Soil Dynamics and Earthquake Engineering 31 (2011) 1123–1131

Contents lists available at ScienceDirect

Soil Dynamics and Earthquake Engineering

journal homepage: www.elsevier.com/locate/soildyn

Dynamics of Rayleigh beam on nonlinear foundation due to moving load using Adomian decomposition and coiflet expansion

Zdzislaw Hryniewicz

Department of Civil and Environmental Engineering, Koszalin University of Technology, Sniadeckich 2, 75453 Koszalin, Poland

ARTICLE INFO

Article history:
Received 16 September 2010
Received in revised form
28 March 2011
Accepted 29 March 2011
Available online 8 May 2011

ABSTRACT

The effective procedure, which enables to discuss the dynamic response of Rayleigh beam resting on nonlinear viscoelastic foundation subjected to moving load, is developed. By employing the Adomian decomposition method in conjunction with coiflet expansion, the approximate closed form solution has been derived and condition for the convergence of the decomposition series has been introduced. To evaluate the accuracy of the approximate solution a local error index is defined. The presented new complex method is simple and efficient. The parametric study is performed and the influence of nonlinearity, load velocity, load frequency and the radius of gyration on the wave propagation in beam is investigated. The numerical results show that for the supercritical case, the linear model is stiffer giving rise to small displacement of the beam at the load passage.

1. Introduction

The infinite beam subjected to moving load has already been considered for linear models employing a number of methods. A lot of researchers have studied this problem using Fourier transform and employing Green's function [1] or using FE method [2].

In a lot of papers the foundation has been assumed to be linear in order to simplify the model.

It is clear that the main factor, which strongly affects the dynamic soil-structure problem, is the validity of the foundation model.

The case of a nonlinear elastic foundation is of great theoretical and practical significance in railway engineering.

In practice the foundation is highly nonlinear. The effect of nonlinearity on the displacements and the contact length of the beam due to dynamic load is investigated by Coskun [3]. Dahlberg [4] obtained some results due to moving load and found that the nonlinear model simulated the beam deflection fairly well, compared to measurements, whereas the linear model did not. More recently Wu et al. [5] used a similar nonlinear model and studied the dynamic response using FE method.

In the reference given by Kargarnovin et al. [6], the governing nonlinear equations of motion are solved using a perturbation method in conjunction with the Fourier transform, Green's function and the Cauchy's residue theorem. The reference given by Hsu et al. [7] deals with the free vibration problem of non-uniform Euler–Bernoulli beam and the technique of solution is based on the modified Adomian decomposition method. A beam considering the effect of the rotary inertia and subjected to axial compression and lateral loads is called Rayleigh beam [8].

The objective of this paper is to develop the effective procedure, which enables to discuss the dynamic displacement response of an infinite Rayleigh beam on nonlinear elastic foundation subjected to moving load. The foundation is considered as elastic with damping of linear hysteretic or a viscous nature.

A closed form solution is derived using Fourier transform and Adomian decomposition [9] in conjunction with coiflet expansion method [10,11].

A parametric study is carried out and the influence of nonlinearity, load velocity, load frequency and the radius of gyration on the wave propagation in beam is investigated. The proposed new approach to solve the nonlinear dynamic system can be considered as an efficient technique in solving many structural dynamic problems.

2. Problem formulation

The governing equation of motion for the Rayleigh beam resting on an elastic nonlinear foundation [6] subjected to harmonic distributed moving load can be written as

$$EI\frac{\partial^4 w}{\partial x_1^4}-N_a\frac{\partial^2 w}{\partial x_1^2}+m_b\frac{\partial^2 w}{\partial t^2}+c\frac{\partial w}{\partial t}-m_b r^2\frac{\partial^4 w}{\partial x_1^2\partial t^2}+k_L w+k_N w^3=-P_{f1}(x_1-Vt)e^{i\Omega t} \tag{1}$$

where EI, N_a, m_b, c, k_N, r are the beam bending stiffness, the axial force (positive and negative signs represent tension and compression, respectively), the mass and viscous damping per unit length,

E-mail address: zdzislaw.hryniewicz@tu.koszalin.pl

0267-7261/$ - see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.soildyn.2011.03.013