POTENTIALLY PLASTIC ZONES CONFIGURATIONS IN BOTTOM COLUMNS OF ECCENTRICALLY BRACED FRAMES

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ANALYZED FRAMES:
The present paper is intended to illustrate the advantages and disadvantages of different structural details for the potentially plastic zones located near the bottom end of the columns. Several structural details were analyzed considering: reduced flanges cross-sections and/or transversal and longitudinal stiffeners for the bottom zone of the columns.

Two eccentrically braced frames located in Bucharest were considered for the analyses. For both frames the story height was 3.5 m, the span was 6.6 m and the length of the dissipative members was 1.2 m.

Built-up I-shaped cross-sections were used for all types of structural members.
ANALYZED FRAMES:
Dynamic nonlinear analyses were performed for each structural configuration. The N-S component of the Vrancea 1977 earthquake acceleration record was used. The acceleration record was calibrated to a peak ground acceleration value of approximately 0.24 times the acceleration of gravity.

The maximum values of the bending moments, the axial forces and the plastic deformations in the potential plastic zones at the bottom end of the columns were compared.

Four different constructive details were considered for the bottom end of the first-story columns.
Configuration 1 is the reference analysis detail.

The column has the same cross-section on the entire height of the first story column.

Transversal web stiffeners (P3) were used to avoid early local buckling in the potentially plastic zone.
In the second considered detail an additional longitudinal stiffener (P4) was placed on the web. This pair of stiffeners was used to reduce the axial loading level in the flanges, to make room for stresses generated by bending moment.

Plates P5 were placed to facilitate the axial load transfer from the column flanges (P1) to the longitudinal web stiffeners (P4) reducing at the same time load concentrating effects.

Transversal web stiffeners (P3) are kept in all configurations to reduce the risk of local buckling in the potentially plastic zone.
Configuration 3:

The third configuration has a reduced flange cross-section in the potentially plastic zone (resembling to dog-bone detail).

In configuration 3 the reduced width of the flanges in the potentially plastic zone is about 25% smaller than the flanges width in the rest of the first-story column.

The longitudinal web stiffeners were kept to assure about the same axial capacity all along the first-story column height.
In the fourth considered detail the first configuration column cross-section was kept for the potentially plastic zone, whereas the rest of the column has larger flanges in order to increase the buckling capacity of the first-story column. The reduced flange width in the potentially plastic zone is also about 25% smaller than the flange width in the rest of the first-story column.

All connections between structural members, as well as the connections to the infrastructure were considered as fixed.
Forces at the bottom of the columns

Configuration 3 (with reduced column flanges in the potentially plastic zones) leads to the smallest bending moment values at the bottom end of the first-story columns.

The maximum bending moments recorded during the dynamic nonlinear analyses at the bottom of the columns in the other considered configurations are nearly the same. Compared to these values, the bending moments registered for configuration 3 are about 20 ÷ 26% smaller.

The maximum axial forces recorded in the first-story columns during dynamic nonlinear analyses are quite the same for all considered configurations. It seems that the considered constructive details do not affect significant the values of the maximum axial forces noticed in the first-story column.
Maximum bending moments at the bottom of the first-story columns

Frame K
Bending moments marginal columns

Frame V
Bending moments marginal columns

Frame K
Bending moments central columns

Frame V
Bending moments marginal columns
Buckling resistance of first-story columns

The buckling resistance of first-story columns was evaluated using relations (6.61, 6.62) and annex B from EN 1993-1-1:2005. It can be observed from the graphics in the figure below, that configuration 4 provides the greatest buckling resistance for the situations when inelastic deformations appear in the potentially plastic zones at the bottom of the columns.

Frame V Marginal Columns
General Stability Criterion

Frame K Central Columns
General Stability Criterion
Maximum plastic hinge rotations

The greatest plastic hinge rotations in the potentially plastic zones of the first-story columns were recorded during dynamic nonlinear analyses for configuration 3.

The values of the maximum plastic hinge rotations at the bottom of the columns for the other considered configurations were in the same range. Compared to these values, the plastic rotations for configuration 3 were about $37 \div 45\%$ greater.
Maximum plastic hinge rotations

Frame K - Marginal Columns
Maximum plastic hinge rotations

Frame K - Central Columns
Maximum plastic hinge rotations

Frame V - Marginal Columns
Maximum plastic hinge rotations

Frame V - Central Columns
Maximum plastic hinge rotations
Conclusions

Compared to the other considered constructive details, configuration 3 leads to smaller bending moments and greater plastic hinges rotations at the bottom of the columns. The smaller bending moment values conduct to smaller anchor bolts for the columns.
Conclusions

Configuration 4 appears to be the safest from the point of view of assuring the general stability of the first-story column in the situation when plastic deformations occur in the potentially plastic zone at the bottom of the column.
In configuration 3 and 4 the distribution of plastic deformations along the first-story columns is better controlled. The inelastic deformations along the first-story column are concentrated mainly in the column segments with reduced flanges width.
In eccentrically braced frames subjected to severe seismic actions configuration 3 or 4 bottom end details for first-story columns should be used.
Thank you very much for your attention