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EXTENDED ABSTRACT

Designing a Fuzzy-Based Hybrid Control System to Reduce Structure Vibration Using Rooftop Tank and MR Damper

Sehraneh Ghaemi [a,*], Alireza Aran [b], Mahdi Mansoury [a], Javad Katebi [b]

[a] *Faculty of Electrical & Computer Engineering, University of Tabriz*
[b] *Faculty of Civil Engineering, University of Tabriz*

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1. Introduction

MR damper as a semi-active control tool and rooftop tank as a passive control element are effective alone in reducing structural responses. By using these two control systems in one structure, a hybrid control system is built which improves the efficiency of the structural control system. In this research, the novel hybrid control system is proposed to reduce the responses of the structure. In the proposed hybrid control system, an MR damper is considered on the last floor of the structure, and instead of adding more MR dampers to the structure, a tank is utilized as a tuned liquid mass damper on the roof of the structure.

2. Methodology

A 10-story structure equipped with MR damper and rooftop tank is considered as a hybrid control system. The optimal parameters of the tank, i.e frequency ratio (γ_b) and damping of elastomeric pads (ξ_b), are obtained using the pattern search algorithm (Table 1) and the fuzzy controller is designed for the MR damper with a capacity of 1000kN. The performance of this control system which is excited by the vibration of two far-field and two near-field earthquakes is evaluated.

3. Results and discussion

According to the obtained results, it can be seen that in most of the investigated structures, the performance of the hybrid control system is better than the passive control system and the design of this system has been successful. For example, in the structure excited by the Hector mine earthquake and equipped with a hybrid control system where a tank with a liquid height of 200 cm is used, the average displacement response has decreased by 45% and the average acceleration response has decreased by 30%. In the same conditions, the structure equipped with a passive control system has been able to reduce the average displacement response by 40% and the average acceleration response by 17% (Fig. 1).

$$J_2 = \frac{\sum_{i=1}^{n} (RMS_d)_c\,(i)}{\sum_{i=1}^{n} (RMS_d)_{uc}\,(i)} \quad (1)$$

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* Orcid Cod Corresponding Author: 0000-0002-4731-6577
E-mail addresses: a.aran@tabrizu.ac.ir (Alireza Aran), ghaemi@tabrizu.ac.ir (Sehraneh Ghaemi), mahdimansoury@tabrizu.ac.ir, jkatebi@tabrizu.ac.ir (Javad Katebi)

$$J_2=\frac{\sum_{i=1}^{n}(RMS_a)_c\,(i)}{\sum_{i=1}^{n}(RMS_a)_{uc}\,(i)} \tag{2}$$

Table. 1. Optimal tank parameters for the structure excited by Hector mine earthquake

Liquid Height	Parameters	Depth Ratio				
		0.3	0.5	0.75	1.0	1.5
50 cm	γ_b	0.9409	1.1156	1.0841	1.0424	1.0246
	$\xi_b(\%)$	0.31	0.42	0.92	0.88	0.86
100 cm	γ_b	1.0335	1.1441	1.0602	1.1605	1.0738
	$\xi_b(\%)$	0.66	0.55	0.53	0.52	0.49
150 cm	γ_b	0.9974	0.8876	0.9753	1.1769	1.1178
	$\xi_b(\%)$	0.43	0.58	1.25	0.87	0.58
200 cm	γ_b	0.8482	0.8136	0.8725	0.8868	1.1894
	$\xi_b(\%)$	0.90	0.57	0.55	0.51	0.43

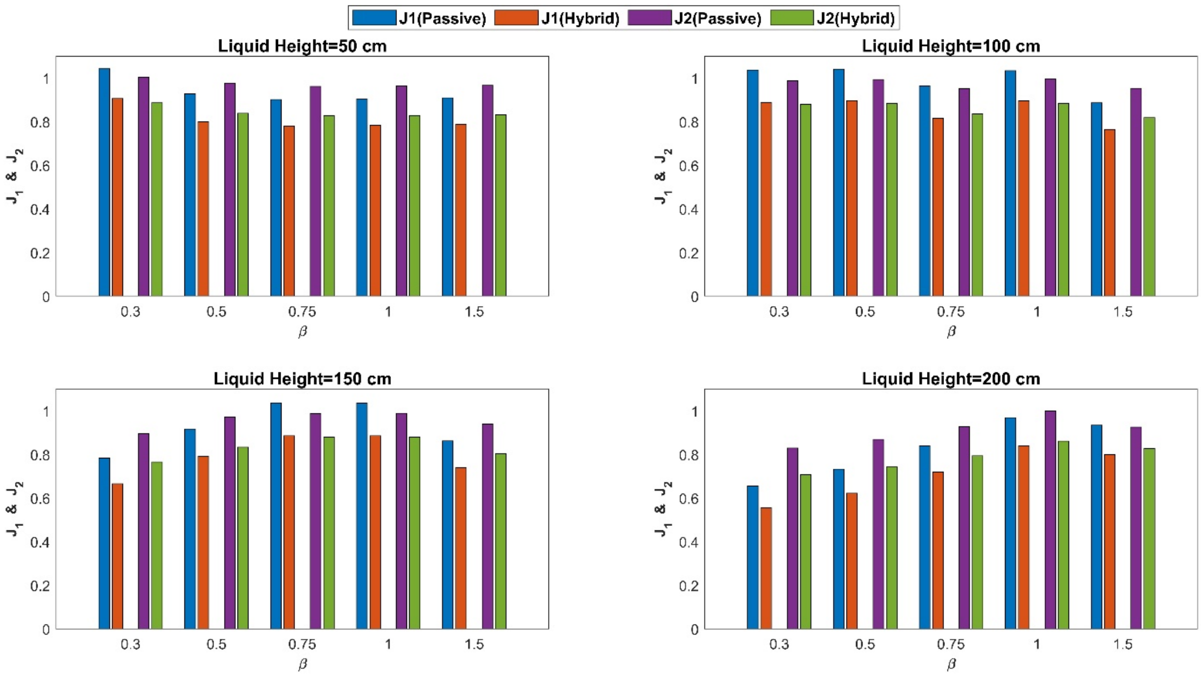

Fig. 1. Performance index J_1 and J_2 for the structure excited by Hector mine earthquake

4. Conclusions

In this research, a 10-story building structure equipped with a tank on the roof and an MR damper on the last floor (hybrid control system) was considered which is excited by two far-field earthquakes and two near-field earthquakes. The parameters of the tank used as a passive control system were optimized using the pattern search algorithm and the optimal frequency ratio of the tank was obtained about 1. Tank modeling was considered with the assumption of a depth ratio greater than 0.3 according to Housner's method for deep tanks. The used MR damper was considered as a semi-active control system with a capacity of 1000kN, and its input voltage was calculated using a fuzzy-based controller. The design of the fuzzy system was performed based on the accelerating or decelerating movements of the structure. The results illustrated that the proposed hybrid control system can reduce the average response of displacement and acceleration of the structure by 45 and 30%, respectively. Also, the analysis of 20 hybrid control systems with different dimensions of the tank excited by four different earthquakes showed that increasing the liquid height and tank volume has an effective role in reducing the response of displacement and acceleration of the structure.