Pushover analysis of traditional masonry buildings: influence of refurbished timber-floors stiffness

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Abstract The main purpose of this paper is to evaluate the effects that in-plane stiffness of different types of wooden diaphragms, yield on the capacity curve of a traditional masonry building, obtained by means of a nonlinear static (pushover) analysis. In order to determine it, an equivalent-frame modelling has been employed to schematize a two-storey building, the like of which is fairly common in the Italian building legacy. Both as-built and retrofitted wood floor types have been taken into account. As to better understand and control all the aspects that rule the global seismic behaviour of a masonry construction, a general-purpose FEM software has been adopted. Therefore every "feature" has been manually implemented.

Keywords in-plane stiffness, pushover analysis, wooden floors, masonry building, equivalent frame

The numerical model used to investigate the effects that the real in-plane stiffness of wooden floors yields on seismic behaviour of masonry buildings, is based on the so-called "equivalent frame" method. Consequently every pier and every spandrel is schematized with an elastic frame element. The mechanical nonlinearities are concentrated in particular cross-sections (plastic hinges) placed both in the middle and in the ends of the elastic frames. Since the analysis of real "post-earthquake" masonry buildings has shown that most of the damages do not involve the intersections between piers and spandrels, rigid offsets are inserted where the vertical elements meet the horizontal ones. The length of these offsets depends on the geometry of the openings (windows and doors). Referring to the in-plane behaviour of walls, the bottom ends of the vertical frames (piers) have been modelled as fixed (FEMA 356). On the other hand, considering the global seismic performance of masonry buildings, the out-of plane stiffness of the walls has been regarded as negligible and therefore moment releases have been introduced at both ends of the piers (FEMA 356).
Six different types of unreinforced/reinforced wood-floors have been modelled. The mechanical properties of diaphragms have been derived from an experimental campaign previously carried out at the Laboratory of the Department of Mechanical and Structural Engineering (DIMS) of the University of Trento (Piazza et al. 2008). Only the membranous behaviour of floors has been taken into account,

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by means of nonlinear, two-dimensional finite elements. An equivalent shear stiffness G_{eq} has been calculated from the experimental data, regarding the diaphragm deformation as equal to the shear deformation of a simply supported beam under a uniform load distribution.

From the presented results (Figure 1) it would appear that a floor strengthening and stiffening is quite basic to the improvement of the seismic response of a masonry construction.
Yet, apart from the single straight-sheathed floor (whose in-plane stiffness is almost negligible), it appears that the maximum base shear is not affected by variation of the in-plane stiffness of diaphragms. In addition, in both directions the global stiffness does not show appreciable differences changing the type of floor refurbishment.

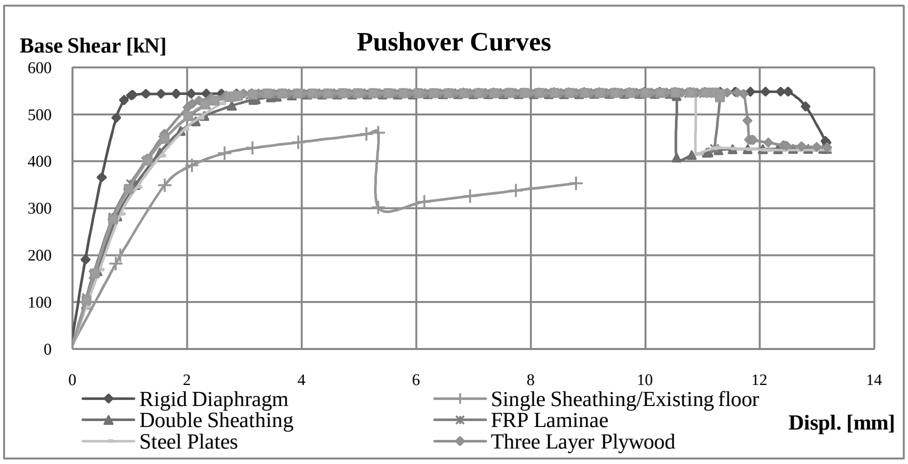

Figure 1 - Nonlinear static analyses: capacity curves

Together with the in-plane stiffness of wooden floors, many other parameters that affect the global seismic behaviour of a traditional building, have been analyzed. For example, two different lateral load patterns have been examined: an inverted triangle (first mode) load pattern and a mass proportional one. It has also been studied what happens when the coupling actions of both spandrels and stringcourses is not taken into account and the masonry walls are modelled as cantilever beams (soft spandrel hypothesis).

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