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The Prediction of Energy Flow in Stiffened Plate using Vibration Intensity

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1. Introduction

The transmission of vibrational energy flow in stiffened plates is analyzed using vibration intensity method. To improve the vibration intensity visualization, lines in a vector field is also presented. These lines present the direction at any points which are similar to the direction of the vibration intensity field.

2. Structural Intensity in a Plate

The instantaneous structural intensity component in the time domain can be defned as [1]

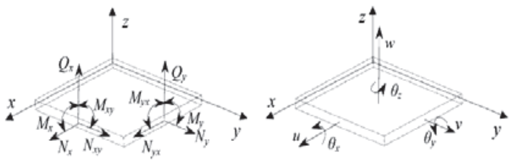
$$i_k(t) = -\sigma_{kl}(t)v_l(t), \quad [1]$$

where σ_{kl} (t) and σ_{kl} (t) are the time history of stress and velocity in the *l*-th direction.

The structural intensity can be expressed in the form of the net energy flow per-unit width for shells and plates. The energy flow lies in the plane tangential to the midsurface of the structure. Displacements of any point of a thin-walled structure can be expressed by translational and angular displacements of the midsurface. The two components of the structural intensity for a flat thin plate are as follows [1]

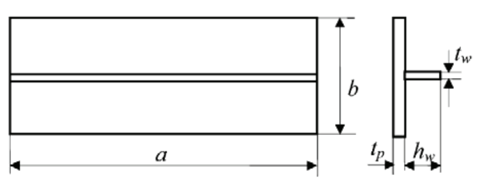
$$I_x = -\frac{\omega}{2}\mathrm{Im}\left[N_x u^* + N_{xy} v^* + Q_x w^* + M_x \theta_y^* - M_{xy}\theta_x^*\right] \quad [2]$$

$$I_y = -\frac{\omega}{2}\mathrm{Im}\left[N_y u^* + N_{yx} v^* + Q_y w^* + M_y \theta_x^* - M_{yx}\theta_y^*\right] \quad [3]$$



The present paper is concerned with energy transmission in a plate, which is stiffened by a series of parallel and crossed stiffeners with different spacing.

3. Computation Method



The model used in this studyis a rectangular plate with length a=1080 mm, width b=1440 mm, and thickness t_p = 21 mm which is attached with one central longitudinal flat-stiffener with stiffener height h_w = 110 mm and thickness t_w = 6 mm, as shown. . The material properties of this model are: elastic modulus E = 205.8 GPa, Poisson's ratio = 0:3 and mass density =7800 kg/m^3. A constant damping ratio of 0.07 is considered herein. An excitation force with a magnitude of 1 N is applied at x = 270 mm and y = 1260 mm along the z direction on the plate and a viscous damper with a damping rate of 2000 Ns/m is attached to the plate at x = 810 mm and y = 180 mm for all the cases.

In order to account for the effect of changes of the stiffener on the structural intensity in stiffened plate, a number of cases are considered, namely (1) un-stiffened plate, (2) one longitudinal stiffener (3) two longitudinal stiffeners with different spacing,

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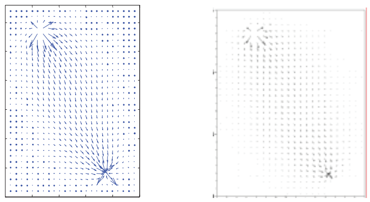
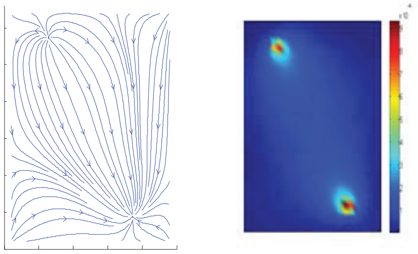
4. Computation Results

(1) No Stiffener

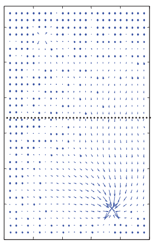


(a) Calculated VI (b) Ref. [1]

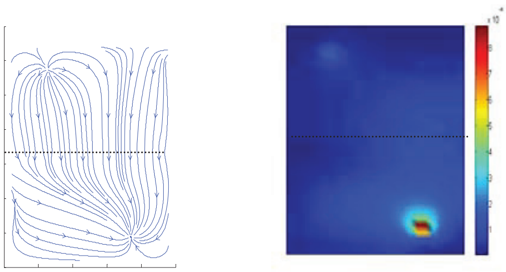


(c) Calculated Streamlines (d) Energy Contour

(2) 1 Stiffener

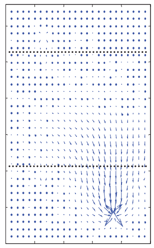


(a) Calculated VI

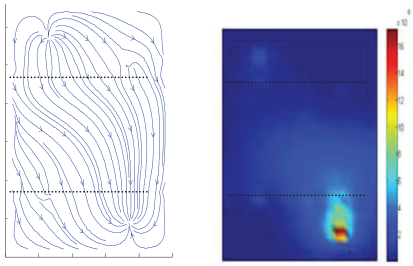


(b) Calculated Streamlines (c) Energy Contour

(3) 2 Stiffener



(a) Calculated VI



(b) Calculated Streamlines (c) Energy Contour

5. Conclusions

The calculation results showed that, despite the existence of stiffeners within the plate, the structural intensity fields can still clearly indicate the source, the sink and the direction of energy flow from the source to the sink. Meanwhile, the existence of stiffeners will change the energy flow in plate. The visualization using the streamlines plays an important part in the analysis especially showing the vortex as well as the energy dissipation by structural damping.

6. References

[1] X.D. Xu, H.P. Lee. The energy flow analysis in stiffened plates of marine structures. Thin-Walled Structures 42 (2004) 979–994

[2] [1] Gavric L, Carniel X, Pavic G. Structure-born intensity fields in plates, beams and plate-beam assemblies. In. Int Conf on Intensity Techniques, Senlis, France, 27-29 August, p. 223-230.