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Nonlinear Dynamic Response of an Isotropic Rectangular Plate resting on elastic foundation under influence of moving mass

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Abstract

In this paper, nonlinear dynamics of an isotropic rectangular plate resting on elastic foundation under influence of a moving mass is considered. The governing nonlinear coupled partial differential equations of motion is derived by energy method using Hamilton's principle based on the large deflection theory in conjuncture with the Von-Karman strain-displacement relations. Then the Galerkin's method is used to transform the equations of motion into the three coupled ordinary differential equations and then the numerical integration method is applied to compute the dynamic responses of the plate on elastic foundation under the travelling mass. To verify the validity of the obtained results, some special case of this study is compared to other researcher's study. A parametric study was conducted by changing the foundation parameters and the velocity of the moving mass. Furthermore, normalized time histories of the plate central point were calculated for various load velocity and compared with the linear solution results. It is observed that the inclusion of geometrical nonlinearity and foundation stiffness into the system will produce significant effect in the plate's dynamic response.

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Keywords: Nonlinear dynamics, rectangular plate, moving mass, elastic foundation, Galerkin's method

1. INTRODUCTION

Structures subjected to moving mass are often encountered in engineering practice, such are: ropes of transporting systems, weapon firing barrels, overhead cranes and wheel loads from moving vehicles and planes In the analysis of roadways and runways of airports, the structure is usually modeled as a plate resting on an elastic foundation. In general, loads on these types of structures are moving loads or moving masses such as the wheel loads from moving vehicles and planes. In each of these systems, the accurate calculation of the response is essential for reliable design. This study is the first attempt to initiate and investigate the nonlinear dynamic response of plate resting on elastic foundation subjected to moving mass.

In [1], many simple moving load problems and their analytic solution were described. In [2], a procedure incorporating the finite strip method, together with a spring system has been developed and applied to treat the response of rectangular plate structures resting on elastic foundation due to moving accelerated loads. The effects of initial moving velocity, acceleration and initial load position on the response are discussed. Dynamic response of a rectangular plate subjected to multiple forces moving along a circular path was determined in [3]. In [3], the finite element method is used and all the external loads on a structural system were be replaced by the equivalent force (and moment) applied at the associated nodes first and then the equation of motion for the entire system with the last equivalent nodal forces (and moments) as the excitation mechanism was solved. In [4], combined application of the Ritz method, the Differential Quadrature (DQ) method, and the Integral Quadrature (IQ) method to vibration problem of rectangular plates subjected to accelerated traveling masses was studied. In [4], the effects of following parameters having something to do with the title problem are investigated: moving load speed and acceleration, and transverse inertia of the moving load. In [5], the dynamic displacement and stress responses of a plate of infinite extent on a viscous Winkler foundation subjected to moving tandem-axle loads with amplitude variation have been investigated. Formulations have been developed in the transformed field domain using a triple Fourier transform in time, space, and moving space for moving loads with arbitrary amplitude variation, and a double Fourier transform in space and moving space for the steady-state response to moving harmonic loads. In [6], The stability and dynamic displacement response of an infinite thin plate resting on a Winkler-type or a two-parameter elastic