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Effect of Number and Position of Rotational Friction Dampers on Seismic Response of Steel Frame

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***Abstract* – This paper deals with effect of number and position of friction dampers on seismic response of 2D steel frame. For the present study four structures with six storeys are subjected to a time history analysis. For each story are using two, four and six friction dampers with different positions keeping slip load and stiffness constant. To study the effect of number and position of dampers in structures, are analysed the time period, top roof displacement, maximum base shear and percentage energy dissipated in accordance with energy induced in the frame. The results indicate that number and placement of damper affects the structural response. A large number of dampers do not always lead to best benefit in terms of energy dissipation.**

Keywords – dissipation energy, friction damper non-linear time, history analysis

1. INTRODUCTION

Earthquake-resistant design of structures using energy dissipation devices such as viscoelastic dampers, viscous fluid dampers, metallic dampers and friction dampers have proved the potential for reducing seismic risk without compromising the safety and reliability. Friction dampers have revealed to be capable of providing structures with considerable added damping to reduce the member forces, joint displacement, and floor acceleration of structures produced due to seismic excitations [1].

The present paper presents the effect of number and position of friction damper on the seismic response of 2D frame structure. Non-linear times-history analysis using Vrancea 1977 ground motion record scaled to 0.3g was performed for each structure.

2. EXPERIMENT DESCRIPTION

For evaluating the behavior of structures for different number and position of friction dampers, a nonlinear dynamic time-history analysis was used. This tipe of analysis show the response of the structure during seismic action. The property of friction damper are shown in **Table 1**. The mechanism of rotational friction dampers is shown in **Fig. 1.**

The program ETABS 17 [2] was used to assess the response of structures. Four design scenarios were taken into consideration using different positioning and number of the 50KN slip load dampers.

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Table 1. Properties of friction damper

Element used for modeling	Plastic (Wen)
Slip load	50 KN
Stiffness	149833,33 KN/m
Post yield stiffness ratio	0,0001
Yielding exponent	10

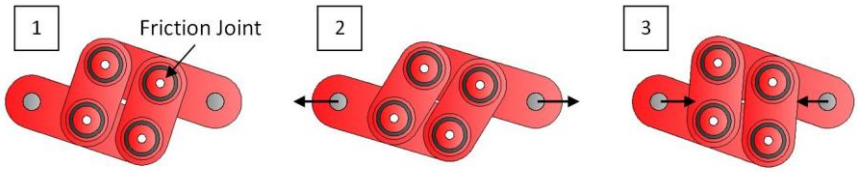

Fig. 1. Mechanism of friction damper in brace [3]

Fig. 2. Structure 1

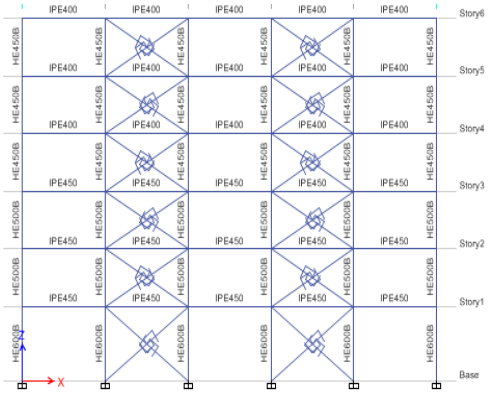

Fig. 3. Structure 2

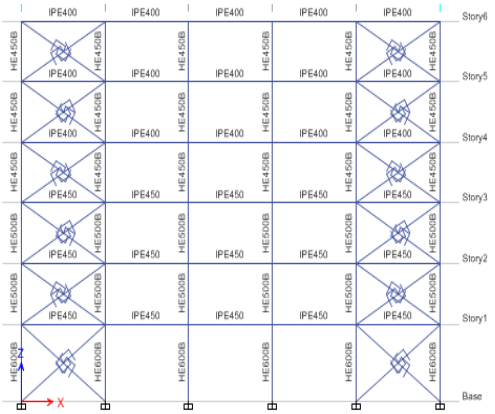

Fig. 4. Structure 3

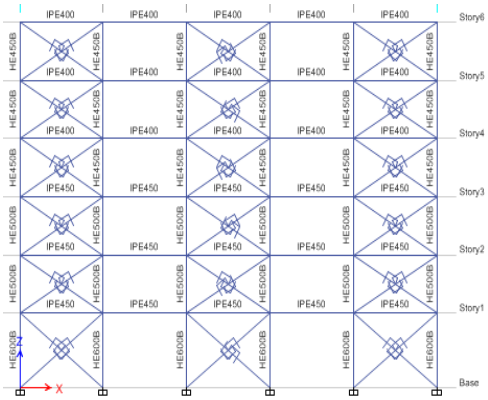

Fig. 5. Structure 4

The span length is 6 m, first level has 4,5 m height, and rest of levels have 3,5 m. The material is Steel S355. The response of structures in all four design versions was subjected

to Vrancea 1977 earthquake recording **(Fig. 6)** scaled to 0,3g. The response in terms of top roof maximum displacement, maximum base shear and percentage energy dissipated in accordance with energy induced in the frame are listed below.

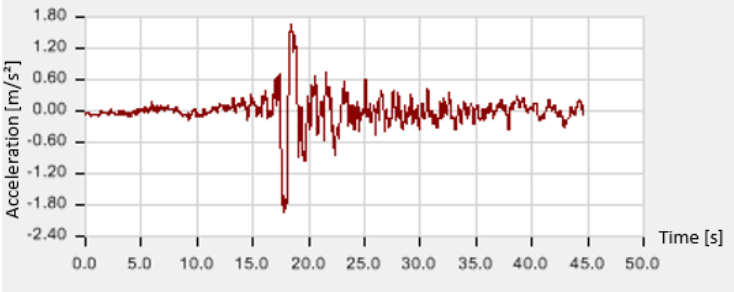

Fig. 6. Earthquake Vrancea 1977 accelerogram

3. RESULTS AND SIGNIFICANCES

In **Table 2** are evaluated the dynamic characteristics of the structures in terms of periods of vibration. The fundamental period of the structure 1 is 18,3 % bigger than the average of last three structures. The structures 2, 3, 4 have similar fundamental periods.

Table. 2. Dynamic Characteristics of Structures

-	**Structure 1**	**Structure 2**	**Structure 3**	**Structure 4**
Periods [s]	0,633	0,475	0,474	0,396
	0,214	0,161	0,163	0,136
	0,124	0,117	0,117	0,116
	0,117	0,115	0,113	0,105
	0,115	0,091	0,105	0,103

From the **Figure 7** it has been observed that the maximum top displacement for structure 1 is greater than the rest of the structures, while the structure number 4 has the lowest displacement. The maximum displacement values of structures 2 and 3 are both closed to 60mm.

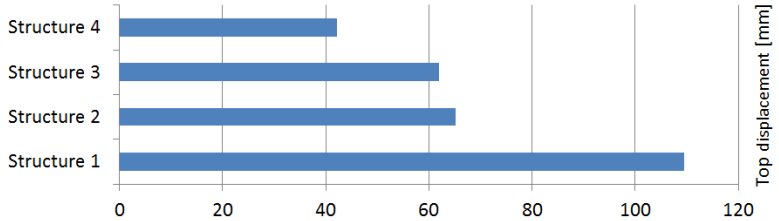

Fig. 7. Comparison of maximum top displacement

By observing the maximum story base shear for structure 1, the value is more than the other three structures. The structures 2, 3 and 4 have appropriate values around 3400 KN (**Fig.8**).

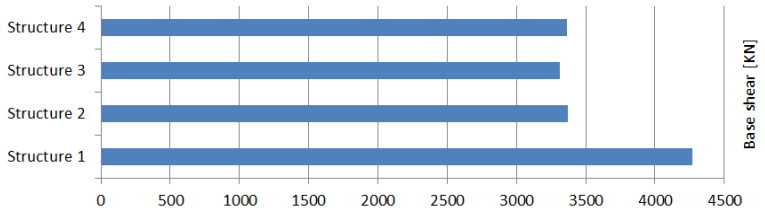

Fig. 8. Comparison of maximum base shear

From **Figure 9** it is clear that structure 1 has the values of input energy greater than the others three structures. The structures 2, 3 and 4 have appropriate values.

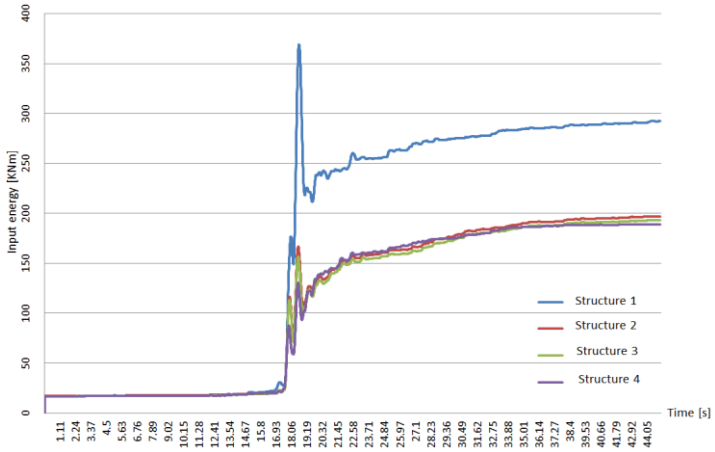

Fig. 9. Comparison of input energy

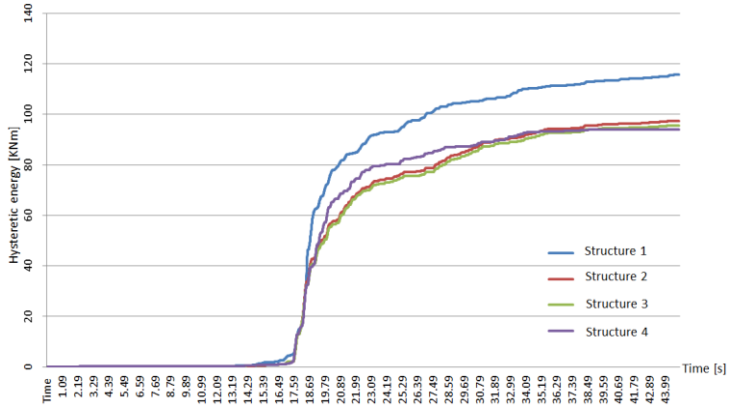

Fig. 10. Comparison of hysteretic energy

The maximum hysteretic energy is induced in structure 1. Structures 2 and 3 have similar values (**Fig. 10**). **Table 3** shows that the values of input energy and dissipated energy through friction dampers are different for each structure. It is visible that by keeping number of friction dampers same but changing its location, changes input energy and dissipated energy in the structure.

Table. 3. The maximum values of dissipation energy for each structure

Structure	Input energy [KNm]	Hysteretic energy [KNm]	Dissipation [%]
Structure 1	292,55	115,79	39,58
Structure 2	196,79	97,28	49,43
Structure 3	192,93	95,55	49,53
Structure 4	188,82	93,94	49,75

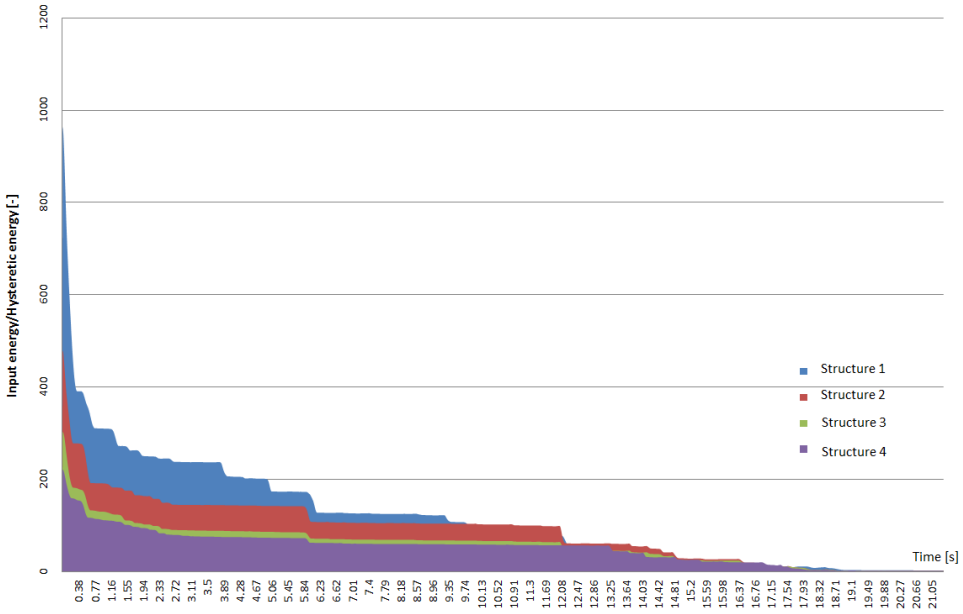

Fig. 11. The dissipation energy in time

Even the maximum percentage energy dissipation for structure 2,3,4 are around 49,5%, the **Figure 11** shows that dissipation energy in time for structure 3 is quite similar with structure 4.

4. CONCLUSION

This study shows that that number and placement of damper affects the structural response in terms of energy.

It is visible that structure with six friction dampers per story has the minimum response in terms of top roof displacement, but the Structure 3 is optimal solution in terms of dissipated energy. A large number of dampers do not always lead to best benefit in terms of energy dissipation.

6. REFERENCES

[1] S.S. Sanghai and P.Y. Pawade (2014), *Effect of Position and Number of Friction Dampers on seismic response of Frame*, International Journal of Earth Sciences and Engineering, ISSN 0974-5904, Volume 07, No. 05
[2] https://www.csiamerica.com/
[3] https://www.damptech.com/diagponal-bracing

Note:

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