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To cite this article: E A Nurdiah and A Juniwati 2020 *IOP Conf. Ser.: Earth Environ. Sci.* **490** 012004

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Bamboo architecture as a learning project for community development of rural area in Indonesia

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Abstract. Concrete and steel have become common building materials in Indonesia and used as main building materials by both local people as well as architects in their design project. In Indonesia, common people in urban and rural areas, engineers and architects are also more familiar with the utilization of industrial building materials rather than local materials. However, industrial building materials area often questionable as sustainable materials. While bamboo, as local material, has been known as a sustainable material. Therefore, the usage of bamboo in nowadays architecture need to be elaborated and taught to the young generation and the society for the community development project. This paper aims to discuss the method of using bamboo as local material for community development in Indonesia while involving students from architectural education for the design process. The case study was taken during the community service project for Jarak Village's residents which was done by students and lecturer from Petra Christian University. By discussing the issue and methods, in the future bamboo architecture will present not only as a building that provides space for activities but also as an instrument of the learning process and community development.

Keywords: Bamboo material, community project, local material, sustainable material

1. Introduction

Challenges in using sustainable building material in construction keep arising and research on environmentally friendly, affordable and accessible building materials are increasing as an actual effort to overcome global warming and to prevent the widespread of environmental damage. Building material plays a role in answering the issues since energy consumption in the construction industry, both directly and indirectly, is considered as high which is estimated to consume around 40 % of total energy consumption [1]. Thus, the selection of sustainable and eco-friendly building material can contribute greatly to reducing environmental damages [2].

In Indonesia, concrete and steel are common building materials and have been the first choice for building construction since wood becomes more expensive and scarce due to deforestation. People in urban and rural areas are familiar with the materials. Builders, construction engineers, and architects also tend to utilize them for building they construct or design. In architecture and civil engineering schools, students are taught using the materials thus they become accustomed to the materials rather than to other alternative building materials like bamboo. Moreover, construction with materials like concrete and steel consume a large quantity of energy which occurs in five phases: extracting, manufacturing, transporting, operating and demolishing [1]. While bamboo as building materials have lots of potential as sustainable material to be used as the primary building material.



In regards to address environmental issues, such as deforestation, pollution, and carbon footprint, bamboo can be considered as interesting material for construction since bamboo is easy to cultivate, produce, harvest, transport and handle [3]. As one of fastest-growing natural construction, bamboo can be harvested in 3 yr to 5 yr cycles which makes bamboo become more sustainable than wood [4].

1.1. Bamboo as a building material

Bamboo (*bambusoideae*) classified as a grass member belongs to the Gramineae family which can be found in tropical to sub-tropical regions [5, 6]. Indonesia has a rich variety of bamboo which has around 154 types bamboo while it is recorded around 1 250 to 1 500 types of world bamboo diversity [7]. It can be found easily in Indonesia, especially in rural areas. Bamboo also has been cultivated since it gave huge benefits to the environment, such as its capability in absorbing and storing soil water, as well as to the local people.

According to Patil and Mutkekar, bamboo has high tensile strength, the weight to strength ratio is considered as decent which can withstand up to 3 656 kgf cm⁻² of pressure [1]. While according to Awalludin *et al*, bamboo's strength depends on age range and species which also might determine the suitability in construction when it reaches maturity age of around 3 yr to 4 yr; as when bamboo is matured, it possesses an optimum strength and can be used for heavy-duty applications [6].

In addition, Bamboo is considered as a material with decent resilience, flexibility, and durability value. The strength-weight ratio of bamboo can resist wind load and earthquakes [1] and according to Yuan *et al*, bamboo building possess a shock-absorbing effect which can reduce the destructive impact caused by seismic waves, thus reduce casualties and increase the rescue operation speed [8]. Species and methods in treating bamboo might affect the durability of bamboo and if properly treated, its lifespan can reach 30 yr to 40 yr, thus make bamboo as environmentally friendly, energy-efficient and cost-effective construction material [1].

1.2. Community development of rural areas

Rural areas in the world might face the same crisis due to urbanization, such as depopulation, poverty, unemployment, lack of adequate infrastructure and environmental problems [5, 9]. The issue needs to be addressed with some strategies which are not only to address the need for physical development but also to empower the local community. Thus, it aims to be sustainable development for the environment and people.

According to Toledo, sustainable community development can be defined as an endogenous process through which community takes (or recover) control over the process that determines and affect it, which are: taking control of its territory, the appropriate or non-destructive use of natural resources, the cultural control, the taking of social control, the economic control, and the political control [10]. Moreover, according to Cattaneo, *et al.*, goals and strategies for sustainable projects in rural area can be defined as: (i) building and design which important for enhancing local culture, history as well as local business; (ii) environment which means enhancing the quality of the territory and its natural resources; (iii) Community who makes places for living, strengthens the quality of place and gives hope to people, thus improving their quality of life; (iv) Economy, which can revive productive activities and employment opportunities [9]. Among all aspects mentioned by Cattaneo *et al.* [9], it can be said that appropriate building materials also play a role in sustainable development both for physical infrastructure and community.

1.3. Bamboo architecture for community development

The long history of traditional houses in Indonesia, bamboo has been used as building material along with other natural materials, such as timber, palm fiber, thatch, and stone. Some houses in rural areas also use bamboo for roofing or wall construction. The nuances of closeness and familiarity created by bamboo can be used as an emphasis point for a building which targeted for community development in Indonesia, besides the advantages of bamboo as a building material. According to Fitrianto, a bamboo project can serve as a platform for participation which allows community members to do activities

together like gather, plan, design and even construct the building together due to the possibility of uncomplicated construction of bamboo [11].

There are several examples of buildings built for community development purposes in Indonesia which using bamboo as a primary building material. One of them is Green School which was built by the Hardys at Sibangkaja, Bali. The school uses bamboo and depends on the construction to the experience of local craftsmen. The sustainability approach of the school not only laid on the durability of bamboo but also on the symbiotic relationship between the school community, social and cultural life of the adjacent neighborhood, as well as the artisanal tradition of Bali [10].

Another project is Dodoha Mosintuwu, owned by Institut Mosintuwu, an NGO focus on empowering women and children in education. It is a building functioned as a restaurant, function room, library and office for the institute. The whole building is using bamboo as the primary building material. Based on research by Sofian *et al.* [2], the bamboo architecture of Dodoha Mosintuwu induce environmental awareness movement which is rooted in local knowledge and inspire local people to utilize bamboo in construction. The ambiance of the architecture brings a calm sensation and provides thermal comfort. Children feel familiar with the facility, they even love playing and reluctant to go home.

Based on these phenomena, this paper aims to discuss how to empower the local community using bamboo architecture as a tool for community development as well as educate both community and students as the future architect on the potential of bamboo architecture to be used to enrich local knowledge. The discussion is based on the case study which is a community service project conducted at Jarak village, East Java, Indonesia.

2. Method

The research on bamboo architecture for community development was conducted as part of the community service program by the Department of Architecture at Petra Christian University (PCU) which was requested by Jarak village's headman. Jarak village's residents aspire to create a facility which can be used to develop the villagers' skill and knowledge, provide additional income, and employ young generation. The project not only needs to be low-cost in construction but also has to be uncomplicated since the villagers will build it with their own resources. Therefore, participatory action research (PAR) is used as the research methodology in order to answer the needs.

PAR as a method consists of cyclical steps of planning, action, observation, and result [4, 12]. According to Kattopo and Sudradjat [12], this method is suitable to be implemented for community development, especially in rural areas within developing countries. Moreover, Kattopo and Sudrajat proposed a combined method of PAR with Design Thinking (DT) method to unveil the truest meaning of architecture in its social contest, which engaged everyone within it, thus at the end will make architecture as places where people can actively engage and share knowledge production activities that emancipate and empower people [12].

In this research, the community or people in Jarak village are heavily involved in the design process. Starting from the preliminary research to the result. Due to the community also need to be trained and taught on how to utilize bamboo, therefore, the project is divided into two phases (see Figure 1). The first phase, which was already conducted in 2018, is preliminary design and introduction to bamboo architecture since the community already have their own perception of bamboo for building. While the second phase will be conducted started from May 2019 to August 2020. The second phase will consist of finishing the masterplan design for the facilities and training program for the local community on how to treat and use bamboo in building construction.

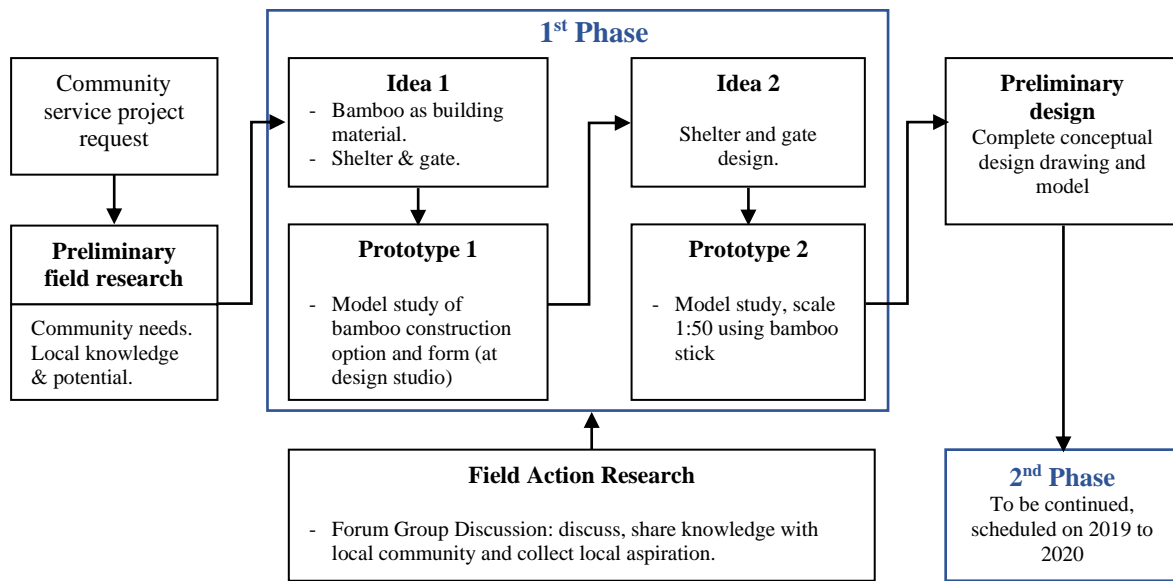


Figure 1. The sequence method used for design research and community development at Jarak village.

The community service project was conducted through field research, design process and result. During preliminary research, the PCU team worked together with the teams from the local community and discussed to find local potentials and resources. The design process also involved the local community through a Forum Group Discussion (FGD) activities. Through FGD, PCU team collected the local’s aspirations and interests for the project. The last stage was giving the idea to the community to be used as a model and learning tools for the next phase.

3. Analysis and Discussion

3.1. Case study: Jarak village description

Jarak village is a small village in Wonosalam district, which is part of Jombang city, East Java, Indonesia. It is located around 36 km from Jombang city center. The topography is hilly at Mount Anjasmoro’s slope, surrounded by Mount Arjuno, Mount Welirang, Mount Kawi and Mount Kelud, thus Wonosalam district is known as highlands with beautiful scenery and nature. Wonosalam, as a district, has nine villages and some recreational areas which highlight the picturesque nature and scenery, for example, waterfall and Banyu Mili eco-tourism. Jarak village as part of Wonosalam district also has hilly topography with farms, plantation, and natural forest.

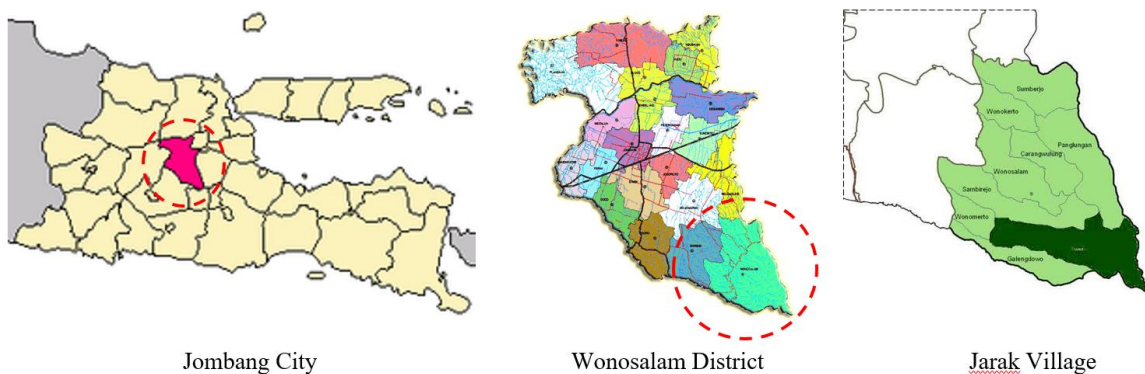


Figure 2. Map of Jarak village, East Java, Indonesia.

Since the village fund program has been announced by Indonesia government, local community has an aspiration to create a facility with the aim to empower the community by providing employment for the locals. They have seen that another village, Karangwulung village, has successfully developed Banyu Mili ecotourism facility, thus they seek to make a similar facility which suitable with the village resources. To reach the goal, the headman already prepared a team, consist of youths from *Karang Taruna* (youth organization in the village), women organization for housewife, and officials of the village. He also discussed and communicated the plan intensively to all the residents of Jarak village. From the intensive discussions, the headman and the residents agreed to plan an integrated area for recreational facilities and will be located at Pencaringan hill.

This facility will not only build as a recreational facility but also play a role as a community development project for Jarak village residents. The facility will not manage by company or professional worker in leisure industries, but by the local community. Since the planning stage, construction to operations will be handled by local communities and village officials. Thus, an integrated program for community development definitely needs to be defined. In this phase, the program will focus on architectural planning as the first step into an integrated program that will need other skills and knowledge to complete.

3.2. Finding local resources

Since the locals realize that they did not have sufficient resources for planning and managing the project, they requested assistance from PCU. During meeting with the local team members of Jarak village, they only had a plan to create a complex of recreational place at Pencaringan hill which consists of tracking area, pictorial area, and place for eating. However, details of the facilities needed and programming have not been stated.



Figure 3. The scenery of Wonosalam district.



Figure 4. Pencaringan hill, location for the facility.

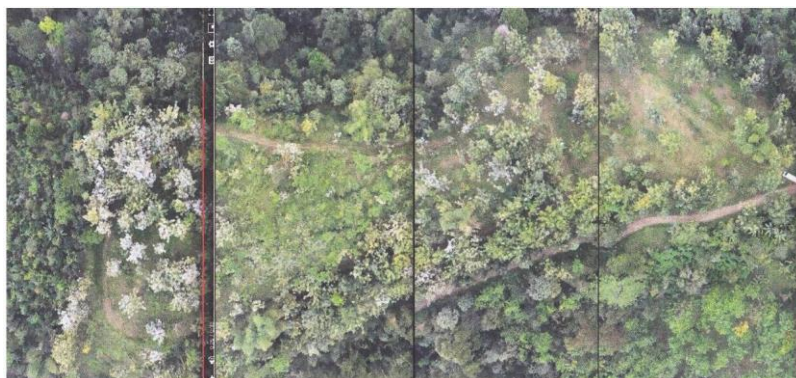


Figure 5. Pencaringan hill, site aerial view.

During the discussion with the locals, the PCU team found the importance of finding local and natural resources since Jarak village has abundant natural resources thus it would not be difficult to find materials for construction. After field survey to the location, live-in, and intensive discussion with the locals, we found that bamboo can be easily found and grows abundantly in Wonosalam district. Some of the species found in Wonosalam are *bambu petung* [*Dendrocalamus asper* (Schult - Backer)] which is a giant bamboo with thick culm suitable to be used for heavy-duty structure, and *bambu apus* [*Gigantochloa apus* (Schult. & Schult.f.) Kurz ex Munro]. Other bamboo species also grow in Wonosalam district, therefore, it is easy and cheap to collect bamboo from nearby places.

Wonosalam's terrain and soil condition are ideal for cultivating bamboo, it is hilly with springs and streams. Planting bamboo on the hillside also has benefits in reducing soil erosion, preventing landslide and storing excessive rainwater. Thus, to ensure the future demand of bamboo material, it can be regrowth and cultivated in the area.

Moreover, lots of local handymen and artisans in the village have knowledge of how to harvest good quality bamboo. Harvesting bamboo should be done during the right season and time in order to get low moisture and low starch which can make bamboo damage and decay in a short time. However, they did not have proper knowledge of bamboo treatment and preservation as well as skill in designing a building using bamboo in an unconventional way.

3.3. Idea 1: Utilize bamboo as a building material

Convincing the local community to use bamboo as a building material was challenging. The locals already had views and perception on bamboo. For them, bamboo is cheap material, non-prestigious and only for ugly building. They used bamboo only for temporary structures, for example for simple gate or humble shack. Figure 5 is an example of how the locals perceived bamboo building. They said that bamboo only can be used as walls (called *gedhek* or bamboo weaved for walls) which are not impressive and only for the poor or for cattle pen. They want bricks and concrete buildings with ceramic floors, like other common buildings they familiar with.



Figure 6. Local's perception of bamboo building.

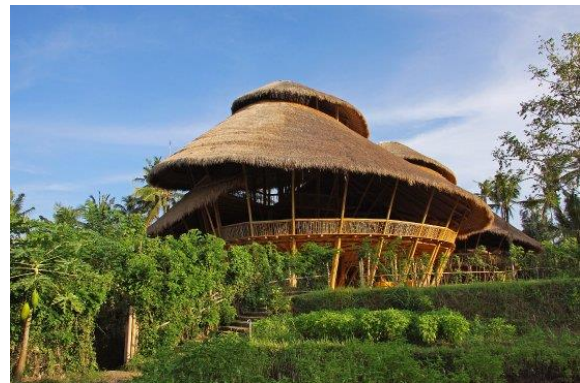


Figure 7. Green school as a stimulate to attract the locals' interest in bamboo building.

Therefore, the first step was to stimulate the locals to consider bamboo as a potential building material for their community project. Firstly, the potential, the benefit and the importance of bamboo for sustainable and environmentally community development project were communicated to the local then simple presentation was made along with a model library which contains examples of bamboo buildings in many forms as precedent. Later, the idea was presented to the locals in FGD session.



Figure 8. Forum Group Discussion (FGD), presented ideas on bamboo architecture for the community development project.

The FGD participants consist of the headman, village officials, the members of Village Owned Enterprise (*Bumdes: Badan Usaha Milik Desa*), local women empowering organization and youth organization. Each member of the local organizations has a role in this project. The Village Owned Enterprise is a local company formed and appointed by local people to manage the commercial facilities in the village. Thus, this enterprise will be responsible for managing the management, operational and profit of the proposed project in the future. Local women organization will play a role in providing, selling and developing local culinary products. While the youth organization will be the main source of human resources for the facility.

In the FGD, to attract locals' interest and to seek their perception on bamboo, PCU team showed some pictures of “common” bamboo building which commonly found in Indonesia in the first presentation. These are close to Figure 6, which are consists of the photos of simple bamboo houses and bamboo gates usually built during the celebration of Indonesia Independence day. During the presentation, the locals whispered and shouted that those pictures were the factual representation of bamboo buildings. Some of the comments are as follows:

“Yes... that exactly what a bamboo building we knew... a shabby shack.”

“We have bamboo abundantly, however, we will not build like that, right?”

“I use bamboo for fences and cattle pen.”

After showing the “common” bamboo buildings, PCU team presented the attractive bamboo buildings similar to Figure 7. Attractive bamboo buildings and unconventional bamboo structures were showed to the locals. The reactions were varied from amazed and interested to cautious and careful. Most of the youngs became attentive and curious seeing the precedent buildings while the elders chose to inquiry more about the bamboo, especially the concern on bamboo lifespan.

Without preservation, bamboo will have a short lifespan because it is fragile to insect attack, fungus, and mold. However, bamboo can last more than 10 yr with proper preservation and design which protects bamboo from weather exposure such as rainwater and sun radiation. As PCU team informed and explained that bamboo can be preserved and have a longer lifespan, the locals' were interested and their preferences of the building design became clearer and showed from the discussion. They communicated their preferences as follows:

“I want something curved, sheltered space.” (pointing one of the precedent buildings with arch)

“It will be nice if the visitor could experience the curved roof. So, make it (space) a little longer.”

“I like the spherical form, it is better and more suitable for a shelter.”

Through FGD, the locals learned from precedents of bamboo architecture and fascinated on how bamboo can be pushed and formed into building that they never saw before. Due to the impression and

new understanding, the locals agreed to utilize bamboo as a primary building material and started to discuss which facilities they wanted to design first and what architectural form they expect. From the discussion process, the locals decided to design a shelter as the pilot model. The model also will be used as a learning project where the locals can learn the skill in bamboo construction.

3.4. Idea 2: The concept of design and the process

The result from first idea and FGD was used to formulate a design for shelter. The forms desired by the locals were transformed into a conceptual design by PCU team. To transform into a design of shelter, students did several model simulations using bamboo sticks. Students made structural models of reciprocal, trusses and arch to simulate form and construction process. As mentioned before, the structure and construction system must not be too complicated since the locals will construct it using their own resources. Thus, from models had been made, students need to analyze the possibility of the construction system.

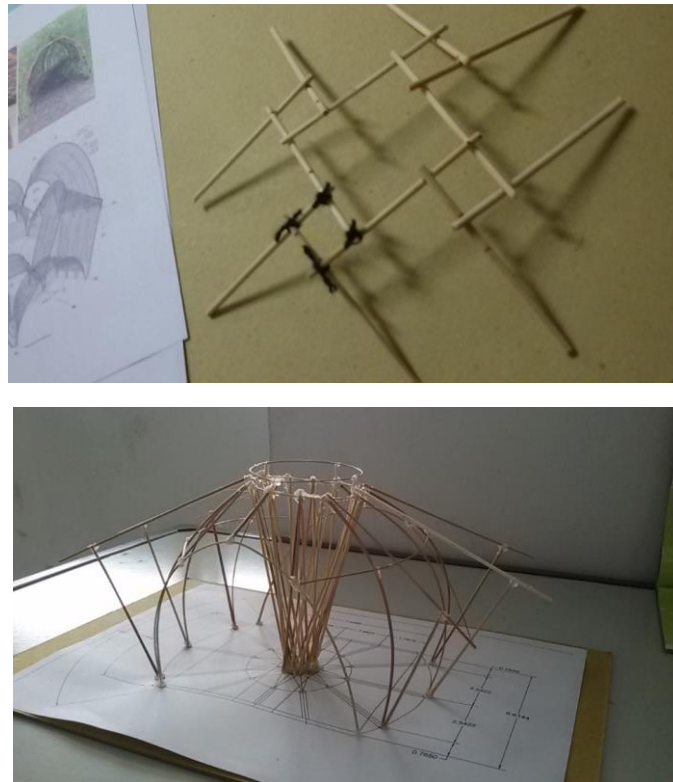


Figure 9. Model for study of structure and construction system

Students also considered the locals' preferences of the shelter form. Based on FGD, they want it to be curved or spherical form. The interesting fact was the locals understand the space and ambiance they wanted to create for the facility. Therefore, students explore the possibility of curved and spherical form through sketching and building the models. During the process, students found that it was challenging to bend the bamboo stick; subsequently, they tried to optimized the radius of the curved considering that the locals can build it with their skill. Students also considered the joinery systems for the structure to meet the needs of the locals. The project will be built in a rural area thus complicated joinery systems were avoided and familiar joinery systems, such as lashing technique, bundling technique, and nut and bolts joinery, were used in the design.

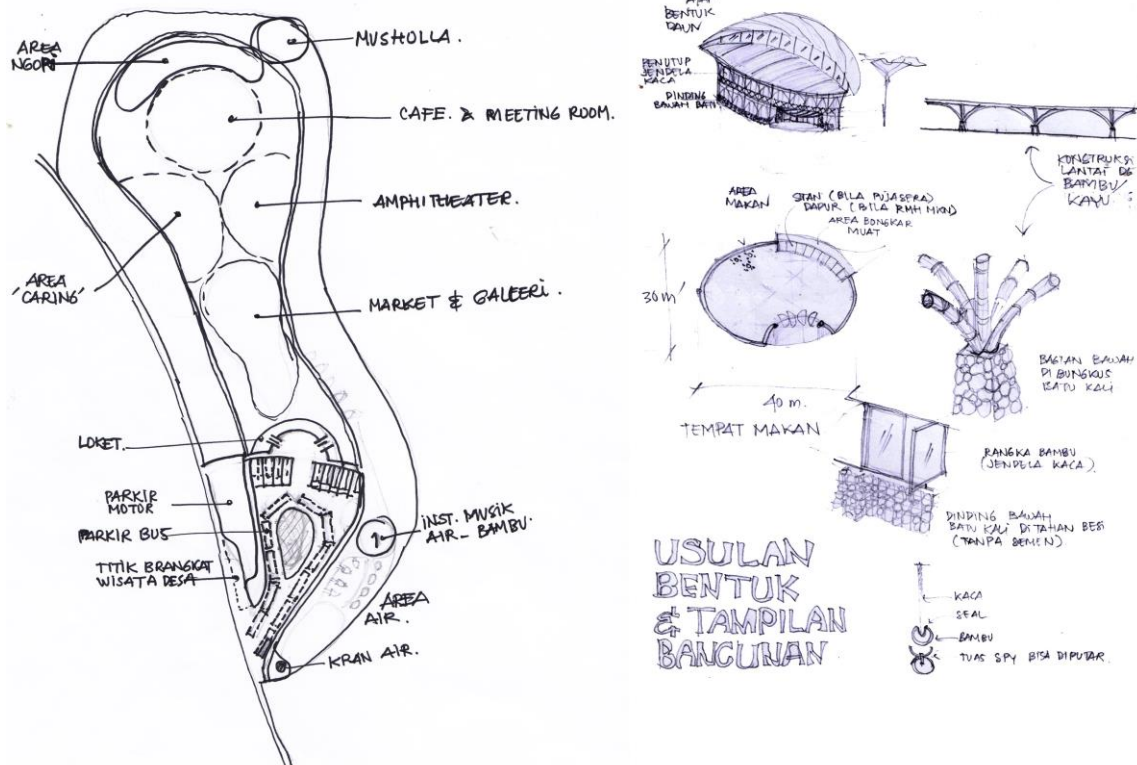


Figure 10. Students’ sketch of the first shelter design.

After several model attempts and analysis, finalized design for the second idea was a shelter using arch structures. The arch structures designed to be built in truss thus the need to curve the bamboo can be minimized and it can be formed from short members. The arches can be assembled on the ground and erected one by one afterward. To make it have a dynamic form, the arches' height was getting lower in the middle thus it created a curve roofline.

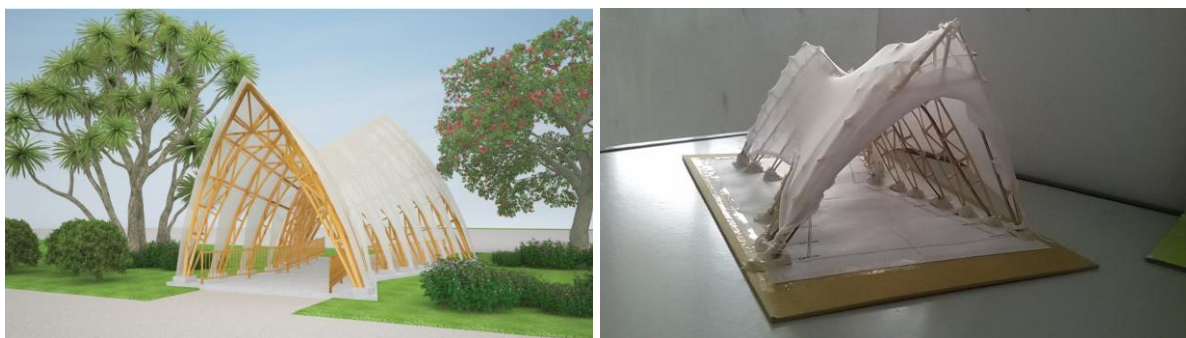


Figure 11. The final model for the shelter.

3.5. Design 1st phase result

The design of the shelter was accepted by the locals and they started to learn how to construct bamboo while preparing to plan the 2nd phase which will be planning the master plan of the facility and construct the facility. Currently, the communities are using new knowledge on bamboo and set up

training for the young generation and artisans. They started to build a workshop on bamboo construction and learn how to treat bamboo.



Figure 12. Workshop bamboo in Jarak village.

The bamboo workshop was initiated by the Headman, followed by local artisans and the members of Village Owned Enterprise. As this was a voluntary workshop and most of the participants have their own jobs respectively (as farmers, builders, and other jobs), the workshops were only held when they had time to gather, thus they did not establish a rigid schedule and participants were allowed to join when they had time. They held the workshop near the riverbank where bamboo grows lavishly hence they could cut the bamboo whenever they need. They could leave their unfinished structures and continued to work again on the next gathering time.

There was no professional trainer but the local artisans tried to share their knowledge of bamboo construction and explored the form. It was their first attempt to curve the bamboo and created an arched bamboo truss. During one of the workshops, students were coming to learn how to harvest bamboo and working with bamboo and to explore the development of the local communities, their skills, and knowledge.

From the exploration, it was found that the locals develop their knowledge by trial and error, they found it difficult to bend the bamboo and to choose the proper dimension for the trusses. They excelled in selecting the high-quality bamboo but lacked in preservation knowledge. Considering the needs of professional trainers and the knowledge of bamboo preservation, PCU team decided to hold a workshop as well as invite an architect and artisans who have designed and built bamboo architecture in the second phase.

4. Conclusion

This first phase was the first step to introduce bamboo architecture to the local community and the locals acknowledged it very well. The finding from FGD shown that at the beginning, the locals' understanding of bamboo architecture was limited to simple and humble buildings. However, their

perspective was changing when the precedents were presented and the interest in bamboo was escalating. Moreover, based on FGD, the locals' preference was on organic and curved form rather than the platonic solid. And after the shelter design was completed as the first model study by the students, the local communities did not waste their time and started to learn bamboo construction.

Based on the findings, to escalate the preferences on bamboo as a building material in the rural area, precedents are one of the key roles. The more fascinating the precedents are the more locals' curiosity and interest have risen, thus the precedents play a role as a stimulation. Moreover, integrating the learning process in architectural education and community service for local communities also can be an effective method because not only local communities will gain the benefit but also students. The students can learn how to design based on locals' condition as well as to communicate and grow the empathy to local communities.

Lastly, bamboo not only as a building material but also as local material will play a role in community development in Indonesia. Since most local people and artisans have basic knowledge of bamboo and it existed since a long time ago, reviving the bamboo architecture in new ways, new forms, and new structure and construction systems may stimulate more local communities to utilize bamboo in unique ways. Thus, the development and empowering programs for local communities in the future will focus on the utilization of local resources.

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