for reducing effectively and treating more realistically (Zhang *et al.*,1997; Liao *et al.*, 2002; Park and Koh, 2004; Kim and Roschke, 2006; Tani *et al.*,1998).

One of the popular control algorithms about robust control is the so-called variable structure control (VSC). VSC method is well known due to its attractive features, such as fast response, insensitivity to parameter variations, and invariance to certain external disturbances（Yang, 1995; Yang, 1995; Yang, 1996; Yang, 1996; Zhao *et al.*, 2000; Cai and Huang, 2002; Gao, 1996; Ou, 2003; Zhang *et al.*, 2006）. However, due to the chattering problem (too many switches in the control bounds) of conventional VSC, the time histories of control forces can not be realized by the real controllers. So the chattering problem of VSC needs serious attentions.

The fuzzy set theory was introduced by Zadeh (1965). Mamdani (1974), by applying Zadeh's theories of linguistic approach and fuzzy inference, successfully used the 'IF-THEN' rule on the automatic operating control of steam generator (Wang, 1997). In civil engineering, fuzzy theory has been recently proposed for the active structural control (Tani *et al.*, 1998; Park *et al.*, 2002; Park *et al.*, 2004; Al-Dawod *et al.*, 2004; Ahlawat and Ramaswamy, 2004; Choi *et al.*, 2005; Alli and Yakut, 2004; Park *et al.*, 2005; Wang *et al.*, 2005). Since especially buildings in civil engineering are getting so higher and bridges are getting so longer that those structures are very complex systems of multi-degree of freedom, it is very difficult to find an exact mathematical model to describe the behavior of the structures. Because the fuzzy controller does not rely on the analysis and synthesis of the mathematical model of the process, the uncertainties of input data from the external loads and structural response sensors are been treated in a much easier way by the fuzzy controller than by classical control theory.

To avoid excessive chattering effect, Zhao (2000) and Cai (2002) proposed an exponential reaching law method to be applied for variable structure control law. However, the excessive chattering effect will appear when the "ε" parameter —the parameter mainly influences the control system performance to resist the outer disturbance— becomes a bigger value. In fact, in order to guarantee to have a sliding mode, we must select a bigger value for the "ε" parameter. The chattering problem in the conventional discrete-time variable structure control (DVSC) theory can be compensated with fuzzy logic control (FLC). In this paper, combining FLC and DVSC theories, a new discrete-time variable structure control method involving fuzzy adaptive regulation of reaching law has been applied for seismically excited linear structure. This new method has the advantages of both DVSC and FLC. It can be shown that the new method presented in this paper is quite effective in reducing the number of switches in the control bounds without degrading the other system performances. Using linguistic fuzz rules, the trajectory can be returned to the selected sliding surface by applying a large or small "ε" parameter value while the trajectory is leaving from the sliding surface.

In this paper, an idealized three Degree-of-Freedom (DOF) structure model proposed by Yang (1995) is used for studying thoroughly the feasibility of the proposed method. The 3DOF structure is counteracted by an active brace system (ABS) implemented on the first storey unit. Then, the simulink models of the new discrete-time variable structure control method involving fuzzy adaptive regulation of reaching law and the discrete-time variable structure control involving exponential reaching law have been developed for the numerical simulations. After that, the obtained results have been compared with each other. To verify the robustness of the new control method against the parametric or structural uncertainties, the performance of the new controllers presented in this paper has been presented at the deviations of the stiffness values. Finally, some conclusion remarks have been given.

2. Dynamic equation of structural system

For an n-Degree-of-Freedom building structure subjected to the horizontal earthquake ground acceleration $\ddot{x}_g(t)$ and the active control force $u(t)$, the matrix equation of motion can be expressed as

$$M\ddot{x}(t)+C\dot{x}(t)+Kx(t)=Du(t)-m\ddot{x}_g(t) \qquad (1)$$

in which $x=[x_1, x_2, ..., x_n]^T$, is an n-vector with $x_1(t)$ being the relative displacement of the ith storey unit with respect to the ground $x_g(t)$; $M = diag[m_1, m_2, ..., m_n]$ and $m = [m_1, m_2, ..., m_n]^T$ are an $(n \times n)$ diagonal mass matrix and