fib/CNI International Seminar on
Precast Concrete in Seismic Regions
and International Perspectives

La sperimentazione sui prefabbricati a supporto della progettazione strutturale

Prof. Roberto Nascimbene – roberto.nascimbene@iusspavia.it

Thursday 29 September 08:45 - 19:00

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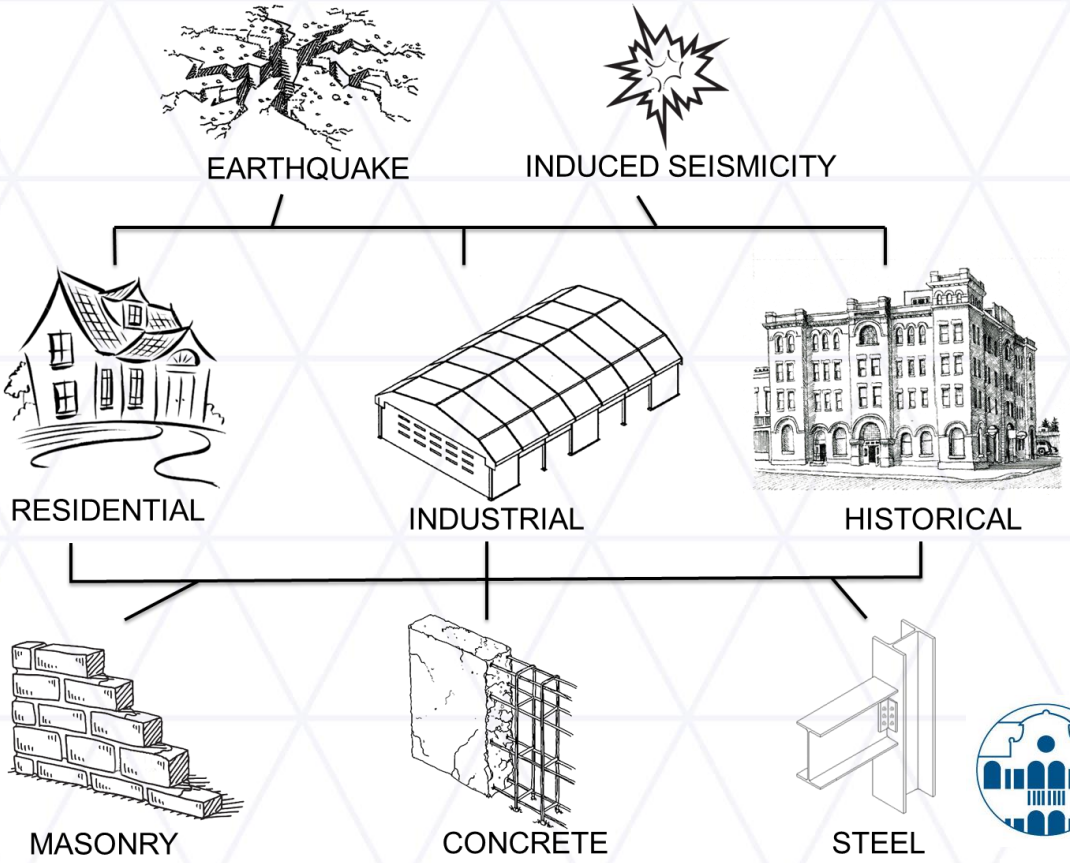
Outline of the presentation

1. Past earthquakes (direct experiences from European context – mainly Italy)
2. Field observation of damages on buildings – precast structures
3. Field observation of damages on industrial products – «non» - structures
4. **Can experimental and numerical techniques help us ?**



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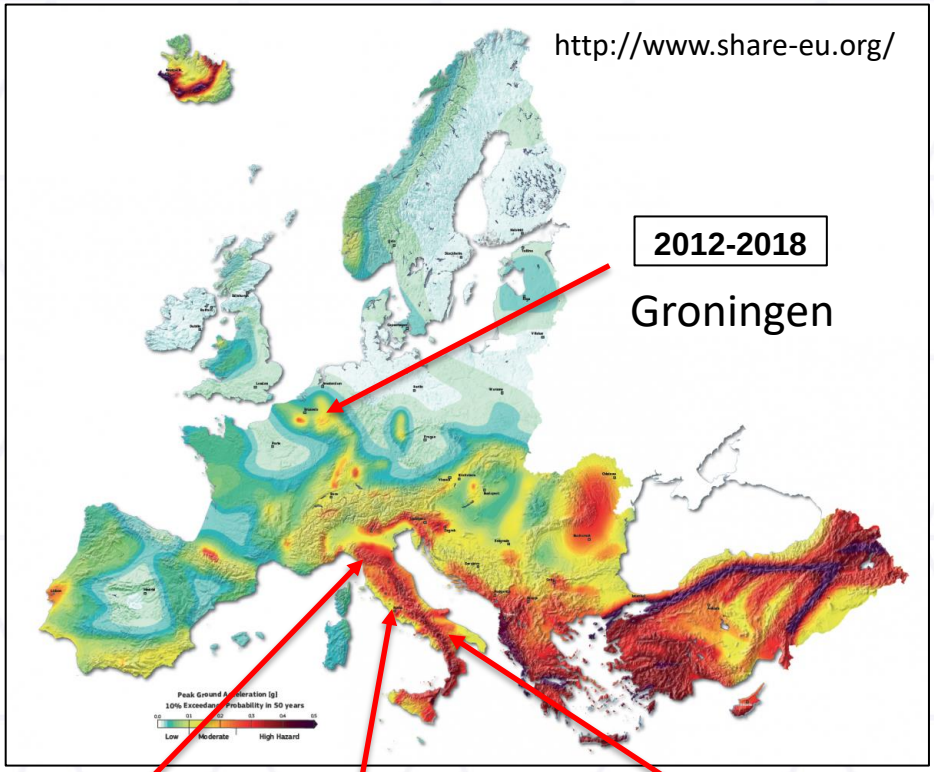
1. Past earthquakes (direct experiences from European context – mainly Italy)



http://www.eqclearinghouse.org

2009

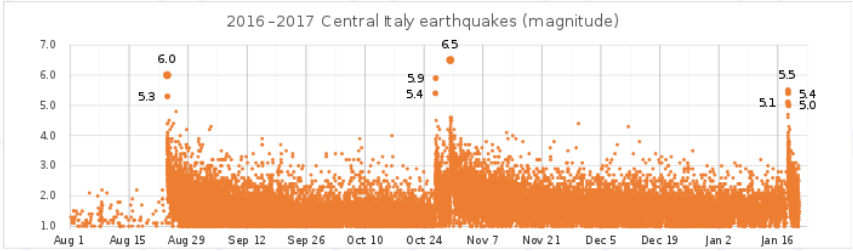
M 6.3 April 6, 03:32:00 UTC

2012

M 6.0 May 20, 02:03:52 UTC
M 5.8 May 29, 09:00:03 UTC

2016

M 6.0 August 24, 01:36 UTC
M 5.4 October 26, 17:10 UTC
M 5.9 October 26, 19:18 UTC
M 6.5 October 30, 06:40 UTC



Earthquakes from August 2016 to January 2017.

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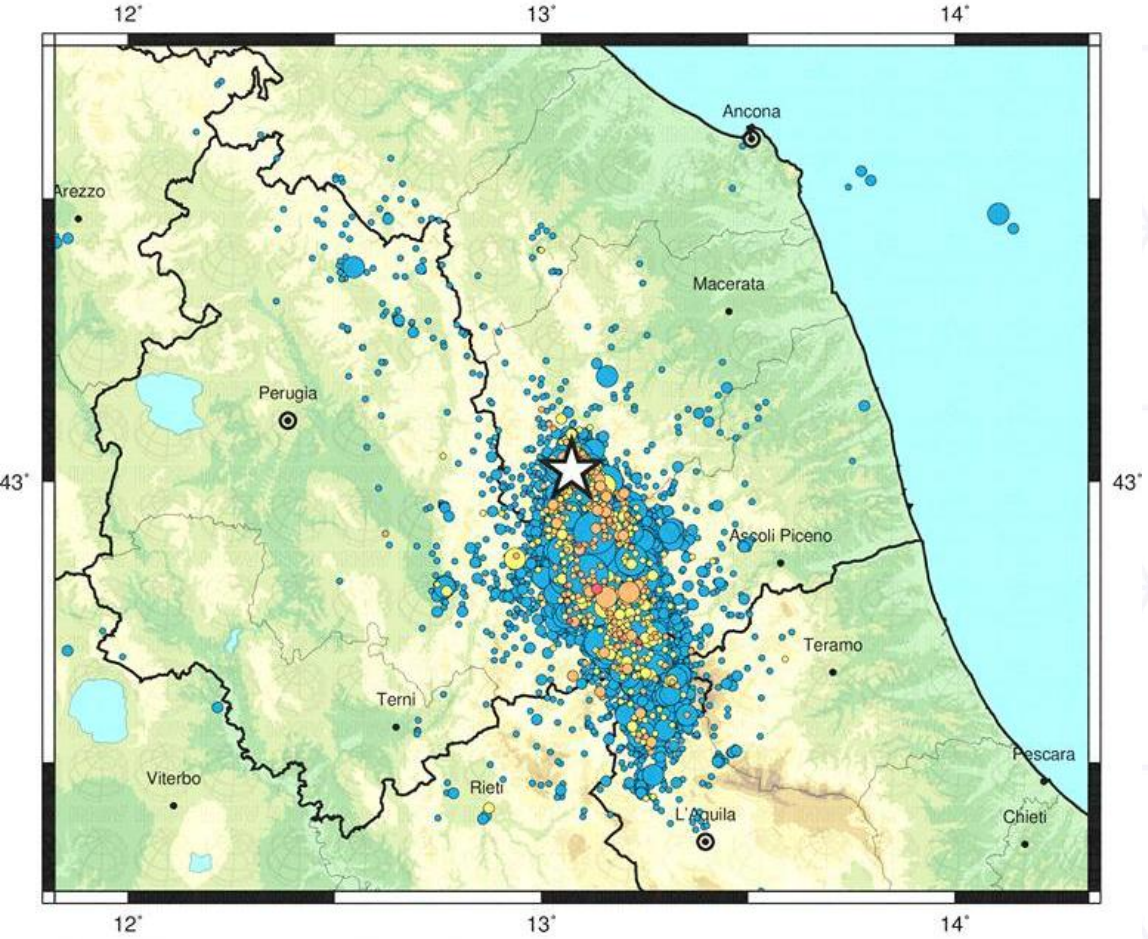
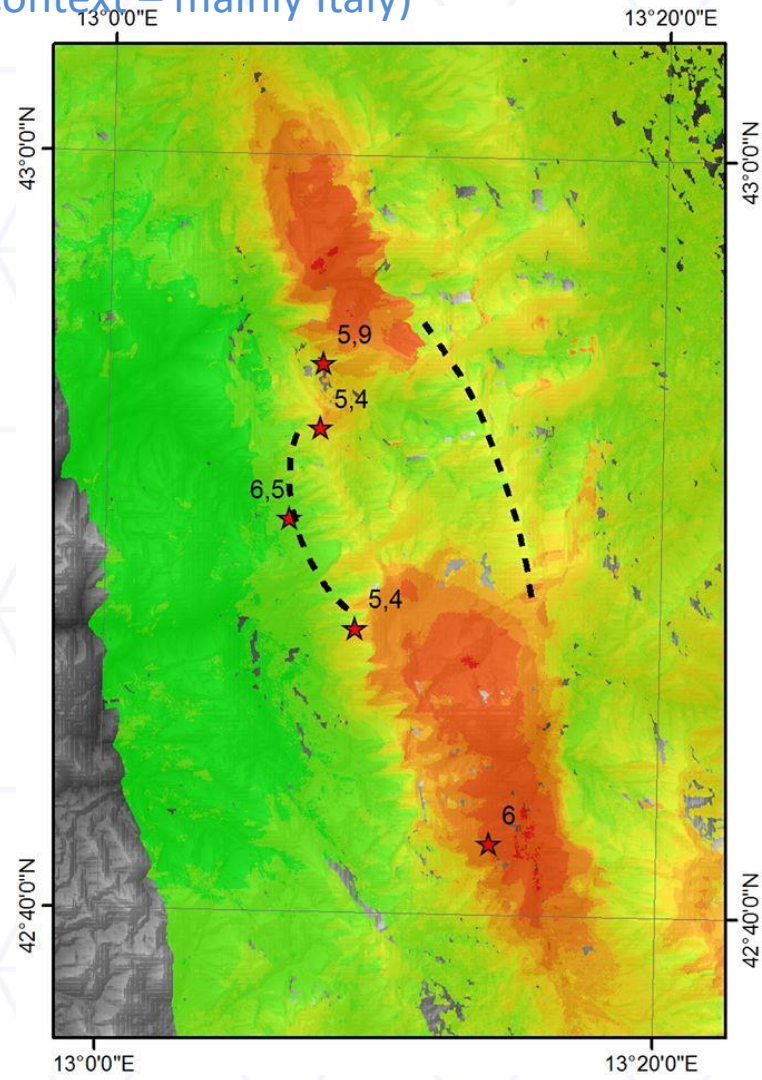
1. Past earthquakes (direct experiences from European context – mainly Italy)





Magnitudo

- da 1.0 a 1.9
- da 2.0 a 2.9
- da 3.0 a 3.9
- da 4.0 a 4.9
- da 5.0 in su

Tempi

- ultima ora
- ultime 24 ore
- ultime 72 ore
- giorni precedenti

Sono riportati gli eventi sismici localizzati dalla Rete Sismica Nazionale negli ultimi 90 giorni di magnitudo >= 1.0. Dati: iside.rm.ingv.it

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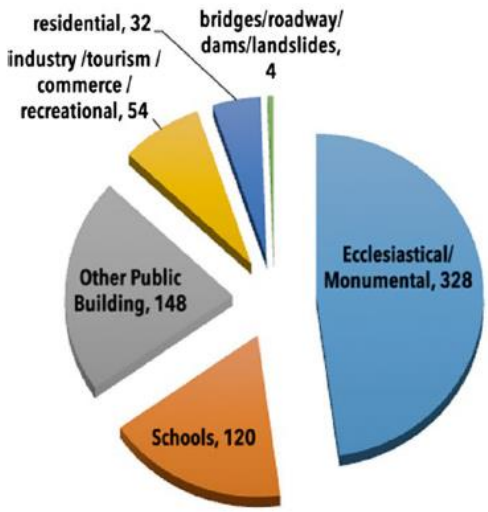
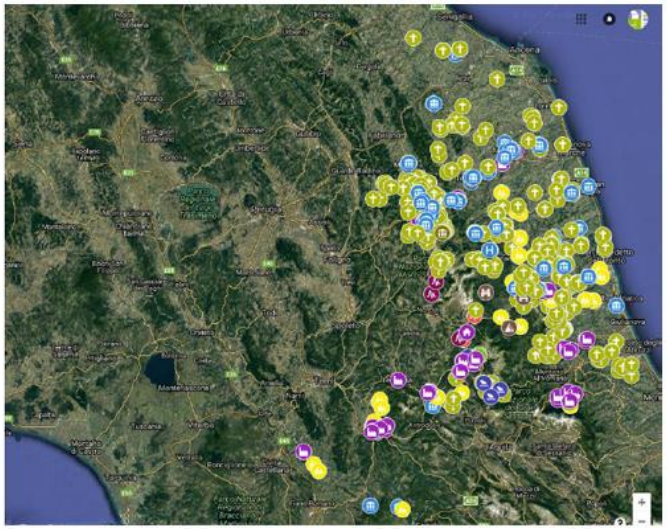
1. Past earthquakes (direct experiences from European context – mainly Italy)



Credits to Dr. Chiara Casarotti



About **700 inspections** were completed in the aftermath of the seismic events. Most of these inspections were performed on **critical** (schools, hospitals and public, industrial) and ecclesiastical/ monumental buildings.

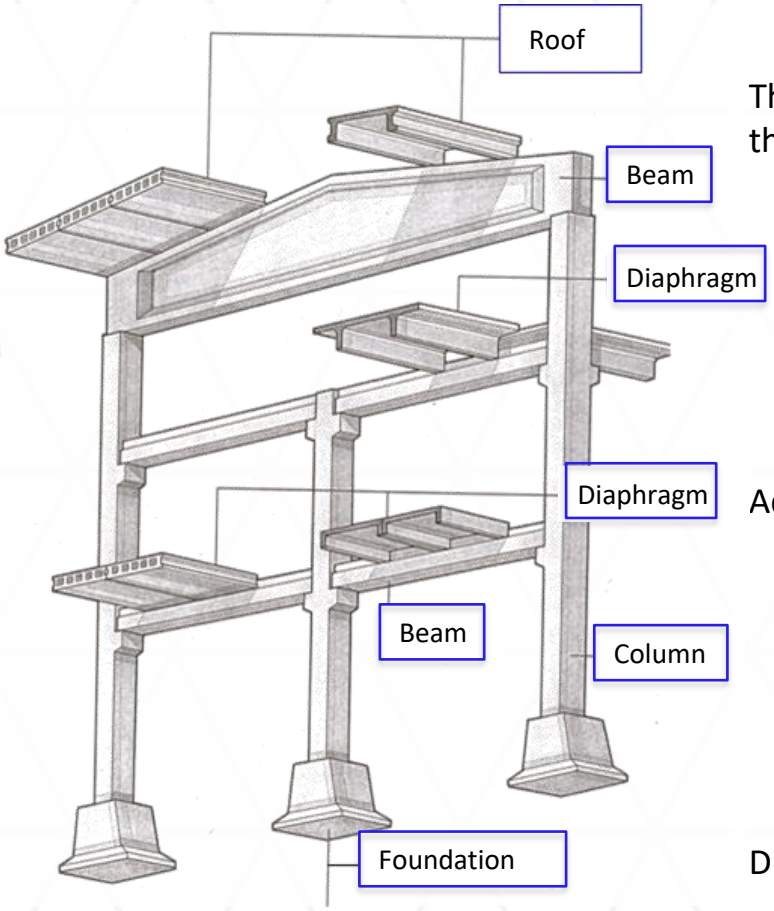
1. **Infill walls, internal partitions and facade**
2. **Ceiling systems**
3. **Piping systems**
4. **Storage racks**
5. **Chimneys, appendages and parapets**
6. **Glazing systems**
7. **Mechanical equipment and tanks**
8. **Hospital medical equipment**
9. **Stuccoes, decoration and roof tiles**
10. **Precast**
11. **Masonry**
12. **Reinforced concrete**

What about performance ?

2. Field observation of damages on buildings – structures

PRECAST

- Precast Structure: assembly of elements (columns, beams, joists) produced in specific factories, carried to the field and assembled (or produced in-situ)
- Prefabrication: “industrialized managing of RC members production”, developed in connection with the evolution of prestressing techniques in concrete elements, aiming to reach an optimized constructive process



The adoption of precast structural elements has progressively grown since the mid-fifties, due to favorable conditions as:

- improvement in basic material performance and quality checks
- improvement in industrialized production techniques
- development of prestressing techniques for RC members
- development of road network
- industrialization applied to constructive process

Advantages

- Speed of construction
- Relatively low costs
- Quality check of products
- Improved performance in static conditions and against fire
- Material durability

Disadvantages

- Transportation

2. Field observation of damages on buildings – structures

PRECAST

Recent major earthquakes in the Italian territory have reaffirmed the seismic vulnerability of precast industrial buildings typical of past **European building practices**, highlighting structural deficiencies observed during previous events and primarily related to the transfer of horizontal forces between structural and nonstructural elements.

Loss of bearing capacity in correspondence of the principal beam of one-storey precast structure. Subsequently built up transverse beams (due to an enlargement of the existing building) with friction-only beam-column connection

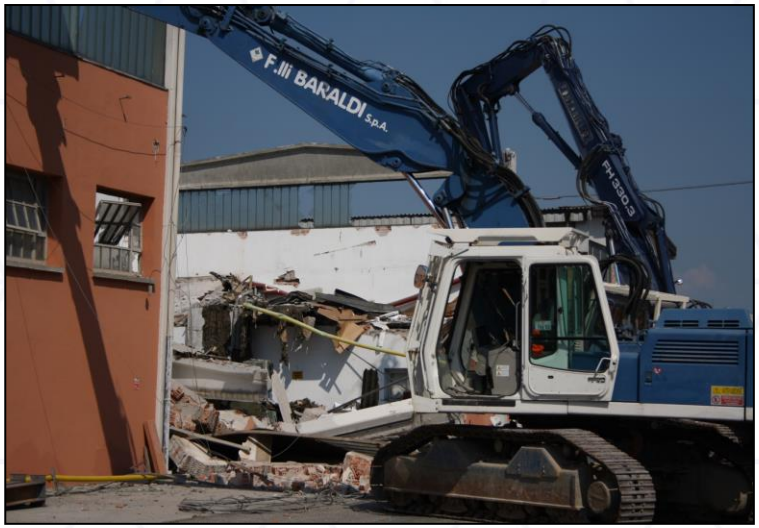
2. Field observation of damages on buildings – structures

PRECAST

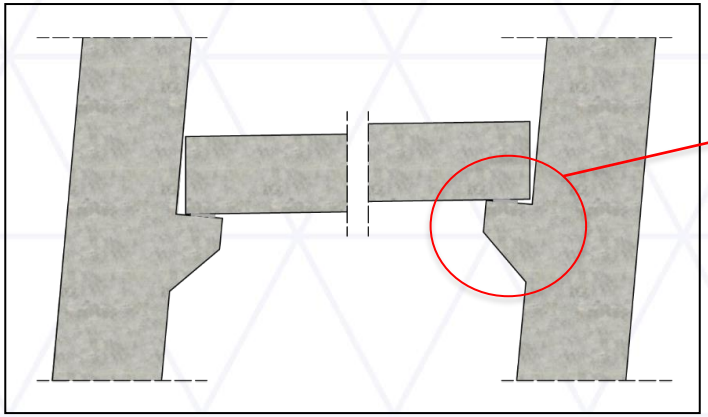
2. Field observation of damages on buildings – structures

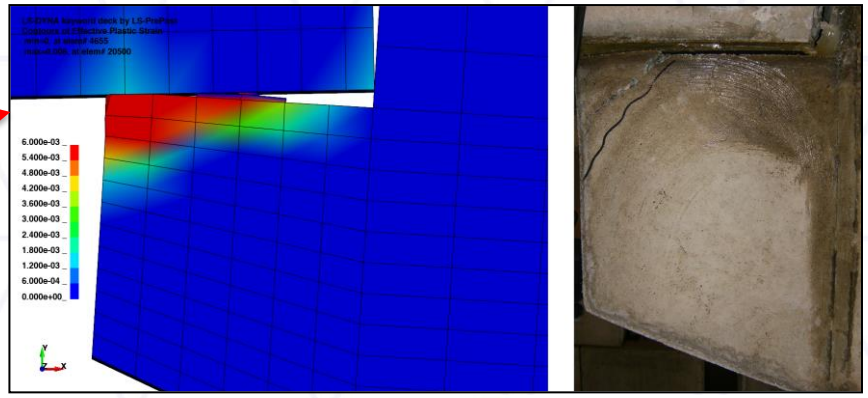
PRECAST

29th may 2012



28th may 2012





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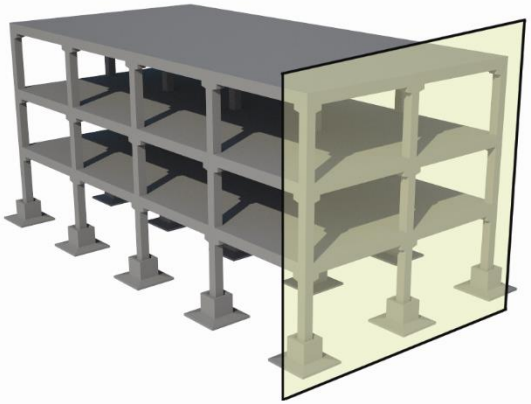
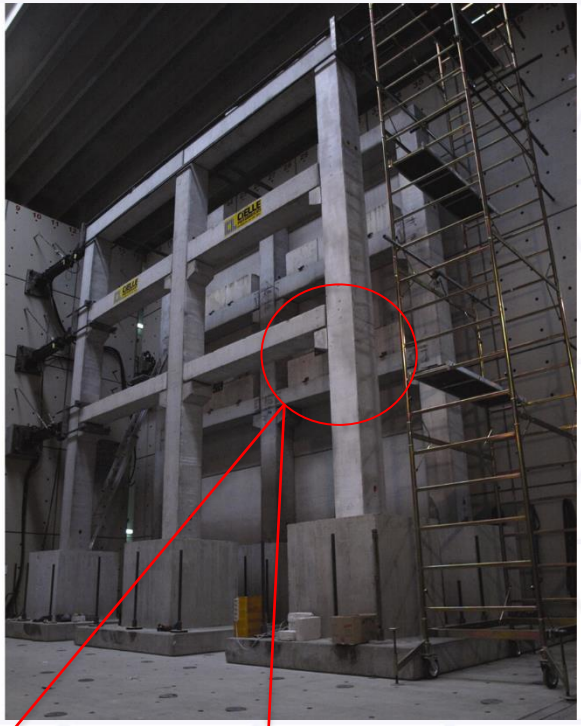
4. Can experimental and numerical techniques help us ?

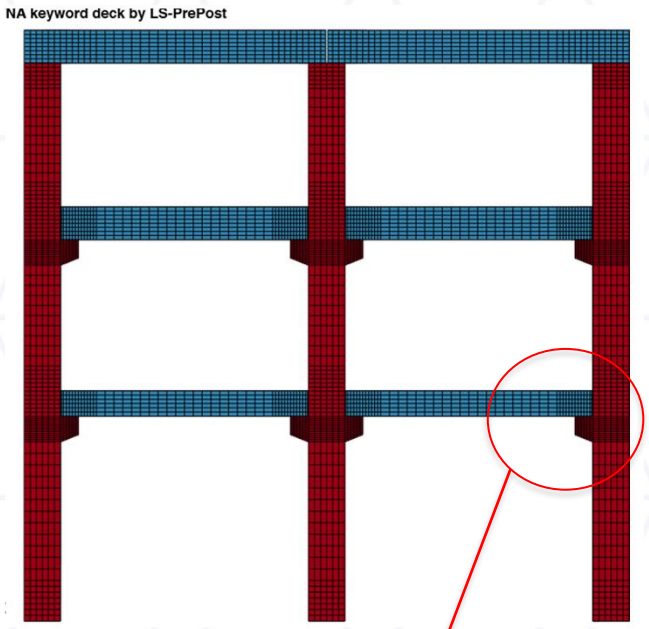
2. Field observation of damages on buildings – structures

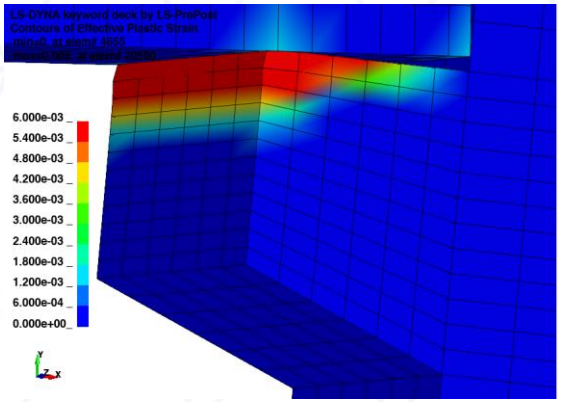
PRECAST (FRAME)

Floor	Floor height, mm	Beam height, mm	Beam weight, kN	Dead load, kN	Live load, kN	Total distributed, kN/m
3	7900	450	18.6	20.0	10.0	8.70
2	5500	450	18.6	27.0	20.0	13.6
1	3100	350	16.6	42.0	25.0	19.4

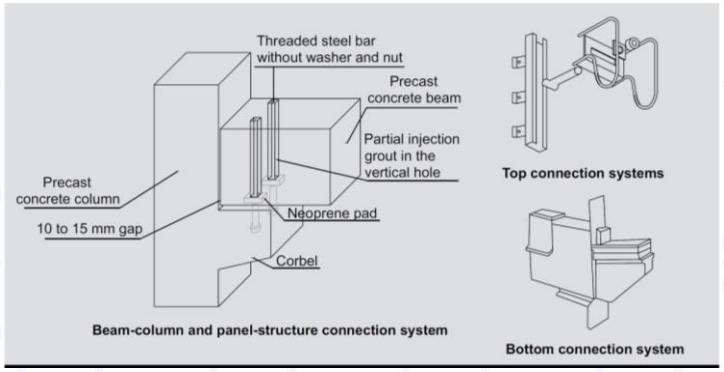


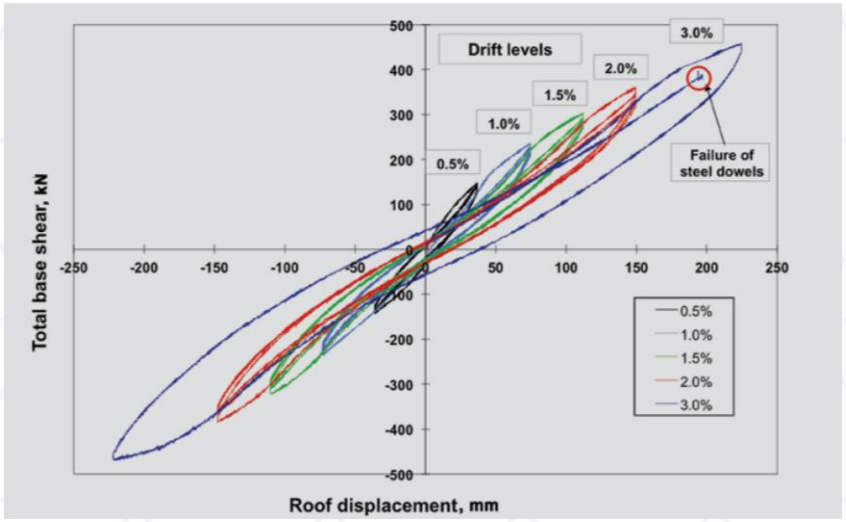




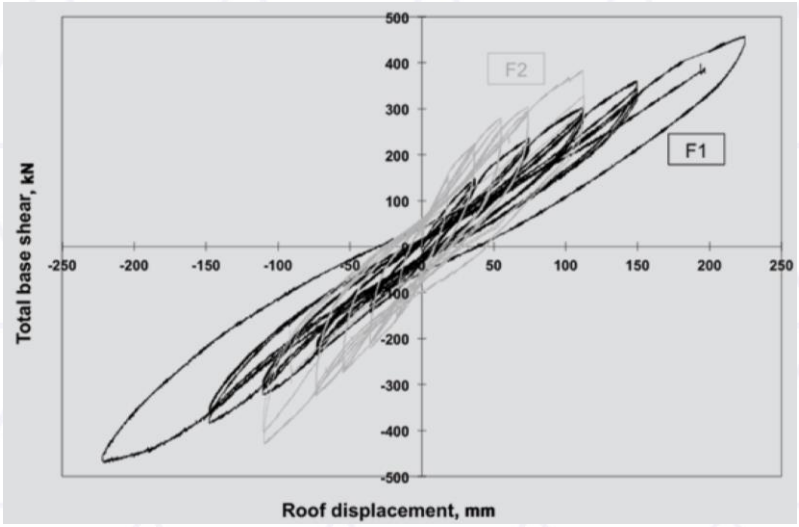


PRECAST (FRAME)





global response of the bare frame F1 in terms of total base shear versus roof displacement hysteresis loops



Total base shear versus roof displacement hysteresis loops of prototype F2 with panels

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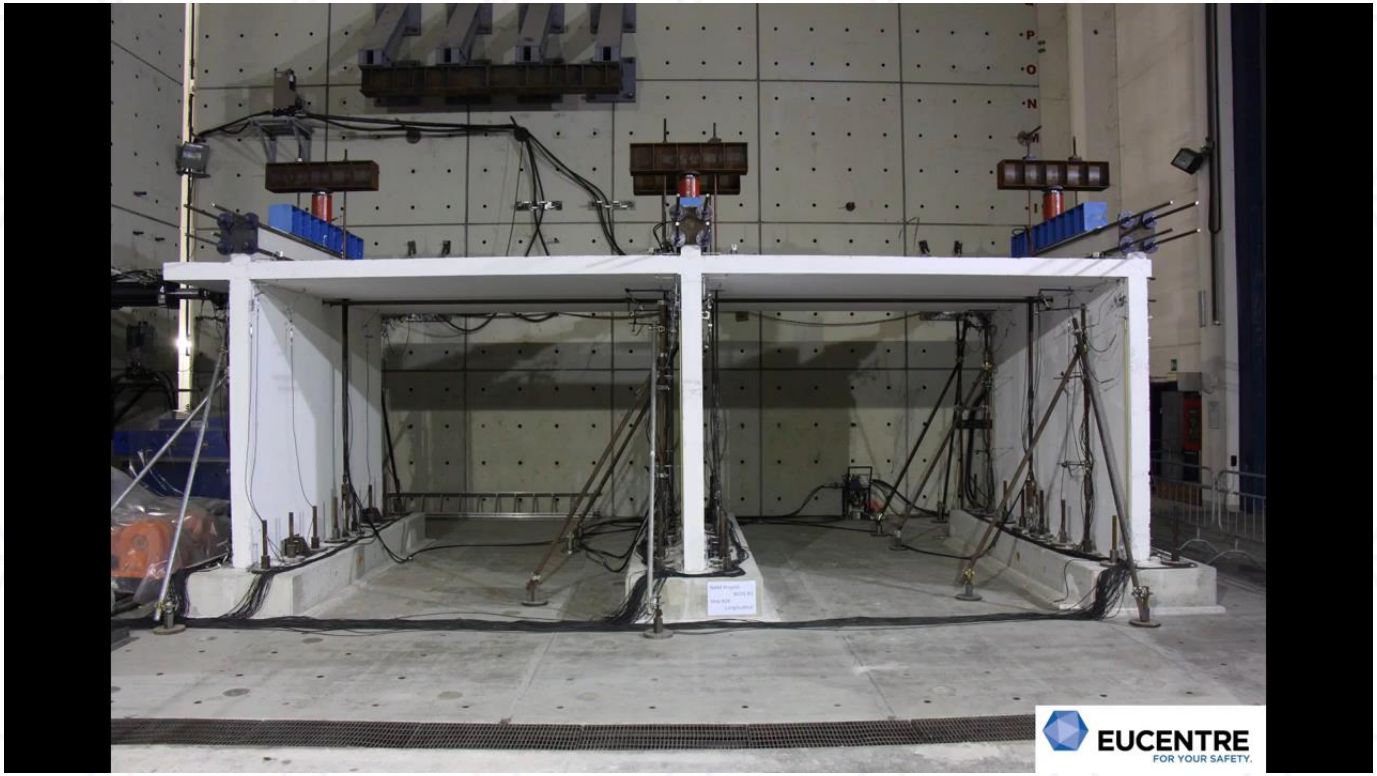
PRECAST (PANEL)

SHAKELAB
EUCENTRE



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Testing of precast houses (friction-based connections)

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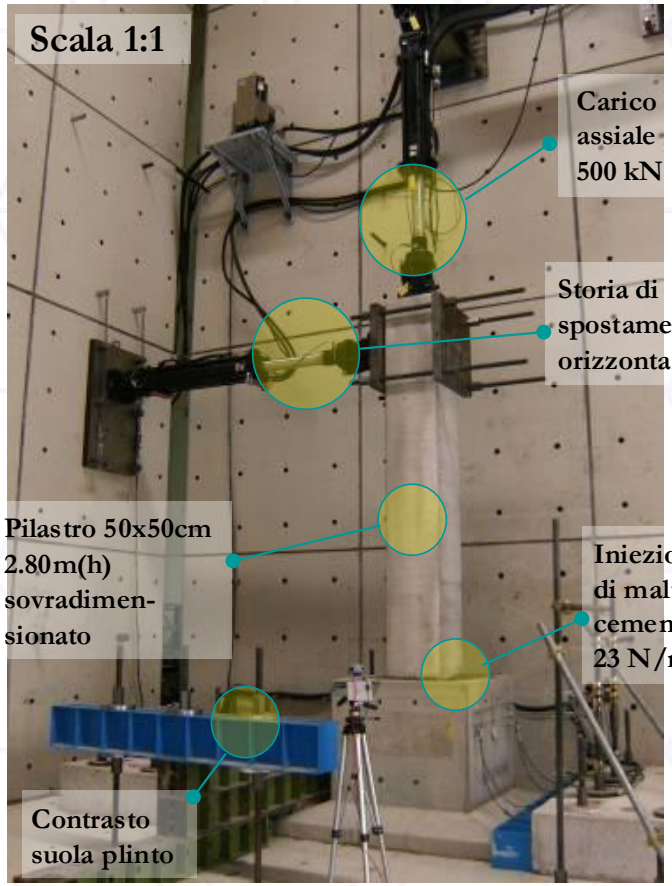
PRECAST (Pocket foundation)



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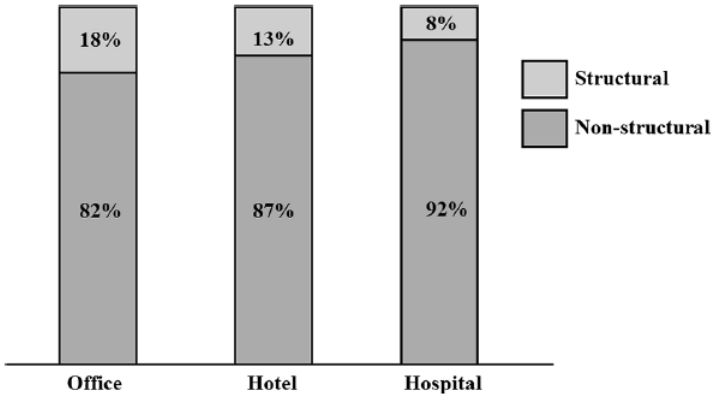
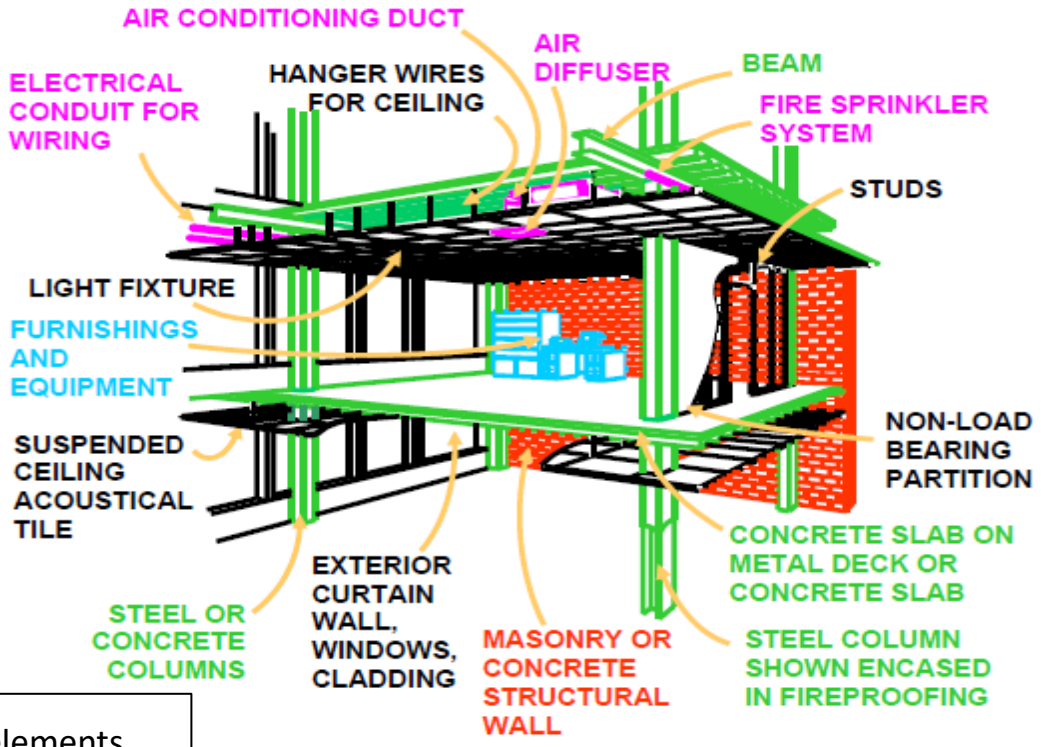
3. Field observation of damages on industrial products – «non» - structures

Non-structural elements represent most of the total construction cost of typical buildings. A significant portion of the total losses in recent earthquakes worldwide, has been attributed to damage to non-structural elements. Damage to non-structural elements occurs at low levels of ground shaking, and can significantly affect the post-earthquake functionality of buildings.





- ✓ Architectural elements
- ✓ Contents
- ✓ Mechanical Equipments

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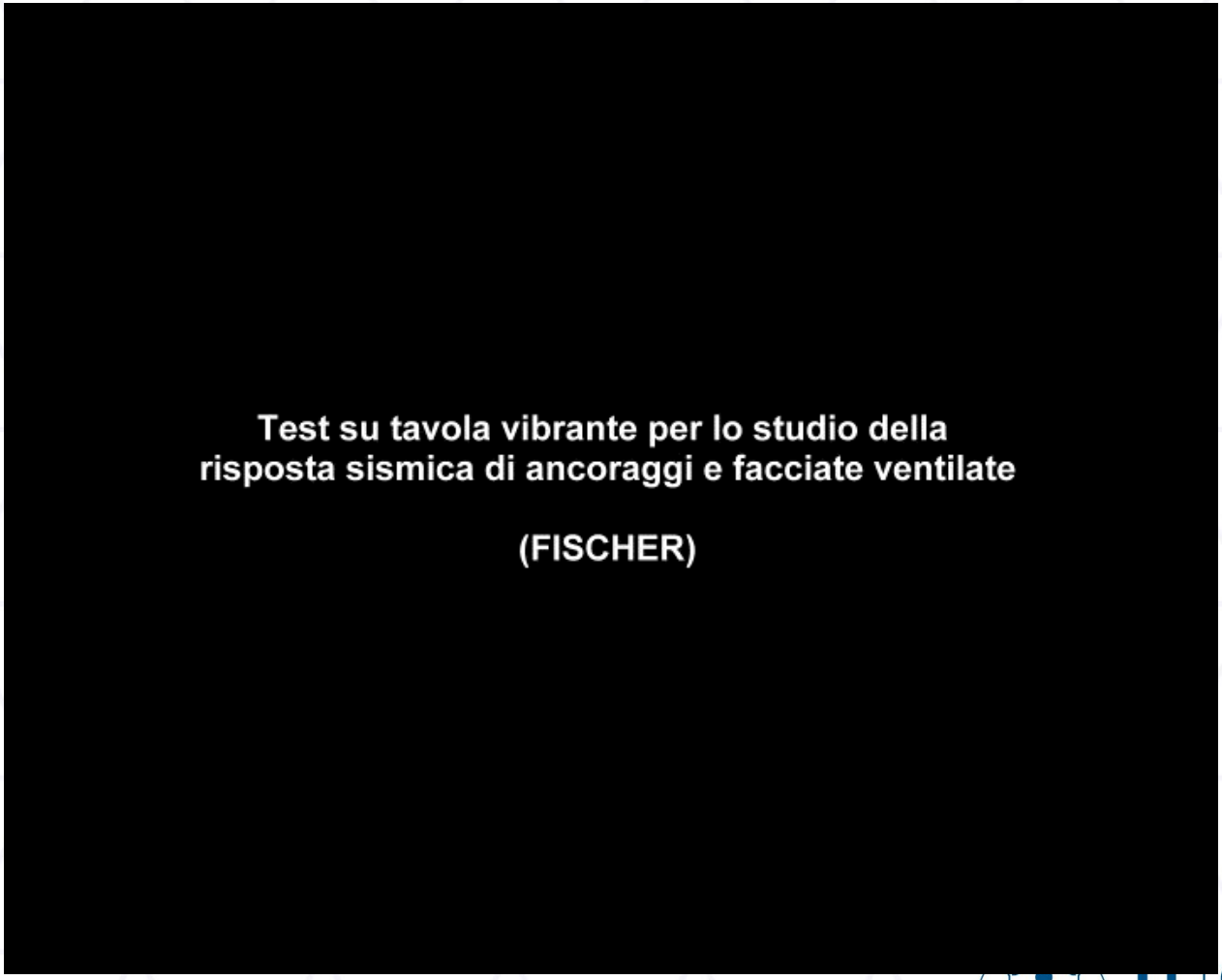
3. Field observation of damages on industrial products – «non» - structures



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Infill walls, internal partitions and facade

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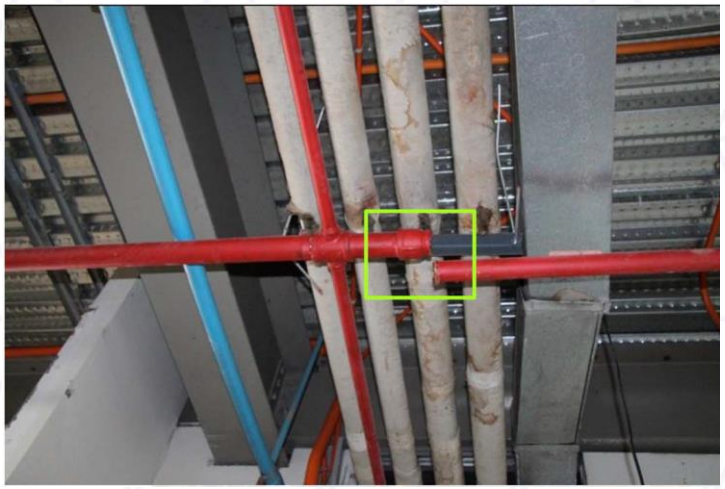
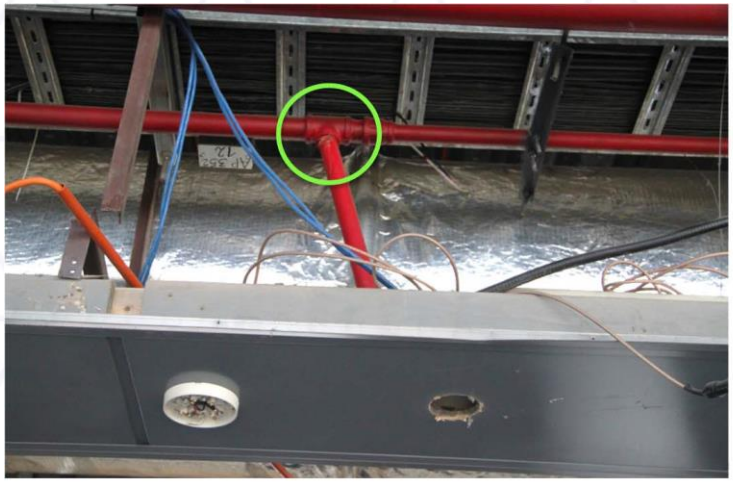
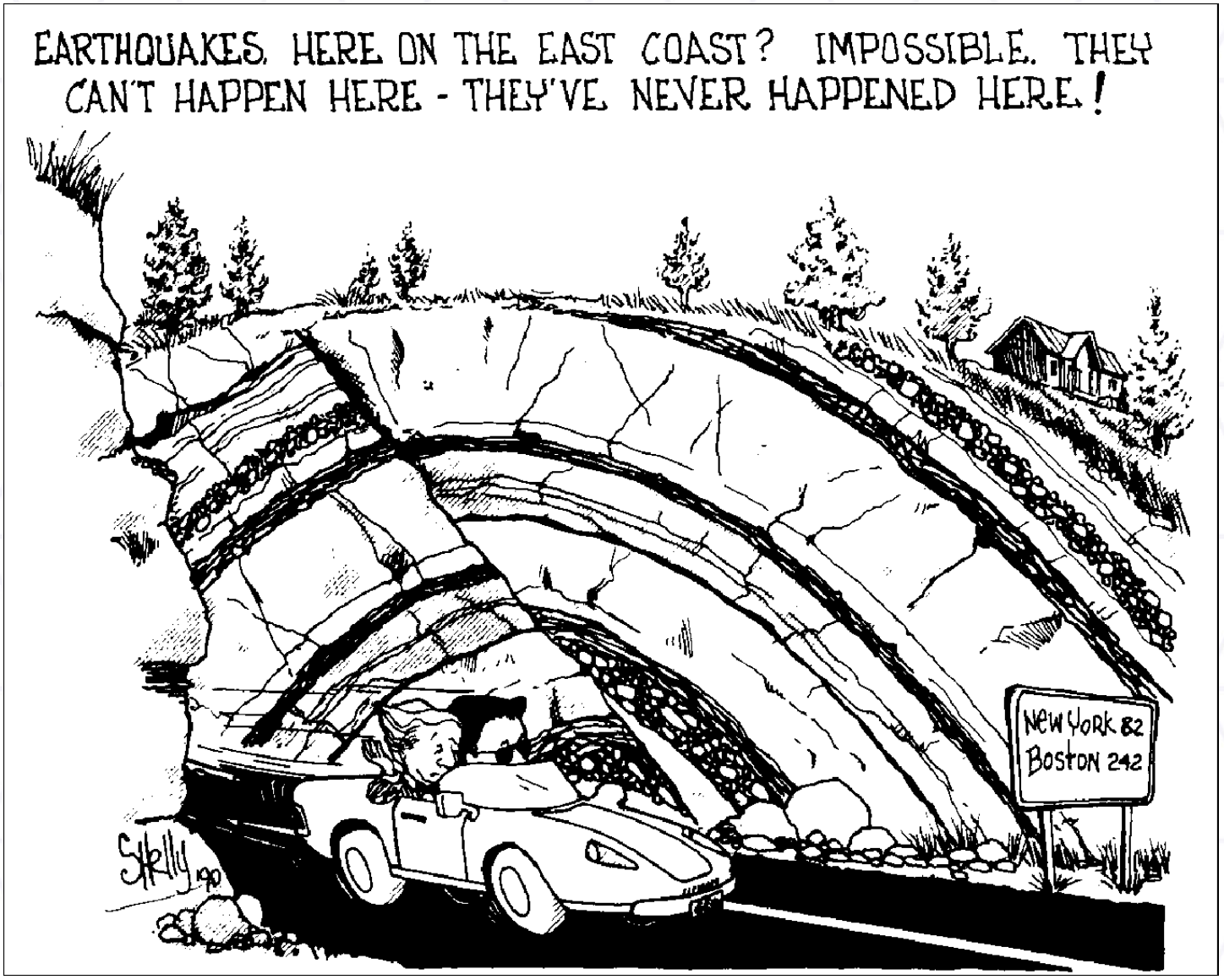
Piping systems





Closeup view

Glazing systems and facade



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