UNS UNIVERSITAS SEBELAS MARET

ARSITEKTURA
JURNAL ILMIAH ARSITEKTUR DAN LINGKUNGAN BINAAN
ISSN 1693-3680
E-ISSN 2580-2976
available online https://jurnal.uns.ac.id/Arsitektura

Volume 18 Issue 2 October 2020, pages:327-336

Potensi Teknik Perlindungan Dinding Bebak untuk Meningkatkan Stabilitas Konstruksi dan Kekuatan Ikatan Material

The Potential of the Bebak Wall Protection Technique on Increasing Construction Stability and Material Bond Strength

Eugenius Pradipto [1]*, Nabila Afif [1]
Department of Architecture and Planning, Faculty of Engineering, Universitas Gadjah Mada[1*]
e.pradipto@ugm.ac.id

DOI: https://doi.org/10.20961/arst.v18i2.44225
Received: September 8, 2020 Revised: October 23, 2020 Accepted: October 23, 2020 Available online: October 31, 2020

Abstract
Bebak, *the local building material of East Nusa Tenggara, has long been used as the primary building material, especially as wall material. However,* bebak *wall construction commonly used today is not yet ideal in terms of its material protection and function.* Bebak *is a relatively quick damage construction due to termites, which eventually causes the enclosed space's thermal conditions less comfortable. This research is part of the quality improvement program of healthy housing in that region, which focuses on* bebak *wall protection by plastering the wall with concrete plaster. Two scale models were examined; a wall plastered only on one side, and a wall plastered on both sides. By using a simple construction approach, the research aims to evaluate the* bebak *protection technique's effects on the construction stability and the bond strength between the* bebak *composite wall materials. The results of visual evaluations revealed that single-sided plaster on* bebak *walls could maintain the construction stability and the bond strength of the composite material better than the double-sided one. Furthermore, the evaluation also reveals additional benefits of the plastered walls for the users, such as adaptability and simplicity of modular wall replication to build affordable healthy housing.*

Keywords*:* bebak *wall, concrete plaster, composite wall, simple construction.*

1. INTRODUCTION

1.1 *Bebak* as a building material

In remote parts of Indonesia, the vast majority of house walls are made from plants, such as wooden planks, bamboo, and tree fronds. In East Nusa Tenggara, the locals know "*bebak*" as *Gewang* fronds (Corypha utan Lamk.), which have been connected by pinning them with a bamboo blade (Prasetiyo et al., 2008). *Bebak* has now become a home industry and is traded with a width of 40-50 cm from 10 fronds and a length of 200-300 cm.

Bebak has been known and used as a construction material for a long time. It is commonly utilized as building elements, such as for floors (Badan Penelitian dan Pengembangan PUPR, 2017; Subyakto et al., 2005), ceilings, and walls (Ormeling, 1955; Naiola el al, 1992 as cited in Naiola, 2004). As a wall element, *bebak* is installed in an upright and lined up position. The construction of *the* *bebak* wall is very simple. *Several bebak* are installed in a row, arranged and reinforced or sandwiched between wooden beams that cross the building columns, as seen in Figure 1.

Figure 1. Exterior wall made of *bebak*
Source: Author, 2017.

Bebak is considered stronger and more durable than bamboo when used as wall material. However, as frequently happened to plant-based building materials, *bebak* can be damaged due to termite or fungal attacks, especially in parts directly exposed to humidity sources, such as water or soil.

1.2 The problem with current usage

In Malaka Regency, East Nusa Tenggara, *a bebak* wall's construction as a room divider is commonly installed on the ground or supported by rocks as relatively low foundations. It causes very quickly damage to *the bebak* wall due to termite attacks. The humidity level above 60% and 26-29° C temperature are the perfect places for subterranean termites (Waryono, 2008). Moreover, plant-based material has a hygroscopic characteristic in which it will continuously absorb water from the air though it has been dried beforehand (Alimah, 2013). Those are two major damage factors which cause the *bebak* wall cannot last long, for approximately 2-3 years.

Based on a 2017 research, it is suggested to avoid any direct contact between *bebak* and ground to increase the material's durability as a wall component (Prabawa, 2017). Nevertheless, direct observation on the field has shown another urging challenge in its daily use.

Fronds material for making the *bebak* walls are taken directly from trees. The fronds are connected by pinning them with a bamboo blade. Consequently, the *bebak* arrangements and their edges are often untidy and have many gaps and transparent hollows that allow wind to enter the enclosed space, as seen in Figure 2. This condition is less favorable for areas with the hot, dry climate in daytime and cold at nights, as in the case of the Malaka Regency, East Nusa Tenggara.

Figure 2. Air gaps in the *bebak* wall
Source: Author, 2017.

From a more pragmatic perspective, since 2011, there has been research that discusses the potential utilization of laminated *bebak* for increasing the quality of wall material in Nusa Tenggara Timur (Lie & Laurens, 2019; Munarto & Suprijanto, 2012; Suprijanto et al., 2012). Nevertheless, projects cited in those research are still the government's project in which the development of the laminated material itself is government-produced (Badan Penelitian dan Pengembangan PUPR, 2017). Thus, the technology is not readily available for the local to self-develop.

Therefore, considering all the factors mentioned earlier, this research offers an original and unique standpoint from an architectural perspective. The durability of the *bebak* as wall material and the locality orientation of the technology are both optimized as an alternative to the laminated *bebak*. Moreover, the material's aesthetic potential is also explored as an added value of the research result. An explanation of this factor is provided in the latter part of the paper.

1.3 Composite construction material

There have been many studies examining various methods to improve the quality of plant-based building materials. One of the applicable techniques is plastering with another stiffer material, such as concrete plaster, that has been implemented in wooden floor cases (Rijal et al., 2016). Composite construction is a mixed construction of several materials with different characteristics that result in synergetic construction elements with the same behavior, especially when they withstand loads (Singgih Prasetyo et al., 2016).

In general, there are four types of composite materials: (1) fibrous composite, (2) laminated composite, (3) particulate composite material, dan (4) combination (Jones, 1998). The laminated construction material discussed in this study is in the laminated composite category, which means that the composite material comprises several layers.

1.4. Plastered *bebak* as the development of the composite construction material

The plastered *bebak* models developed in this study are based on the development of a composite construction model. In this composite arrangement, there were three primary materials used: (1) concrete, (2) stainless steel wire mesh, and (3) *bebak*. Concrete that has excellent compressive strength is used to form a composite material and seal gaps on the *bebak* surface so that the wall will be wind and water resistance. Several studies examining the wall quality improvement have shown a positive synergy between the concrete composite and natural plant fiber (Mufida et al., 2018; Reis, 2006; Savastano et al., 2009), while wire mesh can increase the solidness of concrete-based walls that make them more resilient to shear forces (Anggreni et al., 2015; Purbotunggal, 2016). Meanwhile, *bebak* is chosen following the research framework to improve the quality of the wall material.

1.5 Research as a part of an applicative program to improve housing quality in Malaka

This research relates to a collaborative program between the authors and the Directorate of Self-Help Housing, Directorate General of Housing Provider, Ministry of Public Works and Public Housing of the Republic of Indonesia in 2017 entitling “Improving Housing Quality in Malaka Regency, East Nusa Tenggara”.

Based on the program’s objective and evaluation of the field’s actual condition, the authors developed a plastered *bebak* wall model. From the constructional point of view, this plastering aims to increase the wall durability by reducing the direct contact of *the bebak* wall with rainwater. Meanwhile, from the functional point of view, the plaster functions to cover up the gaps that emerge from the varying density of the *bebak* walls. Thus the wall could function better in withstanding cold winds at night. Additionally, regarding *the bebak* installation for the exemplary healthy house, the modular composite walls are placed on a layer of brick arrangement. This method aims to reduce the direct contact of the modular wooden frame with the ground. Although it does not include in the research scope, this additional information is essential to provide a more comprehensive context in assessing the healthy housing quality improvement program.

1.6 Research objective, scope, and limitation

Apart from several other aforementioned constructional strategies applied in the program, the research discussed in this paper focuses only on constructing the modular composite wall. This research aims to evaluate the effects of the *bebak* protection technique on the construction stability and the bond strength between the material used on the wall using a simple construction approach. Understanding on the stability and durability context in this research is referred to other studies related to composite material; in which stability means the ability of composite material to resist excessive deformation during its lifetime, and durability means the resistance of composite materials to the damage factors, such as water and temperature over a long period (Haris, 2019).

Two models were developed for comparison; *bebak* wall plastered on one side and *bebak* wall plastered on both sides. The examination methods for each model are presented in detail in the Methodology section, while the detailed construction methods are provided in the Data and Discussion section.

2. METHODOLOGY

This research is an experimental research using 1:1 scale models. This research employs two main models in which the formation and examination undertake several steps. The most significant difference between the two models is the element arrangement inside the composite wall; the first model is a *bebak* wall plastered on both sides, while the second model is a *bebak* wall plastered only on one side, as shown in Figure 3 and Figure 4.

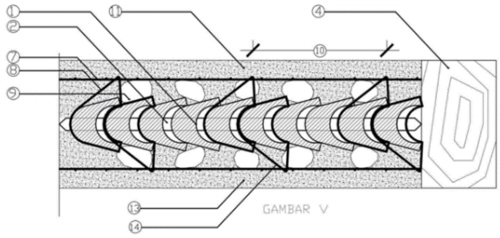

Figure 3. Constructional drawing of the first model
Source: (Pradipto, 2019)

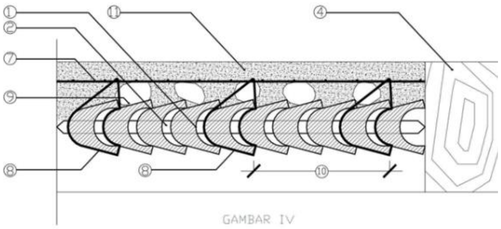

Figure 4. Constructional drawing of the second model
Source: (Pradipto, 2019)

The first model undertook two examinations. The first one was executed after the model was placed in an open area that allowed maximum exposure to the sunlight and rain for a month. This treatment took place in Yogyakarta in June 2017, with the average relative humidity of 84%. Regarding the placement, the model was positioned in an upright position, and the fiber direction of the *bebak* was relatively parallel to the model's contact surface with the ground, as seen in Figure 5. This treatment aimed to simulate extremely humid conditions.
The following was visual testing to evaluate the effect of extremely humid conditions on the stability of *bebak* composite wall construction. The indicators included are the cracks on the scale model's surface and the overall shape changes of the scale model.

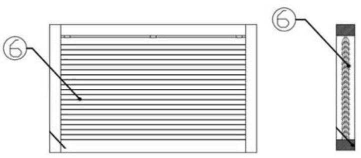

Figure 5. Positioning of the first model for testing

Adapted from: (Pradipto, 2019)

Under the same treatment, the second visual testing was undertaken two years later. In this second test, the central part of the composite wall was opened to evaluate the effect of extremely humid conditions on the stability of the composite wall construction and the bond strength between the wall's materials. The indicators included are the bond's coherence between the concrete and *bebak,* and the bond's coherence between the concrete and the stainless steel wire mesh.
The second model only passed a single examination. It was done when the model had been used as a modular composite wall element for two years in Malaka Regency, East Nusa Tenggara. Regarding the treatment, the model was placed under the roof in an upright position, and the fibre direction of the *bebak* was perpendicular to the model's contact surface, as seen in Figure 6. Visual testing was done to evaluate the stability of the *bebak* composite wall construction and the bond strength between the composite wall materials in the actual use.

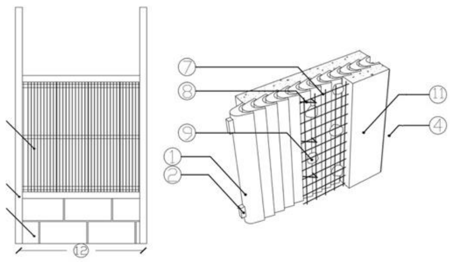

Figure 6. Positioning of the second model for testing
Adapted from: (Pradipto, 2019)

3. RESULT AND DISCUSSION

3.1 The construction method of the first model

The constituent materials of the first model include (1) *bebak* (10 fronds), (2) stainless steel wire mesh with 1-inch wire diameter, (3) rebar tying wire with 1 mm diameter, (4) concrete mix in a ratio of 1 cement : 2 sand : 3 gravel, (5) 5/7 coconut wood frame, and (6) concrete spacer rocks with 2-3 cm diameter. The model's size was adjusted to the size of the available *bebak,* which was 42 x 98 cm.

The construction method started with making the *bebak* arrangement by pinning several fronds together with bamboo blade, as seen in Figure 7.

Figure 7. *Bebak* fronds arrangement

Then, it was framed with 5/7 wood. The wood is positioned in a way to reach a 7 cm thickness of the frame. *Bebak* was installed to be the frame filler so that the construction model of *bebak* would finally be 49 x 112 cm. The stainless steel wire mesh was then set over the wooden frame by giving 2-3 cm of space between the wire mesh and *bebak*. The space was secured by a wedge of several 2-3 cm stones.

The concrete plaster was then affixed to *bebak* covered with wire mesh. The plaster application started from the bottom up so that the concrete mixture would not be collapsed. *Bebak* plastering undertook two stages, with the second layer was done following the previous method after the first layer started to get dry. The weight of the first model, with a volume size of 49 x 112 x 10 cm plastered with concrete on both sides, was 100.8 kg. Illustrations of these abovementioned construction stages are provided in Figure 8, 9, 10 and 11.

Figure 8. *Bebak* as the frame filler

Figure 9. Wire mesh on top of the frame

Figure 10. Space between the wire mesh and *bebak*

Figure 11. Plaster application on the model

3.2 The construction method of the second model

The constituent materials of the first and the second models are very much alike. There have been only minor adjustments to the element and module's size, as described below: (1) The coconut wood frame's size became 6/10 following local building materials' availability. *Bebak* as the frame filler was mounted on a side with 10 cm thick; (2) an adjustment to the concrete layer's location. In the second model's construction, the concrete plaster was only applied to the outer side, and the inside of the wall was left open. Furthermore, the plastering was only done on top of *bebak* as a wall filler, while the wooden frame was left open; (3) an adjustment to the overall size of the model. The model's size was adjusted to the modular size of the available space in the selected healthy house where the composite wall was applied, as seen in Figure 8, 9 and 10.

Figure 8. On-site rebar tying wire installation on the 2nd model

Figure 9. On-site concrete spacer installation on the 2nd model

Figure 10. On-site concrete plaster installation of the 2nd model

The height of the window module (90 cm) affected the height of the wall module, the distance between the practical columns in the house (120 cm) affected the module width, and the size of coconut wood for frames, as well as reduction of the concrete layer on one of the modular sides, affected the thickness of the module. The width and length of the module are modifiable and adjustable to any room need and size. The weight of the second model with a volume size of 90 x 120 x 10 cm plastered with concrete on only one side was 42 kg. Illustration of the second model is provided in Figure 11.

Figure 11. The second model with one-side application of concrete plaster

3.3 Examination results of the first model construction

The construction of the first model was executed in Yogyakarta and underwent treatment and testing as a standalone element in the same location. Like the explanation mentioned above in the methodology, there were two tests during extremely humid conditions with a span of one month and two years, respectively, since the completion of the model construction.

The first testing aimed to visually evaluate the effect of extremely humid conditions on the stability of *bebak* composite wall construction with the cracks and overall shape changes on the scale model's surface as indicators. The visual evaluation results revealed the satisfactory physical construction indicated by the absence of both cracks and shape changes on the model surface.

As the research timeline coincides with the housing quality improvement program in Malaka Regency, East Nusa Tenggara, the initial evaluation's positive results were used as the basis for the second model that will be constructed and implemented in South Alas, Malaka Regency, East Nusa Tenggara.

The second testing was to evaluate the effect of extremely humid conditions on the stability of the composite wall construction and on the bond strength between the material and the composite wall using the coherence of the bond between the concrete and *bebak,* and the bond between the concrete and the wire mesh as indicators. The visual observation of the model's outer layer showed no crack and shape change on its surface. The dimension of the model also reminds the same, as seen in Figure 13.

Figure 13. Measurement on the thickness of the model showed no dimensional changes in the model after 2 years

The mouldy concrete plaster in the second examination, as seen in Figure 14, was the only visually identifiable difference between those two examinations.

Figure 14. Moldy plaster on the exterior of the first model after 2 years

However, following the opening of the central part of the wall, it was found that the bond strength of the material had decreased. The decrease was indicated by the condition that the two concrete plaster boards and *bebak* were no longer bound up with rebar tying wire, as seen in Figure 15.

Figure 15. Damaged inner material of the first model after 2 years

From the observation of the concrete plaster's inner surface, it had a rough texture forming the shape of the *bebak*. This condition proved that water from both the concrete mixture and rainwater could enter the composite wall and close gaps on the *bebak* surface.

The visual test resulted in two phenomena as the consequences of having the *bebak* composite wall construction plastered on both sides with fibre direction that paralleled the contact surface. The phenomena are as follows:

Firstly, the *bebak* wall stood between two concrete plaster boards which were solid, non-transparent, wind resistance. This condition increased the humidity and temperature of the material that was placed in between. The water entering the central space was absorbed and stored in *bebak*. The humidity level above 60% and temperature of 26-35° C are the perfect places for subterranean termites. Therefore, termites eat cellulose inside the *bebak*, which significantly degrades its quality within two years.

Secondly, during the examination in an open space, *bebak* functioned as the wooden frame filler while having its fiber direction parallel to the model's contact surface. Water stored in *bebak* could not flow smoothly following its fibre direction and the force of gravity. Therefore, water was trapped inside the material and contributed to the *bebak* material's decomposition between two concrete plaster boards. This condition corresponds to the destruction phenomenon caused by termites that occurs more rapidly when bamboo is positioned parallel to its fibre direction, as seen in Figure 16.

Figure 16. Bamboo damaged by termites

Therefore, although the model satisfied the first indicator (as the bond between the concrete and wire mesh was coherence), it did not meet the second indicator, which was the bond's coherence between the concrete and *bebak*.

3.4 Examination results of the second model construction

The construction of the second model was executed in South Alas, Malaka Regency, East Nusa Tenggara, to undergo treatment and examination as the element of a modular composite wall plastered on one outer side as applied in the exemplary healthy house in the same location. There was only one visual test within two years after the model construction was over. Visual testing was done to evaluate the *bebak* composite wall construction's stability and the bond strength between the wall material the actual use.

The visual observation of the model's outer layer showed neither a crack nor a shape change on its surface. Since only one side being plastered, the visual observation of the material bonding could be done without dismantling the modular wall. The observation proved that the composite concrete wall and *bebak* were still properly bonded as no single layer was detached from the other layers, as seen in Figure 17.

Figure 17. Good condition of the second model after 2 years of installation (interior view)

Additionally, there was no fungus on both the concrete plaster surface and the exposed *bebak* surface, as seen in Figure 18.

Figure 18. Good condition of the second model after 2 years of installation (exterior view)

This condition indicated that the wall construction model with one side open could maintain the ideal humidity for the wall.

3.5 Added values of the construction

Apart from the comparative assessment on the constructional aspects of the two wall models, the basic form of modular wall developed in this research bears an added value of modularity for functionality and aesthetic. Walls made of any of the models could be modified in size to follow not only to fit a room dimension but also to particular pattern design, as seen in Figure 19.

Figure 19. Modular construction differs in size to create an aesthetic accent (interior view)

Furthermore, regardless of the visual observation results about the model itself but knowing this can improve the healthy housing quality, it is essential to investigate the implication of the model construction adaptation as one indicator of success in terms of its usefulness.

The observation towards other housing around the exemplary healthy house showed that the *bebak* composite wall model plastered on one side has started to become a trendsetter for other buildings by the time this paper is written. The locals carry out the replication of this construction model without the help of skilled labor, which potentially leads to more affordable healthy housings. Thus, generally, this construction method can be of benefit to its users.

4. CONCLUSION

This research is focused on evaluating an experimental construction method of plastered *bebak* wall as a modular composite wall. The result of the visual observations of the two models developed in this research has shown the importance of reckoning the location of concrete plaster on controlling the effect of humidity on the composite material's bond strength.

The examinations' results revealed that *bebak* construction plastered only on one outer side offers a better resistance value than *bebak* construction plastered on both sides. The double-sided plastered wall has weaknesses in maintaining the physical condition of the constituent materials, especially the unexposed parts; for example, termite attacks can occur uncontrollably.

On the contrary, a single-sided plastered *bebak* wall allows the other side to maintain free and continuous contact with the surrounding air. Thus, the hygroscopic characteristic of *bebak* as an organic material can be maximally utilized, especially in setting the humidity level of the material surface. In addition, although it is not included in the scope of research, the hygroscopic function of *bebak* walls potentially gives a positive contribution to maintaining the thermal comfort inside the covering space.

ACKNOWLEDGMENT

The authors thank the Directorate of Self-Help Housing, Directorate General of Housing Provider, Ministry of Public Works and Public Housing of the Republic of Indonesia that has provided funds for the development and implementation of models to improve the housing quality in Barada Village and South Alas Village, Malaka Regency, the Province of East Nusa Tenggara.

ADDITIONAL NOTE

The *bebak*-concrete composite construction model has been listed on the Directorate General of Intellectual Property of the Republic of Indonesia (Direktorat Jenderal Kekayaan Intelektual Republik Indonesia) with the invention title of “Dinding Bebak Berplester” and patent number IDS000002827 issued on January 17, 2020.

REFERENSI

Alimah, D. (2013). Peningkatan kualitas kayu sawit. *Galam*, *6*(1). http://foreibanjarbaru.or.id/wp-content/uploads/2016/07/Galam-Volume-VI-Nomor-1-2013-PENINGKATAN-KUALITAS-KAYU-SAWIT.pdf

Anggreni, M. Y., Sudarsana, I. K., & Sukrawa, M. (2015). Perilaku Tekan dan Lentur Dinding Pasangan Batako tanpa Plesteran, dengan Plesteran dan dengan Perkuatan Wiremesh. *Jurnal Spektran*, *3*(2), 10–19.

Badan Penelitian dan Pengembangan PUPR. (2017). *Bebak Laminasi dari Gewang*. Badan Penelitian Dan Pengembangan PUPR. https://litbang.pu.go.id/2017/09/19/bebak-laminasi-dari-gewang/

Haris, H. (2019). Analisis Pengujian Stabilitas dan Durabilitas Campuran Aspal dengan Tes Perendaman. *Jurnal Linears*, *2*(1), 33–47. https://doi.org/10.26618/j-linears.v2i1.3026

Jones, R. M. (1998). *Mechanics of Composite Materials*. CRC Press.

Lie, L. M. C., & Laurens, J. M. (2019). Fasilitas pemberdayaan masyarakat Noelbaki di Kabupaten Kupang. *EDIMENSI ARSITEKTUR*, *VII*(1), 961–968.

Mufida, A., Suprayogi, M. R., & Azwar, E. (2018). Analisis reduksi suara dan kuat tarik komposit beton serat gedebog pisang hasil delignifikasi dengan pelarut natrium hidroksida (NaOH). *Inovasi Pembangunan - Jurnal Kelitbangan*, *06*(02), 105–120.

Munarto, D. R. A., & Suprijanto, I. (2012). Prototype Model Rumah Murah Sejahtera Berbasis Potensi Bahan Bangunan Lokal di Provinsi Nusa Tenggara Timur Pendahuluan. In R. G. Sunaryo & A. Asri (Eds.), *Seminar Nasional Menuju Arsitektur berEmpati* (pp. 483–493). Jurusan Arsitektur, Fakultas Teknik Sipil dan Perencanaan, Universitas Kristen Petra.

Naiola, B. P. (2004). Preliminary Study on the Potential of Gewang (Corypha utan Lamk.) of East Nusa Tenggara Savanna as New Source for Food, Drink and Alcohol Industry. *Berita Biologi*, *7*(3), 169–172.

Prabawa, S. B. (2017). Ketahanan Bebak Gewang Sebagai Komponen Rumah Masyarakat Nusa Tenggara Timur Terhadap Serangan Rayap Tanah. In T. Listyanto, M. Muin, I. Wahyudi, & Krisdianto (Eds.), *Proseding Seminar Nasional Masyarakat Peneliti Kayu Indonesia XX* (pp. 81–86). Fakultas Kehutanan, Universitas Gajah Mada bekerjasama dengan Masyarakat Peneliti Kayu Indonesia.

Pradipto, E. (2019). *Dinding Bebak Berplester* (Patent No. S00201809658). Direktorat Jenderal Kekayaan Intelektual Republik Indonesia.

Prasetiyo, K. W., Subaktyo, & Naiola, B. P. (2008). Sifat Fisik dan Mekanik Batang Gewang (Corypha utan Lamk .) dari Nusa Tenggara Timur. *Journal of Tropical Wood Science and Technology*, *6*(1).

Purbotunggal, S. (2016). Kuat geser dinding panel dengan perkuatan wiremesh. In *Program Studi Teknik Sipil*. Universitas Muhammadiyah Surakarta.

Reis, J. M. L. (2006). Fracture and flexural characterization of natural fiber-reinforced polymer concrete. *Construction and Building Materials*, *20*(9), 673–678. https://doi.org/10.1016/j.conbuildmat.2005.02.008

Rijal, R., Samali, B., Shrestha, R., & Crews, K. (2016). Experimental and analytical study on dynamic performance of timber floor modules (timber beams). *Construction and Building Materials*, *122*, 391–399. https://doi.org/10.1016/j.conbuildmat.2016.06.027

Savastano, H., Santos, S. F., Radonjic, M., & Soboyejo, W. O. (2009). Fracture and fatigue of natural fiber-reinforced cementitious composites. *Cement and Concrete Composites*, *31*(4), 232–243. https://doi.org/10.1016/j.cemconcomp.2009.02.006

Singgih Prasetyo, F., Murni Dewi, S., & Martin Simatupang, R. (2016). Kekuatan lentur balok komposit beton dan bata ringan tulangan bambu dengan variasi tinggi bata ringan. *Jurnal Mahasiswa Jurusan Teknik Sipil Universitas Brawijaya*, *1*(2). https://media.neliti.com/media/publications/110724-ID-kekuatan-lentur-balok-komposit-beton-dan.pdf

Subyakto, Prasetiyo, K. W., Subiyanto, B., & Naiola, B. P. (2005). Potential Biomass of Gewang (Corypha utan Lamk.) for Biocomposites. *Proceedings of the 6th International Wood Science Symposium LIPI-JSPS Core University Program in the Field of Wood Science*.

Suprijanto, I., Rusli, Kusmawan, D., & A.M, D. R. (2012). Peningkatan Kualitas Rumah Rakyat Menggunakan Papan Bebak Laminasi (Rumbela) Di Provinsi NTT. In R. G. Sunaryo & A. Asri (Eds.), *Seminar Nasional Menuju Arsitektur berEmpati* (pp. 569–577). Jurusan Arsitektur, Fakultas Teknik Sipil dan Perencanaan, Universitas Kristen Petra.

Waryono, T. (2008). Ekosistem Rayap Dan Vektor Demam Berdarah Di Lingkungan Permukiman. *Kumpulan Makalah Periode 1987 - 2008*. https://staff.blog.ui.ac.id/tarsoen.waryono/files/2009/12/33-ekosistem-rayap.