Estimation of corrugated cardboard strength using tensile test

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Keywords: Corrugated cardboard; strength; tensile

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 structure is not well understood. The objective of this study is to propose and estimate the strength of corrugated cardboard using tensile test. As a result, new practical tensile test considering the glue bonding strength was proposed and the factory of these test method was investigated.

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].

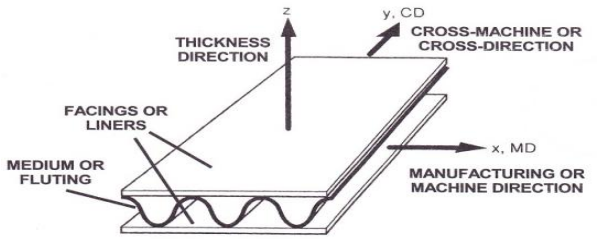

Figure 1 Corrugated cardboard structure showing the three principal axes [1].

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. 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. Cross-sectional size change with dimension of the tensile test specimen with 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 round bar to the corrugated medium as shown in Figure 3. The crosshead speed was set at 20 mm/min in a tensile machine and the experiment was repeated 10 times. All experiments was conducted in humidity 50%RH and constant conditions of temperature 23 degree. The grip distance between the aluminum round bar is approximate 44 mm. 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 4 shows the position of corrugated cardboard specimen for tensile test using INSTRON2716-015.

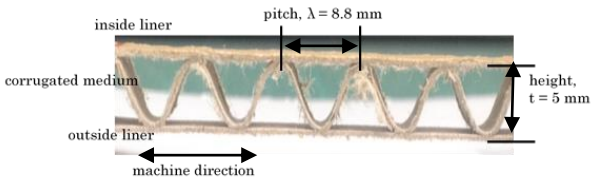

Figure 2 Cross sectional dimension of A flute corrugated cardboard.

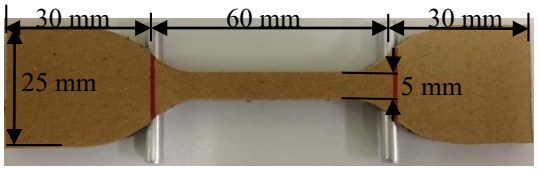

Figure 3 Size of specimen for dumbbell pattern JIS K7217 of corrugated cardboard.

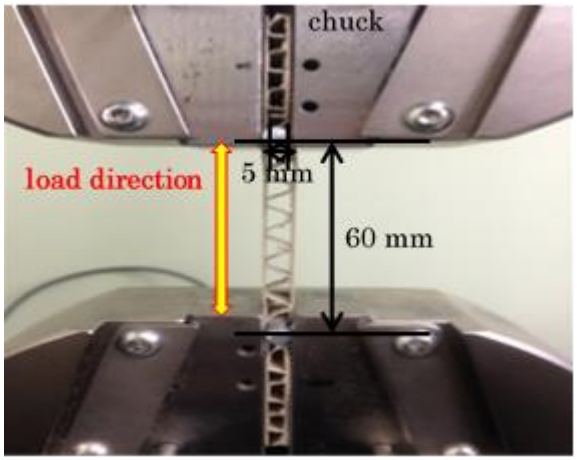

Figure 4 Specimen position during test used INSTRON (2716-015).

3. RESULTS AND DISCUSSION

Figure 5 shows the result for 10 specimen of tensile test on corrugated cardboard. The stress of corrugated cardboard was calculated by Equation (1).

$$Stress = \frac{Load}{Thickness \times 2} \quad (1)$$

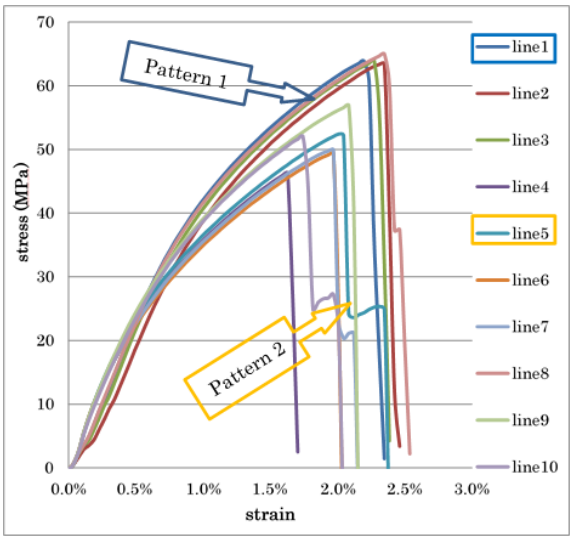

Figure 5 Result of corrugated cardboard on tensile test.

From Figure 5 shows that the fracture pattern of tensile test using this method can be divided into 2 pattern. The average yield breaking was 56.3 MPa and the average strain breaking was 1.7%. In this study, the fracture pattern was addressed as pattern 1 and pattern 2. Pattern 1 of graph is without the effect of change with wavy lines and also for the others and pattern 2 of graph is with the effect of corrugated medium.

For pattern 1, the fracture occurred at both; inside and outside liner as shown in Figure 6. Thus, results show that fracture occurred far from the adhesive bond. Figure 6 show the result that fracture occurred is not in the straight line. This is because the effect of corrugated medium does not appear. For pattern 2, the fracture occurred at both; inside and outside liner. The result show that fracture occurred near from the adhesive bond due to the effect of corrugated medium.

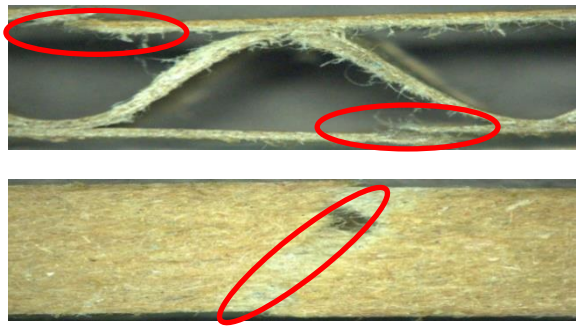

Figure 6 Cross-directional and upper view of pattern 1.

Strength ratio was been calculated by using Equation 2. The average yield breaking was 1.2 times and the average strain breaking was 1.4 times. The range of yield breaking and strain breaking was 18.7 MPa and 1.1% regarding from Figure 5. However, the range for both yield breaking and strain breaking is still huge.

$$Strength\ ratio = \frac{Corrugtaed\ cardboard\ (5\ mm)}{Liner} \quad (2)$$

4. CONCLUSIONS

As conclusions, method to estimate the strength of corrugated cardboard as structural properties had been proposed. Moreover, estimation of corrugated cardboard strength had also been done. However, this proposed method need to be revised for better result or small range different between yield breaking and strain breaking.

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