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A Comparative Study on the Hydroelastic Behavior of Floating Plates Imposed by Various Types of Boundary Conditions

J. N. Reddy
Department of Mechanical Engineering, College of Engineering, Texas A&M University
College Station, Texas, USA

Xuan Vu Nguyen
Faculty of Civil Engineering, Ho Chi Minh City University of Technology
Vietnam National University Ho Chi Minh City (VNU-HCM), Vietnam

Tan Ngoc Than Cao
College of Technology, Can Tho University (CTU)
Can Tho City, Vietnam

Xuan Qui Lieu and Van Hai Luong†
Faculty of Civil Engineering, Ho Chi Minh City University of Technology
Vietnam National University Ho Chi Minh City (VNU-HCM), Vietnam

In this paper, hydroelastic responses of floating plates subjected to a moving load are studied using a numerical approach. In this approach, the floating structure is discretized into a number of finite elements based on the classical plate theory, whereas the linear water wave theory is employed to define the fluid that is divided into a number of constant boundary elements. Responses of floating plates under moving loads imposed by two types of boundary conditions are investigated. The results obtained reveal that, at the speed below the critical value, the boundary conditions at the upstream and downstream of the floating structure significantly affect the dynamic amplification factor and the contact force's curve of orbit. However, the value of critical speed is independent of the boundary conditions. On the other hand, at the critical speed, unlike floating plates in an unbounded water domain, the maximum displacement of investigated structures does not occur at the center of the depression.

INTRODUCTION

Because of their relatively simple construction and ease of maintenance, very large floating structures (VLFSs) are considered to be one of the more promising solutions for a floating bridge, floating airport, runway, etc. The elastic responses of such structures are more important than their rigid-body motions, owing to the possession of a small ratio between the thickness and lengths. The behavior of VLFSs subjected to incoming waves has been an interesting subject of many studies, as indicated by Watanabe et al. (2004). However, when no incoming waves exist, the structures considered still have flexural responses because of impulsive and moving loads, such as moving of vehicles, landing, or take-off of airplanes. Up to now, there have been some studies closely related to the above-mentioned problem. For instance, Watanabe et al. (1998) presented numerical results for elastic responses of an elastic plate under impulsive loadings using the finite element method (FEM). Qiu (2009) also applied the FEM to analyze a free-free flexible beam under a moving load floating in an unbounded water domain. Yeung and Kim (2000) represented the results of the drag force in terms of Fourier transform and also introduced a critical speed. At this speed, the deflection is greater than that at other speeds. This outcome has also been reported by Takizawa (1988). Regarding this issue, Frýba's monographs (Frýba and Steele, 1976) have shown the relationship between natural frequencies of a structure under moving load and this quantity. Because of the dependence of natural structural vibrations on boundary conditions, the boundary can affect the critical speed. However, the model used in most of the aforementioned works was an infinite plate. Thus, the critical speed may be different from that of a finite floating plate. For the violation of boundary conditions, by using the mode-expansion method, Fleischer and Park (2004) evaluated the effect of water depth on a continuous floating bridge subjected to a movable weight with two simply supported opposite sides, yet the critical speed was not reported in this work.

On the other hand, according to Takizawa's experimental results conducted on a sea ice sheet at Lake Saroma, Hokkaido, Japan, using a Skidoo snowmobile as a moving load (Takizawa, 1988), the position of maximum deflection is located at the center of the depression (the depression around the moving load). In the case of enclosed water, thanks to the incompressibility, the motion of fluid is not similar to that of infinite-domain problems. This means that the maximum deflection locates at another position.

This paper is therefore concerned with numerical simulation for analyzing the behavior of finite floating plates with various boundary conditions during the passage of a moving load by utilizing a hybrid method (i.e., boundary element method (BEM) and FEM). This methodology was offered as an efficient time-domain numerical method for studying the hydroelastic behavior of a floating plate (Jin, 2007). In that study, the boundaries of a

†Corresponding author.
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