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ANALYSES OF DYNAMIC CHARACTERISTICS OF A FLUID-FILLED THIN RECTANGULAR POROUS PLATE WITH VARIOUS BOUNDARY CONDITIONS**

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ABSTRACT: Based on the classical theory of thin plate and Biot theory, a precise model of the transverse vibrations of a thin rectangular porous plate is proposed. The first order differential equations of the porous plate are derived in the frequency domain. By considering the coupling effect between the solid phase and the fluid phase and without any hypothesis for the fluid displacement, the model presented here is rigorous and close to the real materials. Owing to the use of extended homogeneous capacity precision integration method and precise element method, the model can be applied in higher frequency range than pure numerical methods. This model also easily adapts to various boundary conditions. Numerical results are given for two different porous plates under different excitations and boundary conditions.

KEY WORDS: thin rectangular porous plate, Biot theory, vibration, extended homogeneous capacity high precision integration method

I. INTRODUCTION

Owing to their excellent sound and energy absorbing performance, porous materials play an important role in many branches of engineering, such as soil mechanics, bioengineering, and aeronautical and automotive engineering. The vibroacoustic performances of porous structures, especially the porous beams and plates, have been widely studied [1, 2].

In 1941, the theoretical description of three-dimensional fluid-saturated porous elastic consolidation was firstly presented by Biot [3]. In the following years, Biot extended this theory to the anisotropic media [4] and poroelastic case [5]. So far most existing poroelastodynamic studies have been based on Biot theory, which was published in two famous papers, one for the low frequency range [6] and the other for the high frequency range [7]. Theodorakooulos and Beskos [8] developed the classical elastic thin plate theory to the porous plate by adopting Biot's stress-strain constitutive relationship. Neglecting the in-plane flow motion of the fluid relative to the frame, they proposed two governing equations to describe the coupled effect between the displacement of the frame and the pressure of the fluid, and those equations were solved by Navier's algebraic solution for a rectangular porous plate with four edges simply supported. Later, two simpler equilibrium equations for a porous thin plate were established in Ref. [9] by virtue of an alternative form of Biot's stress-strain relationship applied in Ref. [10]. In their model, the complex dissipation term was added, and the delayed after-effect was discussed due to the introduction of the relative fluid/solid motion. Nevertheless, their model was valid only for the plates thinner than any acoustic wavelength. By using the Rayleigh-Ritz decomposition, Leclaire et al. [11] extended their study from simply-supported rectangular porous thin plate to the one with four edges clamped. Experimental results were also given to verify the proposed model. However, when the boundary condition changed, the eigenfunction should've been changed correspondingly, and the solution process should've been resolved again. Therefore, the method was inconvenient for the theory analysis of porous plates. A mathematical model of a rectangular porous plate with mechanical properties varying continuously in the thickness direction of the plate was presented in the work of Mielniczuk et al. [12], which took into account shearing deformations based on

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