Tools and strategies to reduce non-structural damage

C. S. Oliveira[1], M. Lopes[1], F. Mota de Sá[1], M.A. Ferreira[1], P. Candeias[2], A. C. Costa[2], R. Rupakhety[3], F. Meroni[4], G. Musacchio[4], R. Azzaro[4], S. D'Amico[4], H. Langer[4], S. Falsaperla[4], L. Scarfi[4], G. Tusa[4], T. Tuvé[4], and the KnowRISK Team

[(1)] Instituto Superior Técnico, Portugal (csoliv@civil.ist.utl.pt), [(2)] Laboratório Nacional de Engenharia Civil (LNEC), Portugal, [(3)] Earthquake Engineering Research Centre, University of Iceland, Iceland, [(4)] Istituto Nazionale di Geofisica e Vulcanologia, Italy

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Know your city
Reduce seISmic risK
through non-structural elements

The KnowRISK Team

C. S. Oliveira, M. A.l Ferreira, D. S. Silva, G. Musacchio, R. Rupakhety

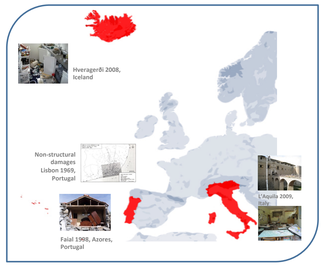
S. Falsaperla, F. Meroni, M. Lopes, J. M. Proença, F. Mota de Sá, P. Candeias, A. C. Costa, P. Machado, Á. Pereira, R. Azzaro, M. Crescimbene, S. D'Amico, E. Eva, H. Langer, G. L. Piangiamore, N. A. Pino, D. Reitano, S. Solarino, T. Squarcina, L. Scarfi, G. Tusa, T. Tuvé, P. Acharya, S. Olafsson, S. Þorvaldsdottir

Summary Non-structural components of a building include all those components that are not part of the structural system, more specifically the architectural, mechanical, electrical, and plumbing systems, as well as furniture, fixtures, equipment, and contents. Securing the non-structural elements improves the safety during an earthquake and saves lives. KnowRISK aims at identifying non-structural seismic protection measures in the three pilot areas (Portugal, Italy and Iceland) and at developing a portfolio of good practices for the most common and serious non-structural vulnerabilities. This systematic identification and portfolio will be achieved through a "cross-knowledge" strategy between previous researches and evidence of non-structural damage in past earthquakes. Shake table tests of a group of non-structural elements will be performed. These tests will be filmed and, jointly with portfolio, will serve as didactic supporting tools to be used in workshops with building construction stakeholders and in risk communication activities. A Practical Guide for citizens will be prepared on the basis of the outputs of other project Tasks and taking into account the local culture and needs of each participating country.

Common non-structural elements

Non-structural elements of a building are those elements that will not cause a building to collapse if they fail, but might cause injury and might temporarily affect the use of the structure, causing a loss of function.

Non- structural elements include:
- **Building contents**: furniture, book cases, computers and desktop equipment
- **Exterior building elements**: parapets, chimneys, exterior facing windows and doors
- **Interior building elements**: partition walls, suspended ceilings
- **Building utilities**: heavy equipment , pipes/ducts and connections for heating, AVAC, electricity, gas, water , communications and elevator systems.



Post-EQ damage observations

- **1964 Alaska EQ**: Economic loss due to non-structural components in the order of 65-70%.
- **1971 San Fernando EQ**: Significant financial loss due to non-structural elements.
- **1989 Loma Prieta EQ**: 95% injuries were caused by falls, being struck by falling or overturned objects, or being thrown into objects.
- **1989 Loma Prieta EQ**: the streets of San Francisco´s financial district were covered by broken glass, and people were buried under the facade of brick building that fell forward into the streets.
- **2000 and 2008 Iceland EQ**: Majority of losses are due to non-structural elements.
- **2014 Napa Valley EQ**: significant non-structural and contents damage
- **2016 Alborán sea** (Morocco) EQ: Essentially non-structural damages.

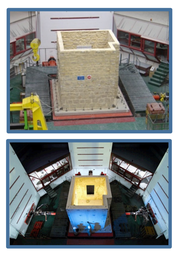
Damage on industrial storage racks, 1980 Terceira (Portugal).

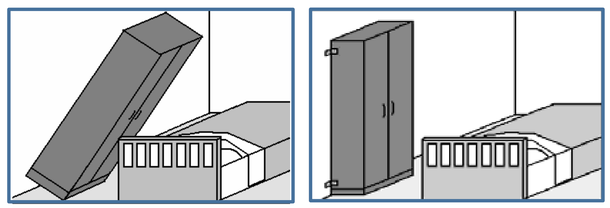
Ornamental exterior appendages after L'Aquila earthquake.

Damage to ceiling systems (Hospital) surveyed in 2009 L'Aquila (Italy).

Shaking table tests

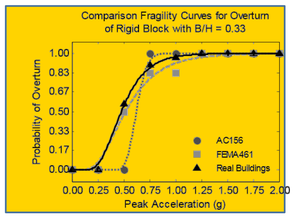
Shaking table tests will be performed in the laboratories of LNEC in Portugal, to investigate the behavior of anchored and unanchored content inside the building, including furniture items and objects. LNEC 3D shake table has a platform with dimensions of 4.6 m by 5.6 m and a height clearance of around 8 m.





Anchored and unanchored interior furnishings and contents will be tested

The outcomes of the shaking table tests will be utilized to derive fragility curves for some non-structural elements.



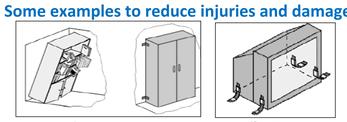
Comparison fragility curves for several testing protocols. Rocking block B/H=0.33 (Source: https://nees.org/site/resources/pdfs/Burningham)

The value of these tests are extremely high in terms of educational materials (disaster mitigation education): Shake table test will be used also to promote dissemination for general public and schools through various types of movies.

Portfolio Solutions & Practical Guide

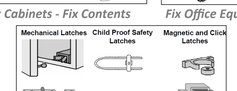
Earthquake damage to non-structural components and contents poses direct and indirect threat to safety of people as well as loss of critical function and economy. In this context, a focused research is required to:
- Better understand the performance of non-structural components and contents;
- Prepare safe design methodologies and installation procedures by using low-cost solutions;
- Prepare with help of industry a kit with the minimum tools to fix some contents.

Some examples to reduce injuries and damage during earthquakes by securing nonstructural hazards



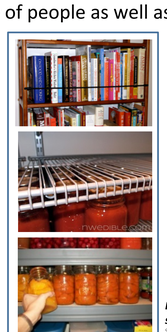
Fix Cabinets - Fix Contents

Fix Office Equipment



Fix Equipment
Source: http://www.justritemfg.com/products

Push-latches for cabinets
Source: http://quaketips.blogspot.pt/



Elastic bands or shelf lips to secure shelved items
Source: http://quaketips.blogspot.pt/; http://blink.ucsd.edu/safety

Many portfolio and practical guides on non-structural elements are already available.
The KnowRISK goal complies with the following objectives:
- Privilege solutions that are economically feasible, easy to implement and viewed as socially acceptable by building construction stakeholders and citizens.
- Reduce damages or losses that limit individual and community livelihood, could impact safe evacuation, continued operations, and rapid recovery for many businesses.
- Schools
- Public in general

Portfolio solutions — Provides information on effective methods for reducing risk associated with non-structural earthquake damage. It is intended for use by a nontechnical audience (building owners, maintenance personnel, store or office managers, agency department heads, and homeowners).
~100 pages

Practical guide — Handy guide and check list to quake safe your home and school.
~20 pages

KIT Fix it — "Fix it" is a earthquake protection Kit with fasteners for furniture, appliances, TVs and cabinets.

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References: *National Institute of Building Sciences (1997). HAZUS technical manual, National Institute of Building Sciences, Washington, DC | Burningham, C.; Mosqueda, G.; Saavedra, R.R. (2011) Comparison of seismic fragility of free standing equipment using current testing protocols and recorded building floor motions. University at Buffalo, State University of New York |*