8th National Congress on Civil Engineering, 7-8 May 2014
Babol Noshirvani University of Technology, Babol, Iran

# Performance assessment of fuzzy controller for responses of building structures equipped with semi-active tuned mass damper

**Saeed Pirgholizadeh[1], Vahed Ghiasi[1], Ali Keyhani[2], Mohammad Hajsadeghi[2]**

**1- Dept. of Civil Engineering and Architectural, Malayer University, Malayer, Iran**
**2- Dept. of Civil Engineering and Architectural, Shahrood University of Technology, Shahrood, Iran**

saeed.pirgholizadeh@stu.malayeru.ac.ir

**Abstract**

In this paper, fuzzy controller has been designed to control the applied voltage of semi-active Magneto Rheological (MR) damper working parallel with tuned mass damper to reduce the structural responses of buildings under earthquake excitations. The main advantage of the fuzzy controller is that it is not based on the mathematical model of the system. According to the high complexity of the behavior of the structure and MR damper system, fuzzy controller can be used to calculate the appropriate voltage, easily. In order to enhance the performance of the fuzzy controller, fuzzy rules should be based on the proper understanding of the operator toward the structural behavior. In this study fuzzy controller is designed based on the groundhook algorithm, according to the displacement and velocity responses of the structure. The responses of a building structure with ten degrees of freedom equipped with semi-active tuned mass damper are compared with those of the passive tuned mass damper and the uncontrolled structure. The results show an appropriate performance of the fuzzy controller in reducing the seismic responses of the structure.

**Keywords: Semiactive Tuned Mass Damper, fuzzy controller, MR Damper, Groundhook Algorithm**

## 1. INTRODUCTION

In recent years, active and semi-active control of responses due to seismic loads in various structures has been the subject of many researches. Active control systems require a significant amount of external power to work while semi-active devices need only a small amount of external power resource to adjust its mechanical properties and do not add energy to structures [1].

Tuned mass damper (TMD) idea is based on adding an auxiliary mass-damper tuned to the resonance frequency of the primary system. For the first time, Frahm [2] used tuned mass damper to reduce the rotational motion of ships. Later, Ormondroyd and Den Hartog [3], Brock [4] and Den Hartog [5] investigated about capability of TMDs in reducing the amplitude of vibration of the single-degree-of-freedom systems. Since then, TMDs is used in vibration control of various mechanical and structural systems. Hrovat et al [6] proposed a semi-active tuned mass damper to reduce wind-induced vibration of tall buildings. Abe and Igusa [7] presented a theoretical analysis of semi-active TMD for the transient excitation. The theory was developed for a structure with one degree of freedom and was extended to a continuous structure. Pinkaew and Fujino [8] studied the effectiveness of a semi-active TMD with variable damping under harmonic excitation analytically and numerically. They obtained a control law to adjust damping using an optimal control theory. They also showed that under harmonic excitation this semi-active controller is significantly superior to passive TMD in vibration suppression by comparing the structure's transient and steady-state responses. Koo [9] used tuned mass damper coupled with a semi-active MR damper as a tuned vibration absorber (TVA) on building floors. In his research, Koo compared the performance of four simple control algorithms and used both numerical and experimental studies.

Zadeh [10] introduced the fuzzy set theory in 1965. Mamdani [11], by applying Zadeh's theories and linguistic variables along with fuzzy inference, successfully used the 'IF–THEN' rules on automatic operating control of a steam generator considering uncertainties in system parameters. Consideration of uncertainties in input data from the system is the most advantageous feature of the fuzzy controller over other conventional controllers. Also, nonlinear factors involved in the mathematical model of the system can be easily overcame in the fuzzy controller. By including human skills in IF-THEN fuzzy laws, the fuzzy controllers can control complex structural systems.