IMPACT OF PAST AND FUTURE EARTHQUAKES

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Earthquake effects on the Earth’s surface

1 – Fault rupture
2 – Landslides, liquefaction and subsidence
3 – Tsunamis
4 – Fires
5 – Strong Ground motion (seismic wave propagation)
Ground Motion

- Main cause of damage (more than 80% appr.)
- It affects all zones around the epicenter ⇒ its consequences can not be avoided only with urban planning instruments
- After the earthquake starts, no human action is possible before the motion is felt
- Civil Protection – acts after the Emergency is declared ⇒ it is too late to avoid the worse

**SOLUTION:** build and strengthen constructions and infra-structures that resist to the effects of ground motions ⇒ **PREVENTION**
Learning from earthquakes of last decade

1994 – Northridge – California (M\leq 7)
Lifelines (bridges)
Learning from earthquakes of last decade

1995 – Kobe – Japan (M≤7)

Lifelines (bridges), factories, post-war R/C and steel buildings
Learning from earthquakes of last decade

1999 – Turkey – (M>7)
post-war R/C buildings
Learning from earthquakes of last decade

1999 – Chi Chi – Taiwan (M>7)

Modern R/C bridges, Modern buildings
Learning from earthquakes of last decade

1997 – Umbria-Marche – Italy (M<6)

Cultural heritage,
Old historical centres,
Poor masonry buildings
Learning from earthquakes of last decade

1999 – Athens – Greece (M<6)
Neighborhoods of a metropolitan area,
Recent
R/C buildings
Learning from earthquakes of last decade

2002 – S. Giuliano – Italy (M<6)

Schools
Potentially destructive earthquakes occur regularly in Europe.

- **31.10.02 Italy, San Giuliano di Puglia** – collapsed school - 27 deaths
- **1.5.03 Turkey, Bingöl** – collapsed school - > 100 deaths
- **21.5.03 Algeria, Boumerdes** – > 2200 deaths – collapsed hospital
- **17.8.1999 Kocaeli, Turkey**: 17,000 deaths
Many existing buildings and facilities are unsafe by today’s standards...

- Building types most at risk are: old unreinforced masonry buildings AND reinforced concrete framed buildings built without seismic design requirements
- Many public buildings, including schools, hospitals and highway structures are unsafe
The historic centres of several major European cities are at risk…
LAST 40 YEARS ITALIAN EARTHQUAKES COSTS (M€-2005)
Today simulation scenario of 1908 earthquake - mean values

| Casualties (dead+injured) No. | Collapsed homes No. 141,000 | Unusable homes No. 204,000 | Damaged homes No. 728,000 | Evacuated people No. 400,000 | Cost of damage to dwelling buildings M€ 25,000 |

N.B: The economic loss is evaluated with reference to the damaged surface area of houses, for a 820 Euro/sqm reconstruction cost.
### Today simulation scenario of 1915 earthquake - mean values

<table>
<thead>
<tr>
<th>Casualties (dead+injured)</th>
<th>Collapsed homes</th>
<th>Unusable homes</th>
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<th>Evacuated people</th>
<th>Cost of damage to dwelling buildings</th>
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</thead>
<tbody>
<tr>
<td>No.</td>
<td>No.</td>
<td>No.</td>
<td>No.</td>
<td>No.</td>
<td>M€</td>
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<tr>
<td>22 500</td>
<td>36 000</td>
<td>206 000</td>
<td>980 000</td>
<td>385 000</td>
<td>20 000</td>
</tr>
</tbody>
</table>

N.B: The economic loss is evaluated with reference to the damaged surface area of houses, for a 820 Euro/sqm reconstruction cost.
Events with $M \geq 5$ considered in the simulation scenarios of last two centuries earthquakes

103 events
1801-1900

164 events
1901-2000

Eventi 1800-1900
Magnitude Ms
- 5.00 - 5.50
- 5.51 - 6.00
- 6.01 - 6.50
- 6.51 - 7.00

Eventi 1900-2000
Magnitude Ms
- 5.00 - 5.50
- 5.51 - 6.00
- 6.01 - 6.50
- 6.51 - 7.00
- 7.01 - 7.50
Based on the last two centuries earthquake history, in the XXI century one could expect:

**ITALIAN SEISMIC RISK XXI CENTURY PROJECTIONS**

- **500 - 2000 casualties / year**
  - $\Rightarrow$ 50000-200000 casualties in total

- **1 - 2 billion Euros / year**
  - $\Rightarrow$ 100-200 billion Euros in total

**N.B.:** The cost estimation is relevant to dwellings only. Total reconstruction costs should include also public and monumental buildings, and infraructures, resulting in an estimated increase of the order of 50-100%.
REASONS FOR HIGH EARTHQUAKE COSTS

HIGH VULNERABILITY OF THE REAL ESTATE DUE TO:

- large number of historical and old buildings,
- degradation of many urban suburbs,
- large number of illegal buildings, particularly in areas where seismic hazard is higher,
- bad knowledge of seismic hazard in the past,
- inadequacy of technical standards and of their application.
Seismic zonation in Italy followed the occurrence of earthquakes, until 1984.

Seismic codes implemented modern design criteria only in the last decade(s).
CONCLUSIONS

- There still exists in many parts of Europe a dangerously high level of risk of a high-casualty disaster from earthquakes.
- We know where the risk is highest and which types of buildings are most vulnerable.
- There are national activities and programmes in some European countries directed towards identifying high-risk buildings and reducing their numbers over time.
- But the experience of other countries suggests that little will be achieved without legislation; **this is an opportunity for the European Parliament**.
- The legislation needs to be backed up by technical and financial support.