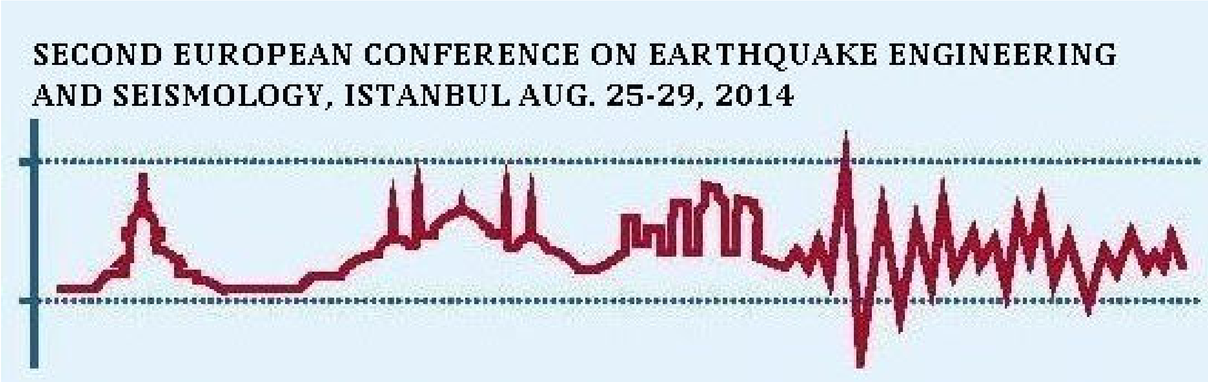

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INNOVATIVE DISSIPATION PANELS FOR SEISMIC RETROFITTING

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In the reconstruction of Lisbon after the devastating earthquake of 1755, city scale anti-seismic innovative measures were adopted. The most remarkable feature was the seismic resistant building technology: structural concept and the distinctive gaiola system. The gaiola was a standardized construction system designed to provide adequate seismic behaviour to the buildings, enabling them to resist horizontal loads and to dissipate substantial amounts of energy (Cóias V, 2007).

The gaiola corresponds to a three-dimensional timber structure inside the building and comprises the timber framed walls and the timber floors and roof structures – Figure 1. The timber framed walls form a two-directional vertical bracing system that is connected with the main stone masonry façade walls. The free spaces of the timber framed walls are filled with a light ceramic and rubble masonry – Figure 1. The “gaiola” designation was coined because the building seemed like a big cage, with the carpentry work high up in the air (Cóias V, 2007).

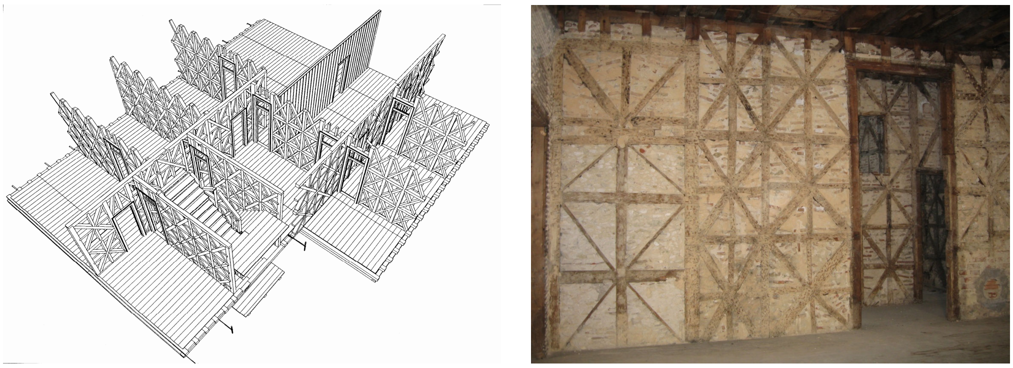

Figure 1. Details of the Pombaline construction. Internal timber frame walls.

The historical downtown of Lisbon, also known as “Baixa Pombalina”, constitutes the most complete collection of the gaiola system. As often as not this type of buildings (and also many other old constructions located in seismic zones) requires interventions to meet present anti-seismic demands (Candeias, 2008; Lopes, 2010).

Innovative dissipation panels for seismic retrofitting are under development. The new technology herein presented can improve the energy dissipation capacity of the buildings whilst respecting their original structural concept and, therefore, their authenticity.

The conception of the dissipation panels was based on the role of the old timber framed walls (that compose the gaiola), as they are a key structural element regarding horizontal loading, as well as on the incorporation of the quite recent seismic protection systems, which reduce damage and limit losses more effectively than the traditional approach (Guerreiro, 2006).

Basic design of the Panels correspond to an articulated supporting frame and a central damper. The Panels have a similar pattern design to the past timber framed walls, so they can be easily integrated within/in respect of the existing structure, thus corresponding to a compatible, low intrusive

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and reversible system that preserves the basic characteristic of the constructions. Complementary, the addition of a damper leads to a significant increase of the energy dissipation capacity.

The Panels are installed between two floors, to which the top and the base of the supporting frame are connected. The dampers occupy the centre of the panel and are connected to the articulated frame by diagonal braces. This paper focuses on the use of steel hysteretic dampers, which were specially designed and developed for the Dissipations Panels. During a severe earthquake, the steel dampers undergo a plastic deformation producing the necessary energy dissipation. All other parts including joints and fastenings remain in the elastic region. The relative displacement between the floors is significantly reduced.

The mechanical properties of the hysteretic damper were obtained by means of cyclic tests that were carried out in a universal Instron testing machine. As the damper yields, the stiffness reduces and energy dissipation occurs due to inelastic hysteretic response. The hysteretic loops present linear growing displacements amplitudes from one cycle to the next cycle. Testing and validation of other types of dampers are included in the scope of this research study.

Full scale models of individual units of a dissipation panel were produced and tested in order to characterize the cyclic behaviour of the panels. The panels were subjected to cyclic quasi-static tests performed in the reaction wall at the Laboratory of Structures and Strength of Materials of *Instituto Superior Técnico* (IST). The tests involved the application of an in-plane horizontal cyclic displacement history on the top of the models.

The activities described in this paper were carried out under the financial auspices of the PORLisboa\QREN\FEDER through the RehabToolBox R&D Project. Stap, in collaboration with Instituto Superior Técnico (IST), has been developing a set of new complementary low intrusive devices and systems designed for structural rehabilitation, including seismic retrofitting, which will enable structural rehabilitation interventions to be carried out "surgically", with only tolerable disruption of the buildings. The full set of devices and systems seeks to respond effectively to the constant search for economically competitive solutions with technical quality that are versatile and easy to handle and apply.

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