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CiAUD Centro de Investigação em Arquitetura, Urbanismo e Design

FCT Fundação para a Ciência e a Tecnologia

Design and analysis of low cost non-intrusive structural reinforcement process for traditional masonry buildings

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Keywords
Lorem Ipsum is simply dummy text of the printing and

Partner Institutions
AAC - Institute for Advanced Architecture of Catalonia

Expected Future Partner Institutions
Faculty of Architecture of Genoa - Italy

OBJECTIVES

The main generic objective is to provide additional seismic protection to masonry buildings under recovery, albeit on a temporary basis, with acceptable and competitive costs compared to the market value of the buildings, minimizing the collapse due to seismic action.

The confinement of structural masonry walls to allow for fragmentation of these when an earthquake occurs, but preventing the collapse and consequent structural collapse of the wall. The solution to be developed will necessarily be to satisfy:

-Low production cost compared to alternative methods;

-Low application cost, compared to alternative methods;

-Total acceptable cost compared to market values for rehabilitated masonry buildings;

-Easy applicability in situ (on site);

-Possibility of obtaining an integrated solution with other requirements of the rehabilitation process, in particular, of thermal insulation.

BIBLIOGRAPHIC REFERENCES

1. Mário Lopes (ed) - Sismos e Edifícios, edições Orion, 2008
2. G. Magenesand A. Penna, "ExistingMasonryBuildings: General CodeIssuesandMethodsofAnalysisandAssessment," Eurocode 8 PerspectivesfromtheItalianStandpoint Workshop, pp. 185-198, 2009.
3. G. Magenesand A. Della Fontana, "Simplified non-linear seismicanalysisofmasonrybuildings," ProceedingsoftheBritishMasonrySociety , vol. 8, pp. 190-195, 1998.
4. P. B. Lourenço, "Computationsonhistoricmasonrystructures," Progress in StructuralEngineeringandMaterials, vol. 4, no. 3, pp. 301-309, 2002.
5. C. Calderini, S. Cattariand S. Lagomarsino, "In-planestrengthofunreinforcedmasonrypiers," EarthquakeEngineeringandStructural Dynamics, vol. 38, pp. 243-267, 2009.
6. M. Tomazevic, P. Weiss and T. Velechovsky, "Theinfluenceofrigidityoffloorsontheseismicresistanceofoldstone-masonrybuildings," EuropeanEarthquakeEngineering, vol. 5, no. 3, pp. 28-41, 1991.
7. N. Mendes and P. B. Lourenço, "Seismic Performance ofAncientMasonryBuildings: A SensitivityAnalysis," in 4th ECCOMASThematic Conference onComputationalMethods in Structural Dynamics andEarthquakeEngineering, Kos Island, Greece, 2013.

ABSTRACT + IMAGES

The research to be carried out seeks to develop low-cost solutions to reduce the seismic vulnerability of old buildings built in masonry. The solutions to be adopted consist of structural coatings using new composite materials, specifically modified and formulated to meet this objective.

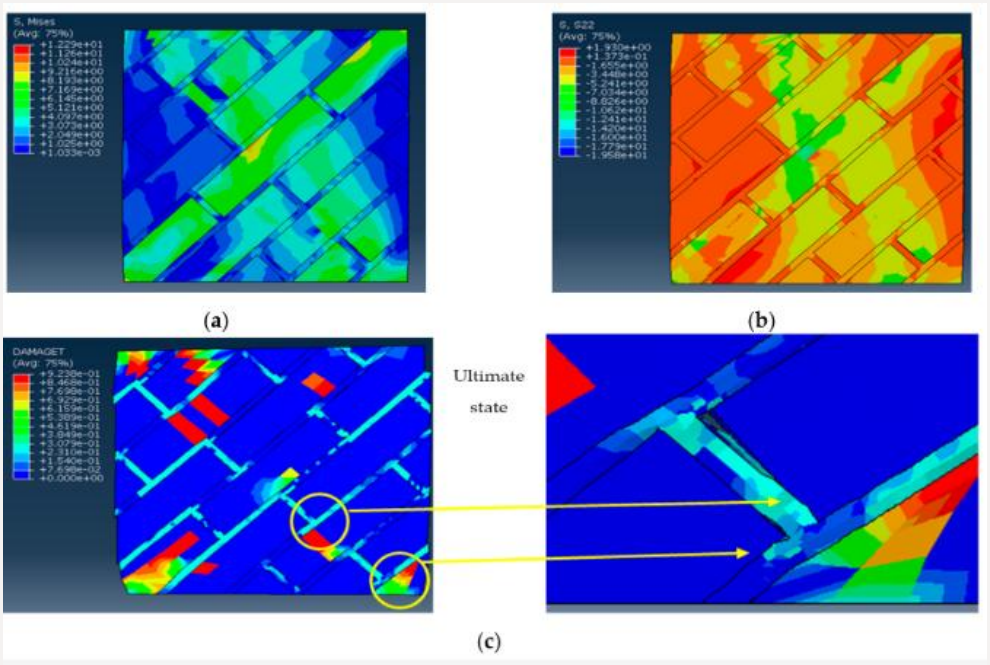
The research aims to find solutions based on composites for light seismic protection structures in order to provide structural reinforcement to the old building built in masonry.

The Portuguese Government and the Municipalities intend to stimulate the sector of recovery of the existing heritage (old buildings). It became the country's economic objective to return functionality and value to old houses, built before the 50s of the last century. Through the action of the real estate and construction companies (contractors), the Government created, albeit temporarily, legislation for rehabilitation and conservation works that exempts this class of buildings from the need to comply with the "anti-seismic structural legislation", so as not to encumber the cost of recovering the works, keeping sales and rental prices (at market values) competitive. The initiative taken by companies in the sector is justified given the nature of the existing standard solutions of a structural nature to improve the behavior of old buildings in relation to seismic actions. The usual regulatory materials to provide buildings with seismic resistance are reinforced concrete and laminated steel. Have these were the standard solutions proposed by civil engineering. The use of these materials, as a structural solution, almost always implies the opening of "rocks", trenches and trenches to insert the new reinforced concrete or steel structure. Obviously, these controlled demolition works have consequences for costs, as they increase the execution time of the works, in addition to incidentally being able to affect the stability of the building's materials, which, as a rule, are made up of traditional materials of low strength.

The cost of the new steel and reinforced concrete structure associated with the increase in the execution time of the works to open the trenches, and their consequent closing. Also contribute to the increase in the financial costs associated with the reduction of the seismic risk of the buildings. As a result, the costs of anti-seismic upgrade of different types of old buildings (pre-pombaline, cages, slab) often lead to a non-competitive product compared to the alternative of demolition and construction of new buildings from scratch (in terms of cost). That said, without carrying out structural reinforcement of the old building, we are in the presence of a permanent threat of something that can occur at any time in the national territory as expressed in the most recent works – an earthquake.

About 50% of the built heritage in the country is made up of old masonry buildings, where the resistant elements are essentially the walls, many of them in a state of conservation greatly aggravated by time and exposure to the weather, with great deterioration of the mechanical properties that already their origin were very weak. On the other hand, Portugal has been witnessing, and is expected to continue for a long time, a current practice of the activity of rehabilitation of the built heritage, especially the old masonry buildings mentioned above. These interventions, where it is also necessary to promote seismic reinforcement, for market reasons lack alternative solutions that are more economical and at the same time effective in obtaining an improvement in the seismic resistance of the intervened walls, avoiding the aggravation or even alleviating the costs of the much-needed reinforcement of the resistance. of these buildings to the seismic actions established in Eurocode 8. In practical terms, based on the conditions for minimum masonry resistance for Type 1 and Type 2 seismic actions, according to EC 8, and considering that the units analyzed are from Group 1.

Make it difficult (prevent) the immediate collapse of the building in the immediate, the main cause of loss of human life, even if the damage caused is classified as significant damage, even near collapse. This project aims to find a viable, low-cost solution to this problem, and subsequently optimize it. Since, in the old buildings considered, the floors are supported by structures (walls) in masonry, it is intended to confine the material that constitutes the masonry (even after disaggregation), in order to prevent structural collapse (collapse) in time. wall useful. In the face of an earthquake, the growth and multiplication of cracks, and the occurrence of localized granular flows (granular rearrangements), are the main processes involved in the disaggregation of masonry. Both have the advantage of allowing an appreciable energy dissipation; and the inconvenience of collapsing will be eliminated if it is possible to confine the granular material in order to prevent the collapse of the floors, at least in the short term. In these circumstances, the masonry, even with a substantial degree of disaggregation, will maintain the support capacity of the floors, like any confined granular material. The proposed solutions, which will be analyzed, involve a strong degree of innovation regarding the selection criteria of the materials to be used, regarding their nature and composition (or formulation), and regarding the processing methods used upstream, as will be later demonstrated.



Digital Numerical Study of Behaviour of Reinforced Masonry
(on line http://www.mdpi.com/2075-5309/10/6/103/htm)

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SCIENTIFIC RELEVANCE FOR THE DISCIPLINE

The project is inserted in tradable and internationalizable sectors, namely in the materials and equipment sector for civil construction:

- The project foresees the use of sophisticated technology in the reinforced with semi-rigid foam, reactive and thermoplastic integral skin foams and molding.

- The use of products for structuring coatings to reduce seismic vulnerability and new market segments upstream of the value chain (production of new solutions and downstream in new segments of national and international customers (provision of new engineering and installation services).

The expected direct impact on the portfolio of products and services that enabled the emergence of:

- A new business area;

- A new range of solutions and a new production process and respective application.

EXPECTED ECONOMIC AND SOCIAL IMPACT

The volume of post-project rehabilitation works acquires continuous and sustainable bases in national and international markets and with sufficiently wide and continuous differentials between pre-project and post-project:

- The investigation is based on the consolidation of new facilitating agents for new products. The creation of a company (spin-off) or the use of the acquired knowledge is foreseen;

- Intellectual property protection strategy in the form of patents or other related matters;

- Identification of other application sectors/target markets for the technology.

The social impacts of the creation of jobs from currents of the commercial implementation of the products and systems developed.

RESEARCH PLAN AND TASKS

From the point of view of the research project methodology, the different types of confinement will be evaluated first, taking into account a set of previously defined types of masonry. After theoretical definition of several possible reinforcement solutions, an optimization process of compositions and formulations follows that will define the optimal definitions for the selected confinement method. The planned sequence of phases is as follows:

A – Screening (pre-screening) of a digit number of previously defined confinement typologies, through a finite element structural analysis program, suitable for modeling masonry elements (in particular, uniaxial compression and cross-section). For each type of confinement, confining materials of a different nature will be used, within the scope of previously established classes of materials (composite materials).

B - Iterative optimization of formulations for composite materials for the two previously selected methods, taking into account the following parameters:

- Characterization of the mechanical behavior of the confining element using finite element analysis software

- Evaluation of the behavior of structural components, using a restricted set of types of masonry selected from those most used;

C - Construction of digital prototypes.

As part of the preliminary discussions between the researchers participating in this research project and following the work carried out at the Building Rehabilitation Research Group - BRRG, a list of various confining materials was prepared for analysis. Given the enormous variability of masonry in buildings, it will be necessary, in particular, to previously select a restricted number of standard masonry to be used in the digital models.

As examples of materials considered for structural reinforcement, the following classes are considered:

• Reinforced thermosetting polymer plates, with semi-rigid foam on one side. Within this typology, the plates may be:

  o Glued to the masonry;

  o Bolted through the masonry.

• Reactive integral skin foams (with properly adjusted formulation). These are plates of a reactive polymer (or thermosetting resin) in which there is only controlled foam formation inside the plate. This method includes some variants as to the production (processing) method of the integral skin foam;

• Thermoplastic integral skin foams. They present some advantages in terms of cell sizes (e.g. microcellular foams), although the production method is totally different from the previous one;

• A promising processing method, still in its infancy, is rotational moulding, where a prior reflection on solutions is foreseen. In case the processing technique proves to be interesting enough for the purposes of the project:

• Composites of recycled polyolefins, modified with cork powder, and produced by sequential rotational molding;

• Composites of reactive polymers (thermosetting) reinforced with short fibers of different materials;

• Reinforcement of masonry with rubble, through the injection of a reactive polyurethane in the rubbled core, through a variant of the process commonly known as "tube à manchete";

After a first cycle of digital calculation, the two most promising processes will be identified, which will later be submitted to a set of tie-breaking analyzes involving the realization of digital models and analyzes in a systematic way by digital models. This first phase will occupy around 25% to 30% of the project's planned duration.

This is followed by the optimization of formulations and design, the creation of digital models and the respective calculation.

Work plan:

a) Bibliographic update and collaboration in the definition of screening analyses;

b) b) In the sorting activity, collaboration in the redesign tasks and identification of the best processes;

c) Participation and collaboration in the analysis and valuation of design aspects associated with the shape and geometry of the containment elements;

d) Participation in the cost analysis and technical-economic evaluation of the solutions under analysis;

e) Environmental impact assessment;

f) Contribution to tasks associated with the promotion and dissemination of results;

g) In the analysis, discussion and definition of the standard types of masonry to be tested within the scope of the project;

h) Production of digital masonry prototypes necessary for the tasks;

i) In the promotion and dissemination of project results;

j) In the best way to explore the results of the project and in the management of the project.

EXPECTED SCIENTIFIC RESULTS

The project is fully framed - strengthening of R&D and innovation capacity.

The research process of structural coating solutions using new materials to reduce seismic vulnerability at low cost (described in the previous topics), will value highly qualified technical and scientific staff (research and doctoral fellows, researchers and internships in the project work).

Production of:

- Technical and scientific articles and participation in conferences through the preparation of reference documents on experimental methods of analysis;

- Publication of technical and scientific articles in journals of related areas and in national and international scientific congresses;

- Opening lines of research for doctoral and master's students;

- Possibility of holding a conference at the FA

BUDGET: € 1.000,00

The costs inherent to the development of the project result from the acquisition of software and dissemination.

- The development of the research project bases its analysis on the use of structural calculation software, its acquisition being a fact of feasibility of the project and the operational plan conceived. (7000 €)

- The dissemination of the results obtained implies the creation of a web site; Registration fees and participation in international conferences (500€)