PhD Open Days

RESIST-2020 - Seismic Rehabilitation of Old Masonry-Concrete Buildings

TIAGO LIPARI PINTO (tiagpinto@gmail.com)

Buildings Structures

The construction of buildings evolved through the use of new materials and new constructive processes.
In Portugal, as it happens in other Mediterranean countries, buildings can be divided into four groups (regarding their structural materials):

1. Masonry | 2. Mixed Masonry-Concrete | 3. Reinforced Concrete | 4. Others (Steel, Timber, etc.)

Figure 1 – Types of materials used for building structures

Analysing all the existing buildings in Portugal, we can see that in the last century the use of reinforced concrete has become more frequent, being nowadays the most usual material for new constructions.

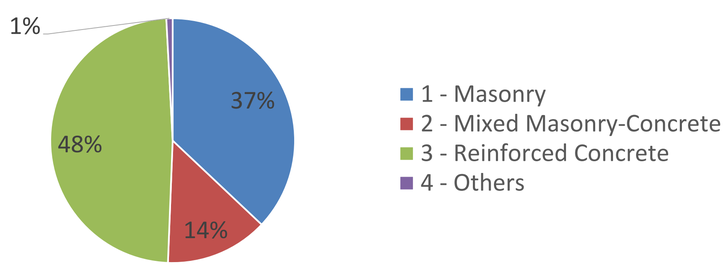

Figure 2 – Percentage of existing buildings in Portugal according to type of structural material (Census 2011)

As shown in Figure 2, there is still a large percentage of existing buildings constructed using masonry as main structural elements (51%).
Masonry buildings still serve as residence for many inhabitants and, in most cases, possess a high patrimonial and architectural value. If we consider that these buildings were constructed prior to the implementation of seismic regulation, it is very important to analyze their seismic behavior as well as study innovative solutions to improve their resistance.

Characterization of mixed masonry-concrete buildings

This type of building, built between 1930 and 1960, represents a transitional period from typical masonry structures with timber floors to those entirely built in reinforced concrete. Their main structural characteristics are:

- Regularity in plan and rarely exceeding 5 storeys;
- Foundations using concrete footings (in case of reinforced concrete columns) or prolongation of the walls to more consistent soils (in case of resistant walls);
- Slabs in reinforced concrete, supported by resistant masonry walls (stone, clay bricks or concrete blocks);
- Facade walls usually in marble stone masonry with 0.70 to 1.00m thickness;
- Roof in timber structure;
- Concrete class similar to C16/20 and smooth steel rebars to S235 class;

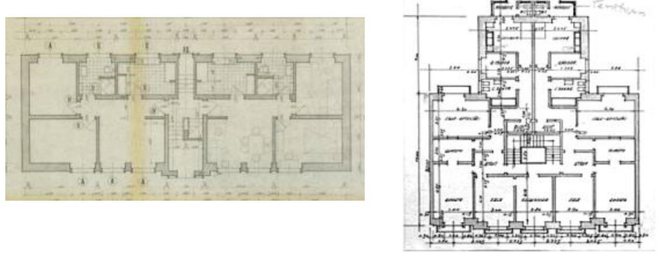

Figure 3 – Typical plan view of a mixed masonry-concrete building

Seismic behavior and resistance deficiencies

During a seismic event, the global behavior of a masonry building is greatly influenced by the type of connection between walls and slabs. A good connection avoids out-of-plane brittle failures and mobilizes the in-plane shear resistance of walls – “box behavior”.

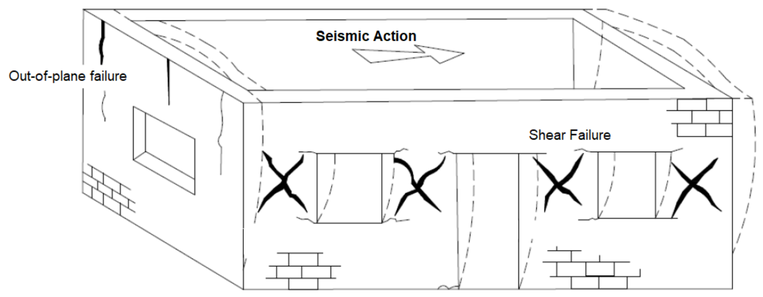

Figure 4 – Collapse mechanisms in masonry walls

Shear failures may occur in three different types: Rocking, Sliding and Diagonal Cracking. Mixed masonry-concrete buildings (and other masonry structures) generally have insufficient strength for in plane and out-of-plane seismic actions.

Reinforcement technique - TSB (Twisted Steel Bars)

Many seismic retrofit solutions have been previously studied and applied in order to improve in-plane strength of walls and/or increase their ductility.
The main objective of this thesis is to investigate the seismic behavior of masonry walls reinforced using twisted steel bars inserted near the surface of the wall.

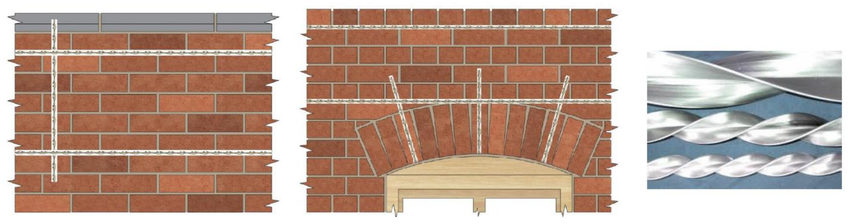

Figure 5 – Twisted Steel Bars mounted near surface

A total of 27 wallets are going to be tested using TSB reinforcement, and several parameters are going to be assessed in this experimental campaign such as: failure modes, shear strength, drift, ductility and elasticity.
After the experimental campaign, numerical modeling will be performed to simulate the seismic behavior of walls with or without the reinforcement technique and an optimized solution will be defined. Finally a design method/procedure will be proposed for reinforcing masonry walls using TSB mounted near surface.

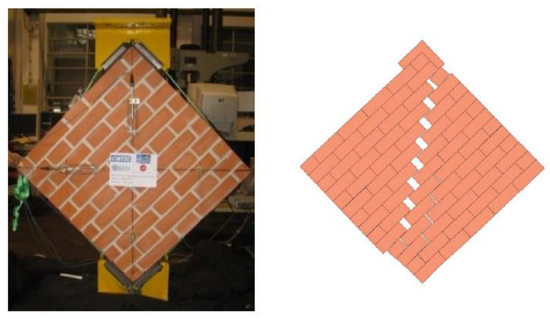

Figure 6 – Diagonal Shear Test and numerical modelling

CERIS : Civil Engineering Research and Innovation for Sustainability

TÉCNICO LISBOA | LNEC | Universidade do Minho, Escola de Engenharia