Deflection of Orthotropic Sandwich Plates

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Theme

THIS paper presents a portion of the results of analytical and experimental studies on the deflection of simply-supported, transversely loaded, orthotropic sandwich plates. Various core depths, face sheet thicknesses, and aspect ratios of the plate are treated in the investigation. Experiment has confirmed the theoretical predictions that 1) the maximum deflection of an orthotropic plate subject to a transverse uniform load does not necessarily occur at the center of the plate, and 2) an upward deflection at some points on the plate surface may occur for a concentrated downward load.

Content

Based on two theories that of Azar[1] and another by Ueng,[2] it is analytically demonstrated that the maximum deflextion of a simply supported orthotropic sandwich plate under uniform loading may not necessarily occur at the center of the plate. Also, it is shown that an upward deflection at some points on the plate surface might be expected under a downward applied concentrated load. These analytical findings are of interest and its importance in the design of sandwich panels have led the authors to its experimental verification.

A total of 66 sandwich plate specimens were prepared and statically tested under two load configurations (concentrated and uniformly distributed). The test panels consisted of three different core depths, three face sheet thicknesses and four aspect ratios. All facings are made of an epoxy prepreg material, 1P181 and/or 1P20. The core is a honeycomb core material 3/8-0.003P(ACG).

Because of space limitation, only a portion of the results are included in the present paper. Figure 1 for the uniform load case provides definite evidence in that the point of maximum deflection may occur at points other than the plate center. Also Fig. 1 demonstrates the hypothesis that an upward deflection may be expected at some points on the plate surface for a concentrated downward load.

Azar's and Ueng's analytical formulas for the deflection of sandwich plates subjected to uniform and concentrated loads are programed for the IBM 360 computer. All computer results are plotted along with the experimental and only a sample of the results is included in this paper.

The test panel deflection curves as obtained by experimental testing are first compared with the deflection obtained analytically using Ueng's formula for uniform loading. Agreement was only fair. For 6 test panels, the experimental and analytical

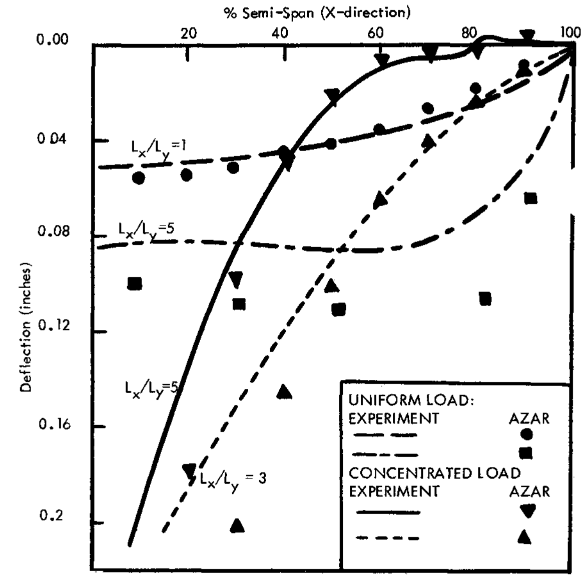

Fig. 1 Plate deflection patterns (core thicknesses = $\frac{1}{4}$ in., $\frac{3}{16}$ in.; facings = 0.0085 in., 0.0085 in. for uniform and concentrated load conditions, respectively). (The circles, triangles, and rectangles are theoretical predictions.)

curves were within about 10% of each other. For 5 test panels, the curves were within 20%. For 3 test panels, the results were within about 30%. For the remaining 19 test panels, the deflection curves had an error in excess of 30%. Figure 2 is a typical example of these comparisons.

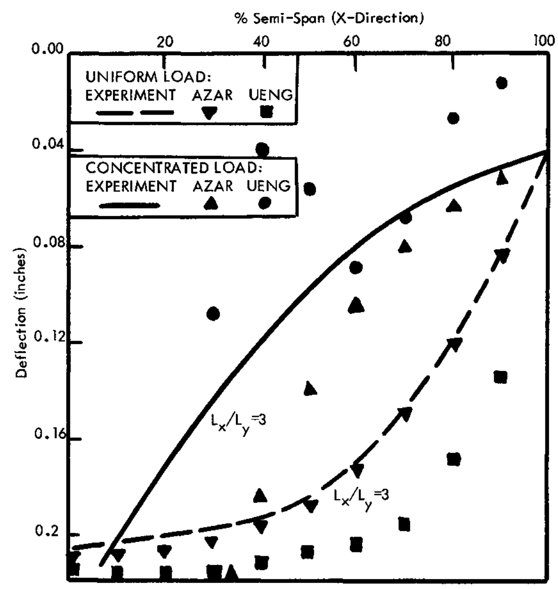

Fig. 2 Plate deflection patterns (core thicknesses = $\frac{1}{4}$ in., $\frac{3}{16}$ in.; facings = 0.004 in., 0.0085 in. for uniform and concentrated load conditions, respectively). (The circles, triangles, and rectangles are theoretical predictions.)

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Reviewing the panel parameters, graphs, and other data, some conclusions may be made. The small aspect ratio panels nearly always had significantly less actual deflection than the theory predicted. This is probably due to the interaction of the face sheet and the honeycomb core to cause additional stiffness unaccounted for in the theory. The panels with face sheets made up of one sheet of 1P20 and one sheet of 2P181, had the poorest agreement. The material properties for this face sheet material were not available nor was test equipment available to determine their actual values. Therefore, the computer input of material property values was an estimation based upon the known properties of the individual material. This estimation is probably low, resulting in deflections higher than the theory should predict.

Test panel deflection curves for the concentrated loading condition had very poor correlation. Figure 2 is typical of all test panels. No reason was found nor can any be surmised for this lack of agreement.

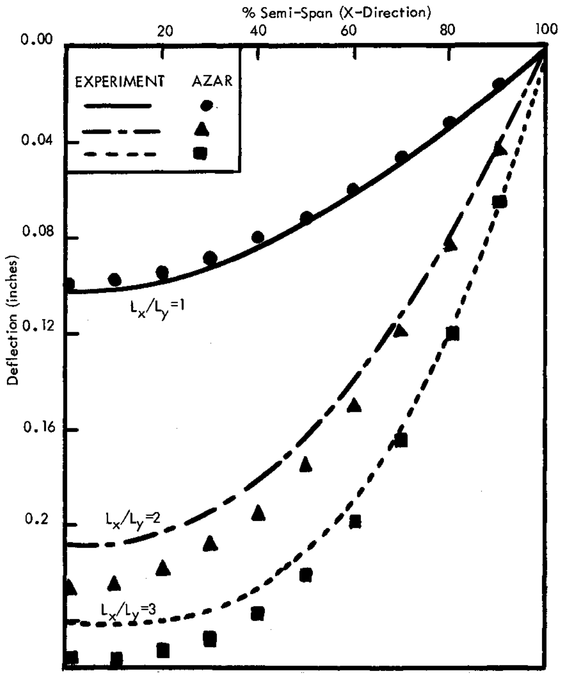

Fig. 3 Plate deflection patterns under uniform load (core thickness = $\frac{3}{16}$ in., facings = 0.0085 in.). (The circles, triangles, and rectangles are theoretical predictions.)

Azar's calculated deflections for a uniform load was next plotted with the experimental deflection curves. For 12 test panels the curves were within about 10% of each other. For 8 test panels the curves were within 20%. No test panel fell in the 20–30% range. The remaining 13 panels exceeded the 30% difference. Figure 3 shows a sample of the good agreement found and Fig. 1 shows the typically poor agreement. For uniform loading, there was the best agreement for thick face sheets, thin core, and low aspect ration.

For the concentrated load curves, much better agreement was found using Azar's formulas than Ueng's. The test panels which have comparatively thick face sheets, thin cores and high-aspect ratio show closer agreement with experiment. Figure 1 shows a typical example of this agreement. Figure 4 shows a comparison between experimental results and the theoretical predictions of Azar and Ueng.

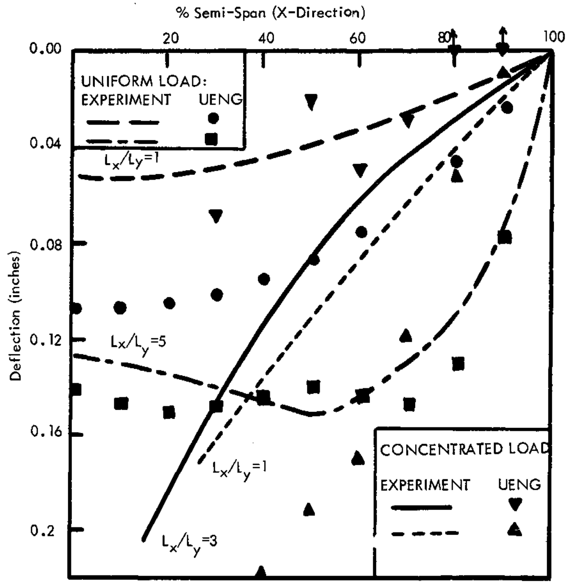

Fig. 4 A comparison of experimental and analytical deflection patterns for a plate with core thickness = $\frac{3}{16}$ in. and facings = 0.0125 in. (The circles, triangles, and rectangles are theoretical predictions.)

References

[1] Azar, J. J., "Bending Theory for Multilayer Orthotropic Sandwich Plates," *AIAA Journal*, Vol. 6, No. 11, Nov. 1968, pp. 2166–2169.

[2] Ueng, C. E. S., "On Deflection of Orthotropic Sandwich Plates," Presented at the 3rd Annual Symposium on High Performance Composites, St. Louis, Mo., Oct. 26-27, 1967, Advanced Research Projects Agency and The Office of Naval Research.