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Tensile characteristics of glass fiber based single face board

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Abstract

A glass fiber based structural sheet (GFSS) is produced in manufacturing industries as a light-weight high-stiffness structure board and other applications. However, the strength characteristic of a single face fiberboard based on glass fiber reinforced plastic is not well understood, due to the divided fabrics structure of corrugated layer and liner layer, and also the difficulties of fixing of fragile material. The objective of this study is to propose and estimate the strength of single face glass fiber board using a proposed tensile test fixture, which is composed of multiple parallel pins and soft-fitted (like a rubber) counter plate. As the result, to use three pins for fastening the corrugated structure contributed to increase the maximum tensile load, and the soft-fitted counter plate made the load response in stable. The lateral direction of GFSS was also investigated using this multiple-pins method.

Keywords: fabrics, corrugated sheet, glass fiber reinforced plastics, fixture, orthotropic properties

1. Introduction

Corrugated fiberboard (Cfb) consists of outer/inner liners and corrugated mediums, and its layered configuration is produced as several combinations, such as single face, double face (single wall), double wall (twin cushion) and triple wall [1][2]. The structure has different properties in its three principal directions as shown in Fig. 1. The mechanical

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properties of Cfb is governed by the structure of liners and corrugated medium, which is determined partly by material properties and partly by geometry. This structure of Cfb is superior for constructing a light-weight high-stiffness structure, and then it is applied to make container boxes and also develop honeycomb structures such as airframes. In the packaging and converting industry, its base sheets (liner and flute) are normally chosen from several materials, such as a 0.2mm thickness kraft paper (the most popular), a polypropylene (known as the plastic corrugated board [3]) and so on. Regarding the base sheet for making Cfb, appropriate fabrics sheets made of high stiffness wires (such as carbon fibers, glass fibers, steel fibers and botanical fibers) are also usable for general purposes. Since the fabrics Cfb is to be applicable to develop a structural reinforced plastic, the mechanical properties of raw material are required to estimate the mechanical performance of Cfb. Figure 2 shows an example of glass fiber based single face Cfb, which is produced by Kubo Corporation. This glass fiber fabrics based Cfb (GFSS: glass fiber based structural sheet) has a good electromagnetic wave transmission. It is designed as a seamless structure of liner layer and corrugated (flute) layer. Since the single face Cfb is easily bent across the flute (wave) with an arbitrary curvature, a sort of cylindrical-laminated structure is also easily produced. In case of thick plane structure, a plain honeycomb which is composed of multiple-stacked single face Cfb is also available.

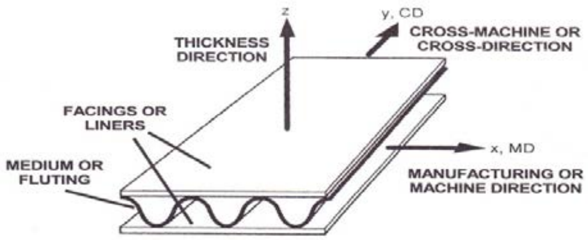

Fig.1 Double face corrugated fiberboard structure showing the three principal axes.

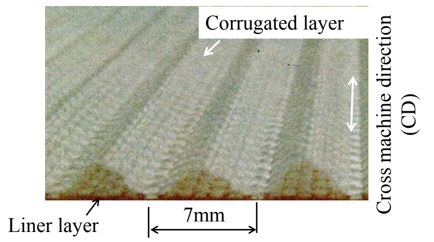

Fig.2 Single face corrugated fiberboard fabricated by using glass fibers.

The mechanical properties of GFSS was not sufficiently investigated in the past. That influences are fabrics pattern, basis weight (or equivalent thickness of liner and flute), physical specification of raw glass fibers, wave shape and pitch size of flute. There are several examination methods such as for the in-plane tensile strength, the flat crush strength (compressive strength of thickness direction), the edgewise compressive strength, the three points bending stiffness and so on [1]. Regarding the in-plane tensile test of Cfb in the machine direction (MD), its fixing condition of specimen was explained as combination of insertion of a pin and wax filling [4]. However, the wax filling seems to be uncertain (be not clarified), and there is not discussion about the cross machine direction (CD). In order to investigate the tensile performance of GFSS in both MD and CD, a certain advanced measuring method is required. A fundamental usage of single parallel pin for fixing a double face Cfb made of kraft paper was reported by N. Wahab et al. [5]. In this case, since the raw kraft sheet had relatively uniform thickness and recognized as a continuum solid, it was possible to prepare a dumbbell type test piece and stably broken at the middle zone of specimen. However, in case of fabrics such as GFSS, a dumbbell type seems to be difficult for testing. Therefore, in this work, the usage of multiple parallel pins for fixing the both ends of straight type GFSS specimen has been investigated for revealing the stability, reproducibility of in-plane tensile response of GFSS.

2. Methods of experiment

The raw sheet of GFSS was produced using twisted yarn, E-glass of Nittobo, ECG75-1/2-3.8S (fineness:135+/-8.1tex, diameter of filament: 9.5µm, number of twists: 3.8 per 25mm) [6,7]. GFSS is knitted with for making its single face corrugated sheet as shown in Fig.2 [8]. The cord count of 25+/-1 per 25mm width was chosen for both the upper (corrugated) and lower (liner) layer in the longitudinal direction (MD), while the cord count of 52+/-2 per 25 mm width was chosen in the transverse direction (CD). Figure 3 is a side view of two waves, which has the wave length of 7mm and wave height of $h_O = 2.5$mm. When the raw sheet of GFSS is knitted, the flute layer and liner layer are smoothly movable with each other. Appropriate gluing is necessary for forming the corrugated-structural profile. After knitting, a few of acrylic based adhesives were injected on the raw sheet of GFSS. The nominal basis weight of