SHELTER – Structural Hyper-resisting Element for Life Threatening Earthquake Risk

Summary

The motivation for the proposed study is to develop a seismic shelter solution for apartments in buildings (houses, offices, etc), taking into account the significant vulnerability of building stock in many countries in the world including in various Portuguese regions. This solution will be technically and economically feasible and architecturally integrated, so that it can be quickly implemented in order to save lives if an earthquake occurs.

The area of anti-seismic constructions has always been of interest to both TDEC and IST, and the major reason for the development of the SHELTER project derives from the goal that TDEC has of improving its capacities in the area of anti-seismic construction at the international level. This positioning will allow TDEC to differentiate itself from its competitors and will also contribute to it being recognized as an innovative construction company, capable of participating in complex engineering projects, which are both innovative and knowledge intensive.

The development of a seismic shelter solution involves its study regarding mechanical and structural behaviour, constructive aspects, architectural integration, functionality, design and ergonomics. The development of the present proposal is built upon a multidisciplinary team (co-promoters and sub-contracted institutions) capable of giving an adequate response to the multiplicity of problems involved.

The study will start with bibliographic research on some of the problems to face that have already been studied in other fields, such as human resistance to violent mechanical actions and survival in confined spaces. Noteworthy are the shelters of conventional and atomic warfare and the cockpits of racing cars, aircrafts, submarines and spacecrafts.

The mechanical / structural behaviour will be evaluated in experimental tests, complemented with the development of numerical models to simulate variant situations to the tested base model. The development of the shelter solution will take into account the compatibility with the existing building and the need for a quick and easy installation with accessible technology and manpower. Architectonic impact is to be minimized, by developing solutions adaptable to existing spaces.

To ensure the shelter operability it is necessary to conduct tests to evaluate the arrival period and its compatibility with the time period available in the event of an earthquake. The project will study the inclusion of "early warning" seismic alarm, already commercially available, which allow for some extra time. Although the time in between the start of the earthquake and the possible collapse of buildings is insufficient to evacuate a building, it should be enough to get into the seismic shelters installed in the houses/offices. A training program will be developed to be implemented with the installation of shelters.

Aspects of design and ergonomics will also be taken into account to ensure the psychological and physiological well-being in the shelter small space until the rescue arrival that, in these cases, may take days. Space functionality will be optimized, and objects and systems will be defined regarding support for nutrition and hydration, breathing, dejection, recreation, communication, alarm emission and locating.

The proposed solution is innovative in what concerns the protection of human lives in the case an earthquake occurs and is envisaged to be very effective and efficient. The scientific and technical community has been approaching the seismic protection of human lives based on the protection of heritage, by strengthening the buildings as a whole. Although there is already enough know-how to reinforce buildings to a resistant capacity compatible with present seismic regulations, such interventions require substantial financial resources, which hinders their widespread implementation.

There are some existing solutions for seismic shelters, but they usually consist of autonomous equipment which are hard to integrate into existing building in easy access locations, where they have to be located in order to fulfil their purpose. The present project aims to develop a seismic shelter that is architecturally integrated with the existing construction, can be installed in a central location of any apartment, and saves the lives of the occupants in the event of a severe earthquake, with very low costs.

The main result to be obtained is a seismic shelter solution to be installed in existing buildings that will help saving lives in the occurrence of an earthquake, with the following characteristics:

- Mechanical resistance to seismic actions, including the global collapse of the building.
- Ensuring adequate levels of physiological and psychological comfort to the victims until rescue.
- Constructive and architectural integration, with minimal impacts on the existing space.
- Very low costs when compared to the structural rehabilitation of buildings as a whole, allowing its immediate implementation in current house/office/etc.
- Installation with low degree of intervention, not requiring the evacuation of occupants.

Project Reference

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Leading Institution

Teixeira Duarte (Portugal)

Partners

IST-ID – Associação do Instituto Superior Técnico para a Investigação e Desenvolvimento (Portugal), LNEC – National Laboratory for Civil Engineering (Portugal)

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CERIS

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Project Website

teixeiraduarteconstrucao.com/sustentabilidade/inovacao-e-desenvolvimento-tecnologico/shelter-project

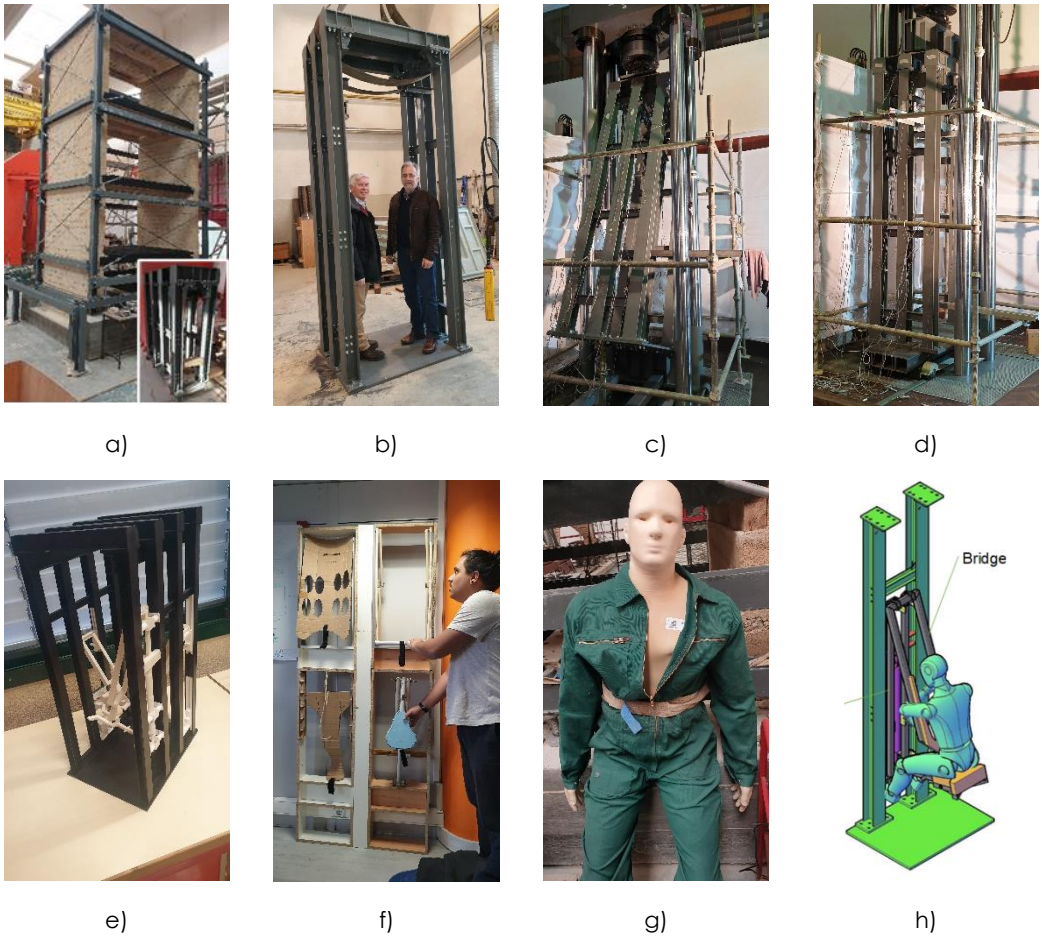

Figure 1. a) Half-scale building for collapse test; b) SHELTER model for static test; c) Tilted static test; d) Vertical static test; e) SHELTER mock up; f) Safety chair studies; g) Crash test dummy for down fall test; h) Numerical study of the safety chair.