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Dynamic analysis of SDOF structures with fractional order damping under harmonic excitation

Javad katebi, Saeed khodadoost*

1. Assistant Professor of Civil Engineering, Tabriz University, jkatebi@tabrizu.ac.ir
2. Master Student of Civil Engineering, Tabriz University, saeedkhdst93@ms.tabrizu.ac.ir

Abstract

In this paper, an effective scheme is provided to solve fractional order differential equation by using Haar wavelet which governs in single-degree-of-freedom (SDOF) structures. Initially, the Haar wavelet method and Haar wavelet operational matrix are described. Afterward, a well-known fractional differential equation has solved to verify and show the procedure. Lastly, fractional order differential equations in SDOF structures presented. The results have shown for three different values of derivative order. The root mean square of responses is presented. Two performance indices introduced to evaluate the results. The results obtained are in good agreement with the existing ones in open literature, and it is shown that the procedure introduced in this paper is robust and easy to apply in the structures.

Key words: Dynamic analysis, Fractional calculus, SDOF, Harmonic excitation

1. Introduction

The second-ordered differential equation of motion, which governs the structures has been studied by several numerical approaches. Mathematically, these numerical strategies are being classified into the two most important domains. Firstly, explicit methods which do not require a factorization of the characteristics of the system in the step-by-step solution of the equation of vibration. Secondly, implicit methods which require a set of simultaneous linear equations for the time instant solution for vibration analysis.

Recently, fractional calculus has become the focus of interest for many researchers in the different field of science because modeling a physical phenomenon does not depend only at the time instant, and it also depends on the previous time history which can be successfully reached by using fractional calculus [1].

There are some techniques to solve the fractional order differential equations including Adomian decomposition method, Variational Iteration Method, Fractional Differential Transform Method, Fractional Difference Method and Power Series Method [2]. Lakestani and et al. construct the operational matrix of the fractional derivative of order α in the Caputo sense using the linear B-spline functions [3]. Haar wavelet techniques for the solution of ordinary differential equation and partial differential equation have been discussed in [4]. Hariharan and Kannan demonstrate that the Haar wavelet method is beneficial and efficacious in solving a broad group of linear and nonlinear differential equations [5]. Lepik applies Haar