EFFECT OF THE INFILL WALLS ON THE STRUCTURAL RESPONSE OF A 13-STORY RC FRAMED BUILDING SUBJECTED TO THE REMOVAL OF A CORNER COLUMN

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1. Introduction

The progressive collapse is defined as "a situation where a local failure of a primary structural component leads to the collapse of adjoining members which, in turn, leads to additional collapse. Hence, the total damage is disproportionate to the original cause". The U.S. General Services Administration developed GSA (2003) Guidelines [1], that provide a threat independent methodology for assessing the potential to progressive collapse of existing buildings and for minimizing the potential for progressive collapse in the design of new buildings. Recently, in 2013, a new version of this Guidelines GSA (2013) was issued.

Other researchers have investigated experimentally [2] or numerically [3] the progressive collapse risk of RC framed structures subjected to accidental removal of a column or more columns. But only few works [4, 5] have taken into account the contribution of the infill walls. A complete analysis should include the effect/contribution of the secondary elements, such as infill walls, in the evaluation of the response of a structure. The objective of this study is to assess the influence of the existing autoclaved aerated concrete infill walls on the behavior of a 13-story RC framed building under the removal of a first story corner column.

2. 13-story RC framed building details

The 13-story RC framed building was erected in 1974 in Brăila, a zone with high seismic risk from Romania. The height of the current floor is 2.75 m, except the first two floors which have 3.60 m in height. The structure consists of five bays of 6 m in the longitudinal direction and two bays of 6 m in the transverse direction. The dimensions of the beams and columns vary along the height of the building: the longitudinal beams from (35x65) cm to (30x55) cm, the transverse beams from (35x70) cm to (30x60) cm and the columns from (70x90) cm to (60x60) cm. The thickness of the slabs is 15 cm. The exterior infill walls have a total thickness of 25 cm and are made of autoclaved aerated concrete (AAC). Two 3D models of structure are generated in the ELS® computer software [6]: a model without infill walls (frame structure) and a model with infill walls. In the first model, the infill walls are considered only as uniform dead load on the exterior beams. In the second model the AAC wall is represented by elements composed of bricks and mortar.

3. Progressive collapse analysis and results

The progressive collapse risk of the structural models is assessed following the GSA (2003) Guidelines [1] for the damaged case when a first story corner column is suddenly removed. A nonlinear dynamic analysis is used and the following combination of loads is applied downward to the structure:

(1) $$\text{Load} = DL + 0.25LL$$

where, DL is dead load and LL is live load.

In this study, the Extreme Loading® for Structures (ELS®) - a very performant specialized software, based on Applied Element Method, is used. For nonlinear dynamic analysis, the time removal of the column is set to $t_r = 0.005$ s and the time step is considered $t_s = 0.001$ s. Also, a damping ratio of ξ = 5% is used in the analysis. In Fig. 1 are shown the curves time-vertical displacement of the node above the removed column for both structural models (the model without infill walls and the model with infill walls), over a time span of t = 3 s. It is observed that if the infill walls are introduced in the model, the maximum vertical displacement of the node above the removed column is reduced by about 48% (from 2.467 cm to 1.287 cm). The results are similar with those obtained by other authors (Lupoae et al. [4], Sasani [5]), which also have investigated the effect of the infill walls on the building response after the removal of one or two columns from the structure.

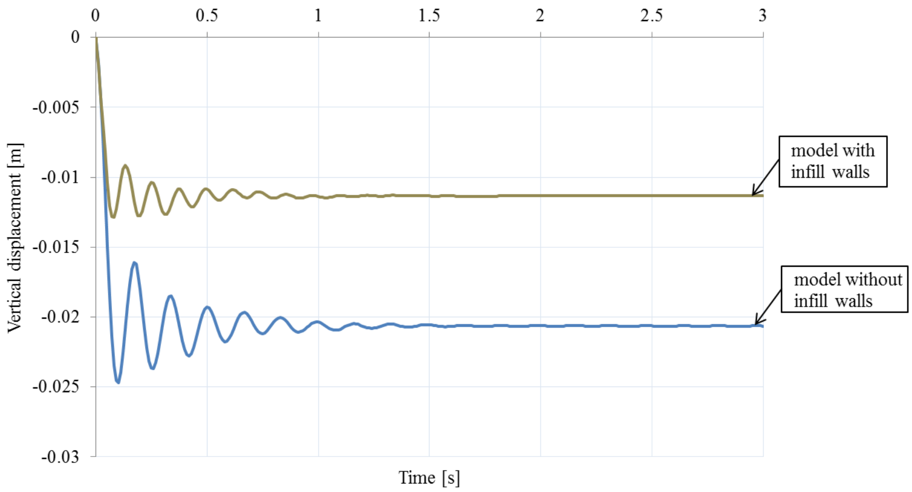

Figure 1. Time-vertical displacement curves: model with infill walls vs. model without infill walls.

4. Conclusions

Based on the results provided by the nonlinear dynamic analysis, it is shown that the existence of the infill walls in the numerical model significantly affect the response of a structure following the removal of a vertical support. The infill walls, modeled in the program as secondary structural components, lead to an increase in strength and rigidity of the structure; therefore, for more accurate results in progressive collapse analyses and especially in the assessment of robustness index of the structure it is recommended to introduce in the numerical model not only beams, columns and slabs, but also the existing infill walls.

5. References

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