Development of Connecting Method for Natural Round Bamboo

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Summary

In this study, the development of connecting method with high strength and high rigidity for natural round bamboo is carried out. These connection methods are developed to promote the use age of bamboo. The joint and connection using these connection methods are tested. The tension tests are carried out to make clear the strength and rigidity performance in bamboo connection. The truss system using bamboo connector with wooden corner brick is proposed. The try to trial-construction for the round bamboo cage with about 10m-diameter scale using this system is carried out.

Keywords: Bamboo, Bamboo connector, Adhesive, Tension strength, Recycle
1. Introduction

The bamboo is one of the most familiar materials in Japan. Processed bamboo have been used for building material, daily tool, toys and so on. However, the demand of bamboo decrease in Japan because of the rise of the plastic new materials. With this decrease of demand, the grove of bamboo spread rapidly as shown in Photo 1. The tree in artificial forest are damaged by the rapid growth of bamboo. In a residential area, the roots of bamboo destroy the house foundation or water service pipe. This means the rapid growth of bamboo and the unlimited resource as material. Bamboos grow up to use only a few years. Main objective of our study is the development of bamboo usage for the structural member. Already, bamboo has generally used widely on the earth. In case of using bamboo as the structural member, The strength and rigidity are required at the connection. But, the traditional connections using rope or cotter pin enough strength and rigidity. We have developed a connecting method for natural round bamboo already[1]. The 2005 world exposition Aichi will be held in Japan. Japanese government pavilions in the expo will be the large scale wooden building with over 6000m² floor space (see fig.1). This building will be covered by huge natural round bamboo cage. The connecting method for round bamboo with high performance is requested. Therefore, in this study, some types new round bamboo connecting method are developed and carried out trial production and test were carried out.

2. Development of Joint

The details of connecting method for joint newly developed by authors are shown in Fig.2 and 3. There are two types of joint. The first one is composed of laminated bamboo connector [2] and split bamboo filler. Another one is composed by steel ring and cup with plaster. The kind of bamboo used in specimens is MADAKE grown in Japan.

2.1 Connecting Methods

The connecting method shown in Fig.2 is mentioned below. After the hollow parts of bamboo is filled by split bamboo filler, the laminated bamboo developed for timber connection by authors is adopted. In this study, urethane adhesive is used in bonding the split bamboo filler to bamboo and bamboo connector. Another one(see Fig.3) is composed by steel ring and cup with plaster. This joint resists by the friction between the steel rings and the surface of bamboo. Between outer layer of bamboo and steel ring. Two steel ring are connected by the bolts. These rings are tighten as increasing tension force by the effect of cup taper.

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Photo.1 Grove of bamboo in Fig.1 The 2005 Expo,

Fig.2 Joint type 1
(Laminated bamboo connector and split bamboo filler)

Fig.3 Joint type 2
(Steel ring and cup with plaster)
2.2 Test Set-up

The test set-up for tension test for joint and the configuration of specimens are shown in Fig. 4. Tensile load is applied by amsler type universal testing machine. The gap of joint is measured by two displacement transducers.

2.3 Test Results

Photo. 2 and 3 show two kinds of typical failure modes of each type of specimen. In the specimens connected by bamboo connector and adhesive, the bamboo connector pulled out by failing adhesive. There is no damage at part of split bamboo filler. This type specimen shows high rigidity until near the peak of load. On the other hand, the steel rings slipped on the outer surface of bamboo in another type of specimen. One of the reasons for this failure is the presence of the gap between bamboo and steel ring. It is necessary to solve this problem that shape and size of cup are improved and torque of bolt is controlled. The maximum load of all specimens is shown in Fig. 5. The maximum load of the specimens with the bamboo laminated connector and split bamboo filler was higher than that of another type specimen. On the other hand, steel rings slipped on the outer surface of bamboo in another type specimen. Bamboo connector and filler type joint have not only high rigidity and high strength, but also fine appearance and good environmental performance because of using no metal. However, the process of filling sprit bamboo need long time. Therefore, the improvement in filling method or development of new filler material is needed. Selection of better material for the filler is needed.

3. Development of Connection

20 or more types of connecting method for bamboo connection are designed and tested by authors. Since, Bamboo is very weak to tear force to perpendicular to the fiber, it is very difficult to realize high strength bamboo connection.

3.1 Connecting Methods

Photo 4, Photo 5 and Photo 6 show typical types of connecting methods for bamboo connection designed by authors. Type 1 shown in Photo 4 is frictional type...
of connection. Bamboo is held by cutting steel pipe with thick rubber and its cutting pipes are weld each other. Type 2 shown in Photo.5 is the application of steel ring and cup connecting developed for joint in the previous section. The connection Type 3 shown in Photo.6 is the mechanical hook type the connection. This hook is composed of angle iron and deformed steel bar hooked to notched of bamboo. The hook is fastened to bamboo tightly.

3.2 Test results

The maximum load was shown in Fig. 6. The strength is over the value requested by structural design. But, all of them have two serious problems. That is heavy weight and bad appearance.

4. Conclusions

In this study, the trial production and experiment for bamboo connecting system were conducted. We propose truss system using bamboo connector with wooden corner brick (see Photo.7) by considering the trial production and experiment. This system can be designed without direct bamboo connection. On the other hand, we will also improve filler, as the gap between the round bamboo and wood filler is filled by narrow split bamboo (see Photo. 8).

5. Reference
