Modification and Innovation of Commode Chair Using a Polyester-based Composite for Elderly Patient

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Abstract

Bamboo stems, which are the source of bamboo fiber or blades, are a type of natural fiber with a lower density than other natural fibers. Apus bamboo is a type of bamboo that has high mechanical strength. Its superior mechanical properties have attracted public interest in developing its potential to become an advanced and functional material. In this community service activity, woven apus bamboo slats obtained from Kalisemo village, Purworejo Regency, Indonesia, combined with woven glass fiber were used as a reinforcing material and fabricated into a hybrid composite material with a polyester binder mixed with 5% eggshell powder. This activity aims to apply hybrid composites to innovative commode chair products as medical devices for elderly patients. The hybrid composite is made with a reinforcing and binder ratio of 20:80 (vol%). Flexural strength and water absorption tests are carried out on composite materials before use. Furthermore, a commercial commode chair made from wood was modified using a hybrid composite product, and the innovation was made by adding right and left-hand grips made from composite to maintain the body balance of elderly patients. The flexural strength of the resulting composite is quite high, reaching a value of 154.34 MPa, and the water absorption test results (1.91%) are relatively low. A composite with this flexural strength value is estimated to be able to withstand a load of > 100 kg so that the commode chair product can be used by the public, not just the elderly. In addition, the relatively low water absorption of composites can extend the service life of commode chair products.

Keywords: (bamboo slat, commode chair, composite, glass fiber, polyester**)**

Introduction

Apus bamboo is often called Tali bamboo with the Latin name *Gigantochloa apus*. This apus bamboo originates from Burma and southern Thailand. It was possibly brought by humans who migrated to Indonesia, especially Java Island, which then spread to other islands. Lombok Island is one of the islands with the most distribution of bamboo, including apus bamboo (Gordon & Waterhouse, 1962).

For the Javanese people, especially the rural community, this apus bamboo is vital because it can be made into various products that support daily life, including cooking wares, furniture, fishing equipment, and house-building structures. Apus bamboo fiber has an average density of 0.68 g/cm^3 (Wulandari, 2020), lower than other natural fibers such as kenaf, sisal, abaca, and other fibers (1.4 – 1, 6 g/cm^3) (Karimah et al., 2021) so that it can be made into lighter composite products.

Additionally, apus bamboo has high mechanical properties (Oka, 2008): i.e., compressive strength of 59.23 MPa, tensile strength of 335 MPa, flexural strength of 115.92 MPa), and modulus of elasticity of 15.8 GPa. Their high mechanical properties make this material potentially used as a base material for advanced products. Therefore, it is regrettable if apus bamboo, which is easy to obtain in Indonesia, is only used for handicraft products.

In past community service projects, we used sawdust, eggshell powder, and epoxy to make hybrid composites that were used to make flexible tables for patients (Sosiati et al., 2021) and innovative walkers (Sosiati et al., 2022), respectively. The composite produced in the former, compared to commercial particleboard, displayed a higher density. This finding offers significant promise for creating adaptable hybrid table goods used by medical patients. Meanwhile, the innovative walkers that resulted from the latter activity were donated to disability patients at the Imogiri 1 Community Health Center.

In this community service activity, we developed the function of apus bamboo to be a product that can help service older people, one of which is a commode chair. This idea emerged because of some commercial products of commode chairs made of wood. In this case, wood has limited durability during use and will often come into contact with water. Thus, we modified wood with a hybrid composite material of woven apus bamboo slats, woven glass fiber, and eggshell powder-reinforced polyester, expecting it to have a higher mechanical strength than wood. The role of adding eggshell powder to the composite is to reduce the composite's water absorption (Sosiati et al., 2023). Besides, the innovation of the commode

chair is also performed by adding right and left handrails to maintain the body balance of elderly patients. Approximately 90% of senior citizens experience high blood pressure, diabetes mellitus, stroke, and blurred eyesight, all of which elevate their risk of falling. In addition, the decline in cognitive function of the elderly further contributes to their risk of falling (Puspitha et al., 2019; Pranata et al., 2021). Therefore, the goal of this activity is to apply hybrid composites to innovative commode chair products as medical devices for elderly patients.

The modified and innovative commode chair produced from this activity was donated to the Community Health Center of Salaman 1 at Magelang Regency, Indonesia, for elderly patients. The purpose of this donation is to help the Community Health Center of Salaman 1 if there are patients in need. The use of natural and synthetic materials and solid waste in these modern and functional products is socialized to the health center employees to become broadly knowledgeable about the technology of processing natural materials and the utilization of solid waste.

Method

A schematic diagram of this community service is depicted in Fig. 1. Apus bamboo used in this activity was obtained from Kalisemo village, Purworejo Regency, Indonesia, as bamboo slats are only used for making craft goods. So, firstly bamboo slats were weaved, then combined with woven glass fiber and eggshell powder to reinforce polyester to make the hybrid composite with a ratio of woven bamboo slats: woven glass fiber: eggshell: polyester was 10: 10: 5: 75 (vol.%).

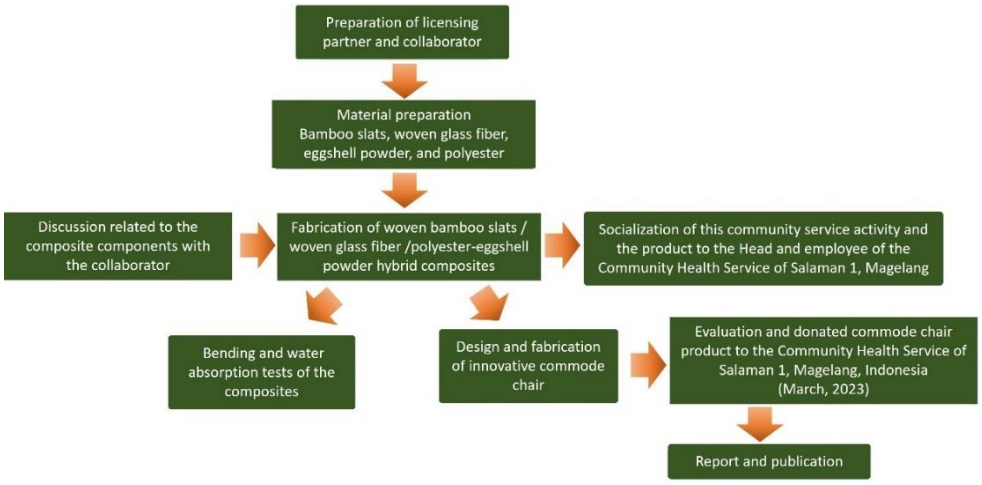

Fig. 1. Schematic diagram of this community service activity.

Before fabrication of the composite, the composite components used in this activity were discussed with the collaborator. Then, the hybrid composite was used to improve and change the commercial commode chair in three steps: (1) technical design on how to make the commercial commode chair more useful and new (Fig. 1); (2) making woven bamboo slats/woven glass fiber/eggshell/polyester hybrid composite test specimens for bending and water absorption tests (Fig. 2) and data analysis; and (3) making a commode chair out of the hybrid composite assembly (Figs. 4 and 5).

Technical design to make the commercial commode chair more useful and innovative

Figure 2 shows a technical design of modification and innovation on the commode chair commercial. A body made of wood (Fig. 2 a) was mainly replaced with a hybrid composite material. However, to simplify the modification, the end of the table legs (with a height of approximately 50%) is covered with a composite material to reduce water absorption because those parts tend to have a lot of contact with water. In addition, the commode chair is improved by adding right and left handrails to keep the bodies of elderly patients.

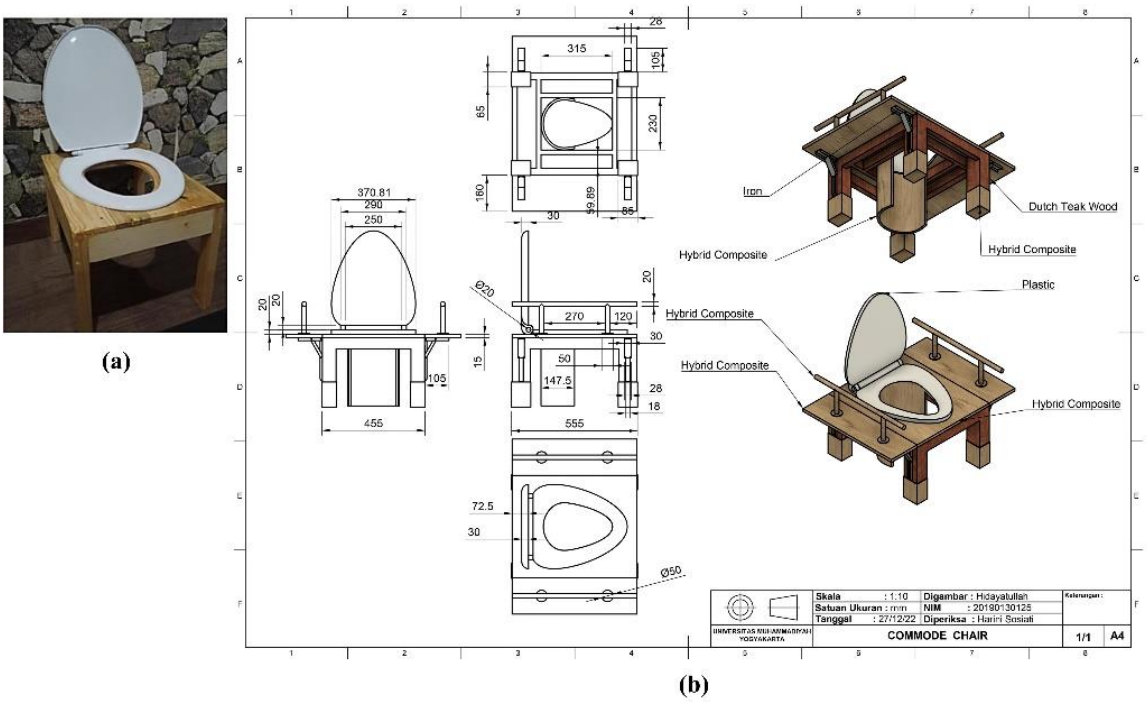

Fig.2. (a) A commercial commode chair made of wood and (b) technical design of modification and innovation on the commode chair were carried out in this activity.

Preparation of the hybrid composite test specimens

Figure 3 depicts the preparation steps for hybrid composite sheets. Before use, the as-received bamboo slats were immersed in water for 5 days and dried to remove dirt adhering to the slat surfaces. Woven apus bamboo slats and woven glass fiber (Fig. 3 a, red arrow for bamboo and green arrow for glass fiber) of as much as 20 vol.% were used to reinforce polyester (75 vol.%) containing eggshell powder (5 vol.%).

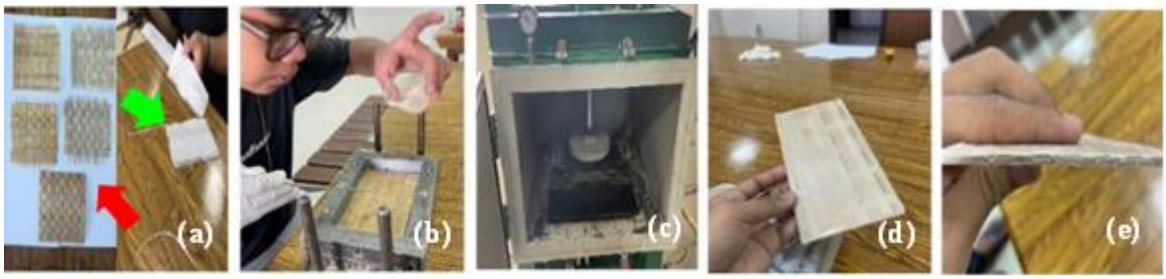

Fig. 3. A Sequence of Fabrication Steps of Hybrid Composite Sheets for Making Testing Specimens.

Fig. 4. Bending (a) and Water Absorption (b) Test Specimens.

Woven bamboo slats and glass fiber were arranged in the mold (17 cm x 9 cm x 3.2 mm) with a ratio of 1: 2 while poured with a polyester and eggshell powder mixture (Fig. 3 b) and then set in the press machine (Fig. 3 c). Figures 3 d and 3 e show the product of composite sheets that are ready to be made test specimens for bending (mechanical) and water absorption (physical) testing (Fig. 4). The testing results are used as the basis for making the hybrid composite for the modification and innovation of commode chairs.

Fabrication and assembly of the commode chair

As previously mentioned, soaking the apus bamboo slats in water and drying them started the fabrication process of the composite for the components of the commode chair. In this case, weaving the dried bamboo slats was bigger than that for the test specimen to adjust the mold dimension of 36 cm x 16 cm x 4 cm (Fig. 4). The composition of the hybrid composite was the same as that of the test specimens. This figure also shows the patterning of a commode

chair part and manufacturing handrails. Fig. 5 exhibits the assembly of the innovative commode chair.

Fig. 4. Route of the Fabrication Process of Bamboo/Glass Fiber/Polyester-Eggshell Powder for the Commode Chair Components.

Fig. 5. Assembly of the Commode Chair.

Results

Figure 6 demonstrates a commode chair product resulting from this community service activity shown from various perspectives: i.e., front view (a), right side view (b), top view (c), and left side view (d). As mentioned above, wing-like composites completed with handrails at the right and left sides are used to balance the bodies of older people or people with tremors. They are foldable if not used for flexibility. It is an innovative part of this product. Another innovative part is shown under the desk (see Fig. 4 b, orange arrow). The composite is made in the shape of the U letter as a feces barrier so

they do not spread everywhere. It can be disassembled as needed (Fig. 4 d). Figure 4 c depicts the commode chair from the top view.

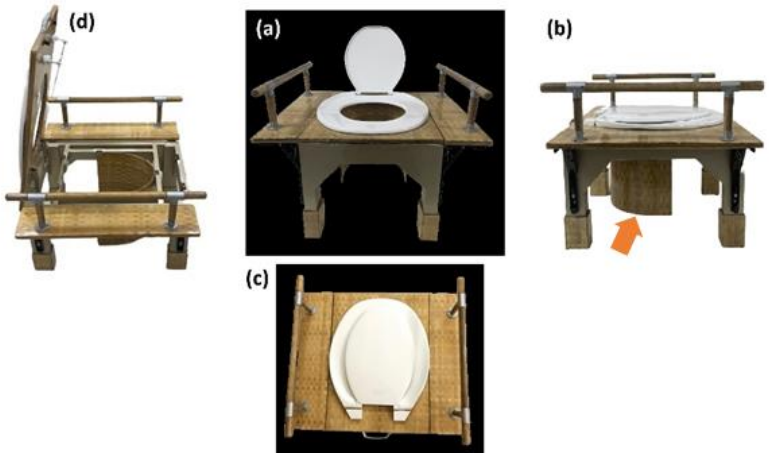

Fig. 6. Photographs of the Modified and Innovative Commode Chair using the Woven Apus Bamboo Slats/Woven Glass Fiber/Polyester-Eggshell Powder Hybrid Composite.

Discussion

The woven bamboo slats/woven glass fiber/polyester-eggshell powder hybrid composites used for the commode chair parts showed good results when tested for bending and water absorption. The mechanical properties of flexural strength, modulus, and strain are 154.34 MPa, 6.64 GPa, and 3.06%, respectively, whereas the water absorption as a physical property is 1.91%. This composite's flexural strength is considerably high, which is higher than that of eggshell (5%)/polyester, either for fresh eggshell (85 MPa) or carbonized eggshell (90 MPa) (Hassan et al., 2012). Still, the flexural strain is low due to the base matrix material of polyester. This flexural strength is also higher than that of a bamboo fiber/glass fiber/epoxy hybrid composite with a bamboo fiber/glass fiber ratio of 4:3 (~78 MPa) (Shi et al., 2023), an abaca/polyester-5% eggshell powder composite of 57.76 MPa (Sosiati et al., 2023), and bamboo/polyester composites of 128 MPa (Ratna Prasad & Mohana Rao, 2011). This composite's water absorption (1.91%), however, is slightly higher than that of 1.3% studied by Shi et al. (2023) but slightly lower than that of abaca/polyester-5% eggshell powder of around 2.5% (Sosiati et al., 2023)

The mechanical and physical properties of the bamboo fiber/polyester, bamboo fiber/epoxy, and bamboo fiber/glass fiber/epoxy composites have been reported. However, those of bamboo fiber/glass fiber/polyester-eggshell powder were not found. An important point underlined is that the composite's flexural strength from this activity is comparable to

the bamboo-based composite material industries (Chin et al., 2020; Dauletbek et al., 2022). Additionally, the low water absorption of this composite benefits the commode chair application and improves the material's durability.

Fig. 7. Photographs of (a) handing over the commode chair product to the user partner (the Community Health Center of Salaman 1) and brief scientific socialization, and (b) demonstration and technical socialization of the commode chair by the students.

Furthermore, this activity is finished by visiting the Community Health Center of Salaman 1 at Magelang Regency, Indonesia, as a user partner and handing over and donating this activity's product from our teams of a lecturer and some students to the head of the Community Health Center, dr. Satrio Suryo Prabowo Wahyuning (Fig. 7 a). During handing over the product, we briefly explained and socialized scientifically about the purpose of manufacturing this product: i.e., (1) to improve the usage of bamboo that is abundantly available in many countries, including Indonesia; (2) concern about utilizing one of the solid wastes, eggshell, that can reduce the composite's water absorption; and (3) use the economical

materials, glass fiber, and polyester, to make helpful and functional products. Besides, the students demonstrated technical socialization about this commode chair product, especially its detailed function and ability to withstand human weight (Fig. 7 b). Based on the flexural strength of the composite used, the product is predicted to withstand a load of ≥100 kg. Finally, based on the evaluation results, the head and employee of the Community Health Center of Salaman 1 provided a very positive response to our performance. The composite material with high flexural strength and water resistance resulting from this community service activity can inspire the next community service activity to make medical devices using reinforcing materials based on woven bamboo and eggshell powder.

Conclusion

This community service activity through non-regular domestic collaboration schemes has succeeded in improving the function of the commercial commode chair and apus bamboo slats that are only used for handicrafts in rural communities. This activity led to the creation of an innovative and useful commode chair product that uses a hybrid composite board made of woven apus bamboo slats, woven glass fiber, and polyester-eggshell powder. This board has a high flexural strength of 154.34 MPa and a low water absorption of 1.91%. These properties make this commode chair product have high strength, durability, and flexibility. At the same time, the two innovation modes resulting from this activity made the product not only for elderly patients but also for general people because the two innovation modes could be disassembled as needed.

Acknowledgments

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