3. The composite frames: conceptual design

To choose the most suitable structural solution with respect to all design actions, several options with the same geometric layout, but different members typologies as defined in the framework of a European Research Project [3] were investigated and summarized in Table 1.

Table 1: Analyzed structural solutions for beam and column elements

<table>
<thead>
<tr>
<th>Type</th>
<th>Main beams</th>
<th>Composite Columns</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>IPE (bare steel)</td>
<td>HEB (partially encased)</td>
</tr>
<tr>
<td>A2</td>
<td>IPE (composite with ribbed steel sheeting)</td>
<td>HEB (partially encased)</td>
</tr>
<tr>
<td>B1</td>
<td>IPE (bare steel)</td>
<td>CHS (circular column filled)</td>
</tr>
<tr>
<td>B2</td>
<td>IPE (composite with ribbed steel sheeting)</td>
<td>CHS (circular column filled)</td>
</tr>
</tbody>
</table>

4. Design and performance for vertical and seismic loadings

Considering that seismic design importance or the relative stiffness between beam and column elements was outlined, three situations accounting for different values of the flexural stiffness ratio r were investigated to assess its influence in fire situation. The performed analyses showed that the "seismic" Type B2 frame (r = 0.1) offered the best performance with respect to both seismic and fire actions when these are considered as independent hazards, since it offered near 0 minutes of fire resistance rating even if unprotected [6]. Therefore, such a solution was chosen as reference case study and thermo – mechanical analyses in the post-earthquake fire situation were

5. Design and performance for fire loadings

6. Seismic and fire performance of composite frames

A. Debonding of the steel sheeting from concrete slab

Neglecting the steel sheeting causing a reduction of the peak compressive force due to the limited expansion of the beam in the heating phase. The presence of steel sheeting can partly enhance the structural fire behavior by adding a 7% to the surviving time. The Code assumption of considering the steel sheeting bonded to the concrete slab for all the duration of the fire is revealed to be not on the safe side in a post-earthquake fire situation.

B. Simultaneous fire spreading in two adjacent compartments

It was supposed that a fire could simultaneously start at the first (F1) and second (F2) floor levels. The obtained results were compared with two "undamaged" situations: FA - fire at first floor level only and FB - fire at second floor level only. Further investigation is needed, anyway it seems that for this design scenario, failure was due not only to extensive damage in the heated beams but in the heated columns as well. The frame global behaviour was satisfactory, achieving a fire resistance rating of nearly 30 minutes and showing a time reduction of 3% with respect to FA and of 20% with respect to FB scenarios.

7. Summary and acknowledgment

The presented performance-based methodology had two main goals. The first was integrating seismic and fire design issues since the early stages: the second was providing an assessment methodology for the evaluation of the post-earthquake fire performance. The application of such a methodology to a set of composite frames showed its effectiveness in the resulting optimized solution showing a satisfactory behaviour with respect to seismic and fire loadings as independent hazards and in the post-earthquake fire situation, as well. Results presented in this work were obtained in the framework of the following European research projects: RFFCs Steel RTD Programme, Contract R. RS-FR-033034 [3]. Nevertheless, the opinions expressed in this paper are those of the writers and do not necessarily reflect those of the sponsors.

References