Estimation and identification of corrugated cardboard strength using tensile test

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ABSTRACT – The corrugated cardboard is widely used in manufacturing industries as a packaging, transportation material and number of other applications. However, the strength of the corrugated cardboard as a sandwich composite structure is not well understood and less studied about it especially using tensile test. The objective of this study is to estimate and identify the strength of corrugated cardboard using tensile test. Experiment were conducted, which used 3 different number (2, 4 and 6) of aluminum rod inserted thru corrugated cardboard. As a result, practical tensile test considering the glue bonding strength was estimated and the factory of these test method was identified. The average yield breaking for all 3 types of results was 53 [MPa] and the average strain breaking was 3.7%.

1. INTRODUCTION

In general, the corrugated cardboard was composed with three layer of paperboard. One is outside liner and inside liner and the other is corrugated medium. The top of corrugated medium is bonded with glue on outside or inside layer surface. The bonded space was decided by company standard. The structure has different properties in its three principal directions as shown in Figure 1 [1].

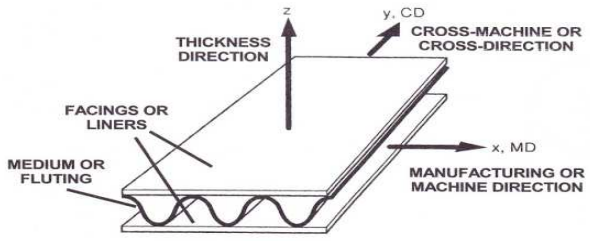

Figure 1 Corrugated cardboard structure showing the three principal axes [1]

Corrugated cardboard is governed by the strength properties of the corrugated medium, which is determined partly by material properties and partly by geometry [2], [3]. The material properties of influence are basis weight, fiber strength and fiber bonding. Geometry properties of influence here are flute shape and flute size.

This research is concern and focus on introducing new method and measuring the strength of corrugated cardboard due to adhesive bond using tensile test. Due to corrugated cardboard structure, it is hard to grip during tensile test. Therefore, method to grip the corrugated cardboard which inserted aluminum rod thru corrugated cardboard had been introduced [4]. Measurement the strength of corrugated cardboard using tensile test provides an important parameter in defining the structural properties and for determining the strength of corrugated cardboard panels for end user justify.

2. METHODOLOGY

A flute corrugated cardboard was used as a test piece in the experiment which thickness of 5 mm with dumbbell pattern JIS K7217 as shown in Figure 2. Test specimens were fabricated by Yoshizawa Industrial Co., Ltd. using 3 dimension cutting machine. Tensile test was conducted using INSTRON2716-015. In order to suppress the collapse of the specimen by the chuck of the tester, it was decided to insert the aluminum rod to the corrugated medium as shown in Figure 3, 4 and 5. The crosshead speed was set at 20 mm/min in a tensile machine and the experiment was repeated 5 times. All experiments was conducted in humidity 50%RH and constant conditions of temperature 23 □. Each specimen was subjected to hand fracture pattern observed with a digital microscope. Then, measurement is performed and the computer configuration of Young's modulus were evaluated for mechanical properties by tensile tests.

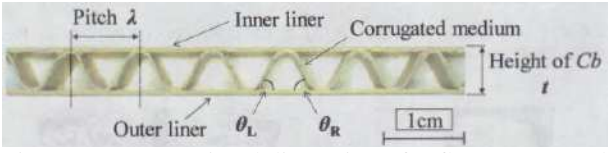

Figure 2 Cross sectional dimension of A flute corrugated cardboard

Figure 3 Two aluminium's rod

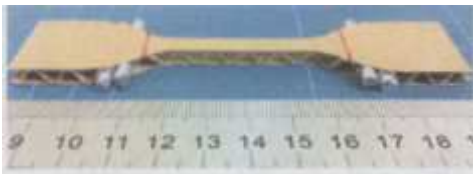

Figure 4 Four aluminium's rod

Figure 5 Six aluminium's rod

3. RESULTS AND DISCUSSION

Figure 6, 7 and 8 show the result for 5 test specimens of tensile test on corrugated cardboard. The stress of corrugated cardboard was calculated by Equation (1) and strength ratio was being calculated by using Equation 2. Overall, from Figure 6, 7 and 8 shows that the fracture pattern of tensile test using this method can be divided into 2 patterns.

1st pattern was with the effect of corrugated medium and 2nd pattern was without the effect of corrugated cardboard. Considering both fracture pattern, the average yield breaking and the average strain breaking as shown in Table 1. The average yield breaking for all 3 types of results was 53 [MPa] and the average strain breaking was 3.7%. The range of yield breaking and strain are consider small.

$$Stress = \frac{Load}{(Thickness\ of\ Upper\ and\ Lower\ Liner) x\ (width)} \quad (1)$$

$$Strain = \frac{Elongation}{Gage\ Length} \quad (2)$$

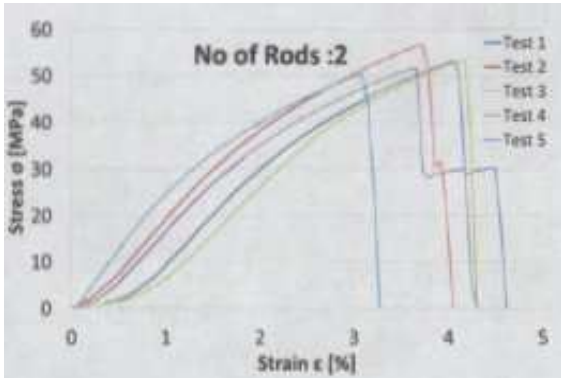

Figure 6 Result of tensile test by using two aluminium's rod

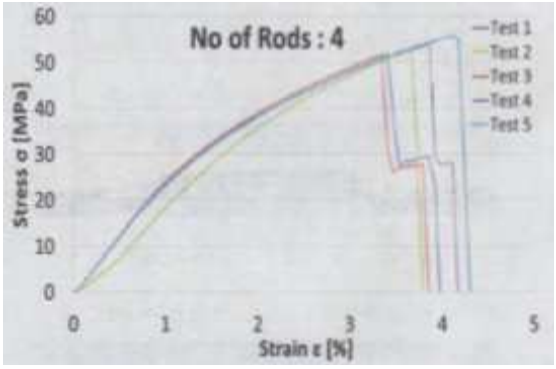

Figure 7 Result of tensile test by using four aluminium's rod

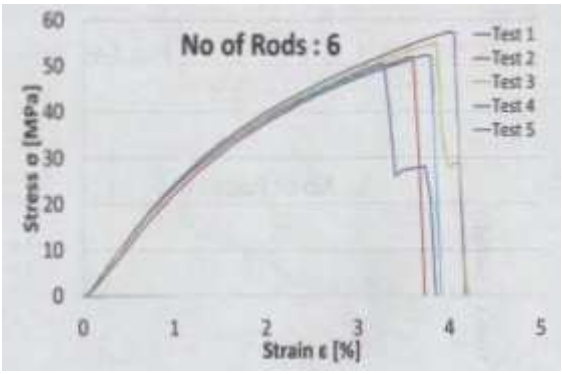

Figure 8 Result of tensile test by using six aluminium's rod

Table 1 Results of Tensile Test by using no. of Aluminium's rods

No of Rods	Two	Four	Six
Breaking Stress [Mpa]	53.0 (50.4-56.8)	53.0 (51.4-55.7)	53.4 (50.5-57.4)
Breaking Strain [%]	3.74 (3.09-4.18)	3.68 (3.34-4.11	3.69 (3.28-3.99)

4. CONCLUSIONS

As conclusions, method to estimate the strength of corrugated cardboard as structural properties had been proposed by applying aluminum rods inserted thru corrugated medium. Moreover, estimation of corrugated cardboard strength had also been done using tensile test.

5. REFERENCES

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