English Title (Arial 18-Point)

Bending Tests of Composite Panels Reinforced with Orthogrid/Isogrid Carbon Fibers

First Author 1, Second Author 1, and Corresponding Author 2\* (Arial 11-point)

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**ABSTRACT**

Abstract Context: Times New Roman 10-Point)

This research is part of the WIG Craft Type C design and construction project at Kasetsart University. To get strong, stiff, and weigh efficient structure, composite panels reinforced with orthogrid fibers or isogrid fibers will be applied to the design of WIG Craft’s fuselage and wing structure. To do this, the properties of the composite curved panels needed to be studied and one of the important properties is bending property. The objective of this study is to perform experimental bending tests of composite curved panels reinforced with orthogrid/isogrid fiber panels. The specimens include composite carbon fiber curved panels of 30x40 cm2 reinforced with corrugated grid carbon composite panels of various grid direction e.g. 0°, 90°, and ±45°, and cured either at room temperature or under heated and pressurized in an autoclave. For each test, compression normal loads are applied up to its ultimate loads. The bending deformation and the normal loads are measured and compared with each other including those of non-reinforced composite panels. The test results are also examined and applied to the bending analysis models.

Keywords: Several keywords (no more than 5 words) for the paper should be given below the abstract. Times New Roman 10-Point.

***Keywords:*** Reinforced Composite Panel, Stiffened Composite Panel, Isogrid Structure, Orthogrid Structure, Bending Test

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**I. INTRODUCTION**

Iso-grid structure, patented by McDonnell Doulas Corporation, is constituted with a thin metal panel reinforced with lattice of triangular stiffening ribs forming an array of continuous equilateral triangles [3]. It has been widely used in aerospace application since 1970s as its advantages of light weight, high strength, high stability, great energy absorption, and low-cost manufacturing. Composite iso-grid and ortho-grid structures were found in the late 1970s and widely developed in early 1990s. Composite materials particularly have advantages for this type of structure as the typical stresses in grid stiffened structure’s ribs are highly directional along the rib axis. The high directionality of composite materials allows for the majority of the material’s stiffness and strength to be directed along this directional axis, leading to an increase in its strength [4].

**II. SETUP AND METHODOLOGY**

Seven test specimens were made with different configurations specified in Table 1. Each test specimens were made from 4 layers of carbon fabrics of TR 30S 3L type (Mitsubishi Chemical Corporation) and lay up in direction of 0°/90° using epoxy YD128:ACCEL618 (mixing ratio 5:3).

**Table 1** Configurations of the test specimens(Arial 10-Point)

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Test Specimens** | **Grid Types & Directions** | **Fabric Directions** | **Curing Processes** | **Panel**  **Dimension** | **Grid Dimension** | | | **Weight**  **(g)** |
| **h (mm)** | **w (mm)** | **d (mm)** |
| PCP-301 | Plain Curved Panel  (No Stiffened Grid) | 0°/90°  (4 Layers) | Room Temp. at 30°C/1bar | 30 x 40 cm2 | - | - | - | 195 |
| OGU-301 | Ortho-Grid  0° (Uni-direction) | 0°/90°  (2+2 Layers) | Room Temp. at 30°C/1bar | 30 x 40 cm2 | 10.0 | 73.9 | - | 242 |
| OGU-904 | Ortho-Grid  0° (Uni-direction) | 0°/90°  (2+2 Layers) | Autoclave at 90 °C/4 bars | 30 x 40 cm2 | 10.0 | 73.9 | - | 241 |
| OGS-301 | Ortho-Grid  0°/90° (Square) | 0°/90°  (2+2 Layers) | Room Temp. at 30°C/1bar | 30 x 40 cm2 | 10.0 | 73.9 | 74.9 | 259 |
| OGS-904 | Ortho-grid  0°/90° (Square) | 0°/90°  (2+2 Layers) | Autoclave at 90 °C/4 bars | 30 x 40 cm2 | 10.0 | 73.9 | 74.9 | 258 |
| IGT-301 | Iso-Grid  ±45°/0° (Triangle) | 0°/90°  (2+2 Layers) | Room Temp. at 30°C/1bar | 30 x 40 cm2 | 10.0 | 75.3 | 125.1 | 269 |
| IGT-904 | Iso-Grid  ±45°/0° (Triangle) | 0°/90°  (2+2 Layers) | Autoclave at 90 °C/4 bars | 30 x 40 cm2 | 10.0 | 75.3 | 125.1 | 271 |

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Description automatically generated A black background with blue lines and letters

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1. OGU (b) OGS (c) IGT

**Figures 1** Grid arrangements of stiffened grid panels, (a) Unidirectional ortho-grid panel, (b) Square ortho-grid panel, and (c) Iso-grid panel (IGT) (Arial 10-Point)

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**Figure 2** Cross section and dimension of the stiffened curved panels

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**Figure 3** Cross section of the grid stringer of the ortho-grid and iso-grid panels

**III. RESULTS AND DISCUSSION**

To make the test results meaningful, it is necessary to transform the loading force and deflection displacement to flexural stress and strain. These were done for PCP-type and OGU-type specimens using the analysis of thin-walled beam [1] and the analysis of stiffened curved panel [2] as the following formulas.

All equations and mathematical formulas should be typewritten. Equations should be numbered serially on the right hand side by Arabic numerals in parentheses. Leave proper space above and below all of the mathematical expressions.

, where (1)

, where (2)

, where (3)

**IV. CONCLUSIONS**

Present work studies bending properties of carbon composite curved panels reinforced with grid stiffened panels of various grid configurations using 3-point bending test technique. The tested specimens, unidirectional ortho-grid panels (OGU), square ortho-grid panels (OGS), iso-grid panels (IGT), and plain curved panel (PCP), were fabricated and cured under either room temperature or heated and pressurized control in autoclave.

**ACKNOWLEDGMENTS**

Acknowledgments should be kept in minimum words and be given as a paragraph at the end of the text.

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**REFERENCES**

References should be numbered in the order in which they are cited at the end of the manuscript in the following format:

a. The format of author name should be last name followed by the first initials.

b. Journal name must be in italics and cannot be abbreviated.

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