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INFLUENCE OF MASONRY INFILL WALLS ON LONGITUDINAL FORCES IN COLUMNS OF CAST-IN-SITU FRAMED BUILDING

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ABSTRACT

In this paper the result of conducted numerical studies based on space calculation models are presented. It presents the results of a conducted numerical assessment of the influence of masonry infill walls on variation and redistribution of efforts arising in columns of a cast-in-situ framed building. The quantitative data of the influence of masonry infill walls on the redistribution of longitudinal forces in columns of a nine-story of a cast-in-situ framed building are given. It is also shown the particularity of the redistribution of efforts in columns depending on their location on the plan and on elevation of a cast-in-situ framed building with masonry infill walls when designing considering the wind load or the failure of masonry infill walls of the first-floor.

Keywords: cast-in-situ framed building; masonry infill walls; columns; longitudinal forces; variation of forces.

1. INTRODUCTION

In practice of designing of cast-in-situ framed buildings, the most common types of filling are masonry walls. Masonry infill walls can be found as interior and exterior walls in reinforced concrete frame structures. Masonry infill walls affect the strength and stiffness of infilled frame structures.When erecting such buildingsthe masonry walls are oftenmade before the bearing reinforced concrete elements. These masonry walls are densely framed with columns and beams of the main reinforced concrete frame.

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El-Dakhakhni et al. [7] and Kose [13] mention that in seismic areas, ignoring the frame-infill panel interaction is not always on the safe side, since, under lateral loads, the infill walls dramatically increase the stiffness by acting as a compressed diagonal «strut/area», resulting, thus, in a possible change of the seismic demand due to significant reduction in the natural period of the composite structural system.

The rationale behind neglecting infill walls in the design process is partly attributed to incomplete knowledge of the behavior of quasi-brittle materials such as unreinforced masonry, of the composite behavior of the frame and the infill, as well as due to the lack of conclusive study results to substantiate a reliable design procedure for this type of structures, despite the extensive experimental efforts (Buonopane and White [4]; Santhi et al. [21], [22]), and analytical investigations (Asteris [1], [2]; Chrysostomou et al. [5]; Kakaletsis and Karayannis [10]; Moghaddam [18]) over the past years.

Many studies indicate that masonryinfill walls increase the stiffness parameters of the frame (Farshidnia [8]; Kashif et al. [12]; Kulkarni et al. [14]). Masonry infill wallsmay lead to desirable or to undesirable effects (Derkach [6]).

In avoiding costlier experimental studies, numerical studies, based on finite element methods are recently used to investigate the influence of the masonry infill walls, which are currently used more actively. In numerical studies, masonry infill walls are replaced by equivalent rod elements. This lead to the strut model (Kumbhar et al. [15]). Masonry infilling walls may also be replaced by a plate model while micro-modelling or macro-modelling (Goutam and Sudhir [9]; Kashevarova [11]) the cast-in-situ framed building with masonry walls.

In literature sources, it’s mentioned that more influential factors on the results of study of influence of wall fillings are: the strength of masonry walls, the openings, the connection between walls and reinforced concrete elements, as well as the ratio of height to the length of wall filling.

The openings in masonry infill walls reduces the stiffness parameters of masonry infilled reinforced concrete frames (Goutam [9]; Sigmund et al. [23]; Mohammad et al. [19]; Panagiotis et al. [20]). Also, the interface between masonry infill walls and the frame influence on the stiffness parameters of the reinforced concrete frames. In numerical studies, the interface of masonry infill walls with reinforced concrete elements was investigated and was consideredas rigid connection or flexible spring connection (Madan et al. [16]; Wael et al. [24]).

These studies on the influence of masonry infill walls were conducted mainly on flat frames. This shows that the influence of masonry infill walls on the spatial work of cast-in-situ framed buildings was not sufficiently studied. There are few works on the variability and redistribution of forces in constructive elements of cast-in-situ framed buildings.

Based on 3D Finite Element (FE) models this study is directed to quantify the influence of masonry infill walls on longitudinal forces arising in columns of nine-story cast-in-situ framed building by taking into consideration the variability of the strength of masonry infill walls in different cases of acting loads.

2. METHODOLOGY

This study was conducted on the nine-story cast-in-situ framed building with masonry infill walls (Fig. 1– Fig. 6). It was created a spatial finite element (FE) model of the investigated nine-story cast-in-situ framed building for to study the influence of masonry infill walls on efforts in columns. Also, for the study there were created cast-in-situ framed building with masonry infill walls on all floors and a cast-in-situ framed building without masonry infill walls on the first floor as the main cases of models for to conduct the assessment.

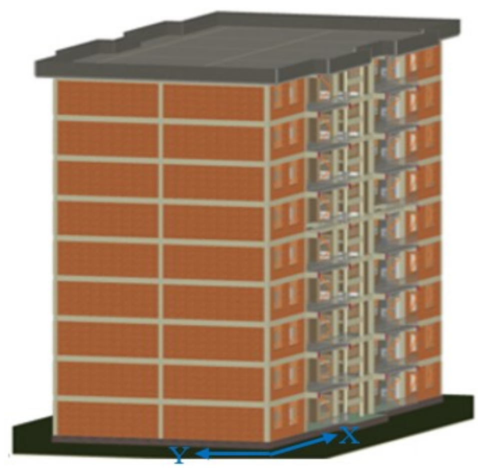


Fig.1. Architectural model of the studied nine-story cast-in-situframed building

2.1. Main characteristics of the studied nine story building

Characteristic strength of the concrete (f_{c28}) is equal to 25MPa. In the study the design strength of the masonry infill walls (f_d) were variated from 1 MPa to 3 MPa. Poisson ratio (v) was equal to (0.25). The interface between masonry infill walls and concrete elements was adopted as a hinge.

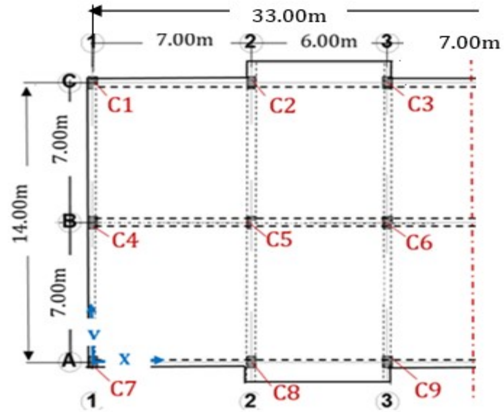


Fig.2. Choice of columns (C1- C9) to be studied on a given floor, considering the symmetry of their location on the horizontal plan

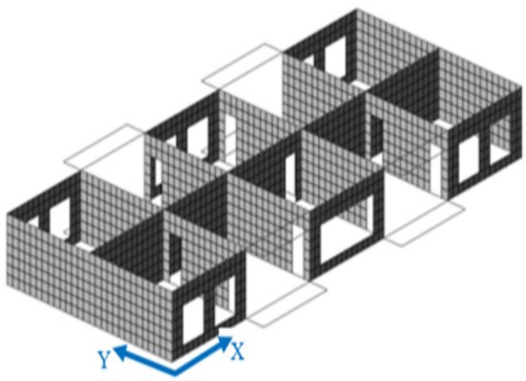


Fig.3. Location of the bearing masonry infill walls (with or without openings) on a floor

Column sections (h x b) equal to (38 cm x 60 cm). Beam sections (h x b) equal to (38 cm x 60 cm). Thickness of the slab was equal to 18 cm.Thickness of the masonry infill walls was equal to 38 cm.

As loads in this study were taken the dead loadsof constructive elements, standard load for residential building (taken equal to 1.5 kN/m^2) and the wind load acting perpendicularly to the longitudinal side of the studied building (equal to 1.16 kN/m^2). Loads design and loads combinations were drawn up by the simplified approach of Eurocode for residential buildings in program LIRA-SAPR 2013.

2.2. Case of numerical models for conducting the study

As the goal was to study the variation of internal forces in columns, before this it was required to verify the reliability of the built numerical model by verifying the and satisfying the overall stability of the constructive system; the bearing capacity of the more loaded column, the general stability of the constructive system, the vertical displacements in slabs, the horizontal displacements of the upper points of constructive system, the strength and stability of masonry infill walls (Mikerego [17]).

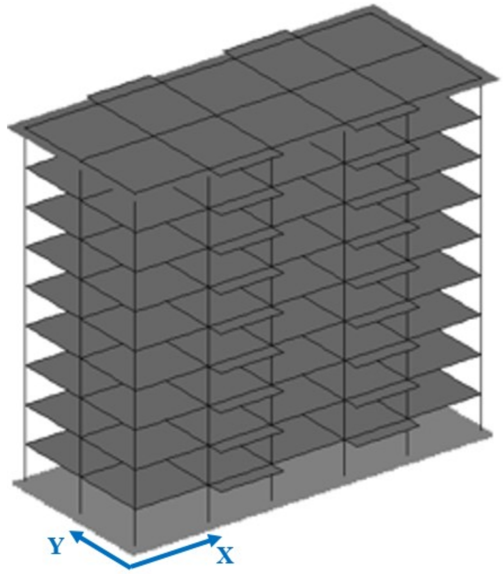


Fig.4. 3D finite element (model 1) of the studied cast-in-situ framed building without masonry infill walls

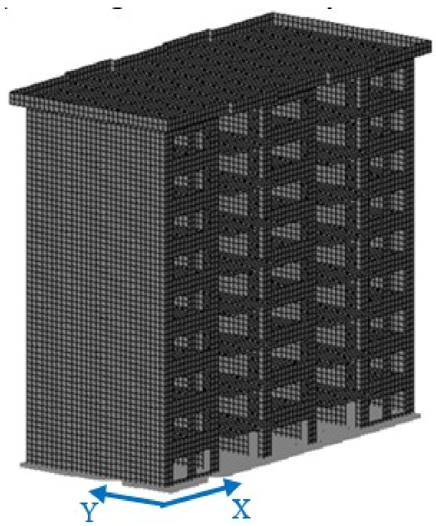


Fig.5. 3D finite element model (model 2) with masonry infill walls on all the stories

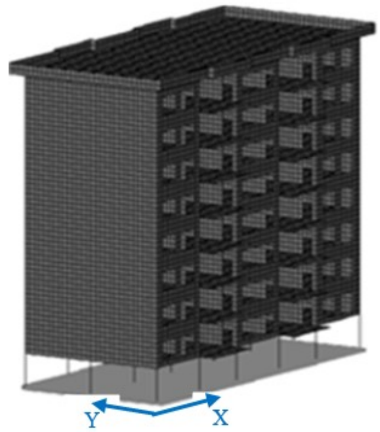


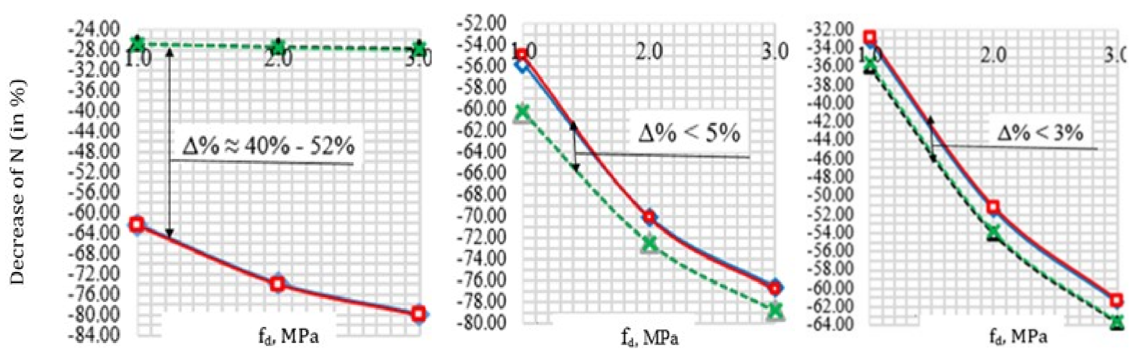
Fig.6. 3D finite element model (model 3) without the masonry infill walls on the ground floor

2. RESULTS AND DISCUSSION

In this study, the results are given for internal column (C5), external non-corner column (9) and for the corner column (C1). On the diagrams below the value Δ means the difference of the measured quantitative parameters resulted due to the kind of considered frame and loads. Also, the following legend used:

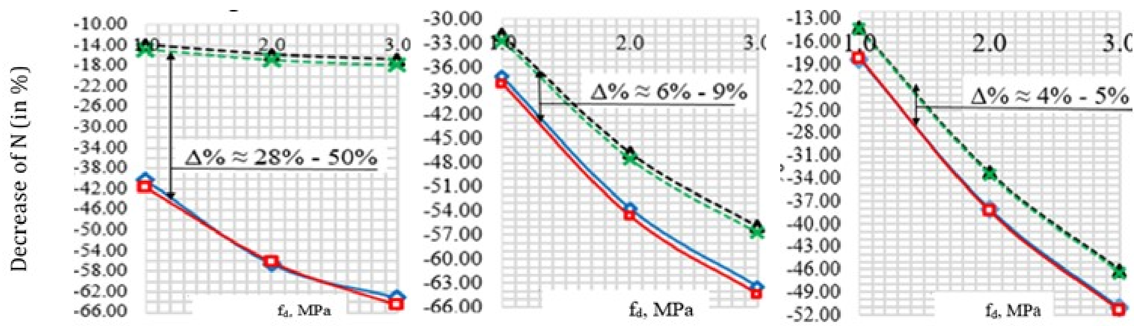
- Frame without masonry infill walls (without wind load);
- Frame with masonry infill walls (with wind load);
- Frame without masonry infill walls on 1st floor (without wind load);
- Frame without masonry infill walls on 1st floor (with wind load).

Variations of longitudinal forces (N) in internal columns are shown in fig. 7. Variations of longitudinal forces (N) in external non-corner columns can be seen in fig. 8. Variations of longitudinal forces (N) in external corner-columns are shown in fig. 9.



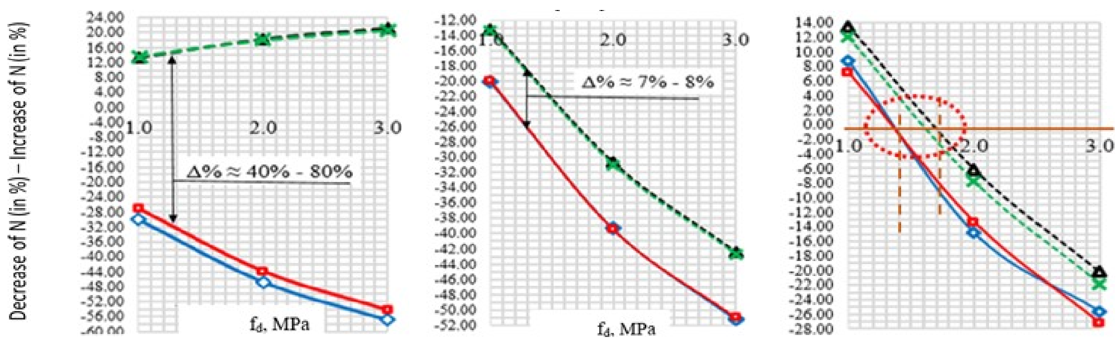
(7.a) – 1st floor (7.b) - 5th floor (7.c) - 9th floor

Fig.7. Decrease of longitudinal forces in internal columns according to the strength of the masonry infill walls and kind of loading: (a) on the lower floor; (b) on the middle floor; (c) on the upper floor



(8.a) – 1st floor (8.b) – 5th floor (8.c) – 9th floor

Fig.8. Decrease of longitudinal forces in external non-corner columns according to the strength of the masonry infill walls and kind of loading: (a) on the lower floor; (b) on the middle floor; (c) on the upper floor



(9.a) – 1st floor (9.b) – 5th floor (9.c) – 9th floor

Fig.9. Decrease of longitudinal forces in corner columns according to the strength of the masonry infill walls and kind of loading: (a) on the lower floor; (b) on the middle floor; (c) on the upper floor

Obtained results show that masonry infill walls significantly unload the column depending on their location on the plan and elevation of a Cast-in-Situ framed building. On a given floor, the internal columns (Fig. 7) and external non-corner columns (Fig. 8) are more unloaded. The corner-columns are less unloaded (Fig. 9). At the elevation of the Cast-in-Situ framed building the significant reduction of longitudinal forces arise in the columns of the lower floor. And the minimum reduction of longitudinal forces arises in the columns of the upper floor.

In this study, the results show that the masonry infill walls with design compressive strength less «1.4 MPa» and «1,8 MPa» do not participate in unloading the corner columns of the upper floor respectively in model with masonry infill walls on all floors and in model without masonry infill walls on the first floor. This results from thegap occurring between the masonry infill walls and the beam of the roofing slab of the upper floor.

Received result from this study shows that the failure of masonry infill walls on the first floor reduces the degree of decrease of longitudinal forces in non-corner columns and increase the longitudinal forces in corner-columns (Fig. 9.a).

3. CONCLUSION

A variability and a distribution of longitudinal forces in columns of a nine-story Cast-in-Situ framed building have been studied.

The quantitative data have been given which indicates how significantly masonry infill walls influence on the values of efforts arising in columns of Cast-in-Situ framed building according to the strength of masonry infill walls, the location on the plan, the story level and the kind of acting forces.

It is found out the significant reduction of longitudinal forces in columns depending on their location on the plan, and the elevation of a Cast-in-Situ frame building.

It is shown how the redistribution of longitudinal forces in columns of the first floor significantly depend on the failure of masonry infills wall of that floor.

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