9th EWICS

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Use of fluid dampers in order to improve the seismic performance of reinforced concrete buildings with asymmetric plan-view

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Introduction

One of the most popular passive control devices for buildings subjected to seismic motions is viscous fluid dampers, which increase the damping ratio of the structure and the energy dissipation capacity.

R/C buildings with asymmetric plan-views are very common structural systems in countries with high seismicity. Large rotation angles are observed for lateral seismic motion of the base and, consequently, the perimeter structural elements suffer from serious damages.

In case of existing buildings with high values of eccentricity and of new buildings with certain architectural and functional needs that do not allow the optimum choice of the structural system, an alternative solution would be the placement of passive control systems

Objective

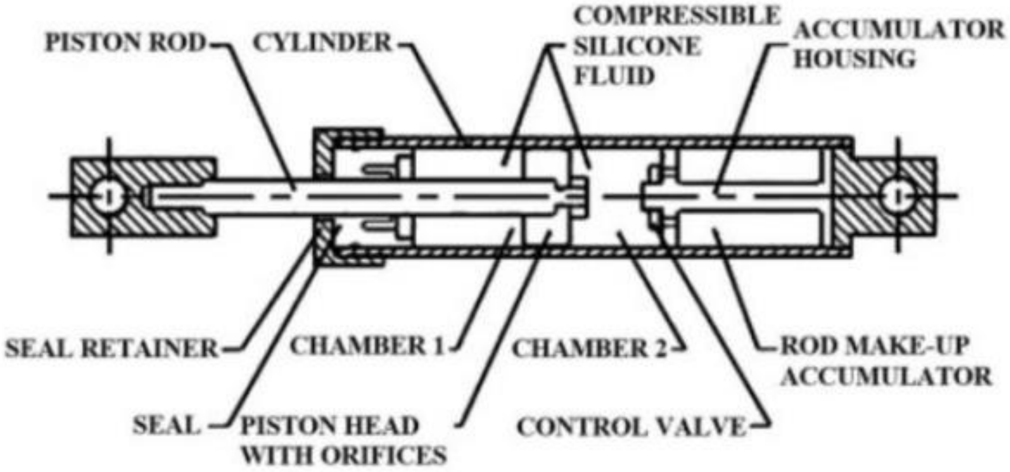
The most efficient distribution of viscous fluid dampers in improving the seismic response of an asymmetric in-plan structure is investigated.
The paper proposes four different procedures of choosing the exact positions that the dampers should be placed in order to achieve the best seismic performance of the building.

The evaluation of the building's seismic performance is carried out with the aid of linear and nonlinear time history analyses using nine real earthquake records.

Certain conclusions about the efficiency of the proposed procedures are drawn.
A flow chart for the optimal placement of the viscous fluid dampers in case of any building is proposed.

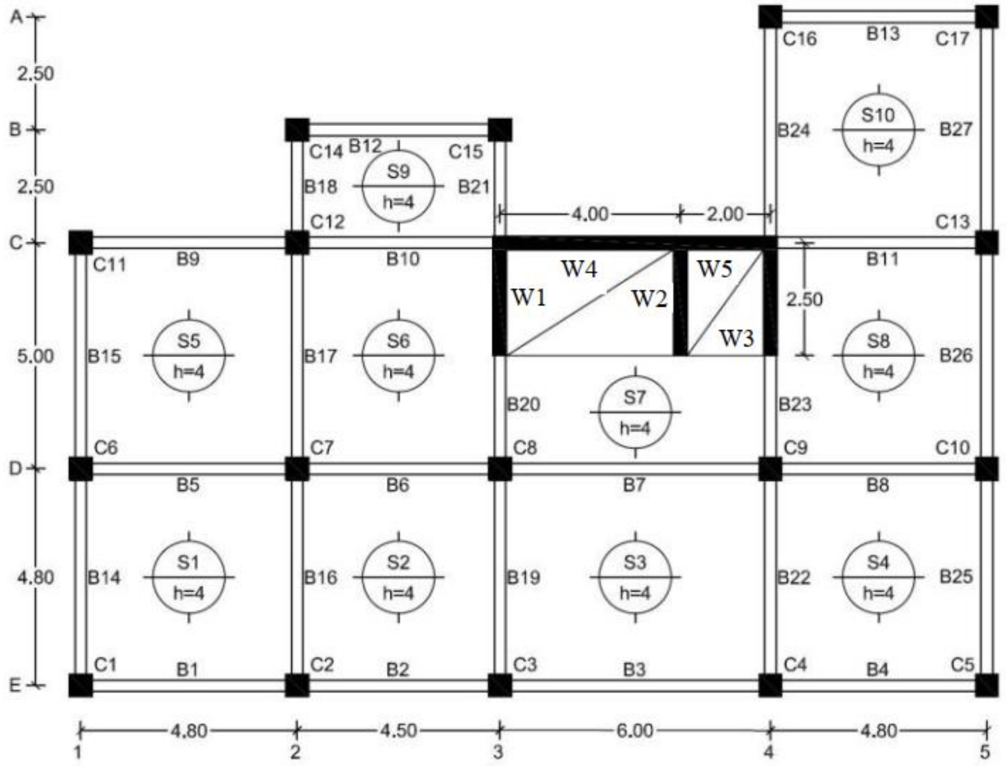
Fluid Viscous Dampers

The function of fluid viscous dampers is based on the principle of energy dissipation due to the flow of fluid through orifices



$$\sum_{j=1}^{nd} c_j \left(f_j \cdot \Delta u_j\right)^2 \geq 2M_i^* \omega_i \xi_{d,i} \qquad (1)$$

Investigated Building – Earthquake Records



Storey	Beams	Columns	W1, W2, W3	W4	W5
1^{st}-5^{th}	25/50	50/50	250/30	400/30	200/30

- Concrete: C30/37
- Steel: B500C
- Stories' Heights:
  1^{st}: 4.0m, 2^{nd}-5^{th}:3.0m
- Design Spectrum: EC8
- a_{gR}: 0.24g
- Ground Type: B
- Behavior Factor: q=2.0

The assessment of the seismic performance was carried out using 9 real strong motion pairs of horizontal bidirectional earthquake strong motions. The selected ground motions are far-fault records and have been recorded on Soil Type B according to EC8.

Modeling and Position of Dampers

Four different procedures of choosing the exact positions that the dampers should be placed are proposed.

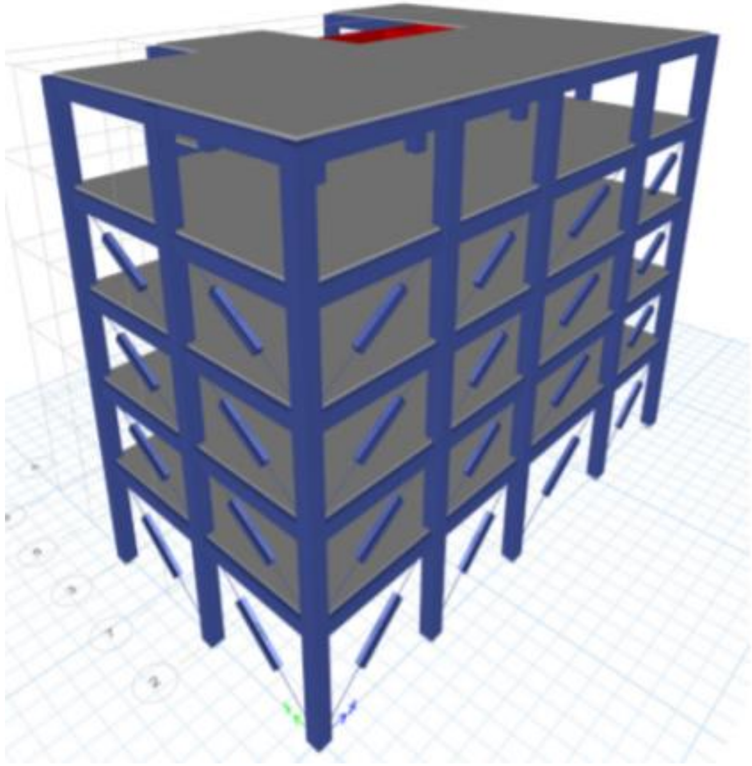
Common choices for all the procedures:

- The dampers are placed only along the perimeter frames of the building, so there are 75 different possible locations along the building's height that they can be placed.
- A total number of 24 dampers has been chosen. The analyses revealed that this number of dampers leads to a critical damping ratio associated with the viscous dissipation of approximately 20%.
- The viscosity of the dampers has been considered to be the same for all of them and equal to c=2000 kNs/m.

Modeling and Position of Dampers

The four procedures of choosing the positions of the dampers are the following:

- P1: The viscous damping of each damper was computed with the aid of Eq. (1) and using the results computed by the 1st eigenmode. The 24 dampers with the larger damping ratio ξ_d were selected.
- P2: The viscous damping of each damper was computed with the aid of Eq. (1) and using the results computed by the 2nd eigenmode. The 24 dampers with the larger damping ratio ξ_d were selected.



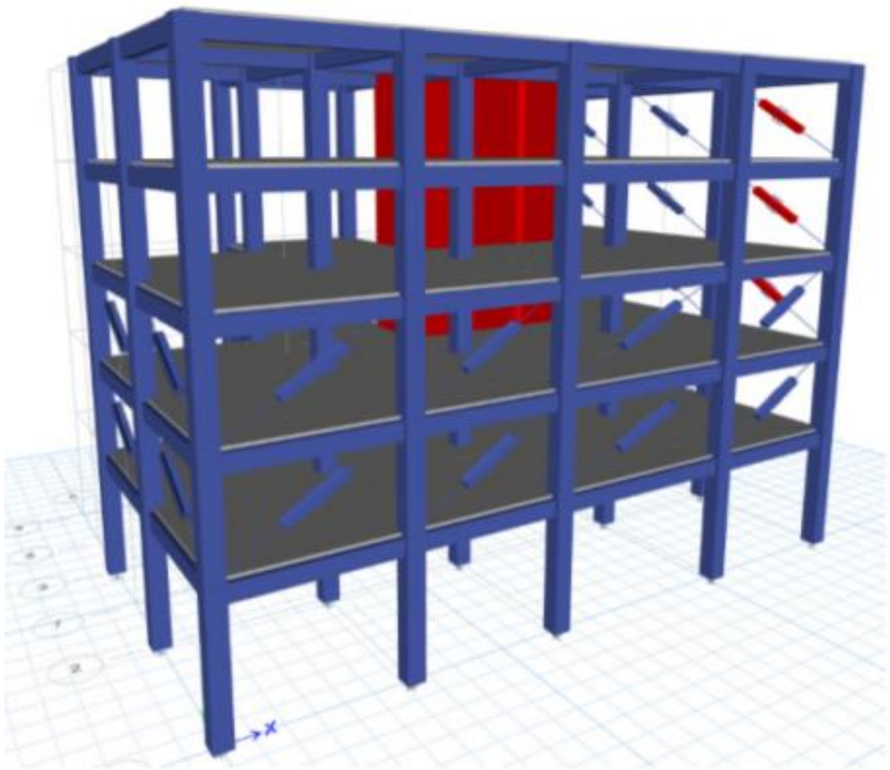
Dampers' positions according to P1

Modeling and Position of Dampers

The four procedures of choosing the positions of the dampers are the following:

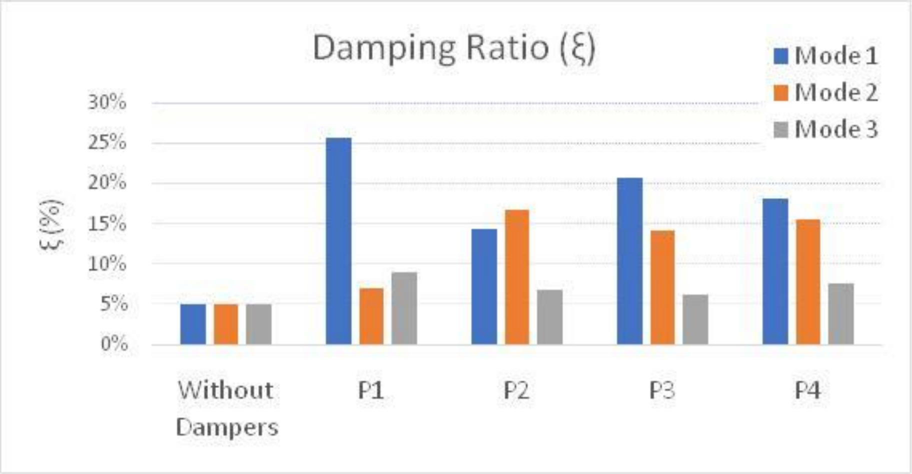
- P3: The 12 dampers with the largest damping ratio ξ_d according to P1 and the 12 dampers with the largest damping ratio ξ_d according to P2 were selected.

- P4: For each one of the 9 chosen records linear time history analysis was conducted and the max force applied by each one of the 75 dampers was computed. The 24 dampers with the largest applied force were selected.

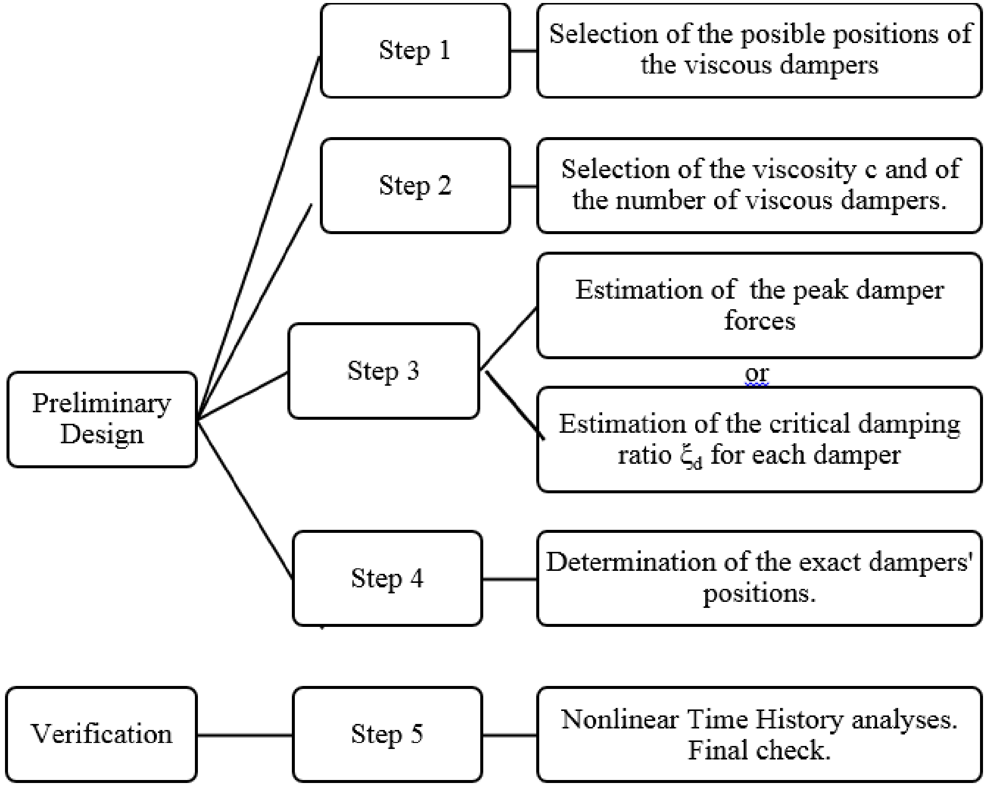


Dampers' positions according to P3

Modeling and Position of Dampers



Damping ratios of the structure with and without dampers



Flow chart for the optimal sizing and distribution of the viscous fluid dampers

Analyses

The assessment of the seismic performance was carried out with the aid of linear and nonlinear time history analyses using the 9 real strong motion pairs.

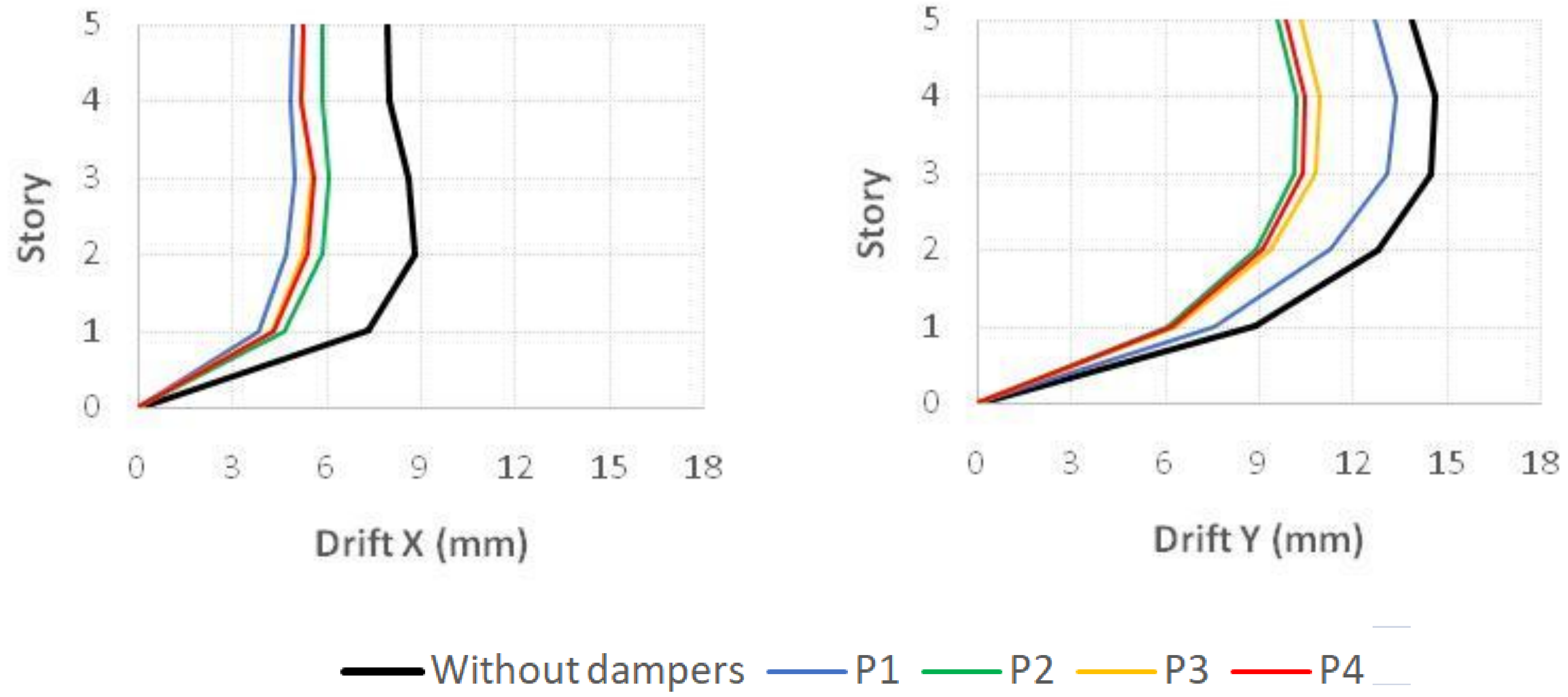
Each pair of the earthquake records was applied along two horizontal orthogonal axes forming two different incident angles (0^o and 90^o) with the structural axes of the building.

For each ground motion the relative displacements (drifts) along axes X and Y, as well as the rotations of the floors were computed as damage measures.

For each earthquake record and response measure the max of the values for the two incident angles was considered. Then, the average of these values for the nine records was determined according to the most seismic code provisions.

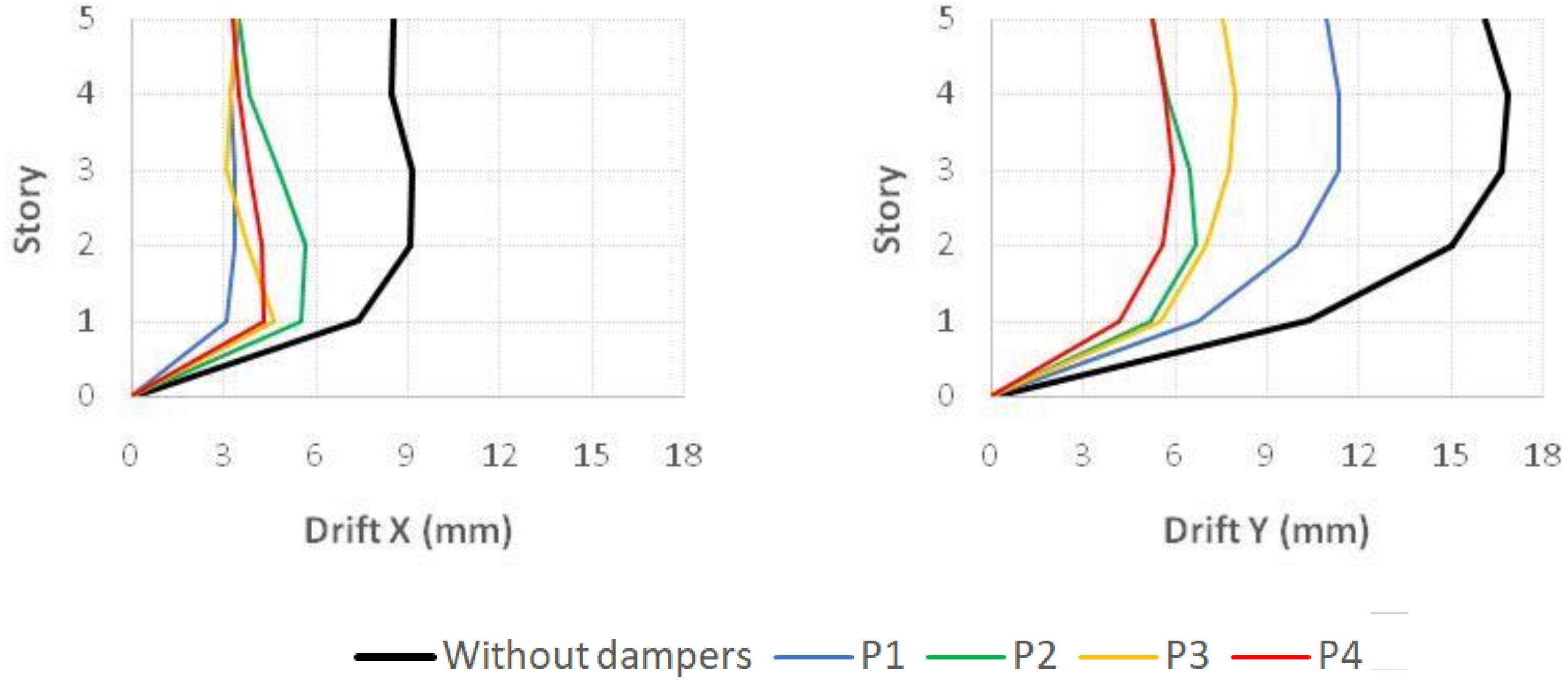
Results

Linear analyses: Average drifts along axes X and Y



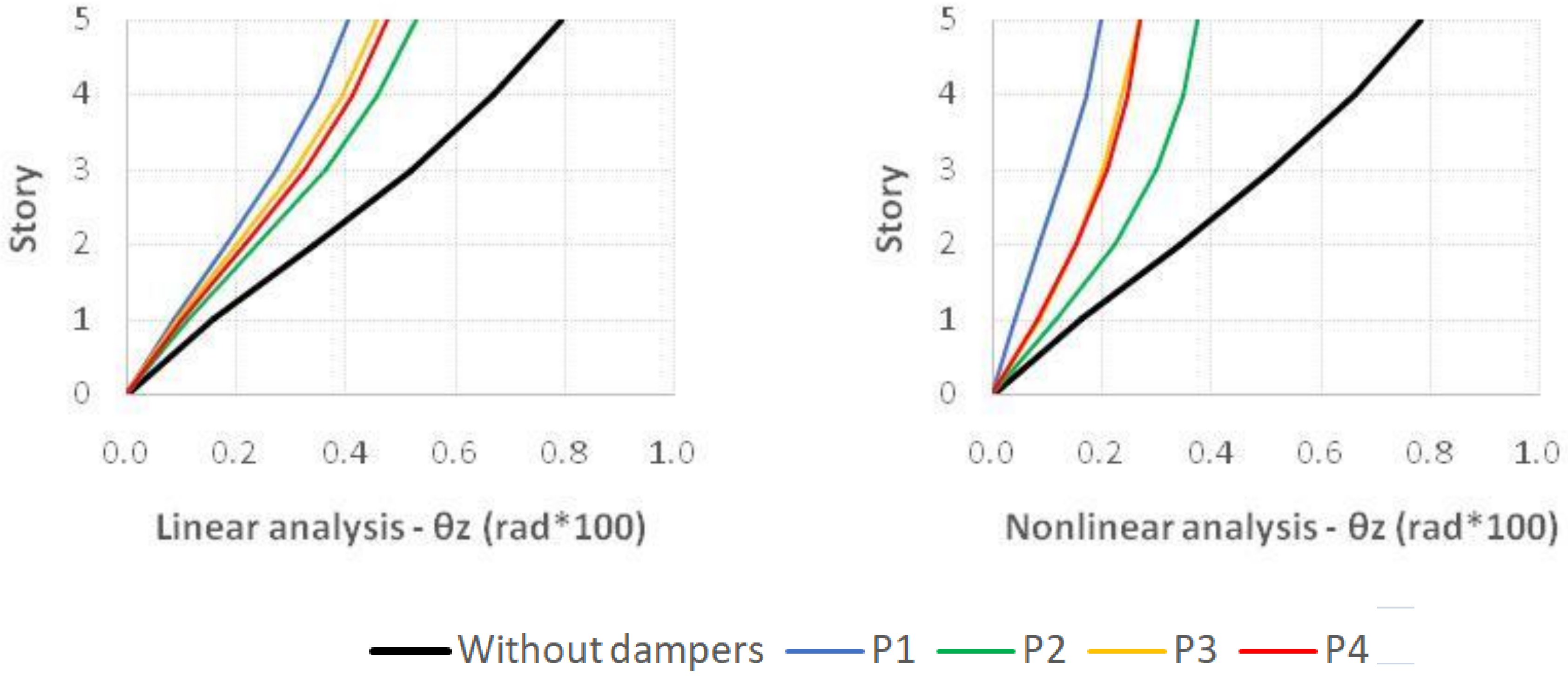
Results

Nonlinear analyses: Average drifts along axes X and Y



Results

Average floor rotations



Conclusions

The use of viscous fluid dampers reduces significantly both the drifts and the floor rotation of buildings with asymmetric plan view. In case of these buildings, the distribution of the dampers should also be asymmetric according to the proposed procedures.

The use of the dampers is more efficient in improving the seismic performance of asymmetric buildings in case of the nonlinear analyses.

The efficiency of the procedures depends on the damage measure. Procedures P4 and P1 led to the best results in case of drifts and floor rotations respectively.

A flow chart for the optimal placement of the viscous fluid dampers in case of any asymmetric building is proposed.

Thank you for your attention