, and 4 of them, respectively. Also, when the reinforcing bamboo is located in Ca concrete, the covering is approximately 25mm. Two specimens are made for every one kind. Using these specimens, we performed four-point bending tests. Here, the loading rate is 2.0mm/min. We examine the fracture characteristics of

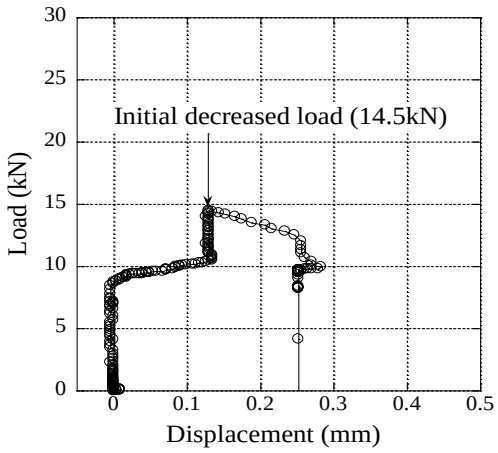


Figure 2. Bending load and displacement relation.

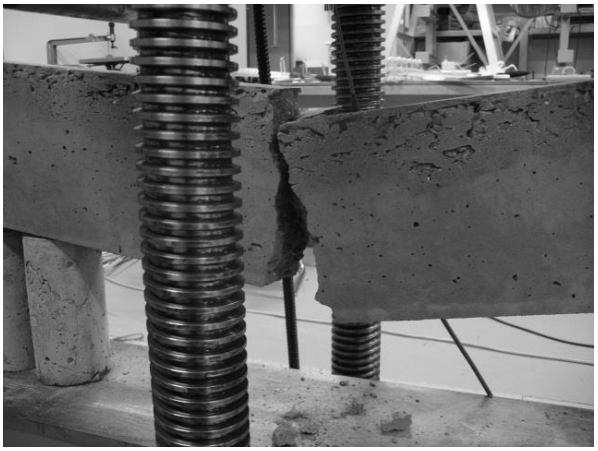
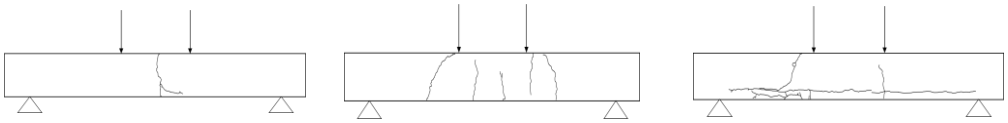


Figure 3. State of fracture after bending test.



(a) One reinforcing bamboo (b) Two reinforcing bamboo (c) Four reinforcing bamboo

Figure 4. Fracture conditions of each specimen after the bending test.

bamboo reinforced concrete from comparing these tests results with non-bamboo tests results.

4 EXPERIMENTAL RESULT AND CONSIDERATION

4.1 Result of Ca Concrete Member without Reinforcing Bamboo

The bending test result of Ca concrete member without reinforcing bamboo and the state of fracture are shown in Figure 2 and Figure 3, respectively. It shows that the load decreased after the peak load from Figure 2. Also, it is considered from Figure 3 that rapid fracture occurred after the peak load because a large crack occurred at tension side.

4.2 Fracture Condition

The fracture conditions of the each specimen after the bending test for the each number of bamboo are shown in Figure 4. Figure 4(a), (b), and (c) are shown as one reinforcing bamboo, two reinforcing bamboo, and four reinforcing bamboo, respectively. It shows that bending crack appeared in the range of pure bending span at all specimens.

In the case of Figure 4(a) reinforced by one bamboo, fracture of concrete occurred after the bending cracks in the range of pure bending span reached load surface. On the other hand, in the case of Figure 4(b) reinforced by two bamboo and Figure 4(c)

reinforced by four bamboo, the bending cracks occurred in the range of shear span after the bending cracks occurred in the range of pure bending span. As the cause that the bending cracks occurred in the range of shear span, if more bamboo were located in concrete, the surface area of bamboo would expand and the bond of concrete and bamboo would become strong. So, the friction between concrete and bamboo rose. Therefore, the bending moment in the range of shear span became larger than the occurrence moment of the bending cracks because the bending cracks occurring in the range of pure bending span did not extend due to that effect and not reach load surface, so it would be considered that the bending cracks occurred in the range of shear span. And then, it would be considered that the bending cracks in the range of shear span changed to the flexural shear cracks extending slantwise to direction of load points. Also, in Figure 4(c), it shows that lateral cracks occurred at the lower part locating reinforcing bamboo in the concrete. As this cause, when Ca concrete was cast to formwork locating reinforcing bamboo, which was not fixed to somewhere, the reinforcing bamboo was stirred to neighborhood of side surface of specimen and then its bamboo absorbed water existing at side surface of concrete. So, it would be considered that lateral cracks occurred along reinforcing bamboo at that part because the concrete at that part shrunk.

Therefore, it would be important to satisfy the enough covering for the bamboo reinforced Ca concrete to prevent shrinkage of the concrete.

4.3 Effect of the Number of Reinforcing Bamboo on Relationship between Bending Load and Displacement

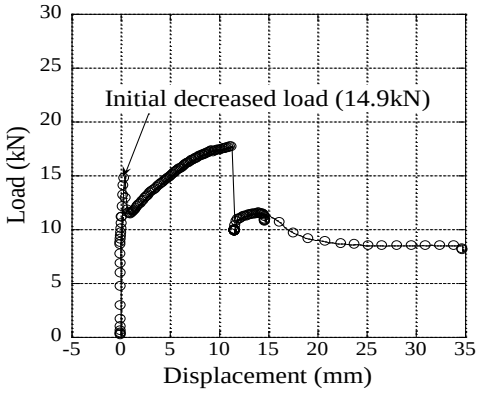
The relationship between bending load and displacement at the tension edge of central part in specimen is shown in Figure 5. Figure 5(a), (b), and (c) show the typical each example of the reinforcing bamboo number of one, two, and four, respectively.

In comparison with the result of non-bamboo reinforced Ca concrete at Figure 2, the load decreased after reaching 14.5kN as peak load in Figure 2. However, in the all relationships of the bamboo reinforced Ca concrete, it shows that the load increased again after the concrete fracture started and the load decreased once. It would be considered that even if the concrete fracture occurred, the specimens endured the more load due to bamboo strength. Also, the values of initial decreased load in Figure 5(a), (b), and (c) are shown as 14.9kN, 15.6kN, and 26.4kN respectively. If the initial concrete fracture occurred at these values, the values increased than the value of Figure 2. Therefore, it became clear that the occurrence load of concrete fracture rose with increase of the number of bamboo.

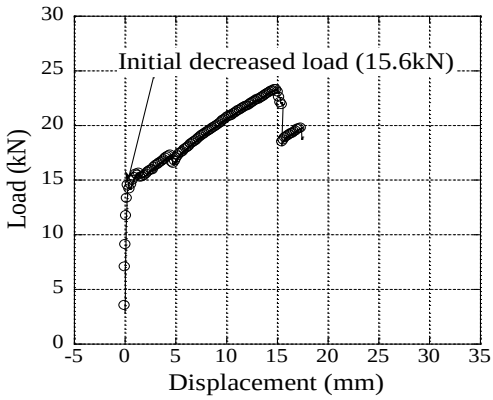
From the above, it would be considered that the bamboo is effective as reinforcement material of Ca concrete.

4.4 Effect of the Number of Reinforcing Bamboo on Relationship between Bending Load and Reinforcing Bamboo Strain

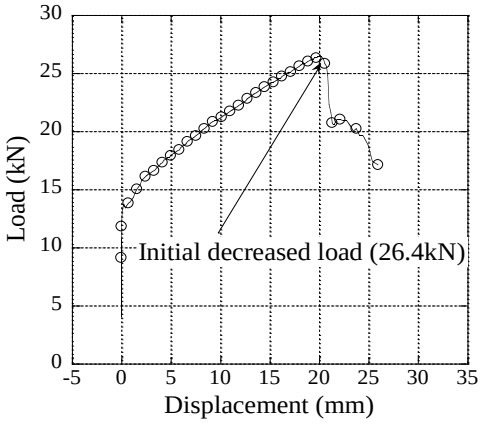
The relationship between bending load and reinforcing bamboo strain is shown in Figure 6. Figure 6(a), (b), and (c) show the typical each example of the number of reinforcing bamboo and correspond to Figure 5(a), (b), and (c), respectively. Here, Figure 6(c) shows result of two of four reinforcing bamboo.



(a) One reinforcing bamboo

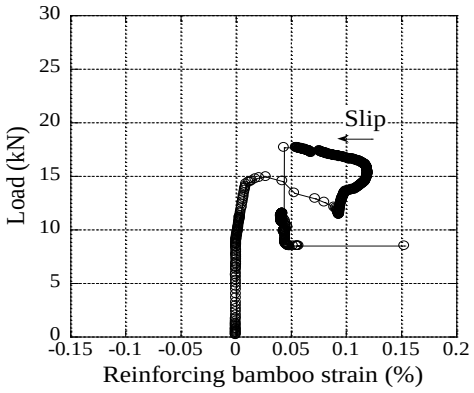


(b) Two reinforcing bamboo

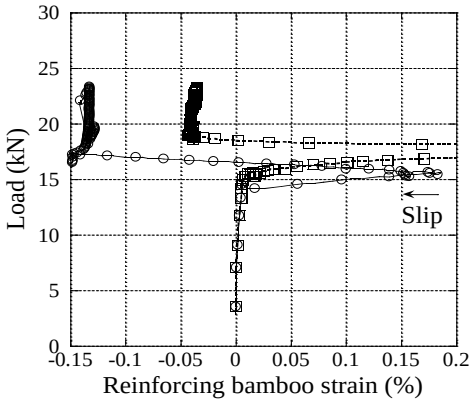


(c) Four reinforcing bamboo

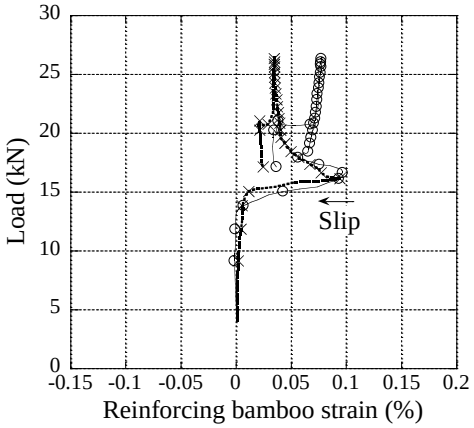
Figure 5. Bending load – displacement relation.



(a) One reinforcing bamboo



(b) Two reinforcing bamboo



(c) Four reinforcing bamboo

Figure 6. Bending load – reinforcing bamboo strain relation.

In Figure 6 (a) as one reinforcing bamboo and (b) as two reinforcing bamboo, it would be considered that the reinforcing bamboo did not yield because the strain only slightly occurred at initial decreased loads which are 14.9 kN and 15.6 kN. Therefore, the concrete fracture started before the reinforcing bamboo yielded. Since the general fracture tendency of reinforced concrete is that fracture occurs after reinforcing steel yields, this tendency is different from the general fracture tendency of reinforced concrete. Thus, it would be considered that the concrete and the reinforcing bamboo were not unified because the bond strength between concrete and reinforcing bamboo was low. On the other hand, in Figure 6 (c), as four reinforcing bamboo, it would be considered that the reinforcing bamboo yielded before concrete fracture occurred because the strain substantially occurred before reaching initial decreased loads of 26.4 kN. As this reason, as previously described, if more reinforcing bamboo was located in concrete, the surface area of reinforcing bamboo would expand and the bond of concrete and bamboo would become strong. So, the friction between concrete and bamboo became larger than locating one or two reinforcement bamboo in the concrete and it would be considered the concrete and reinforcing bamboo were unified more.

Furthermore, it shows that the strain of reinforcing bamboo shifts from positive direction to negative direction in all Figure 6. Thus, slip occurred at reaching certain load because the bond strength of concrete and reinforcing bamboo was low. Also, it would be considered that the fracture of concrete with less number of reinforcing bamboo occurred at initial decreased load before reinforcing bamboo yielded because this slip might occur near initial decreased load. Therefore, in bamboo reinforced Ca concrete, it would be important to raise the bond strength and prevent slip.

5 CONCLUSIONS

In this paper, the effect of bamboo for Ca concrete was investigated from four-point bending test. As a result, the knowledge obtained in this paper is the following.

(1) When bamboo reinforced Ca concrete is used, it will be important to have enough covering to prevent shrinkage of the concrete since bamboo absorbs water from the concrete. Shrinkage cracks occur at the concrete surface of near the bamboo.

(2) The bamboo will be effective as reinforcement material for Ca concrete because the occurrence load of concrete fracture rose with increase of the number of bamboo.

(3) For more effective using of bamboo reinforced Ca concrete, it will be important to raise the bond strength and prevent slip.

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