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PRIORITIZED SLIP LOAD OPTIMIZATION OF FRICTION DAMPED-BASED STRUCTURES

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Considering the main concern of friction dampers that allows the building to move elastically, it is crucial to maximize the energy absorption of the frame configuration. Therefore, finding the optimum slip load in which the energy of earthquake could be dissipated effectively has a critical aspect. The novelty of this article is presenting an approach in order to control the total acceleration as well as top acceleration and displacement of structures. To this aim, two optimization problems have been presented which yield the optimum slip load regarding the priority level between minimum top acceleration, top displacement and total acceleration. Both problems are solved using SGA algorithm. The results show that using non-uniform slip loads in each floor, total acceleration of structure would be controlled effectively while in uniform case, controlling top displacement and acceleration have a major priority in structure's seismic retrofit.

Regarding the basic motion equations, two optimization problems are defined. The first one is supposed that slip load of each story is the same while in the second, considered there is a non-uniform slip load. in both problems, the target function is to minimize the top acceleration. The significant aspects of problems is that for acheiving the minimum acceleration in problem 1, controlling of inter story drift has a priority and it is issued in constrain *(i)*. On the contrary, controlling the total acceleration of structure is a main concern and it is defined as constrain (i) in problem 2.

Problem 1: (1)

$$Find\ \vec{S}, \vec{S} = S_0\ \forall\ all\ of\ nstory$$

$$\textbf{Minimize}\ \ \boldsymbol{J}(\boldsymbol{S}) = \boldsymbol{a}_{\boldsymbol{max}}(\boldsymbol{S})$$

$$Subject\ to$$

$$(i)\ D_{max} \leq \gamma$$

$$(ii)\ S^{Min} \leq S_0 \ \leq S^{Max}$$

Problem 2: (2)

$$Find\ \vec{S},\ \ \vec{S} = [s_1\ s_2\ s_3\ \ldots . s_{nstory}]$$

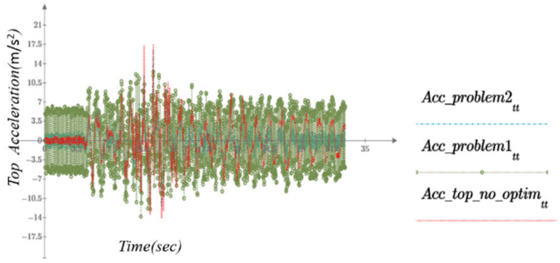
$$\textbf{Minimize}\ \ \boldsymbol{J}(\boldsymbol{S}) = \boldsymbol{a}_{\boldsymbol{max}}(\boldsymbol{S})$$

$$Subject\ to$$

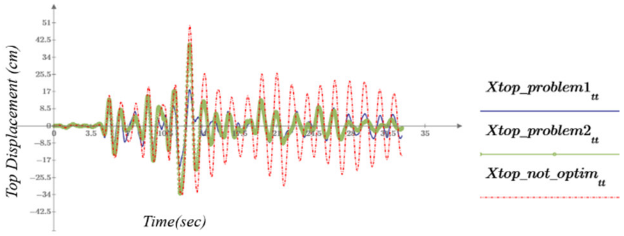
$$(i)\ \sqrt{\boldsymbol{a}_1^2 + \boldsymbol{a}_2^2 + \cdots + \boldsymbol{a}_n^2}\ \leq \beta$$

$$(ii)\ S_{nstory}^{Min} \leq S_{nstory}^{i} \leq S_{nstory}^{Max}$$

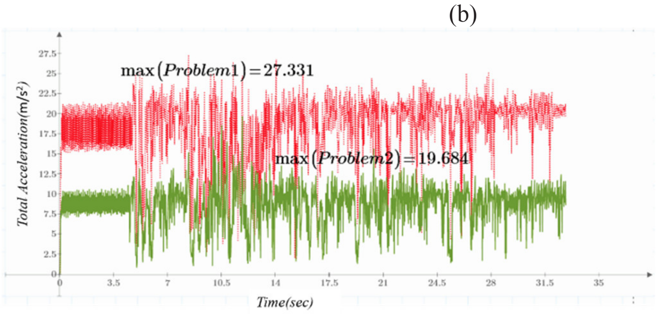
To solve the optimization problems, the search group algorithm (SGA) is used. The analogy of the two optimization problems in view point of top acceleration is shown in Figure 1. Both problems depict that using friction damper can improve the top acceleration and displacement comparing non-optimized one. However, there is a trade off between two problems in view point of total acceleration and top displacement (Figures 1-b and 1-c). As can be seen in Figure 1, finding slip load via problem 2 leads to lower total acceleration. Thus, problem 2 is more beneficial on controlling total acceleration of structures.



(a)



(b)



(c)

Figure 1. Comparing the top and total acceleration of 4-story building under two optimization problems.

The extended investigations are described in Table 1. The results show that optimization problem 2 with non-uniform slip load is more effective in controlling total acceleration in such a way that the improvement ratio is higher than 10 percent comparing to problem 1. On the contrary, controlling of inter story displacement has a major priority in problem 1. So, adjusting slip load in uniform case would be more beneficial solution in controlling a displacement of a building with lower natural frequency and a long natural period; which has large displacements and low acceleration.

Table 1. Numerical results of structures under various earthquakes.

No.	Number of Story	Earthquake	Total Acceleration		Inter Story Drift		Slip load (kN)	
			Problem2	**Problem1**	**Problem2**	**Problem1**	**Problem1**	**Problem2**
1	4	Tabas	67%	52%	71%	78%	20	[45,48,48,50]
2	6	Tabas	49%	32%	38%	46%	15	[40,38.5,41,45,44,40.5]
3	10	Tabas	42%	28%	27%	32%	20	[39.7,39.5,40,41,46,44,44,45,42,45]
4	4	Manjil	10%	3%	29%	53%	10	[30,31.8,30.5,32]
5	6	Manjil	36%	27%	18%	30%	10	[30,30,31.7,32.2,33,30]
6	10	Manjil	38%	36%	26%	32%	20	[35.7,34.5,39,41,46,44,44,45,38,36]

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