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Experimental Study on Structural Behavior and Vibrational Characteristics of Sandwich Plate with Aluminum Honeycomb Core

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ABSTRACT

Aluminum honeycomb sandwich structures are known to have not only a high flexural rigidity and strength with a relatively low density ratio but also excellence in anti-vibration and anti-noise properties. These characteristics are essential in the design of airplanes and high-speed ships that require light and high strength. In this paper, the Reissner-Mindlin shear deformation and rotary inertia plate theory was introduced to the rectangular sandwich plate expanded from Hamilton's principle. The results from the equation of motion based on Hamilton's principle were compared with those from the Rayleigh-Ritz method. The applied sandwich models consisted of isotropic and symmetrical aluminum and aluminum honeycomb cores. The structures used for the study had 4 plates with various thicknesses and cores of different cell sizes. This kind of structure was used for a seawater survey ship (SWSS) in Japan in 1993 (Paik and Lee, 1995; Kaneko, Takeuchi and Aokage, 1993). The boundary conditions considered in the research were simple, fixed and free supports.

INTRODUCTION

The development of a large high-speed marine craft requires various advanced technologies related to an effective hull type, light and strong material, efficient propulsion system, seakeeping control system, etc. The aluminum honeycomb sandwich plate (AHSP) structure used for high-speed vessels is almost four times lighter than an aluminum single plate with the same stiffness. Also, it has excellent properties such as high-energy absorption, fire proof, fatigue resistance and weight saving. However, to apply AHSP structure to a prototype, more detailed research is strongly required to understand its structural behaviors and characteristics.

This paper investigates the usefulness of known experimental and analytic formula based on the elastic theory by the experimental approach. According to the MIL-STD 401B, static bending tests were carried out and compression tests were conducted to analyze crushing and energy absorption. The results were compared with existing data from the experimental formula. Especially, the structural assessment was applied with virtual single element using an equivalent stiffness theory.

Four flat plates, based on the dimension of the aluminum sandwich element applied to a 13-m seawater survey ship (SWSS) in Japan in 1993, were made for vibrational studies and experiments.

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KEY WORDS: Aluminum honeycomb core, rectangular sandwich plate, natural frequency, cell size, vibrational characteristics, Hamilton's principle, AHSP.

The Reissner-Mindlin shear deformation and rotary inertia plate theory was introduced to a rectangular sandwich plate expanded from the Hamilton principle. This paper compares the results from the equation of motion based on Hamilton's principle with those from the Rayleigh-Ritz method based on energy relation. The applied sandwich models have isotropic and symmetrical aluminum faces and aluminum honeycomb cores. Natural frequencies from experimental analysis using F.F.T and the modal analysis package program CADA-PC were compared with the natural frequencies from the Rayleigh-Ritz method. Also this paper compares the analytical results with those from a finite element program, NISA (Chu, 1961).

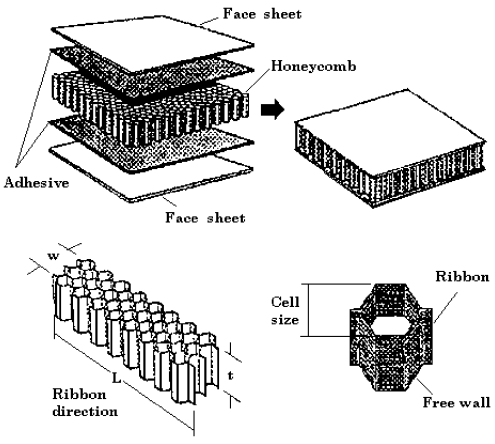

Fig. 1 Example of bonded sandwich assembly and honeycomb terminology