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SEISMIC BEHAVIOUR OF NEW MASONRY BUILDING

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ABSTRACT

The PhD research program proposed here aims at filling a research gap in the scope of seismic behaviour of new masonry buildings. Structural masonry consists of an alternative solution to reinforced concrete frames for low to medium rise residential buildings. To attain the goals of the research program an enlarged experimental and numerical analysis is planned. The experimental characterization of the dynamic behaviour will be based on shaking table tests in three distinct typologies of masonry builds, from which the main features are to be derived. Complementary, the numerical simulation encompasses nonlinear dynamic and nonlinear static pushover analysis of masonry buildings with an adaptive procedure aiming at fully insight of the dynamic behaviour and at the comparison between both numerical approaches. Finally, it is intended to provide guidelines for the seismic design of masonry buildings from displacement-based methodologies. Here, the numerical simulation will be based on macro-element idealization of masonry.

OBJETIVES

structural masonry have advantages when compared to reinforced concrete infill frames and can clearly compete with this system in low to medium rise buildings. Thus, the use of structural masonry in Portuguese construction market requires a deeper insight of the seismic behaviour of masonry buildings, as Portugal is medium to high seismic hazard country. Additionally, complete background on seismic design of masonry buildings is needed. Notice that a reason that contributes to the absence of structural masonry is the lack of academic training. Therefore, in view of this status, the main aims of the proposed research program are: (1) better understanding of the behaviour structural masonry to seismic loadings; (2) study of design procedures promoting the use of structural masonry. In detail, the main goals of this research are:

1. Experimental characterization of structural masonry buildings to seismic action based on shaking table tests. More than walls and piers, it is important to fully understand the global behavior of masonry buildings under seismic loading, namely at the level of the connections among intersection walls and between masonry walls and slabs. It should be stressed that seismic behavior of masonry buildings is only be well studied through dynamic analysis.
2. Numerical simulation of the dynamic behavior of masonry buildings based on finite element method, aiming at analyze and compare distinct numerical methods for structural analysis of masonry buildings, namely nonlinear static and nonlinear dynamic analysis.
3. Evaluation of distinct factors influencing the behavior of masonry buildings to seismic action, namely the geometric configuration of the building. Obtainment of overstrength factors considering concrete block structural masonry.
4. Providing a design methodology for masonry buildings subjected to seismic loading. The design of masonry buildings should following a simplified mechanical approach based on nonlinear static analysis and capacity spectrum method.

CONSTRUCTION TECHNOLOGY

The use of masonry as a structural material dates back the first known civilizations whether in national or international context. Even if in Portugal almost no structural masonry has been built after the first half of the XX century, according to Magenes (2006), Unreinforced masonry structural buildings have been shown structural deficiencies during earthquakes, mainly due to low quality of materials, inadequate connections between intersection walls and between walls and slabs and structural irregularity in plan and elevation. It should stressed that EC8 (2004) recognize that new masonry buildings should comply with simple requirements encompassing material properties, structural geometry and configuration and structural details, enabling the development of the known box behavior during seismic events, The research on masonry under seismic loading has been mostly focused on experimental and numerical analysis of structural masonry elements, namely masonry walls (Tomazevic, 1999; Vasconcelos and Lourenço 2009; Haach et al. 2010). Lesser research has been developed in relation to the global seismic behavior of masonry buildings, particularly in case of new masonry buildings, to which special laboratory facilities (shaking table) and research are needed (Calvi et al. 1996).

GENERAL OVERVIEW OF THE THESIS

State of the art A general overview of literature will be carried out according to the following points: (1) general behaviour of masonry structures to seismic loads; (2) general procedures for the analysis of experimental results obtained in the shaking table tests; (3) design of masonry buildings according to the European code and overview of the existing models for nonlinear static analysis of masonry buildings.

Experimental characterization of materials This task deals with experimental characterization of masonry materials and masonry as a composite material, aiming at obtaining the main mechanical parameters for numerical simulation.

Planning and execution of the shaking table tests shaking table tests carried on distinct masonry buildings at the shaking table of National Laboratory of Civil Engineering (LNEC) will be evaluate, Three masonry buildings are planned to be tested: (1) regular unreinforced concrete block masonry building; (2) reinforced masonry building; (3) irregular masonry building to account for torsional effects.

Analysis of results of shaking table tests The evaluation of the seismic performance of the distinct typologies of the masonry buildings will be made by considering distinct input time series of artificial accelerograms compatible with the design response spectrum of Lisbon with increasing amplitude, The acceleration, velocity and displacement response on reference points of the structure will be obtained and amplification factors calculated. The comparison of seismic performance among the distinct masonry building typologies will be also evaluated based on the evolution of relative displacement along the height on the interstorey drifts and on the hysteresis diagrams relating the base shear and displacement at the top of the distinct buildings.

Numerical analysis of dynamic behaviour of masonry buildings In this task the numerical simulation will be based on finite element modelling (FEM) by following the common macromodeling approach and by considering masonry as isotropic and homogeneous material. The mechanical behaviour of masonry will be based on advanced plastic constitutive models. The numerical model of the distinct masonry buildings is to be calibrated based on the experimental results obtained on the shaking table tests. Parameters like frequencies and mode shapes will be used.

Design guidelines for masonry buildings One the of the major aims of the proposed task is to provide guidelines for seismic design of masonry buildings, as in Portugal there is no experience on the design and construction of new masonry buildings.

Written of the thesis A thesis will be present at the end of the research period.

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AUTHOR BIOGRAPHIES

LEONARDO AVILA VELEZ is Colombian and was born in Medellin in 1984. He is a Civil Engineer since 2006, when he graduated on a 5-year course in the Universidad de Medellin. With a full university scholarship due to his academic records. Afterwards, he worked as engineer for 2 years, in a construction company mainly planning, monitoring and controlling different kind of buildings. Subsequently he won a grant for research in COLCIENCIAS (national administrative department of science, technology and innovation), and develop investigation for more than one year, At the moment he has a book chapter, two international and one national paper in the field of new materials. He is presently interested in everything related to structure Design, especially Nonlinear Structural Analysis and new materials for construction, but always with an engineering approach.