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Free Vibration Analysis of an Asymmetric Sandwich Beam Resting on a Variable Pasternak Foundation

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Abstract

The free vibration analysis of a three layered asymmetric sandwich beam resting on a variable Pasternak foundation subjected to a pulsating axial load have been carried out under various boundary conditions by the computational method. A set of Hill's equations has been obtained by the application of extended Hamilton's principle and generalized Galerkin's method. The effects of elastic foundation variation parameter, thickness ratio of two elastic layers, elastic modulus ratio, the ratio of length of the beam to the thickness of the elastic layer, the ratio of the modulus of the shear layer of foundation to the Young's modulus of elastic layer, the ratio of shear modulus of the core to the Young's modulus of the elastic layer, the ratio of the thickness of the Pasternak foundation to the length of the beam and core loss factors on the natural frequency have been studied.

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Keywords: Elastic foundation variation parameter; Pasternak foundation, core loss factor; modulus ratio.

1. Introduction

Sandwich structural elements are in use for many years in aerospace, ships, military aircrafts and in many other industries, because of their superiority over homogenous ones, when high strength and stiffness-to-weight ratios are desirable. In mechanical engineering many applications are there for beams on elastic foundation. Many researchers have studied the vibration and stability of beams on elastic foundation.

Heteny [1] studied the concept of beams on elastic foundation in details. Yokoyama [2] investigates the effect of an elastic foundation on the static buckling loads, natural frequencies, and regions of parametric instability of Timoshenko beams. The parametric instability of a non-uniform beam with thermal gradient resting on a Pasternak

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foundation was studied by Kar and Sujata [3]. The same authors investigated the parametric instability of Timoshenko beams resting on a variable Pasternak foundation [4]. In [5] the variation of natural frequencies with rotary inertia, shear deformation, elastic foundation constants of a Timoshenko beam were investigated by Wang and Stephens. Ditaranto [6], Mead and Sivakumaran [7], Mead and Markus [8] and Asnanai and Nakra [9] studied the free vibration analysis of sandwich beam by using the classical approach. The free vibration of sandwich beam by using dynamic stiffness method was studied by Banerjee [10]. Banerjee et.al [11] derived a tenth-order differential equation of motion for a 3-layered sandwich beam of unequal thickness and studied the free vibration characteristics using an accurate dynamic stiffness model.

Parametric instability of magnetorheological elastomer based sandwich beam with conductive skins under various boundary conditions was addressed by Nayak et.al. [12]. Banerjee [13] et.al studied the free vibration of three-layered sandwich beam using the dynamic stiffness method. Dwivedy et.al. [14] studied the parametric instability regions of three-layered soft-cored sandwich beam using higher-order theory. Dwivedy et.al. [15] also studied the parametric instability regions of a soft and magnetorheological elastomer cored sandwich beam. The dynamic stability of an asymmetric sandwich beam resting on a Pasternak foundation was studied by Dash et.al. [16]. Nayak et.al. [17] investigated the static stability of a viscoelastically supported asymmetric sandwich beam with thermal gradient. The general analysis of damping by a damping constrained viscoelastic layer was carried out by Kerwin [18]. Lenci et.al. [19] studied the nonlinear free dynamics of a two-layer composite beam with different boundary conditions. Nayak et.al. [20] investigated the dynamic stability of magnetorheological elastomer based adaptive sandwich beam with conductive skins using FEM and the harmonic balance method. The same authors also studied vibration analysis of a three-layer MRE embedded sandwich beam with conductive skins using FEM [21]. The parametric instability of a sandwich beam under various boundary condition was investigated by the Ray and Kar [22].

It has been observed from the above literature that no work has been done to study the free vibration analysis of asymmetric sandwich beam on Pasternak foundation. Thus in this work an effort has been made to study the free vibration of a three-layered asymmetric sandwich beam resting on a variable Pasternak foundation under different boundary conditions. The effects of core loss factor, geometric parameters, elastic foundation parameter and modulus ratios on the natural frequency of the system are investigated by computational method and the results are presented graphically.

Nomenclature

A_i (i=1,2,3)	Areas of cross section of a 3 layered beam, i = 1 for top layer	h_{12}	h_1/h_2
		h_{31}	h_3/h_1
B	Width of beam	l_{h1}	l/h_1
c	$h_1 + 2h_2 + h_3$	t	Time
E_i (i =1,2,3)	Young's Module, i = 1 for top layer	Y	Geometric Parameter
G_s	Modulus of the shear layer of a Pasternak Foundation	$\bar{w}$	w/l
G_2^*	$G_2(1+j\eta)$ complex shear modulus of core	$\bar{x}$	x/l
$g*$	$g(1+j\eta)$ complex shear parameter	ρ_i	Density of ith layer
g	Shear Parameter	m	Mass per unit length
$\bar{P}_1$	Non dimensional amplitude for the dynamic loading	α	E_1A_1/E_3A_3
d	Thickness of the shear layer of a Pasternak foundation	t_0	$\sqrt{ml^4/E_1I_1+E_3I_3}$
ω	Frequency of forcing function	E_{31}	E_3/E_1