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UTILIZATION PATTERN AND POTENTIAL OF GELAM WOOD (*MELALEUCA CAJUPUTI POWELL*) AS A FOUNDATION STRUCTURE

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ABSTRACT: Gelam wood (*Melaleuca cajuputi Powell*) is one of the essential raw materials for traditional foundations in Kalimantan, which is widely available along the wetlands. It plays an important role in supporting the construction of houses and other infrastructure in Indonesia. Consequently, there is a need for sustainable gelam wood cultivation in Kalimantan. Presently, it is not only used in the development of wetland stilt housing, but also for the interior of the house. Therefore, this study aimed to identify the pattern of using gelam wood as a foundation structure and its potential. The qualitative design method was used with an interview survey and literature review. The result showed that the patterns of using gelam wood as a foundation are as follows; 3-6 m length for simple buildings or 1-story houses, 7-10 m length for 2-story buildings or high-rise buildings, and 3-4 m length for road construction. The diameter of gelam wood used varies between 8-15 cm. Furthermore, the potential use is very large, where the need for residential foundations in Banjarmasin City is approximately 30000 m³ in 1 year, and an average of 14000-20000 are needed for 1 road construction project, not including those used for other structures.

Keywords: Gelam, Foundation, Utilization, Structure, Potential

1. INTRODUCTION

Gelam wood (*Melaleuca cajuputi Powell*) also known as galam in colloquial speech, is one of the raw materials for traditional foundations, which is widely available along the wetlands of Kalimantan. It belongs to the *Melaleuca* genus of the *Myrtaceae* family and grows naturally in the peatlands of South and Central Kalimantan as well as other areas. Seven types of *Melaleuca* are common in the world, namely *Melaleuca cajuputi*, *Melaleuca dealbata*, *Melaleuca leucadendra*, *Melaleuca nervosa*, *Melaleuca quinquenervia*, *Melaleuca stenostachya*, and *Melaleuca viridiflora* [1, 2]. In South Kalimantan, gelam wood mainly originates from Batola Subdistrict, Tanah Laut Regency, Tapin Regency, South Hulu Sungai Regency, and some parts of Central Kalimantan, specifically Dadahup Village in Kapuas Regency. As the center of production, Batola Subdistrict has the potential to produce gelam wood between 2.9 to 7.1 m³/Ha, although this has been decreasing every year [3, 4].

Gelam wood plays an important role in wetlands by supporting the construction of houses and other infrastructure in Indonesia. The demand in Kalimantan is huge and continuous. It is not only used in the development of wetland stilt housing, but also in the production of planks and beams for the interior of the house, as well as debris and scraps

used as firewood. [3]. Furthermore, gelam wood as shown in Figure 1 has special properties which make it suitable to be used as part of the foundation of house buildings along the riverbank. The more it is submerged, the better the strength and durability, hence, gelam wood submerged in mud can stay for decades. A study conducted on peat swamps in Central Kalimantan stated that it can last up to 35 years. Moreover, gelam wood foundation used on peat swamp soil for 10-38 years experienced an increase in wood dry density by 28.13%, hardness by 12.83%, and silica content by 1.25% [5].

The potential use of gelam wood in Banjarmasin City and South Kalimantan Province is quite significant. It has several advantages compared to precast concrete foundations, both in terms of cost and adaptability to swamp land. The use of gelam wood is more dominant in the form of logs such as piles or rafts [6, 7], as shown in Figure 2. This is because group foundations have a smaller reduction than single piles [8] and provide better stiffness during lateral pushover [9]. Gelam wood is also one of the most suitable foundation materials because it can adapt to surrounding conditions [1]. This form of adaptation is important, specifically in dealing with tidal effects on soil water content and soil temperature. Meanwhile, several studies showed that changes in soil temperature affect the bearing capacity of the pile foundation [10, 11].



Fig. 1 Gelam wood (*Melaleuca cajuputi* Powell)



Fig. 2 Gelam wood piles on the construction site

Gelam wood is a leading commodity and a potential source of local government revenue when managed properly. In South Kalimantan, the current governance and administrative regulations regarding the management are poor, thereby threatening the sustainability and population which tends to decrease every year [3, 6]. To maintain the sustainability of the use of gelam wood foundations, one of the first steps is to identify the actual pattern and its potential, specifically in Banjarmasin.

Therefore, this study aims to identify the pattern of using gelam wood as a foundation structure and its potential. The expected results are to obtain information about the dimension of gelam wood mostly used for foundation structure. It is also expected that the necessity of gelam wood in a year for foundation structure can be obtained from the results.

2. RESEARCH SIGNIFICANCE

The significance of this study is the identification of gelam wood dimension used specifically as a foundation structure for a variety of construction types. This is also the first study to utilize the construction society in Banjarmasin City as the respondent in terms of using gelam wood as a foundation structure. In addition, the necessity of

use will be obtained, which has not been recorded in any previous study. The results are expected to also provide the necessary information for all the stakeholders and government in the formulation of the future gelam wood utilization strategy to prevent its extinction.

3. METHOD

The scope of the study area is Banjarmasin, South Kalimantan. This study was conducted using a qualitative design through an interview survey and literature review with a cultural approach [12, 13]. The primary data were obtained from the questionnaire given to users of gelam wood in the construction society in Banjarmasin. Questionnaire interviews were conducted individually in a semi-structured form which has previously been evaluated by 3 experts to ensure that the language and questions used can be understood by the respondents. This is important to avoid miscommunication regarding the questions asked [14]. Interview questionnaires were given to 25 respondents according to the minimum number for a single case study on a small scale [15, 16]. The respondents consisted of academics and practitioners who have field experience in terms of using gelam wood as foundation structures. The data obtained were then analyzed to provide a broader picture, understanding, and a practical overview of phenomena in the field [17].

The questions asked are:

1. What do you think about the use of gelam wood as a foundation construction material?
2. What is the size of gelam wood that you generally use for foundation construction, whether simple buildings, buildings, or roads?
3. Where was gelam wood purchased/obtained?
4. How much volume (m^3) is the average use of gelam wood in 1 work project or 1 year?
5. What are the advantages of using gelam wood as a foundation structure material?
6. What are the disadvantages of using gelam wood as a foundation structure material?
7. What are the prospects regarding the availability of gelam wood for construction?
8. What are the challenges regarding the availability of gelam wood for construction?

The provision and collection of questionnaires were carried out directly using face-to-face interviews or through online social media. The answers were compiled using computer spreadsheet software. To support the interview questionnaire, secondary data were used, namely literature and

previous results, as well as related government policies and other relevant data.

4. RESULTS AND DISCUSSION

For the question "What do you think about the use of gelam wood as a foundation construction material?" 40% of the respondents answered that it is very suitable for simple 1 or 2-story buildings. This is based on the building load which is not too large and the relatively cheap price of gelam wood. About 44% stated that gelam wood is very suitable for use because the typical soil of Banjarmasin is swamp or soft. It also has good strength and durability when immersed in peat or swamp soil. In addition, gelam wood was reported to be widely available. Another opinion is that gelam wood is a form of local wisdom among the people of South Kalimantan which has been used as a foundation for a long time. The traditional form of foundation is a raft footing called Kacapuri [18], as shown in Figure 3.

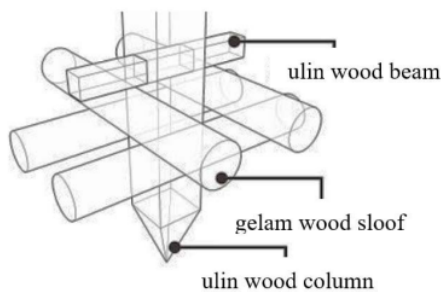


Fig. 3 Form of Kacapuri foundation [18]

These answers are in line with other studies which stated that gelam wood is very suitable to be used for tidal swamp soil, namely as a friction pile foundation. A study conducted in Banjarmasin reported that gelam wood foundation was able to carry the load of a 3-story shophouse [19]. The results are in agreement with another study which stated that the longer the wooden piles were used, the greater the shear strength of the soil [20].

The next question was "What is the size of gelam wood generally used for foundation construction, whether simple buildings or roads?" The size which is mostly used for simple buildings or 1-story houses generally is a diameter of 8-12 cm with a length of 3-6 m. The respondents' answer is in line with other references which mentioned that the required size is a wood diameter between 8 cm to 15 cm and a pole length between 3.5 m to 6 m [21, 22]. Meanwhile, the foundation for 1-story houses is usually in form of a group pile foundation consisting of four wood pile [22], as shown in Figure 4. For 2-story or high-rise buildings, a

diameter of 10-15 cm with a length of 7-10 m is generally used.

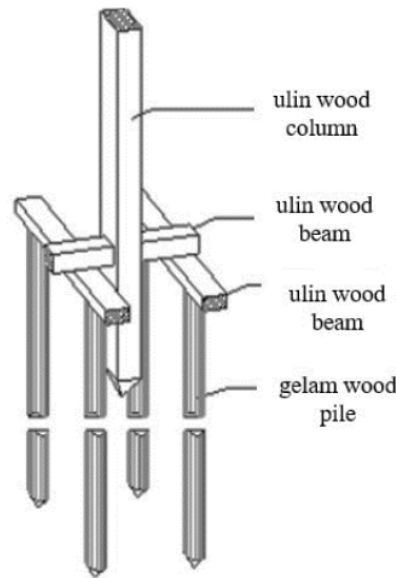


Fig. 4 Gelam wood group pile foundation [22]

To ensure that the pile foundation or gelam wood pile work optimally, the bark should not be peeled off as illustrated in Figure 5. Recently, reinforced concrete slab has also been used for concrete buildings with pile foundation of gelam wood. The addition of gelam wood pile is intended to improve the bearing capacity of the soil [23]. Another study showed that the ultimate bearing capacity of a single pile of gelam wood foundation 12 cm and 14 cm in diameter and 3.5 m long ranged between 567.75 kg to 729.25 kg [24].



Fig. 5 Gelam wood foundation for houses

For road construction, gelam wood foundations are generally used for backfill reinforcement, retaining walls, and fences with a diameter of 6-10

cm and a length of 3-4 m. The questionnaire results are in line with another study which stated that gelam wood used for road construction reinforcement is a 3.5 m long foundation, as shown in Figure 6 [25].



Fig. 6 Gelam wood foundation for road construction [25]

For the question "Where was gelam wood purchased/obtained?" the majority of respondents, namely 60% answered that it was purchased or obtained from Barito Kuala in Marabahan, Margasari and Kapuas Regency, as shown in Figure 7. Meanwhile, about 8% stated that gelam wood was obtained at a collector's place in Liang Anggang, Banjar District. Others generally answered that it was purchased from construction shops and traders around the work site, due to a large number of traders in Banjarmasin, as shown in Figure 8. Aside the supply coming from South Kalimantan, it also comes from Kapuas, Central Kalimantan.

Regarding the question "How much volume (m^3) is the average use of gelam wood in 1 work project or 1 year?", about 48% of the respondents did not provide an answer or were not sure how much gelam wood is used. A total of 16% answered that an average of 1000-2000 gelam logs of 7-10 m long piles are needed for a 1-story building. Another 16% stated that for 1 road construction project, an average of 14000-20000 piles of gelam wood are needed. Based on the building development permit application submitted in Banjarmasin between January 2022 and December 2022 as shown in Table 1, 29745.52 m^3 of gelam wood or around 30000 m^3 is needed in 1 year.

The next question was "What are the advantages of using gelam wood as a foundation structure material?". The main advantage according to the majority of respondents is that it is cheap and easy to obtain. This answer is in line with a study conducted for residential buildings in Banjarmasin which reported that the cost of using gelam wood is still lower than mini-pile concrete for the same type of building construction [26]. This study showed that in terms of construction costs, the selection of gelam wood is more economical than concrete mini

pile foundations.

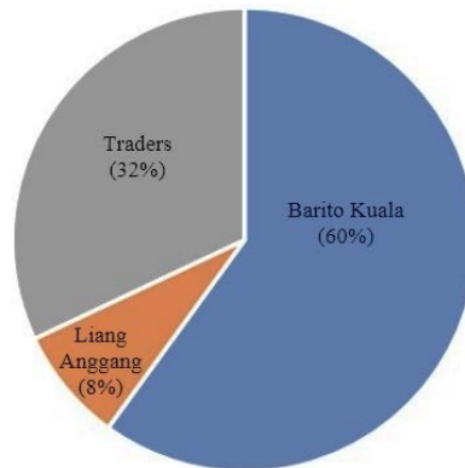


Fig. 7 The origin of gelam wood



Fig. 8 Gelam wood traders in Banjarmasin

Another major advantage is the weight of gelam wood which is lighter compared to concrete pile foundations. The lighter weight made the consolidation of pile is smaller. This is mainly related to the depth of the hard soil of Banjarmasin which ranges from 28 – 42.4 m [27]. This also makes gelam wood more suitable as a friction pile or floating foundation. Apart from these main reasons, 28% of the respondents stated that one of the advantages of using gelam wood is that it is durable even in wet or submerged conditions. This is in line with a previous study conducted in Kien Giang Province, Mekong Delta, Vietnam, which proved the ability of gelam wood to adapt to surrounding conditions and not only in swamps. The study used a fence construction with Melaleuca cajuputi wood to protect the coastal area and the mangrove restoration. The results showed that the fence built contributed significantly to reducing wave energy and holding unstable mud in the restoration area [28].

Table 1 The volume of gelam wood used in residential houses in Banjarmasin City

Residential Name	Location	Number of Houses	Volume (m ³)
Perdana Mandiri Residence	Padat Karya Road	54	346.217
Alamindo Sejahtera Permai Residence	AMD Blok I Road	51	126.946
Berkat Sekumpul Residence	Sungai Andai Road	14	86.240
Green Sunny Estate Residence	Peradapan Karya Road	331	2829.577
Villa Sunny Residence	Tatah Bangkal Luar Road	61	109.277
Asman Banua Anyar Residence	Banua Anyar Road	44	331.886
Citra Modern Type 79 Residence	Tatah Bangkal Road	38	628.290
Citra Modern Type 70 Residence	Tatah Bangkal Road	70	1165.824
Citra Modern Type 54 Residence	Tatah Bangkal Road	26	395.366
Citra Modern Type 45 Residence	Tatah Bangkal Road	71	1071.086
Citra Modern Type 36 Residence	Tatah Bangkal Road	72	1042.725
Antasari Mandiri 3 Residence	Kelayan A II Road	64	263.899
AMD XII Residence	AMD XII Road	46	199.856
Griya Pelangi Residence	Teluk Gampa Road	53	326.480
Kota Asman Graha Residence	Sungai Gampa Road	192	1230.994
Aldi Citra Persada II Residence	Mantuil Permai Road	105	633.600

Table 1 continued

Green Sunny Living	Peradapan Karya Road	224	5969.920
Griya Permata 5 Type 36 Residence	AMD XII Road	66	379.594
Griya Permata 5 Type 45 Residence	AMD XII Road	9	58.551
IONA LAND Residence	Kelayan Timur Road	71	464.137
Wahyu Utama the Residence	AMD XII Road	300	537.429
City Type 36 Bumi Wahyu Utama the Residence	AMD XII Road	75	190.929
City Type 45 Bumi Wahyu Utama the Residence	AMD XII Road	25	392.857
City Type 70 Pinang Indah Residence	Pinang Ujung Road	40	266.514
Royal Mahatama Type 36 Residence	P. Hidayatullah Road	61	550.220
Royal Mahatama Type 42 Residence	P. Hidayatullah Road	38	468.160
Royal Mahatama Type 60 Residence	P. Hidayatullah Road	21	404.250
D'Sunny Regency	AMD Road	348	9274.697
Total Volume (m ³)			29745.52

Regarding the question "What are the disadvantages of using gelam wood as a foundation structure material?", about 64% of the respondents stated that it breaks easily into different lengths and diameters. Others mentioned that it rots quickly in dry conditions, and the bearing capacity of a single pile is relatively small, hence, it requires large number of piles.

The next question was "What are the prospects regarding the availability of gelam wood for

construction?". The majority of the respondents answered that the current prospects regarding the availability of gelam wood for construction are still in sufficient quantities. However, it has become difficult to obtain for large sizes, for example, more than 4 m. When logging is carried out continuously without any replanting or maintenance of the forest, then gelam wood will soon become extinct. To overcome this, some respondents suggested that there must be cultivation before it can be reused periodically, and some also opined switching to other foundation materials, such as concrete piles.

For the next question "What are the challenges regarding the availability of gelam wood for construction?", 96% of the respondents mentioned the difficulty of finding the large sizes and its availability which is becoming smaller and moving towards extinction. This is because the logging for current use is not accompanied by replanting efforts. The scarcity of gelam wood is also triggered by its use for purposes other than as a foundation, for example, scaffolding in building work, as shown in Figure 9.



Fig. 9 Gelam wood as a scaffolding

A previous study stated that based on current monitoring, gelam wood's existence is decreasing due to the conversion of forest into agricultural land and settlements because of the rapid population growth rate [29]. In this case, the management system and regulations governing gelam wood must be made to prevent damage to the regeneration. The limitation of the stem diameter in gelam wood that is cut down must be strictly controlled to sustain its potential [3, 4].

Based on the respondents' answers, it can be concluded that the pattern of using gelam wood as a foundation is dominated by a diameter of 8-12 cm and a length of 3-6 m which is mostly used for simple buildings or 1-story houses. The majority of gelam wood used as foundation came from Barito Kuala including Marabahan, Margasari, and Kapuas regency. Furthermore, the potential of use is very large, where the need for residential foundations in Banjarmasin reaches a range of

30000 m³ in 1 year and an average of 14000-20000 gelam logs are needed for 1 road construction project, aside from those used for other structures. Possible constraints regarding the potential for sustainable use of gelam wood as a foundation include the difficulty of finding a diameter and length that is more than 4-5 m, and declining availability which is even moving towards extinction.

This result is slightly different from similar studies which employed gelam traders as their respondents. Based on the traders, the dimension of gelam wood used for foundation structures is 8-9 cm, and the bigger diameter is used for railway pile and plank [6]. The similarity in both studies is that the potential use is still existing and has continued to increase although its availability in nature is starting to decrease.

5. CONCLUSIONS

This study on the pattern of utilization and potential of gelam wood as a foundation structure obtained the following results:

1. The pattern of gelam wood used as a foundation ranged from 3-6 m length for simple buildings or 1-story houses, 7-10 m length for 2-story buildings or high-rise buildings, and 3-4 m length for road construction. The diameter used varies between 8-15 cm.
2. The potential use of gelam wood as a foundation structure is very large, where the demand for residential foundations in Banjarmasin ranges around 30000 m³ in 1 year, while an average of 14000-20000 gelam logs is needed for 1 road construction project, aside from those used for other structures.
3. The current prospects regarding the availability of gelam wood for construction are still in sufficient quantities.
4. Constraints that might be faced regarding the potential for sustainable use of gelam wood as a foundation are the difficulty of finding the diameter and length of more than 4-5 m, as well as its availability which is decreasing, and moving towards extinct.
5. This result is slightly different from similar studies which employed gelam traders as their respondents in terms of gelam wood dimension used for foundation structures. The similarity in both studies is that the potential use is still existing and has continued to increase although its availability in nature is starting to decrease.

6. ACKNOWLEDGMENTS

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