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Nonlinear Dynamic Analysis of Rectangular Plate Traveled by an Accelerated/Decelerated Moving Force

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Abstract

In this paper the nonlinear dynamic analysis of an isotropic rectangular plate under influence of an accelerated/decelerated moving force is studied. The governing nonlinear coupled partial differential equations of motion are derived using Hamilton's principle based on the large deflection theory. Then the Galerkin's method is applied to transform the equations of motion into the three coupled ordinary differential equations and then numerically integrated to compute the dynamic responses. The appropriate parametric study by taking into account the effects of the magnitude of the traveling and the velocity of the traveling force with a constant acceleration/deceleration is carried out. It was seen that the existence of nonlinear terms in the governing coupled PDEs of motion renders stiffening behavior on the dynamic responses of the plate when traversed by a moving force.

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Keywords: Nonlinear dynamics, rectangular plate, moving force, Galerkin's method

1. INTRODUCTION

Structures subjected to moving load 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 when a vehicle accelerates or decelerates or when a plane takes off or lands. 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 subjected to moving force with variable velocity.

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 this paper, the Galerkin's method is applied to solve the nonlinear governing coupled PDEs of motion of simply supported rectangular plate with immovable edges supports subjected to an accelerated moving force that is derived by applying Hamilton's principle, then the dynamic response of plate are calculated using the numerical integration method.