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Pergamon
Ocean Engineering 30 (2003) 1997–2017
OCEAN ENGINEERING
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Hydroelasticity of a floating plate in multidirectional waves[1]

X.J. Chen [a,*], J. Juncher Jensen [b], W.C. Cui [a], S.X. Fu [a]

[a] *School of Naval Architecture and Ocean Engineering, Shanghai Jiao Tong University, Shanghai 200030, China*
[b] *Department of Mechanical Engineering, Technical University of Denmark, DK-2800 Kgs. Lyngby, Denmark*

Received 4 February 2002; received in revised form 14 June 2002; accepted 4 July 2002

Abstract

The membrane forces are included in the hydroelastic analysis of a floating plate undergoing large vertical deflections in regular monochromatic multidirectional waves. The first-order vertical displacements induced by the linear wave exciting forces are calculated by the mode expansion method in the frequency domain. The second-order vertical displacements induced by the membrane forces are calculated by the von Karman plate theory. The results show that the membrane contribution both in terms of the axial stresses and the effect on the bending stresses can be important.

Keywords: VLFS; Hydroelasticity; Large deflection

1. Introduction

The importance of hydroelasticity of ocean structures has come into focus in recent years. The procedures applied range from two-dimensional linear theory (Bishop and Price, 1979), three-dimensional linear theory (Wu, 1984; Price and Wu, 1985), two-

* Corresponding author. Tel.: +86-21-62932056; fax: +86-21-62933160.
E-mail address: xjchen@sjtu.edu.cn (X. Chen).

[1] The project was jointly supported by the National Natural Science Foundation of China (Grant No. 50039010), the Science and Technology Development Foundation of Shanghai Municipal Government (Grant No. 00XD14015), China Postdoctoral Science Foundation and the EUREKA project MONITUS E!2097.

0029-8018/03/$ - see front matter © 2003 Published by Elsevier Science Ltd.
doi:10.1016/S0029-8018(03)00020-9

Nomenclature

$[\mathbf{A}]$ generalised added hydrodynamic coefficients matrix
A_i wave amplitude of the ith incident wave
B width of the plate
d draught of the plate
D_{11}, D_{12}, D_{22} orthotropic plate stiffness
$[\mathbf{E}]$ generalised wave exciting forces vector
E, E_x, E_y Young's modulus of the material
$F(t)$ Airy stress function for the membrane *stresses* in the plate
$\{\mathbf{F}\}$ complex amplitude of $\{\mathbf{F}(t)\}$
G_{xy} shear modulus of the material
h thickness of the plate
h^* equivalent plate thickness
$\{\mathbf{h}(t)\}_{m\text{x}1}$ generalised nonlinear force vector induced by the nonlinear characteristics of the von Karman plate
$\{\mathbf{h}\}_{m\text{x}1}$ complex amplitude of $\{\mathbf{h}(t)\}_{m\text{x}1}$
$\{\mathbf{H}(t)\}_{N\text{xl}}$ nonlinear force vector induced by the nonlinear characteristics of the von Karman plate
$\{\mathbf{H}\}_{N\text{x}1}$: complex amplitude of $\{\mathbf{H}(t)\}_{N\text{x}1}$
J_x, J_{xy}, J_y flexural flexibilities of the orthotropic plate
k wave number
$[\mathbf{K}]$ generalised stiffness matrix
K_{ii} diagonal element of the generalised stiffness matrix $[\mathbf{K}]$
l_x, l_y half of the length and the width of the plate
L length of the plate
m mode number of the plate
$[\mathbf{M}]$ generalised mass matrix
M_{ii} diagonal element of the generalised mass matrix $[\mathbf{M}]$
M_x, M_y, M_{xy} bending moments of the plate
N node number of the plate
N_x, N_y membrane forces
N_w total number of incident waves
$\{\mathbf{p}\}_{m\text{xl}}$ generalised principal coordinate vector
$\{\mathbf{p}(t)\}_E$ generalised principal coordinate vector induced by the fluid forces
$\{\mathbf{p}(t)\}_h$ generalised principal coordinate vector induced by the membrane forces
Q_x, Q_y shear forces in the plate
$[\mathbf{S}]$ generalised restoring matrix
T_{xy} membrane forces
t time variable
ν_{x}, ν_{y} Poisson ratio coefficients of the material
V_x, V_y effective shear forces in the plate