Influence of Damping Coefficient Value of Fluid Viscous Damperson Seism Behavior of a Ten Stories Building Using ETABS Software

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Abstract. This paper presents the seism dynamic analysis of a ten-stories building equipped with anti-seismic viscous fluid dampers, in order to determine the influence of the damping coefficient c on the building relative displacements and dampers forces during seism. By modifying the damping coefficient c, three cases of analysis were performed: c = 0 kNs/m^2 (for the structure without dampers), c = 10000 kNs/m^2 and c = 17000 kNs/m^2. 21 design accelerograms were considered for dynamic analysis, seven for each value of the corner period Tc (0.7 s, 1.0 s and 1.6 s). In order to compare the results, the time variations of the relative displacements for each story were determined and the maximum values were presented on the same graph to highlight the influence of parameter c. The time variations of the damper forces for each story were processed in the same manner. The analysis of the results shows that for c = 17000 kNs/m^2 there is a reduction of the maximum relative displacements of up to 50% while the forces in the dampers reach the maximum value of 1000 kN. For c = 10000 kNs/m^2 the reduction of the maximum relative displacements is on average 35%, and the maximum damper forces reach values up to 800 kN. In order to establish the optimal value of the coefficient c, an additional study is needed to evaluate the influence of the damper force on the structure nodes area in which the dampers are positioned.

Keywords: ETABS · Fast Nonlinear Analysis · Damping Coefficient

1 Introduction

Romanian design codes for civil engineering do not contain indications for the design of the buildings seism protection systems. The most used dampers for building protection during seism are the fluid viscous damper. The damper forces are transmitted to the areas near the nodes in which they were positioned and can cause cracks depending on the value of the force. A higher damping coefficient ensures the dispersion of a higher seismic energy but also implies a higher value of the forces in the damper. A reduction of the story relative displacements of maximum 40%-50% using viscous fluid dampers implies forces induced in the nodes of the structure with values that ensures the integrity of the areas in which the dampers are positioned [1].

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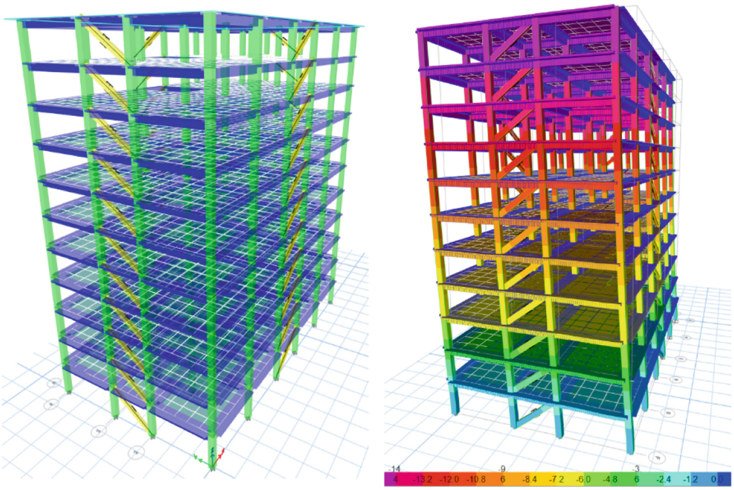

Fig. 1. ETABS F.E.M. model of building equipped with fluid viscous dampers

2 ETABS Seism Analysis of a Ten-Stories Building Equipped with Viscous Fluid Dampers

There are several seism analyses programs [2–5], but for this study we chose the ETABS program. The most suitable ETABS analysis for buildings equipped with seismic energy dispersion devices is Time History Analysis using design accelerograms for seism simulation. The Time History analysis method applied in this paper is the modal non-linear analysis (Fast Non-linear Analysis) which is recommended compared to Direct Integration Analysis [2].

It was considered a ten-stories building (33 m high) for which we chose from the existing types of dampers [6–8], the viscous fluid dampers [6, 8] which were modeled with Link Finite elements. The seismic protection system consists of a single damper on each facade of the building, centrally positioned on each story.

Three values of the damping coefficient c were taken into account: 0 kNs/m^2, 10000 kNs/m^2 and 17000 kNs/m^2. 21 design accelerograms were used, seven for each Tc value (0.7 s, 1.0 s and 1.6 s). These accelerograms are specially defined for seismic conditions in Romania [9]. Figure 1. Presents the finite element model of the building and a sample of the displacements of the building during seism. Time History Analysis results are presented as time variation of story displacements, beam and column efforts and damper forces.

In order to determine the influence of the damping coefficient c [10] on the building seism behavior, we compared the maximum values of the relative displacements and the maximum forces in the dampers, for each story (Fig. 2, 3, 4, 5, 6, and 7.).

In Fig. 2, 3, 4, 5, 6, and 7. The comparative graphs are presented only for a single representative accelerogram from a set of seven accelerograms chosen by the authors for each value of Tc.

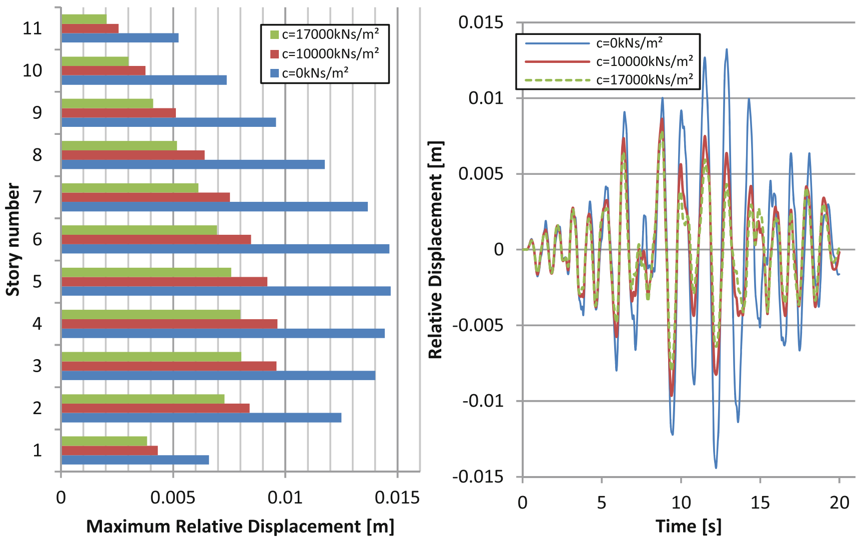

Fig. 2. Comparison of maximum relative displacements for each story (left) and time variation of relative displacements for story 3 (right), using accelerogram no. 22 for Tc = 0.7 s.

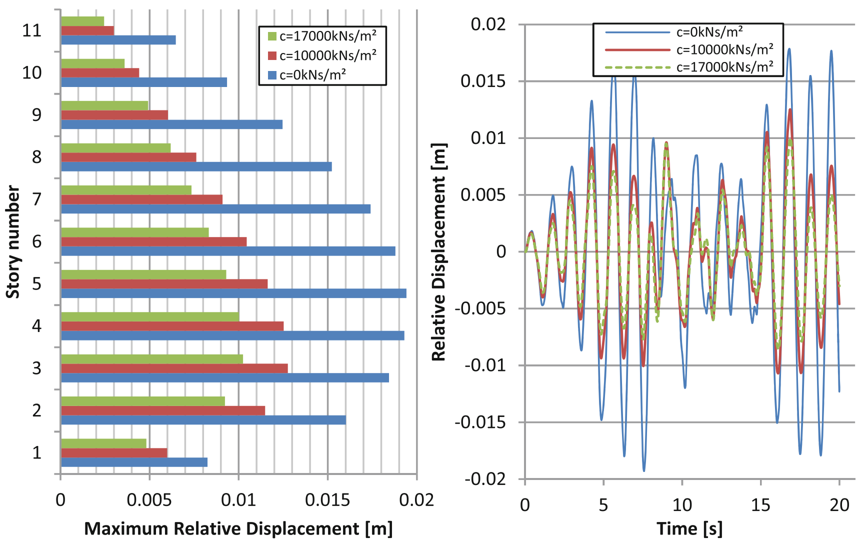

Fig. 3. Comparison of maximum relative displacements for each story (left) and time variation of relative displacements for story 3 (right), using accelerogram no. 07 for Tc = 1.0 s.

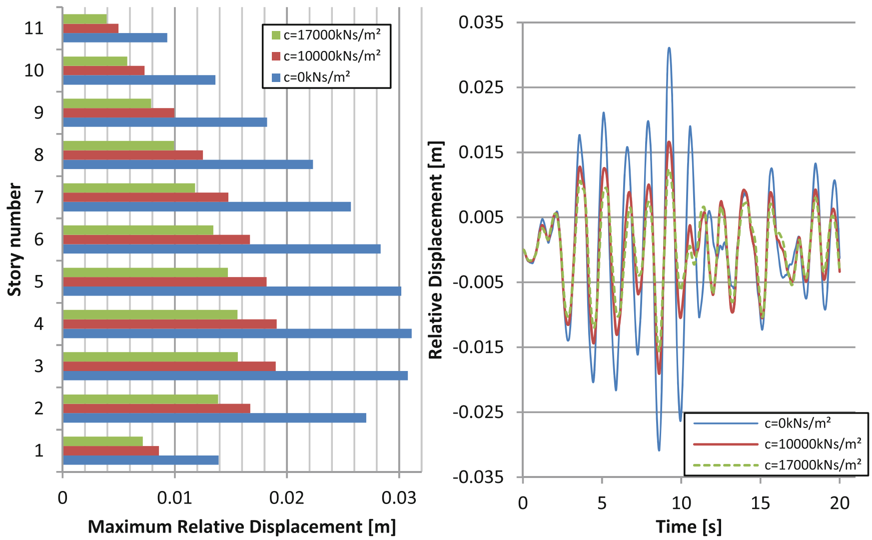

Fig. 4. Comparison of maximum relative displacements for each story (left) and time variation of relative displacements for story 3 (right), using accelerogram no. 05 for Tc = 1.6 s.

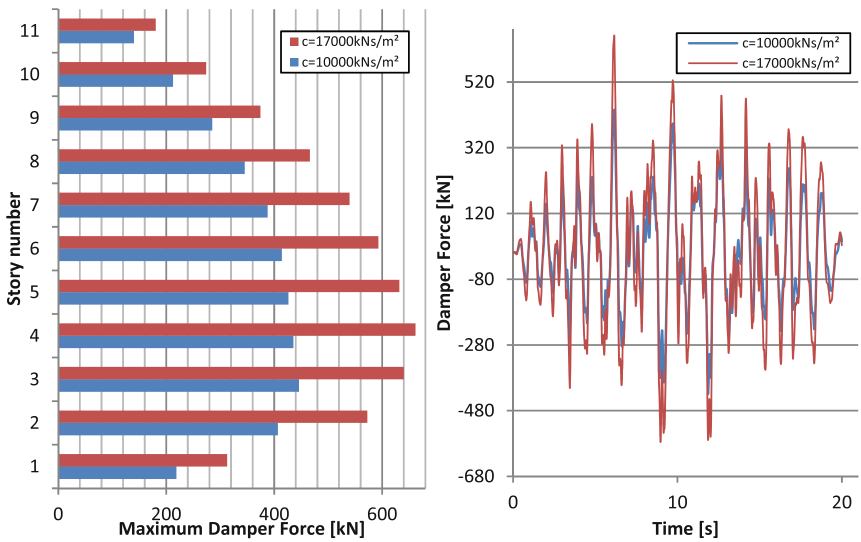

Fig. 5. Comparison of maximum damper forces for each story (left) and time variation of damper forces for story 3 (right), using accelerogram no. 22 for Tc = 0.7 s.

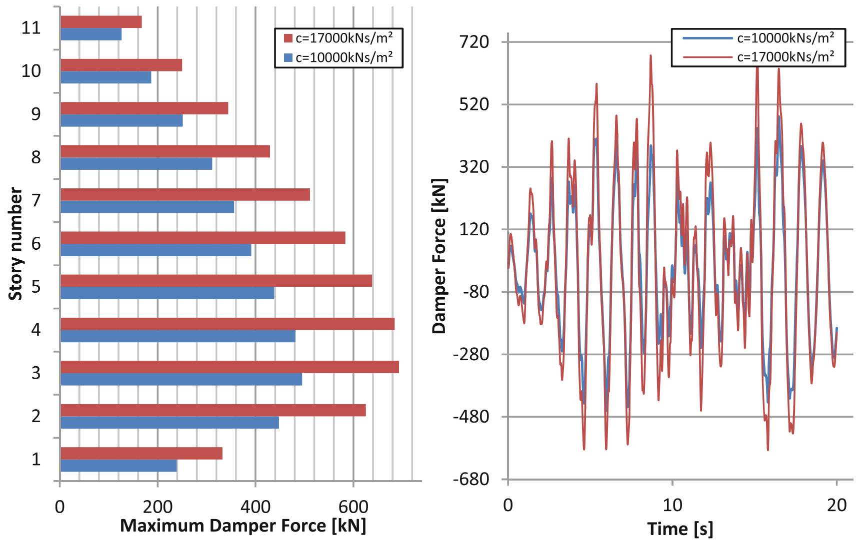

Fig. 6. Comparison of maximum damper forces for each story (left) and time variation of damper forces for story 3 (right), using accelerogram no. 07 for Tc = 1.0 s.

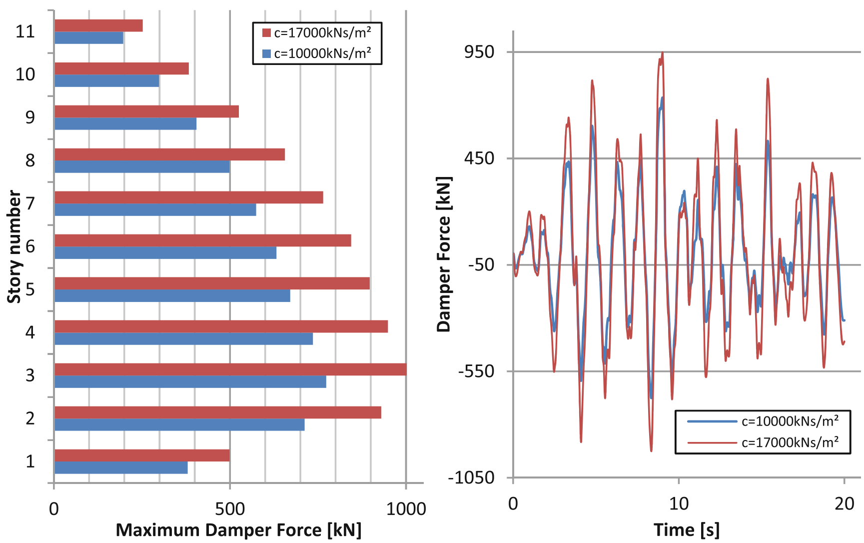

Fig. 7. Comparison of maximum damper forces for each story (left) and time variation of damper forces for story 3 (right), using accelerogram no. 05 for Tc = 1.6 s.

3 Conclusions

For each value of Tc the results obtained from Time-History Analysis are similar for all seven accelerograms considered, so the graphs presented in the paper are representative.

From the analysis of the results, it is observed that for Tc = 1.6 s, the maximum values of the relative displacements and of the damper forces are higher than for Tc = 0.7 s and Tc = 1.0 s. We can explain this by the fact that the fundamental period of the building with a height of 33 m is close to the value of the corner period Tc = 1.6 s.

The use of viscous damper fluid with c = 10000kNs/m^2 reduces the maximum relative displacements by 35%, and for c = 17000 kNs/m^2, the reduction is 50%. The damping forces for c = 10000 kNs/m^2 reach maximum values of 780 kN, and for c = 17000 kNs/m^2, the maximum values are 1000 kN.

It is recommended to use dampers with c = 17000 kNs/m^2 for the analyzed building because the damper maximum forces are not dangerous for this type of building [1].

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