DEVELOPMENT OF A MATHEMATICAL MODEL FOR THE PULSE-FREE PART OF THE NEAR FAULT EARTHQUAKES FOR THEIR TIME DOMAIN SIMULATION

Zakariya Waezi[1], Fayaz R.Rofooei[2], Nader K. A. Attari[3]
1- PhD Student, Civil Engineering, Sharif University of Technology, Tehran, Iran.
2- Professor, Civil Engineering Department, Sharif University of Technology, Tehran, Iran.
3- Assistant Professor, Building and Housing Research Center, Tehran, Iran.
Waezi@mehr.sharif.ir

Abstract

The complicated nature of near-field earthquakes and its effects on the structures, especially MDOF systems, have questioned the credibility of design spectra usage for these kinds of seismological events. In comparison to the far field ground motions, a velocity pulse can be detected at the beginning of near-field earthquakes. This pulse is main factor for many disastrous effects on flexible structures as they can impart a considerable amount of energy to the low frequency structural systems. Therefore, it is desired to provide a mathematical representation of the near-field records for problems which lack recorded motion with those specific characteristics. Many researchers have tried to propose a mathematical model for the velocity pulse present in near field earthquakes. However, neglecting the residual (pulse-free) part of those records could lead to certain inadequacies of the resulting simulated near field records. In this study, using Papageorgiou's pulse model, a simplified model for the Fourier transform of the residual part of near-fault records is proposed for their simulation. The model can be calibrated using a number of parameters to properly match the target records. Subsequently, regression analyses are performed in order to relate the model's parameters to the seismological characteristics of the event. Finally, an algorithm is presented to combine the velocity pulse obtained from Papageorgiou's model and the residual record generated using the proposed mathematical model. Various parameters such as, moment magnitude, epicentral distance, etc., are involved in producing the residual record. MATLAB program is used for numerical analyses.

Keywords: Velocity Pulse, Pulse Shape, Background Earthquake, Near-Fault Earthquakes.

1. INTRODUCTION

It is believed that unlike the ordinary earthquake records, consideration of near-fault earthquakes require much more attention than what is simply being used now as response spectrum method. These types of earthquake excitations possess certain characteristics that make the simulation of near-fault earthquakes impossible by simplified methods. Velocity time histories of near-fault earthquakes contain pulses that form their unique behavior. In other words, a "near-fault earthquake" is an earthquake featured with a large energy pulse at the beginning of its record. These pulses are exclusive for the forward direction of wave propagation from source that occurs in the fault-normal direction of ground motion [1].

Different attempts made for defining a proper pulse form to represent the near-fault records have succeeded from some point of views, raising hopes for their simulation. This is of great importance since it can improve the process of analysis and design of structures located in the vicinity of active faults. Various studies have implied that the response of a structure subjected to these pulses can be correlated with the "form of pulse", "pulse intensity' and "ratio of system's fundamental period to the dominant period of pulse". In the last couple of decades, many efforts have been made to determine an efficient pulse form with not much success. Using Hall's 3 pulses model, Alavi and Krawinkler investigated their suitability in reproduction of the recorded near-fault earthquakes' response spectra [1]. Due to their simple form, these pulses were unable to capture the complicated characteristics of the near-fault earthquakes.

Somerville utilized splines to model the ground motion's largest cycle with smooth curves[2]. Having compared with Alavi and Krawinkler's model, Somerville realized that more half cycles should be included in the model for more complete description of these ground motions. Menun and Fu proposed a 5-parameter model whose parameters can be obtained through a nonlinear regression analysis [3]. However, other researchers like Zhu & Xin-Le believed that having a constant period and limited number of half cycles(4 cycles at most) for simulation may lead to unrealistic results for certain types of ground motions [4].