The durability of OSB composite plywood with avocado, mahogany, and pine wood veneers against drywood and subterranean termites

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Abstract. Biological decay agent is one threat should be anticipated when designing the building materials. This research is conducted to examine the composite plywood’s (comply’s) durability against drywood and subterranean termites’ attacks. The veneers used are those made of Avocado (Persea americana), Mahogany (Swietenia mahogany) and Pine (Pinus merkusii) wood. Those three veneer types may be used to overlay the Oriented Strand Board’s (OSB’s) face and back part. The comply made then fed to both main biological decay agents in Indonesia, namely drywood termites (in the laboratory) and subterranean termites (grave yard test). The research results show that the comply’s durability is increasing against both drywood and soil termites respectively by 41.3% and 71.58%. This research shows that ME comply type (mahogany veneer, isocyanate adhesive) is the comply with the best durability against both biological decay agents’ attacks. This research result is expected to provide various benefits for material efficiency and energy conservation activity supports.

1. Introduction

The production capacity of plywood industries in Indonesia for the past five years shows an increasing tendency. The primary industries of forest products in 2013 had the production capacity of 3.2 million m³ and in the following years until 2015 kept increasing up to 3.6 million m³ [1]. That number includes the laminated veneer lumber (LVL) products which basic material is veneer which layers are arranged aligned with the fibre pattern direction [2-4]. The next challenge is raw material continuity and product diversification.

The availability of plywood raw materials in the future may be provided with the fast-growing species and less known species, yet the quality is good. It is recorded that in the previous study, the woods with good veneer quality and developed as raw materials are sengon, jabon and red jabon (samama) [5-8]. Those woods are proven becoming veneer-based products which meet the quality standard [9-12].

Product diversification which raw material is veneer includes the Oriented Strand Board Composite Plywood (OSB Comply). This product has several advantages, including improving OSB appearance quality and its mechanical characteristics [13]. The next problem is limited information on its durability...
against various biological decay agents. As we know, those decay agents may result in threats and great losses for the development of Indonesia [14-16]. The number is quite surprising, that is, 411 billion rupiahs resulted from the white rotting fungi [17]. Meanwhile, the great loss resulted by the termites’ attacks in Indonesia in 2015 reached 8.7 trillion rupiahs [18].

This research has designed seven comply types with the veneers of three selected kinds of wood to determine the comply’s durability against drywood and subterranean termites’ attacks. The research result is expected to contribute to one superior alternative product highly durability against the biological decay agents’ attacks. The other benefits are to improve the beauty and efficiency of raw materials for energy conservation supports.

2. Materials and methods

2.1. Materials

The main materials used in this research are the Oriented Strand Board (OSB) obtained from the local markets and the veneers of Avocado, Mahogany and Pine wood. The adhesives used are isocyanate and epoxy.

2.2. Methods

2.2.1. Material preparation. Cut the Oriented Strand Board (OSB) and veneers with the size of (35 x 35) cm. Next, overlay both OSB surfaces with the adhesive with the glue spread of 250 grams cm$^{-2}$. The veneers are placed on both OSB surfaces with the adhesive type and veneer arrangement completely presented in Table 1. Cold press the arrangement with the pressure of 15 kg cm$^{-2}$ for 3 hours. Let it conditioned for two weeks before testing.

| Num. | Type | Adhesive  | Core and Back Veneer |
|------|------|-----------|----------------------|
| 1    | K    | -         | -                    |
| 2    | AI   | Isocyanate| Avocado              |
| 3    | AE   | Epoxy     | Avocado              |
| 4    | PI   | Isocyanate| Pine                 |
| 5    | PE   | Epoxy     | Pine                 |
| 6    | MI   | Isocyanate| Mahogany             |
| 7    | ME   | Epoxy     | Mahogany             |

2.2.2. Comply’s durability against dry wood termites’ attacks (SNI 01-7207-2006). Place 50 worker termites in a glass tube (3 cm height with a diameter of 1.8 cm) on the comply surface. Feed them for 12 weeks. Analyse the comply’s durability against dry wood termites based on the comply’s weight loss and the termites’ mortality before and after feeding.

2.2.3. Grave Yard Test (ASTM D 1758-02). Place the testing sample size of (45 x 2 x 2) cm on the grave yard holes with the depth of 25 cm. The distance between samples is 30 cm x 30 cm. After 12 weeks, the testing samples are observed due to the visual damages and weight loss.

2.2.4. Data analysis. The data analysis is conducted using a completely randomized Design with seven treatments. If the treatments as significant, Duncan test will further be conducted.
3. Results and discussion

3.1. Comply’s durability against dry wood termites’ attacks

The research results show that the dry wood termites’ attack level to OSB and comply of all samples is below 2% (Table 2). Based on Indonesian National Standard (SNI), this value is classified into high durability [19]. Based on each treatment, Table 2 shows that the ME comply’s average (mahogany veneer, epoxy adhesive) has a small attack level value. Furthermore, the OSB has the greatest attack level of 1.27±0.50%. The variance test analytical result explains that the addition of veneer layers influences the termites’ attack level ($p=0.000$) since the test is conducted on the comply’s veneer surface, while on control is directly on the OSB surface. Duncan testing result (Table 3) indicates that the OSB control has the greatest termites’ attacks, while the smallest belongs to ME type. In percentage, the comply design may improve the durability against termites’ attacks by 41.3%.

| Type | Weight Loss | Mortality |
|------|-------------|-----------|
| K    | 1.27±0.50   | 96±6.25   |
| MI   | 0.24±0.18   | 93±4.31   |
| ME   | 0.03±0.14   | 100±0.00  |
| AI   | 0.35±0.43   | 86±6.37   |
| AE   | 0.71±0.19   | 81±7.76   |
| PI   | 1.13±0.26   | 89±12.37  |
| PE   | 1.06±0.23   | 88±9.41   |

The addition of adhesive during the comply production is proven reducing the termites’ attacks. The adhesives used (isocyanate and epoxy) have hydrophobic character disliked by the termites. Furthermore, the emission produced by the adhesive is extremely deadly shown by the high level of termites’ mortality. Figure 1 shows that termites’ mortality is 82% comply type AI after tested for 12 weeks. Meanwhile, Figure 2 shows lower termites’ mortality level by only 78% in comply type PI. The previous studies assert that the manufacturing modification aims at improving the adhesives’ penetration and positive implication to the enhancement of product durability [20-22].

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Figure 1. Termites’ mortality by 82% in comply type AI (Avocado veneer, isocyanate adhesive)

Figure 2. Termites’ mortality by 78% in comply type PI (Pine veneer, isocyanate adhesive)

Figure 3. Soil termites’ attacks on comply

Figure 4. Some types of complying damages after grave yard test

3.2. Comply’s durability against subterranean termites’ attacks

There are various influencing factors during grave yard test. First, OSB and comply rotting due to the high humidity, followed with the other decaying organisms, such as subterranean termites (Figure 3). The subterranean termites’ attacks are easily distinguished when compared to the damages caused by the other factors due to the specified attack characteristics. Furthermore, it is visually shown that there are two damage types: (1) all parts of comply and OSB are damaged, (2) the damages are only found in the core part, while the outer layers are still unimpaired (Figure 4). The weakest of this product is located in the middle part that the biological destroyers degrade most samples in the middle parts since the adhesive used is for interior OSB type. In facts, the adhesive used for adhering plywood classified into an exterior category is more resistant to the higher humidity.

During the testing processes, OSB loses its weigh by 72.10±8.74 %, while all comply types are by 51.93±15.80% (Figure 5). The variance testing analysis shows that comply type influences the termites’ attack level with the value of $p=0.018$. Furthermore, the Duncan test shows that Comply type ME
Mahogany veneer, epoxy adhesive) has the smallest weight loss (37.79±13.31%). When compared to the control, the comply design may lower the soil termites’ attack level to 71.58%.

![Graph showing weight loss across different Comply types](image)

**Figure 5.** OSB’s and Comply's weight loss resulted from the soil termites’ attacks

### 4. Conclusions

It is found that there is termites’ attack level difference on OSB and Comply. The Oriented Strand Board has higher termites’ attack level, while ME Comply type (mahogany veneer, epoxy adhesive) has the lowest attack level and consistent to both testing. The dry wood termites’ attack level difference is 41.3% after feeding for 12 weeks and 71.58% in the grave yard test.

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