CAUSES OF DAMAGES
AND
PREVENTIVE ACTIONS

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Securing Europe Against Future Earthquake Losses

CAUSES OF DAMAGES
Fault rupture

Turkey 1999

Taiwan 1999
Landslides
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**CAUSES OF DAMAGES**

**Liquefaction**
Turkey 1999

**Subsidence**
Turkey 1999
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CAUSES OF DAMAGES

Fault rupture  Landslides  Liquefaction  Subsidence

Actions against those causes of damage:

- Do not build:
  - research to define adequate construction sites
  - urban planning

- Soil improvement
  - special cases

- Design to withstand those effects
  - sometimes
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Causes Of Damages

Tsunamis

Sumatra 2004

Hakkeduwa, Sri Lanka

Maddampegama, Sri Lanka

Actions:

- Construction of dykes
- Construction of buildings above ground level
- Tsunami warning centers
- Education evacuation of the populations
- Preparation of the population by civil protection agencies

At short distance from potential epicenter:

Information to recognize the danger before the wave arrival:

Earthquake move, sea subsidence
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Causes Of Damages

**FIRES**

**Actions:**
- Information to the population to reduce risk of gas escapes at homes
- Adequate Design of gas networks and other facilities
- Urban planning to access of fire brigades and limitation of fire extension
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Causes Of Damages

Strong Ground Motion

Turkey, 1998

Greece, 1999

Structural failures

Turkey 1998

Romania, 1991
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Causes Of Damages

Strong Ground Motion

Structural failures

Falling objects

Belgium, 1983

Liege, 1983
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**Causes of Damage**

**Strong Ground Motion: main cause of EQ damages \( \approx 80\% \)**
- Affects all zones around the epicenter
- Consequences cannot be avoided with only urban planning
- After the earthquake at the epicenter no human action possible before only automatic action (EWS)
- Civil Protection actions: ► after the emergency is declared
  ► too late to avoid the worse
  ► vital to help after the earthquake

**Actions:**
- Build new constructions & infra-structures
- Strengthen old to resist to the effects of ground motions before earthquakes happen \( \Rightarrow \) **PREVENTION**

Structures and equipments can be ► designed
► strengthened to resist earthquakes
Examples of strengthening

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Additional RC frames or walls

France

Turkey
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Examples of strengthening

Switzerland

Additional steel bracings California
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Examples of strengthening

Additional ties  France
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Ground Motion

*Actions: technical means against ground motion effect*

- **Existing buildings:** evaluate the seismic resistance, strengthen where necessary, isolate. Best return: strengthen the worse ones.

- **New construction:** Quality control design materials, correspondence to drawings. Damages proportional to lack of quality.

- **Existing lifelines and transportation networks:** evaluate seismic resistance, strengthen where necessary, public and private, industry.

- **Existing “Seveso” type of industry:** impose re-evaluation! HIGH RISKS! low & high seismicity zones.

- **Monuments:** strengthen where necessary. Protection of built cultural heritage.
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Ground Motion

*Actions: means against ground motion effect*

- Saving lives: Civil Protection
  - Does not avoid the worse
  - Acts after the earthquake
  - Important to save live, feed people, stabilize buildings…
    absolutely necessary complement to “technical means”

Feeling impotent…
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Structures and equipments can be ► designed
► strengthened
to resist earthquakes and their effects

New & existing constructions: Eurocode 8 year 2004
National Annexes now

Actions to put technical means into practice.

Education
● Civil engineers: « easy EC8 » to prepare
● Architects !!!: learn seismic conceptual design
● Development of educational tool: “Seismic retrofitting at the occasion of architectural modifications”
● Agreed European curriculum (Bologna)

Enforcement
● consider EC8 for new buildings
● evaluate critical installations « Seveso »
● “European Seismic Certificate” compulsory for designers in seismic zones
● Engineer design compulsory in retrofitting including historical buildings
● Check of potentially falling non structural components