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An Experimental Study on the Vibration Characteristics of FRP Sandwich Structure

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ABSTRACT

Sandwich structures are normally characterized by high flexible rigidity/strength, low-density, and excellent anti-vibration and anti-noise properties. These properties are useful in building airplanes and high-speed ships, which require lighter and high strength elements.

In this study, we have performed a series of vibration experiments of a FRP sandwich plate and structure. We compared the experimental data from vibration tests and simulation results with analytical solutions.

In the case of FRP sandwich plate, we carried out an optimum design to achieve the maximum frequency in the same mass condition, and we performed optimum design of steel stiffened plate having the same natural frequency as the FRP sandwich plate.

KEYWORDS : FRP Plate, Vibration, Sandwich, Optimization

INTRODUCTION

Sandwich construction gives designers many new options. It is a technique that can be applied to structures requiring low weight, high strength and good dynamic properties.

The basic principle is much the same as that of an I beam, which is an efficient structural shape, but unlike the conventional I-beam, that is subject to severe local stresses, a sandwich absorbs the load and distributes the stresses over a much larger area. The result is a structure of uniform strength with no weak point.

In this paper, we obtained the natural frequency of an FRP sandwich plate and structure from a vibration test. The experiment was carried out for a plate and mid-ship section model of a high-speed ship. the section, consisting of a sandwich plate made of Kevlar/Epoxy facing and Klegecell core, was analyzed to determine natural frequencies and corresponding modes of vibration. The experimental data are compared with the analytical solution and the simulation data. For analysis, we used F.F.T. STAR(modal analysis program) and ANSYS.

We performed optimum design of the FRP sandwich plate to get the maximum frequency in the same mass, and we studied the difference of the fundamental frequency for plate element thickness of the FRP sandwich plate.

Also, we performed optimization of steel stiffened plate with the same natural frequency as the FRP sandwich plate. For the optimum design, we used OPTIMUS(optimization program) and ANSYS.

The Plate has a fixed boundary condition and the structure has a free boundary condition.

VIBRATION ANALYSIS THEORY OF SANDWICH PLATES

A study of the vibration of sandwich plates was initiated by YU using the Mindlin bending theory, which comprises shear strain and rotary inertia effect of force and core. Lue has established a nonlinear vibration theory that includes shear strain and boundary conditions of the sandwich plate. using 1966 estimated the natural frequencies of the sandwich plate using the energy method by Lagrangian series which satisfy a fixed boundary condition. Lin et al. completed a vibration analysis using F.E.M(Finite Element Modeling) with various boundary conditions for a hybrid carbon-fiber/glass sandwich plate.

The basic problem in determining natural frequencies of the FRP sandwich plate is formulated in this paper with the result expressed in eq.(1. 1).

Assumptions.(Allen)

(i) Bonding of face and core is perfect.
(ii) Face and core are isotropic, especially the core is antiplanar with a constant shear distribution regardless of the distance of the neutral axis.
(iii) Because stiffness of the core xy plane is smaller than the face stiffness, it is ignored.
(iv) z-directional stress of face, core is ignored.
(v) Shear deformation of face is ignored.

$$\omega_{mn} = \frac{1}{2}\sqrt{\sum_{i=1}^{3} f_i + \frac{\sqrt{\sum_{i=4}^{16} f_i}}{a^2 b^2 (\rho h)^* (\rho I)^*}} \qquad (1.\ 1)$$

where,