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Innovation of Walker for People with Disabilities using Bamboo Waste and Kenaf Fibers Reinforced Composites

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Abstract: *Bamboo has many benefits from roots to stems and is very easy to obtain in Indonesia. Bamboo is widely used for handicraft products, woven materials, textiles, buildings, and bridges. In addition, bamboo fiber has also been processed into various products to increase its potential and economic value, namely for applications in the field of engineering, including automotive, aircraft, and solar panels. However, the availability of bamboo fiber in Indonesia is not easy to obtain, and bamboo waste from handicraft products is generally only used for fuel. The bamboo waste is combined with natural kenaf fiber and processed into a composite material with an epoxy resin binder through this community service activity. The composite product is then used to innovate the walking aids (walkers) for people with disabilities, namely by adding eating and drinking mats to the walker. The composite material has also been tested for its impact toughness before use. This innovative product is expected to increase user benefits in rural communities.*

Keywords: *waste-bamboo, kenaf fiber, epoxy, composite, walker, disabilities*

Introduction

Bamboo is a plant with a high rate of reproduction, and a wide variety of species can be found in various climates, both in areas with low temperatures and tropical climates. Therefore, bamboo is very easy to find, especially in Indonesia with a tropical climate. In addition, bamboo has various functions for human life, both in traditional and modern life. In this case, bamboo stalks can produce bamboo fiber due to extraction and bamboo sawdust as waste from bamboo-based products.

Bamboo can be used from roots to stems. Bamboo fiber is a typical natural fiber extracted from grass/reeds[1] and has the most superior mechanical properties compared

[1] Farideh Namvar et al., "Potential Use of Plant Fibres and Their Composites for Biomedical Applications," *BioResources* 9, no. 3 (2014): 5688–5706.

to other natural fibers.[2] This property is correlated with relatively high cellulose and lignin content[3], so bamboo stems have the potential for building and bridge construction materials.[4, 5] Besides, bamboo is still traditionally used for woven products and various handicrafts. However, bamboo fiber composite technology has been processed into advanced materials with potential for various applications, including in the automotive sector, aircraft, solar panel wind turbines[2], and sound-absorbing materials.[3] Meanwhile, bamboo sawdust waste has the prospect of being produced as a base material for Braille ink[6], bamboo charcoal powder for water purification and air purification[7], and the application of motorcycle brake linings.[8]

In several areas in Central Java and Yogyakarta, such as Purworejo, Magelang, and Kulonprogo, many traditional bamboo furniture companies and bamboo cutlery (chopsticks and spoons) utilize a waste-bamboo powder. The identification of problems in this article is focused on optimizing the utilization of waste bamboo because it was challenging to find stem extract (bamboo fiber). Therefore, in this community service activity, waste bamboo combined with kenaf fiber was fabricated with a resin binder to be the composite material. It is used to modify the walker to produce an innovative walker with additional functions: i.e., by adding the eating and drinking mats. When one with a disability uses a walker and then takes a break to eat and drink, the device can be more useful and effective. In this case, the addition of kenaf fiber is to improve the mechanical properties of the composite[9] because kenaf fiber composite has been applied in the automotive industry.[10]

Community service activities funded by the Community Service Institute (LPM) with the international scheme, Universitas Muhammadiyah Yogyakarta (UMY) has user partners, namely Imogiri 1 Health Center, Yogyakarta, and overseas collaborators from

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[2] Mekete Ababu et al., "Review of the Applications and Properties of Bamboo Fiber Reinforced Composite Materials," *GSJ* 9, no. 3 (2021): 1196–1204.

[3] Theresia Mutia et al., "POTENSI SERAT DAN PULP BAMBU UNTUK KOMPOSIT PEREDAM SUARA," *Jurnal Selulosa* 4, no. 1 (2014): 25–36.

[4] Sukawi, "Bambu Sebagai Alternatif Bahan Bangunan Dan Konstruksi Di Daerah Rawan Gempa," *Jurnal Teras* 10, no. 1 (2010), http://eprints.undip.ac.id/32377/.

[5] Revi Mainaki and Rendra Zainal Maliki, "Pemanfaatan Keanekaragaman Bambu Secara Hidrologis, Ekonomis, Sosial Dan Pertahanan," *Geodika: Jurnal Kajian Ilmu dan Pendidikan Geografi* 4, no. 1 (2020): 44–54.

[6] Erna Wiji Astuti, Fifit Astuti, and Sri Lastuti, "Serbuk Bambu Sebagai Alternatif Bahan Dasar Tinta Braille," *Pelita-Jurnal Penelitian Mahasiswa UNY* 3, no. 2 (2008): 113–124.

[7] Muhammad Ihsan, Almira Fikrani, and Andar Bagus Sriwarno, "PEMANFAATAN LIMBAH PRODUKSI KERAJINAN BAMBU MELALUI DESAIN PRODUK BERBAHAN DASAR ARANG," *Jurnal Sosioteknologi* 18, no. 1 (2019): 43–55.

[8] Rina Lusiani, Sunardi Sunardi, and Nico Purnama, "STUDI EKSPERIMENTAL PENGARUH UKURAN PARTIKEL SERBUK BAMBU TERHADAP SIFAT MEKANIS KOMPOSIT UNTUK APLIKASI KAMPAS REM SEPEDA MOTOR," *FLYWHEEL: Jurnal Teknik Mesin Untirta* 4, no. 1 (2016): 54–63.

[9] Harry Ku et al., "A Review on the Tensile Properties of Natural Fiber Reinforced Polymer Composites," *Composites Part B: Engineering* 42, no. 4 (2011): 856–873.

[10] Mohd F Omar, Haliza Jaya, and Nik N Zulkepli, "Kenaf Fiber Reinforced Composite in the Automotive Industry" (2020). 95-101

Universiti Malaysia Sarawak (UNIMAS), Malaysia. The selection of user partners of the health center was based on the consideration that if there are patients with disabilities who came to check up at that health center, the walkers produced from this activity can be donated. As for the collaborator from UNIMAS, currently, we are also collaborating in the field of composite research for alternative materials for biomedical devices (one of which is prosthetic sockets). They also provide in-kind support in terms of physical and

Figure 1. Profile of Imogiri 1 Health Center as the user partner.

mechanical test facilities. Therefore, in this activity, the expertise of the collaborator is expected to be a consultant to achieve high-performance products. The profile of the user partners is as follows (Fig. 1).

Imogiri 1 Health Center located in Ngancar, Karangtalun, Imogiri, Bantul, Yogyakarta, is a health center accredited by the DIY Quality Agency and a health center capable of PONED, which is capable of handling emergencies in pregnant women and childbirth and newborns. It is currently developing itself as a health center that cares about K3 (Occupational Health and Safety) by paying attention to work safety, including holding joint exercises using PPE (Personal Protective Equipment). In addition, this health center also increases the speed of service by utilizing technology, one of which is AHA (Automatic Hematology Analyzer) in laboratory examinations for routine blood tests. This health center is also heading to the online registration system so that later there will be no need to fill out registration forms.

The organization of the Imogiri 1 Health Center is as follows:

1 Head of Health Center, 1 Head of Sub-Division of TU, 7 Staff, 2 Doctors, 1 Dentist, 1 Pharmacist, 7 Nurses, 3 Dental Nurses, 12 Midwives, 2 Laboratory Analysis, 1 Sanitarian, 2 Nutrition Officers, 1 Medical Record, 1 Office Guard, and 3 Health Workers.

Method

Figure 2 shows a schematic diagram of this community service activity. Materials used for composite fabrication are waste bamboo, kenaf fiber, and epoxy resin. Waste bamboo was obtained from the bamboo handicraft industry in Godean, Yogyakarta. Meanwhile, the epoxy resin consists of a resin (*Bisphenol Aepichlorohydrin*) and a hardener (*Polyaminoamide*) from EposchÖn. The bamboo waste and kenaf fibers were washed and dried, then cut to 5 mm and 5 mm, and 5 mm and 1 mm in length, respectively. The ratio of mixed resin and hardener was 1:1. The composites were made with a volume fraction ratio of 20% (bamboo waste fiber and kenaf fiber = 1:1) and 80% epoxy. Figure 3 demonstrates photographs of the waste bamboo fiber/kenaf fiber/epoxy composites fabrication process (Fig. 3 a, and 3 b), discussion with a collaborator from UNIMAS about the bamboo composites conducted virtually (c), and the design of the innovative walker (d).

Before, the composites were prepared to be innovative walkers. The waste bamboo fiber/kenaf fiber/epoxy composite specimens were fabricated and subjected to an impact test following ASTM D6110 to confirm the impact strength of the produced composites can be used to modify the walker. Besides, an optical microscope was used to observe the impact fracture surface to ensure the compactness from a cross-section view of the composites. In the composite fabrication process, the fiber length of the bamboo waste fiber and kenaf fiber is varied because the uneven distribution of fibers in the binder (epoxy matrix) will reduce product density and composite properties.

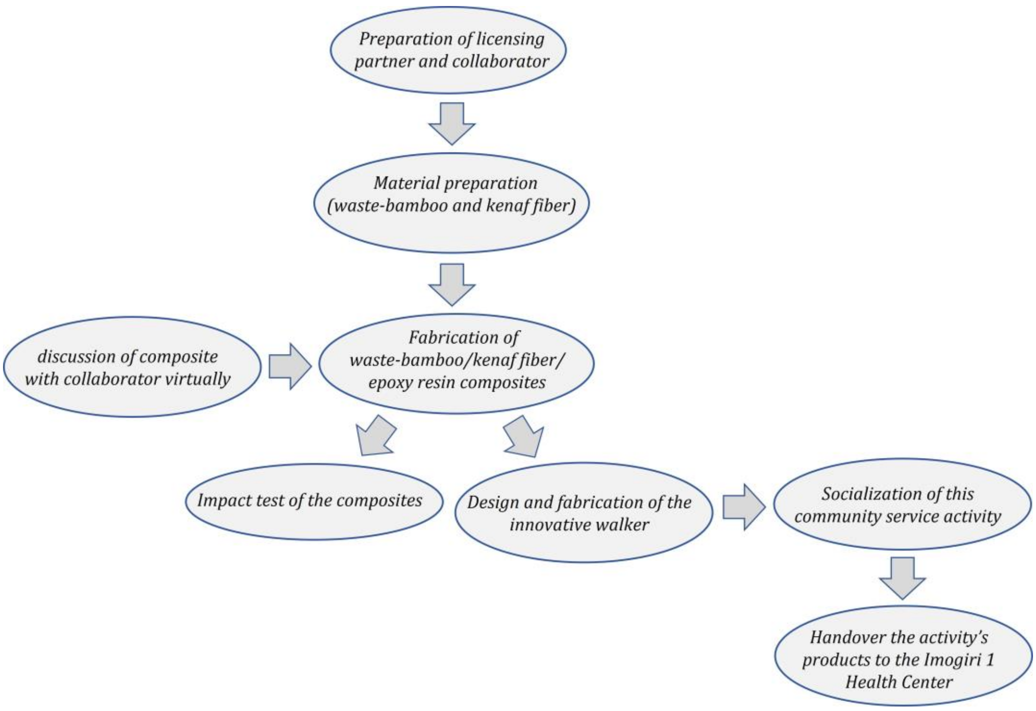
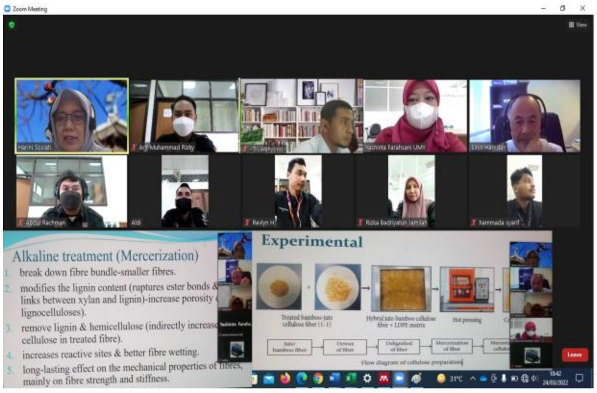
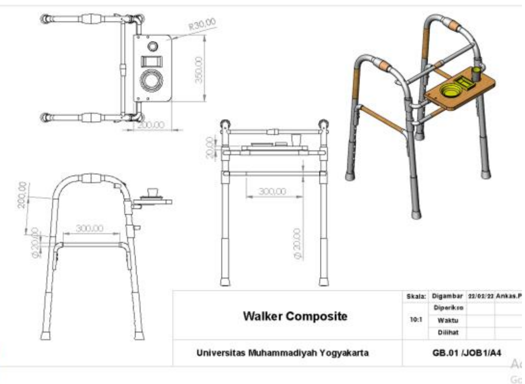


Figure 2. Schematic diagram of this community service activity.





(c) (d)

Figure 3. Waste bamboo fiber/kenaf fiber/epoxy composites fabrication process started from obtaining the bamboo waste to produce the composite sheets (a and b), remote consultation with collaborator (c), and design of the innovative walker (d).

Therefore, in this activity, two variations in fiber length were made, namely, a similar fiber length (5 mm) and different fiber lengths (5 mm and 1 mm). After their impact test was conducted, the composites with the same and different fiber lengths were compared. The composite used for the walker innovation is a composite that has a higher impact strength.

Results

Composite specimen after impact test is represented in Fig. 4 a, and Fig. 4 b displays the difference in optical microstructure of the impact fracture surface of the composite with different variations of fiber length obtained from the area remarked by an arrow in Fig. 4 a. The optical micrographs in Fig. 4 b and 4 c show the difference in microstructure compactness. The voids indicated by red arrows were formed due to the inhomogeneous distribution of the fibers, leading to reduce the mechanical strength of the composite. Different fiber lengths used in the composite in Fig. 4 b showed denser microstructure than another composite used a similar fiber length (Fig. 4 c). As a result, the impact strength of the composite having denser microstructure and lower void volume fraction is higher (7.72 KJ/m^2) than the other one (3.87 KJ/m^2). Therefore, as mentioned above that the composite with better properties was used to innovate the walkers, as shown in Fig. 5.

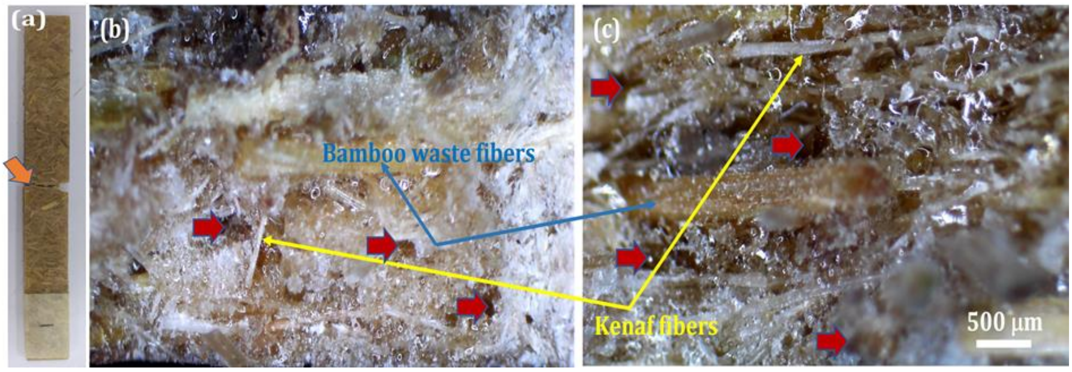


Figure 4. A composite specimen after impact test (a), optical micrographs of an impact fracture surface of the composite with bamboo waste and kenaf fiber lengths 5 mm and 1 mm (b), and 5 mm and 5 mm (c), respectively showing some voids (see red arrows).

Figure 5 shows a series of innovative walker products and the socialization of innovative walker functions to a user partner. Figure 5a demonstrates an innovative walker product equipped with eating and drinking mats donated to the user partner (Imogiri 1 Health Center) represented by the head of the Health Center, dr. Titis Indri Wahyuni and head of the administrative bureau, Heni Tri Hastuti, SKM. Walkers can be adjusted in height to be adjusted to the user's height. Technical socialization by the students on adjusting the height is memorized in Fig. 5 b. Then the demonstration of an innovative walker unit is shown in Fig. 5c, 5d, and 5e. The innovation in this walker was made by considering when the user suddenly feels tired and wants to take a rest while enjoying the food and drinks they brought. In this case, the addition of a composite board on the walker does not add to the walker's weight because the fiber density of bamboo is low; it is lower than other natural fibers[11, 12]so it is still comfortable to use. In this case, the composite products are not only added for eating and drinking mats but some products are modified in the rods-shape and installed to strengthen the legs of the walker.

[11]A H D Abdullah et al., "Physical and Mechanical Properties of Five Indonesian Bamboos," in *IOP Conference Series: Earth and Environmental Science*, vol. 60 (IOP Publishing, 2017), 12014.

[12] K Srinivas, A Lakshumu Naidu, and M V A Raju Bahubalendruni, "A Review on Chemical and Mechanical Properties of Natural Fiber Reinforced Polymer Composites," *International Journal of Performability Engineering* 13, no. 2 (2017): 189.

(a) (b)

(c) (d) (e)

Figure 5. Photographs of innovative walker products (a), a technical explanation of adjusting a walker's height (b), and a demonstration of the use of the additional functions of the bamboo waste/kenaf/epoxy composite board (c, d, e).

Discussion

The final step of this international community service (ICS) activity is the visit of the ICS group to the Imogiri 1 Health Center to hand over or donate products from ICS activities carried out by a team of lecturers and students. This activity was conducted relatively quickly, for three months, from January to March. In addition to technical explanations about the function of the innovative walker, scientific socialization on the reasons for using bamboo fiber was then replaced with waste bamboo fiber. Its fabrication using composite technology, including the discussion result with an overseas collaborator, Prof. Dr. Sinin Hamdan (UNIMAS), was also delivered by the group leader of the ICS activity (Fig. 6 a). Besides innovative walker products, the ICS group also donated commercial walkers and crutches, and various medical goods for the needs of the Health Center (digital tensimeters, masks, gloves, oximeter, and hand sanitizers) (Fig. 6 b and 6 c).

After all the handing over of the products resulting from ICS activities were carried out both formally and informally, it was followed by an evaluation of the results of ICS activities, one of which was filling out an assessment questionnaire on the performance of the ICS activity group and the products. Our performance (the ICS group) received a very satisfactory response based on the evaluation results. The innovative walkers are very useful and helpful, and they will be directly used for walking therapy patients because the Imogiri 1 Health Center also serves inpatient care.

Figure 6. Photographs of scientific socialization of the use of bamboo waste fiber to innovate walkers and handover of the innovative walkers and various medical goods to the head of Imogiri 1 Health Center.

Conclusion

This international community service group activity has succeeded in producing innovative walkers for people with disabilities: i.e., by adding the composite board made of epoxy reinforced with bamboo-waste fiber and kenaf fiber, which has the additional function of eating and drinking mats. The composite products are also modified in the rods-shape to strengthen the legs supporting the walker. These innovative walkers are very valuable for walking therapy patients, especially in Imogiri 1 Health Center, because this place serves inpatient care. Based on this ICS activity, several important points can be underlined, namely:

First, ICS activity products can be utilized by the community, especially people with disabilities and the elderly,

Second, can be a solution for utilizing waste from bamboo artisans or the bamboo handicraft industry, and

Third, can inspire the next activity plan by using other types of natural fibers with a low density to produce something for medical applications.

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