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The Seismic Behaviour Of Reinforced Concrete Frame Structures With Infill Masonry In The Bucharest Area

Ovidiu Bolea[a]*

[a]*Technical University of Civil Engineering Bucharest, Bd. Lacul Tei, 122-124, 020396, Bucharest, Romania*

Abstract

The partitions of reinforced concrete frames can be lightweight (with gypsum board) or heavy (with infill masonry). Regardless of the type of partitions, the actual design code does not take them into account, therefore, the structure is designed as a pure frame. However, if the partitions are made of masonry that intimately connects with the frame, the behaviour of the structure is different than that of a bare frame. Generally, frame structures with infill masonry have an increase in stiffness and strength and a different cyclic behaviour. The interaction between the frame and the masonry is a difficult problem, and there are only a few numerical models for this phenomenon. Therefore, the first goal of the article is to present the state of the art regarding the behaviour and modelling of the masonry infill. Furthermore, the influence of masonry on global response of reinforced concrete frames is analyzed by using dynamic nonlinear analyses for several structures in the Bucharest area. The results are then discussed with respect to the displacement demand of the elements and masonry behaviour.

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Keywords: Collapse mechanism; diagonal strut; numerical model; dynamic nonlinear analysis

1. Introduction

Reinforced concrete frames infilled with masonry panels are very common construction in many countries situated in seismic regions. Usually classified as non-structural elements, the influence of their strength and stiffness are neglected. However, unlike most non-structural components, masonry infills can develop strong interaction with the bounding frames under seismic loads and therefore this approach can lead to substantial inaccuracy in predicting the actual seismic response of framed structures in terms of lateral stiffness, strength and ductility.

* Corresponding author. Tel.: +40761918496
E-mail address: bolea.ovidiu@gmail.com

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Neglecting infill walls in the design phase is attributed to inadequate knowledge concerning to the composite behaviour of infilled frames, the variability of material properties, geometric configurations and construction methods. Additionally, should be considered the overall geometry of the structure, aspect ratio of infill panels, the detailing of reinforced concrete members or the location and dimensions of openings in the infill panels [1].

The review of literature shows that significant experimental and analytical research related to infilled frame structures in the last 50 years was done, since the first study published by Polyakov [2]. Despite of research efforts numerous uncertainties still remain and the seismic performance of these structures in an earthquake remains a major controversy among structural engineers and researchers today.

The role of masonry panels during earthquakes is complex and the code approaches to seismic design of masonry-infilled reinforced concrete frames differ greatly. No consensus among code developers exists regarding the generally favourable or unfavourable effect of common masonry infills from the seismic performance point of view [3], [4]. The Romanian seismic design code, P100-1/2013 [5], as many other national codes, neglects the effect of masonry panels and therefore, the structure is designed as a bare frame.

The goal of this paper is to investigate the seismic behaviour of infilled frame structures based on previous research (analytical and experimental studies, field observations after earthquakes) and to analyse the seismic response using the most complex investigation approach - dynamic nonlinear analyses. At first, the article presents the state of the art regarding the behaviour and modelling of the masonry infill. Second, the influence of the interaction between the frame and the masonry panel is analysed by dynamic nonlinear analyses using an appropriate advanced model for several structures in the Bucharest area in order to provide useful informations of seismic safety for this type of building.

2. In-plane behaviour of infilled frames

Masonry infills received much attention in the past and extensive research has been carried out to predict the influence of infill panels and to carry out adequate structural analyses. The research conducted on the masonry infilled frames can be divided into three areas – experimental investigations and two types of analytical investigations (local or micro-modelling and simplified or macro-modelling) based on results obtained from experimental research. Some extensive state of the art reports can be found in [3], [6].

2.1. Experimental investigations

Several experimental investigations were performed to investigate the effect of numerous parameters on the performance of masonry-infilled reinforced concrete frame structures. In the literature can be found relevant researches on small and large-scale infilled frame structures, focused on the in-plane response, tested with quasi-static and dynamic loads. Major experimental investigations can be found in Polyakov [2], Holmes [7], Stafford Smith [8], Fiorato et al. [9], Klingner and Bertero [10], Zarnic and Tomazevic [11], Negro and Verzeletti [12], Fardis et al. [13], Hashemi and Mosalam [14].

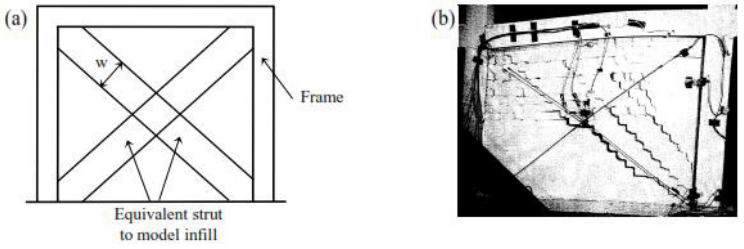

Fig 1. (a) Equivalent strut model [6]; (b) Experimental results showing the formation of strut [6]

All the major experimental studies conducted in the past demonstrate the increase in the strength and stiffness of the infilled frame compared to the bare frame. As was reported by Sattar [6], most of these studies reported the formation of the compression struts at lower force levels. In several cases a change of the single diagonal strut