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Peeling strength of facesheet thickness on rubber wood honeycomb composites

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ABSTRACT

Honeycomb with good mechanical properties and low density are the top priorities in material selection. Therefore, the facesheet thickness is a factor that contributes to it as it made up most of the weight in the structure. Appropriate thickness can optimize the mechanical performance. However, the sandwich composite may associate to high density if the facesheet is of high thickness yet deteriorate the mechanical properties as an overall. As the facesheet is attached to the sandwich structure via matrix, the peeling properties for various facesheet thickness is investigated. The facesheet thickness in terms of one to five layers are glued to the rubber wood core. The structures are tested for its peeling strength under vertical 90° test according to the ASTM standard. The optimal number of facesheet with good peeling strength is discussed.

Keywords:
Rubber wood, Honeycomb core, Facesheet thickness, Vertical 90°, Peel

1. Introduction

Besides having outstanding mechanical properties, one of the advantages of sandwich composites is having low density. These characteristics have drawn the attention of the industries. Due to the uniqueness of the sandwich composite, it has been widely applied in various fields. Different design, materials and geometry parameters greatly enhance the properties and functionalities of the sandwich composite to accommodate its demand [1-7].

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Light weight is one of the main characteristics that makes it a popular material. As an overall structure, the facesheet contains most of the mass compared to the thick core. Though the facesheet is highly dense, its function is very crucial especially in applications demanding high strength. A composite structure with thin facesheets can deteriorate its mechanical performance of the overall structure which unable to effectively transfer the load to the other facesheet. However, a honeycomb with an extremely thick facesheet may contribute to extra weight to the composite.

Therefore, facesheet with adequate thickness in the sandwich panel for optimal properties is the concern of many researchers. For instance, [8] researched on the effect of facesheet thickness on low velocity impact response in composites. [9] focused on the strength and stiffness properties at different plastic facesheet thickness and distance between the flexural supports. [10] investigated the thickness of facesheet for damping purposes. Effect of facesheet and foil on blast resistance subjected to underwater explosion is also studied [11]. The relationship of core-to-facesheet thickness ratio with shear and normal deformation is reported by [12]. On the other hand, [13] explored on the facesheet to core thickness ratio on circular sandwich plate. [14] investigated on the effect of facesheet thickness on the penetration resistance of aluminium sandwich panels. The analysis of facesheet thickness on sound transmission loss characteristic of sandwich is carried out by [15].

As a whole, the facesheet is glued to the core via matrix. The excellent peeling strength can improve the overall performance of the sandwich structure. Besides focusing on the facesheet thickness, it is also important to investigate the peeling properties of the structure with different facesheet thickness. Generally, increasing the facesheet thickness increases the mechanical properties. However, it is aimed to determine its optimal thickness for the peeling properties. This research investigates the thickness of facesheet in the honeycomb composites by finding out the suitable number of facesheet layers for excellent peeling strength in the honeycomb sandwich composite.

2. Material preparation and experimental set up

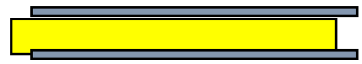
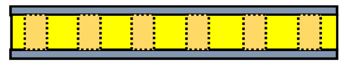
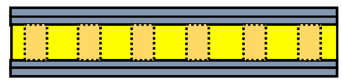
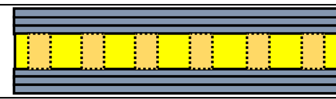
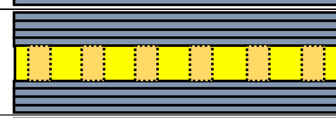
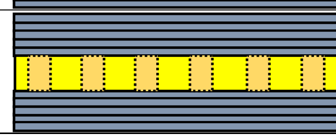
2.1. Fabrication

Two types of samples were fabricated which consisted of a solid rubber wood with a layer of facesheet structure and closed cell honeycomb core with different thickness of facesheet structures. Rubber wood sized 1000 mm x 100 mm x 8 mm was prepared. Laser cutter was used to form hexagonal shape of honeycomb core. Glass fiber was the facesheet material with different thickness ranging from two to ten layers with the increment of two layers, forming one to five layers on each side of the facesheet. The glass fiber was set layer by layer and reinforced by the unsaturated polyester resin. The desired number of layer of glass fiber was laid on one side of the facesheet, the rubber wood honeycomb core was placed and after that the rest of the glass fiber was spread as depicted in Table 1. The composites were then compressed in the vacuum bagging process for 8 hours at the room temperature and left to further cure for one day. After that the composites were prepared into its required dimension for the test.

2.2. Vertical 90° test

The specimens sized 300 mm × 38 mm x t mm (t is the respective thickness) were prepared and the vertical 90° test was carried out using Universal Testing Machine (UTM) until the maximum force was achieved. The test was performed at 23 ± 3°C, relative humidity of 50 ± 5 % with a crosshead speed of 2mm/min as per ASTM C3167. The specimens were mounted on UTM as shown in Fig. 1 and subjected to the force applied until it was all peeled. The maximum force used was recorded. The formula as in Eq. 1 was referred to calculate peel strength of the composite. Test was repeated for five specimens from each sample and was recorded in Table 2.

Table 1
The glass fiber and rubber wood honeycomb core arrangement

Serial Number	Predicted Thickness	Arrangement
Control Solid Rubber Wood (without facesheet)	(0.46 mm × 2) + 8 mm = 8.92 mm	
SN 1 (Honeycomb core + 1 layer of fiber glass)	(0. 46 mm × 2) + 8 mm = 8.92 mm	
SN 2 (Honeycomb core + 2 layers of fiber glass)	(0. 46 mm × 4) + 8 mm = 9.84 mm	
SN 3 (Honeycomb core + 3 layers of fiber glass)	(0. 46 mm × 6) + 8 mm = 10.76 mm	
SN 4 (Honeycomb core + 4 layers of fiber glass)	(0. 46 mm × 8) + 8 mm = 11.68 mm	
SN 5 (Honeycomb core + 5 layers of fiber glass)	(0. 46 mm × 10) + 8 mm = 12.6 mm	

$$\text{Peel Strength (N/mm)} = \frac{\text{Maximum Force, } F_{max}}{\text{Width,w}} \qquad (1)$$

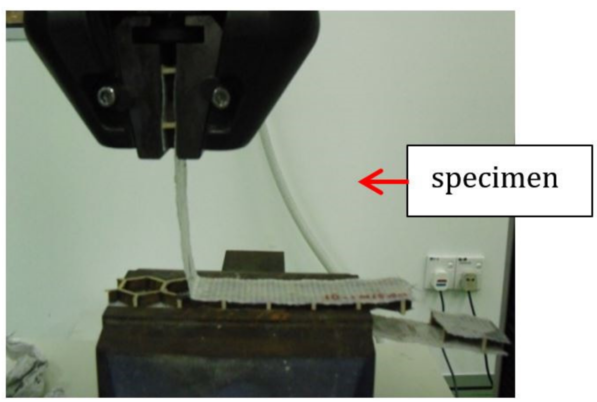


Fig. 1. Vertical 90° test setup

3. Results and discussion

3.1. Vertical 90° test

Vertical 90° test is also known as peel test is defined as the average load per unit width of bond line required to separate the bonded composite where the angle of separation involved is 90°. It is to measure on the adhesive or bond strength between the facesheet and the honeycomb core of the sandwich composite. The results from the test are recorded in Table 2.

Table 2
Results for Vertical 90° test

Specimen	Width, w (mm)	Force, F_{max} (N)	Average of Stroke, s (mm)	Peel Strength (MPa)
Control 1	37.7850	81.08	11.25	0.2380
SN 1	37.3025	28.86	4.20	0.0851
SN 2	36.9400	44.01	4.34	0.1199
SN 3	37.6650	82.06	4.70	0.2026
SN 4	37.0800	93.89	5.80	0.2180
SN 5	37.2675	91.83	4.28	0.1883

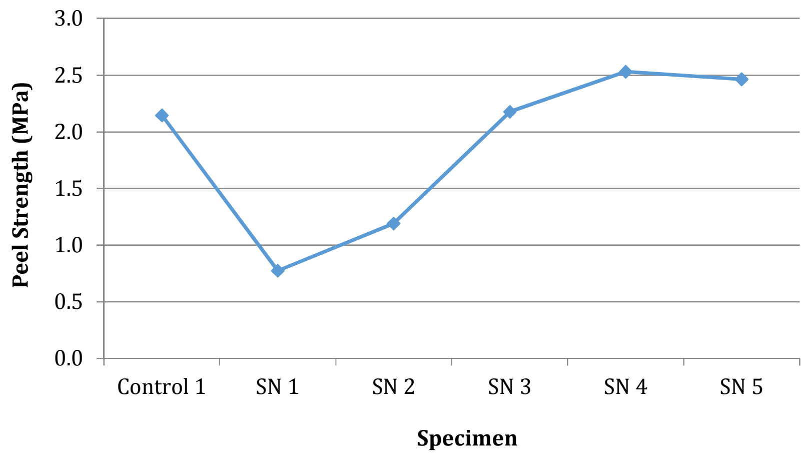


Fig. 2. Peel strength versus specimen curve

Peel strength of the unsaturated polyester as the adhesive in the sandwich composite is tested and displayed in Figure 2. Peel strength of Control 1 is approximately 2.8 times higher than SN 1. It is mainly due to the effective contact surface of Control 1 is significantly higher than SN 1 where its core is made up of honeycomb core. Honeycomb core consists of arrays of hollow hexagonal cells. The thin vertical cell wall is the effective contact surface between the core and facesheet. With a thin cell wall at the core structure, the grip between the interface which is the bond line is largely reduced. Thus, this phenomenon contributes to low peel strength of SN 1. Meanwhile Control 1 possesses a large effective contact surface at the bond line to produce desire peel strength due to the solid core structure instead of honeycomb core [16,17].

On the other hand, the peel strength is steadily increased across SN 1 to SN 4 as the facesheet thickness is increased as the number of glass fiber layer is added layer by layer. By increasing the facesheet thickness, it reflects to improve the overall performance of the sandwich composite. It is believed that the thickness of facesheet somehow plays a role in peeling strength. Some amount of force is absorbed by the facesheet during fiber breakage and facesheet bending with a thicker facesheet thickness [18,19].

However, the peel strength of SN 5 is not the highest though it is made up of the thickest facesheet of five layers for each side. Its peel strength is ranked between SN 2 and SN 3. Therefore, the highest peel strength is seen owned by SN 4. It is believed that four layers of facesheet as found in SN 4 is the most suitable number of facesheet layer for sandwich core of 8 mm. Five layers of facesheet may not be mechanically improve the performance, it is also contributing unnecessary weight to the sandwich composite.

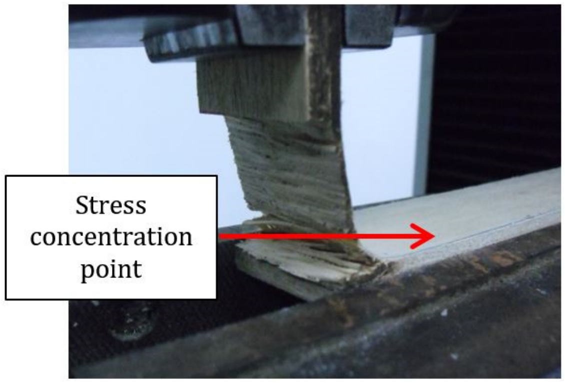


Fig. 3. Location of stress concentration during test

As the test is carried out, the specimen is mounted UTM. The force is continuously applied as the machine jaw is peeling the facesheet of the specimen at the speed of 2mm/min as in Fig. 3. The unsaturated polyester matrix acts as the glue in the structure resisted the peel in the opposite direction. Therefore, the force is gradually increased to pull the facesheet away from the glue joint. The glue joint turns into the stress concentration point where separation between the facesheet and the honeycomb core is occurred [20,21].

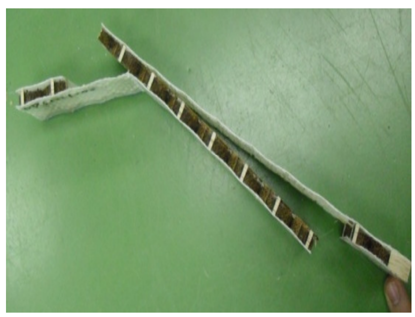


Fig. 4. Peel condition of SN 1 after conducted vertical 90° test

After the test is done, the specimen is removed from the machine. It is obvious that the failure occurred at the bond line. The facesheet is seen peeled off from the core as in Fig. 4.

4. Conclusion

Sandwich composites of solid and honeycomb rubber wood are tested for vertical vertical 90° test with different facesheet thickness ranging from one layer to five layers. It is realized that the higher effective contact surface plays an important role the resistance to peel. Moreover, the thickness of the facesheet is also influence the peel strength. From the test, the ideal facesheet thickness is four layers for a core of 8 mm. Further increment of facesheet may mechanically deteriorate the performance and increase the density of the sandwich composite.

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