Discussion on the Effect of Fuzzy Vibration Control of Structures

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Abstract

Structural fuzzy vibration control provides specific variable parameters by reducing. By introducing the corresponding seismic wave and using MATLAB software to carry out program operation, the required data are obtained. Finally, the effect of vibration reduction under the fuzzy control is obtained by analyzing the data.

Keywords

Fuzzy Control，Variable Parameters，Shock Absorption Effect.

1. Introduction

Because of the uncertainty of ground motion, the traditional seismic design method has great risk, so improving the safety of buildings and reducing the loss of building seismic damage through isolation and shock absorption methods have become the focus of research [1]. Structural fuzzy vibration can simplify calculation model, formulate fuzzy control rules and analyze calculation results. In this paper, a 20-storey structure is established to discuss the effect of vibration reduction of the structure.

2. Brief Introduction of Fuzzy Control Principle

Fuzzy control is a non-linear control method based on fuzzy set theory, fuzzy linguistic variables and fuzzy logic reasoning. In the fuzzy control algorithm, the fuzzy rule is the key to achieve its control effect[2]. Through the corresponding fuzzy control rules, the type of membership function selection and adjustment [3], the proportion factor setting and data processing, the calculation results are obtained.

3. Analysis of the results of calculation examples

In this paper, a 20-storey building structure is taken as an example to simplify it into a discrete multi-degree-of-freedom system with 20 lumped masses. The basic parameters of the structure are mi=2933t, ki=28950000 kN/m, and the damping matrix is in the form of Rayleigh damping. The input seismic wave is divided into Shanghai artificial wave 5 and the maximum horizontal ground acceleration is 4.0m/s2.

3.1.1 A Brief Introduction to Seismic Waves

Shang-hai artificial wave 5 is reconstructed by Taft and applied in IV site. The time interval is 0.01s, the maximum acceleration peak is 35.0cm/s2, the peak acceleration is adjusted to m/s2, and the total number of points is N=4096.

3.1.2 Analysis of calculation results

By introducing Shan-hai artificial wave 5 into the program, the corresponding data are obtained, and the final conclusion is obtained by analyzing the data.

Table1 Comparison of displacement damping efficiency between three algorithms

floor	story drift（AMD）/mm	damping efficiency /%	story drift（fuzzy U_A=7）/mm	damping efficiency /%	story drift（uncontrolled）/mm

0-1	7.52	81.88	13.40	67.71	41.50
1-2	7.38	82.10	13.10	68.23	41.24
2-3	7.20	82.37	12.66	69.00	40.85
3-4	6.96	82.72	12.18	69.75	40.27
4-5	6.65	83.15	11.70	70.36	39.48
5-6	6.29	83.62	11.27	70.68	38.43
6-7	5.90	84.09	10.93	70.52	37.07
7-8	5.46	84.60	10.63	70.03	35.47
8-9	5.03	85.03	10.24	69.52	33.59
9-10	4.65	85.25	9.76	69.06	31.54
10-11	4.27	85.43	9.17	68.68	29.29
11-12	3.87	85.65	8.46	68.59	26.95
12-13	3.49	85.70	7.60	68.89	24.43
13-14	3.24	85.13	6.66	69.43	21.78
14-15	2.92	84.62	5.84	69.27	18.99
15-16	2.53	84.28	5.11	68.21	16.07
16-17	2.07	84.10	4.31	66.90	13.01
17-18	1.66	83.10	3.40	65.47	9.83
18-19	1.17	82.25	2.37	64.05	6.58
19-20	0.60	81.74	1.23	62.74	3.30

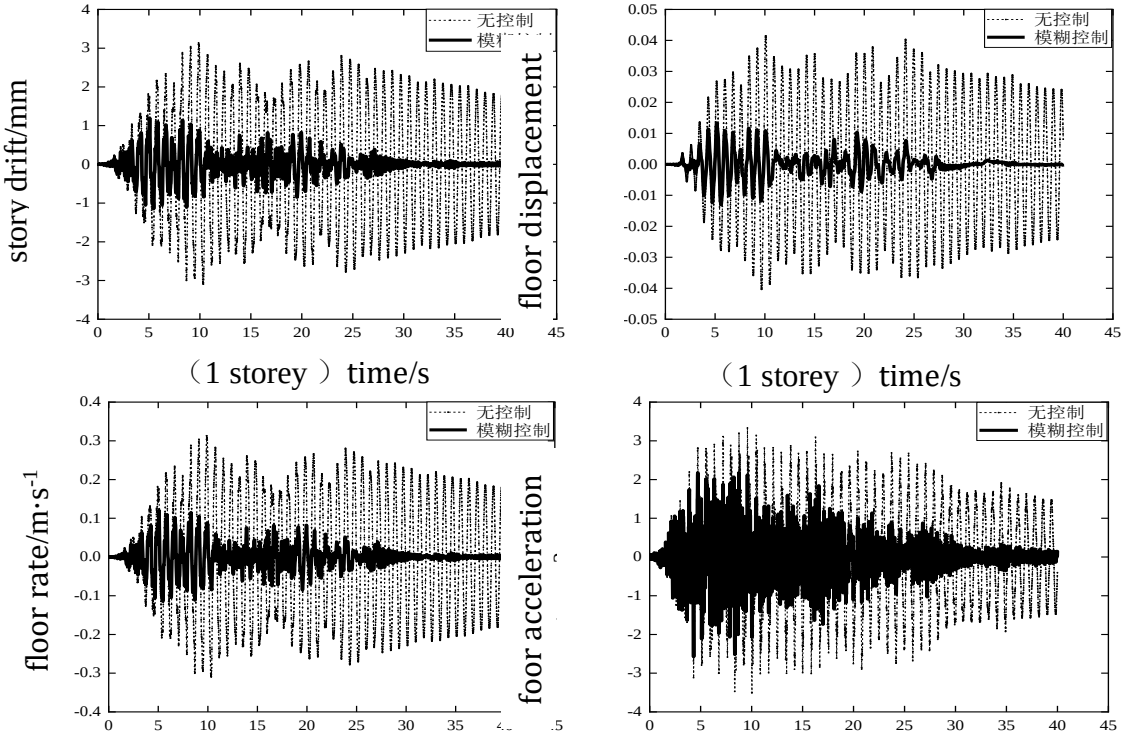
As can be seen from Table 1, compared with uncontrolled, both AMD control and fuzzy control have a good effect on reducing interlayer displacement, and the numerical value of interlayer displacement decreases with the increase of layer height.Under the control of AMD, the seismic reduction efficiency of inter-story displacement is over 80%, and the effect of seismic reduction is remarkable. Under the fuzzy control, the effect of inter-story displacement is more than 62%, and it also achieves a relatively good level of vibration reduction.

Table2 Comparison of floor acceleration and damping efficiency of three algorithms

floor	floor acceleration (AMD) /m.s^{-2}	damping efficiency /%	floor acceleration (fuzzy U_A=7) /m.s^{-2}	damping efficiency /%	floor cceleration (uncontrolled) /m.s^{-}
0-1	1.55	53.37	2.18	34.53	3.33
1-2	2.76	54.85	4.08	33.32	6.12
2-3	3.75	58.05	5.87	34.29	8.93

3-4	4.67	58.76	7.16	36.72	11.32
4-5	5.15	61.14	7.98	39.78	13.25
5-6	5.32	65.51	8.96	41.90	15.42
6-7	5.21	70.21	9.51	45.62	17.48
7-8	5.23	73.06	9.89	49.05	19.41
8-9	5.28	75.24	9.85	53.82	21.33
9-10	5.39	76.44	10.32	54.86	22.86
10-11	5.63	76.70	10.25	57.57	24.15
11-12	5.84	76.93	9.72	61.59	25.29
12-13	5.83	77.78	10.81	58.79	26.24
13-14	5.71	78.80	11.64	56.79	26.94
14-15	6.10	77.67	12.21	55.29	27.31
15-16	6.40	76.67	12.40	54.80	27.44
16-17	6.79	75.18	12.43	54.53	27.34
17-18	7.05	75.41	12.32	57.00	28.66
18-19	7.17	75.93	12.33	58.60	29.79
19-20	7.20	76.49	12.37	59.63	30.63

From Table 7, it can be seen that compared with uncontrolled, AMD control and fuzzy control have obvious effect on reducing floor acceleration, and the value of acceleration increases with the increase of floor height. Among them, the efficiency of AMD control is better than that of fuzzy control.



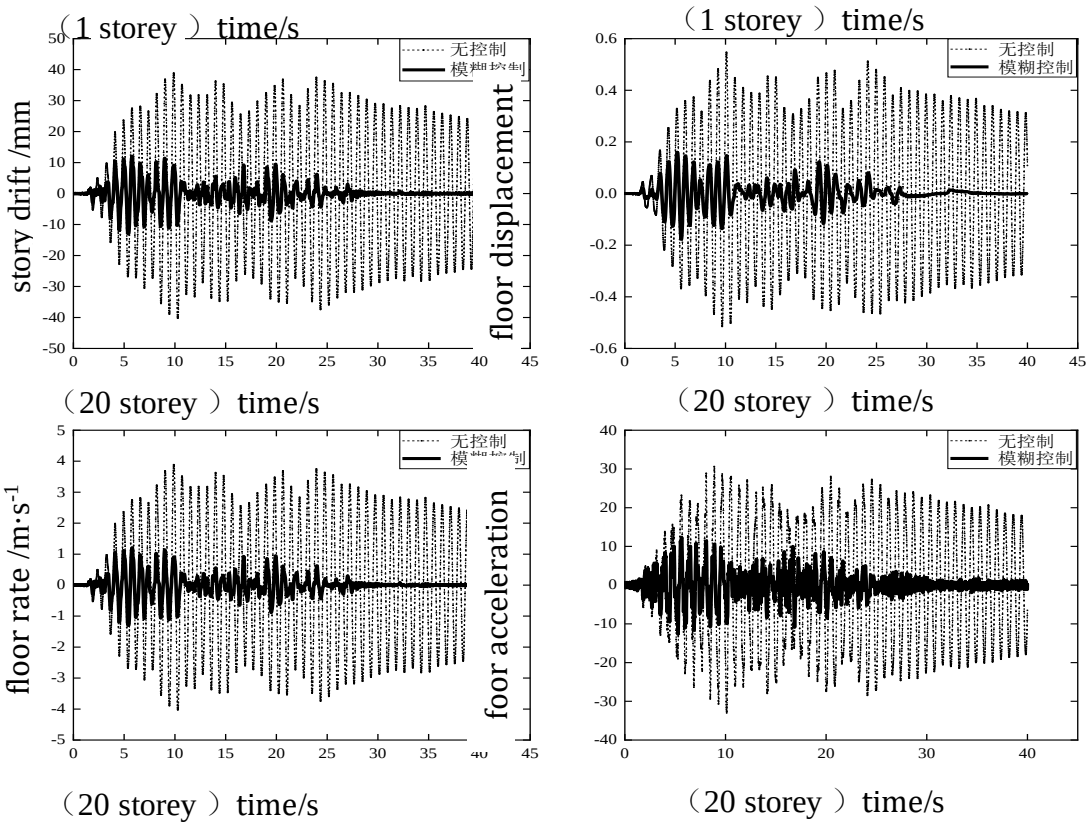


Fig.1 Time history of structural seismic dynamic response（U_A=7）

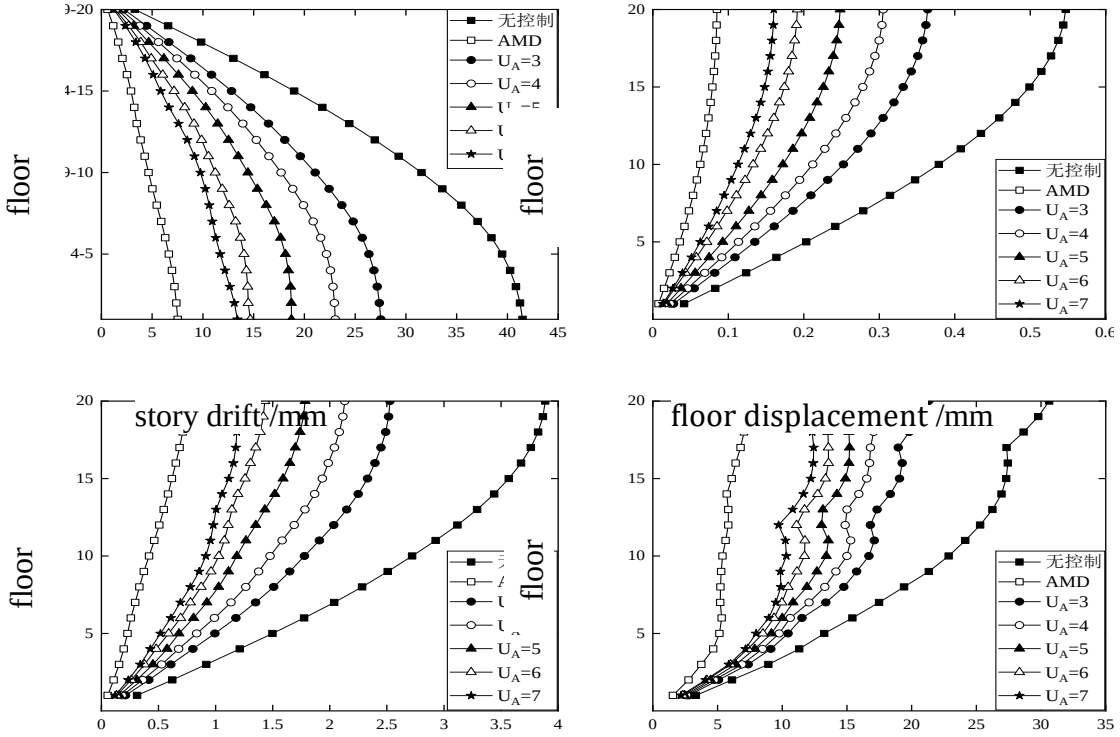


Fig.2 Structural seismic dynamic response

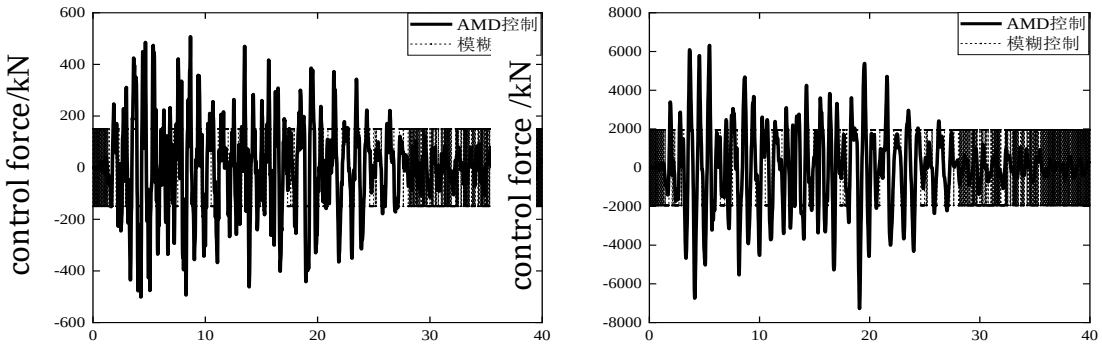


Fig.3 Fuzzy control force time history diagram（U_A=7）

From Figure 1, it can be seen that the effect of fuzzy control on inter-floor displacement, floor displacement, floor velocity and floor acceleration reduction is better, but the effect on acceleration reduction of the first floor is worse. As can be seen from Figure 2, the control effect of the fuzzy control on the four variables is between the optimal control and uncontrolled control of AMD, and with the increase of the value of the control force, the control effect is gradually enhanced. As can be seen from Figure 3, the values of the fuzzy control force are all in a stable range, but the values of the AMD control force vary widely, and the values of the control force also exceed the range of the fuzzy control force.

4. Conclusion

Based on the above calculation results and data analysis, it can be concluded that Shan-hai artificial wave 5 has obvious reduction effect on floor displacement, floor displacement, floor velocity and floor acceleration under earthquake action. AMD optimal control has the best shock absorption effect. Fuzzy control can enhance the shock absorption effect by increasing the control force.

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