A Practical Strategy to Reduce Earthquake Risk for Critical Infrastructure Systems

Interdisciplinary Workshop on

Management of Earthquake Risks

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Content

- What is an infrastructure system and which function does it have during an earthquake?
- Types of infrastructure systems
- Experiences, behaviour during earthquakes and rehabilitation of infrastructural systems
- Measures to reduce the risks
- Example of a methodology

Infrastructure

Systems on regional scales

- Energy: Gas, electricity, pipelines, district heating
- Supply/disposal: Water, sewage, warehouse
- Transportation: Roads, railway, airports, ports
- Information: Telecommunication, radio, TV
- Health Services: Hospitals, medical services, pharmacies

: "Linear" elements (e.g. pipes, transmission lines, etc.)

: "Local" elements (e.g. command/control centres, etc.)

Importance of infrastructure

- Disaster response
  - intervention forces
  - telecommunication
  - medical services
  - transportation, etc.
- Survival phase
  - transportation
  - telecommunication
  - warehouses, etc.
- Reconstruction
  - transportation
  - energy
  - telecommunication, etc.

Big problem: Legal status of infrastructure

- Government-owned (e.g. public roads)
- Private (e.g. toll roads)
- Owned by individual Municipalities (e.g. water system)
- Owned by several Municipalities (e.g. regional water system)
- Private – public partnership

➔ Often no clear responsibilities

➔ Different requirements in neighbouring areas

➔ Interface problems

Reduced mode of infrastructure

- Daily working mode ➔ all services operational
- Emergencies, reconstruction ➔ reduced operational mode (has to be acceptable!)

Effects of earthquakes on infrastructure systems

Primary effects

- **Vibrations** (➔ important for buildings)
- **Subsoil deformations** (➔ linear elements)
  - slope instabilities
  - soil liquefaction
  - excessive settlements
  - tectonic deformations

Secondary

- **Flooding**
  - Seiches
  - Tsunamis
  - Dam brake
- **Fire**
- **Rock fall, avalanches, etc.**

Vulnerability of infrastructure systems

Important: **functionality** of individual elements and the system

function of („structures" ➔ no collapse,
equipment / installations ➔ remaining operation,
energy supply ➔ remaining operation,
control ➔ remaining operation,
redundancies ➔ available?)

Key competences of stakeholder

Utility

- **knowledge of network**
- **data base**
  - geology of area
  - construction history
  - materials
- **areas with damage accumulation**

Earthquake eng.

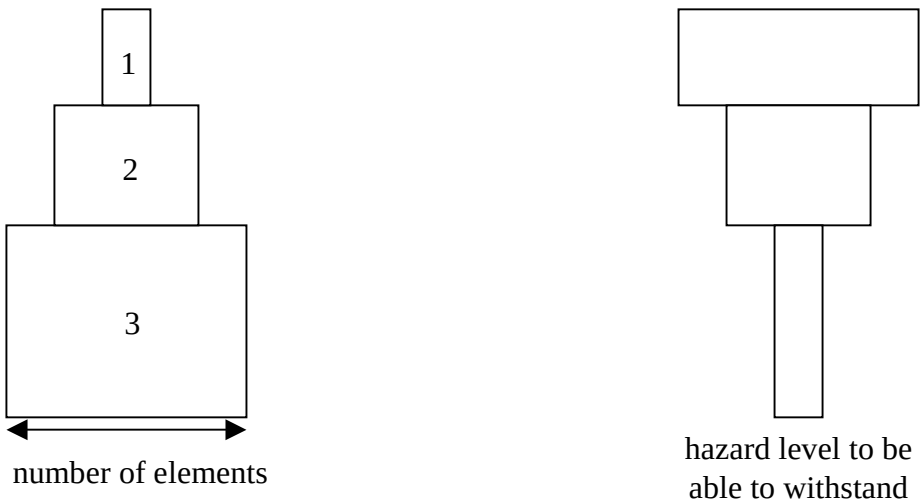
- **vulnerability assessment**
  - structures
  - equipments
  - pipes/ pipelines
- **hazard assessment**

Aim

➔ **Pre-defined function of entire system in pre-defined scenario event**

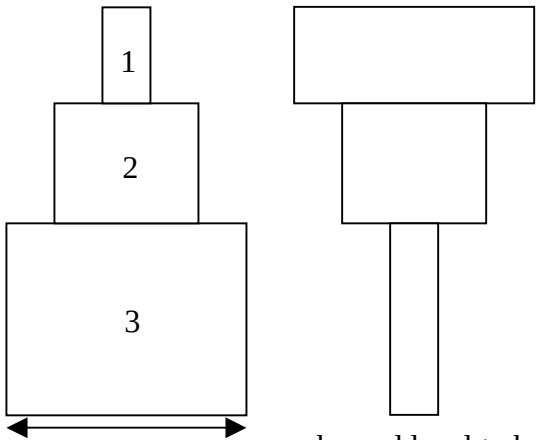
➔ Need: involvement of political authorities (e.g. local Governments)

Importance classes and hazard level



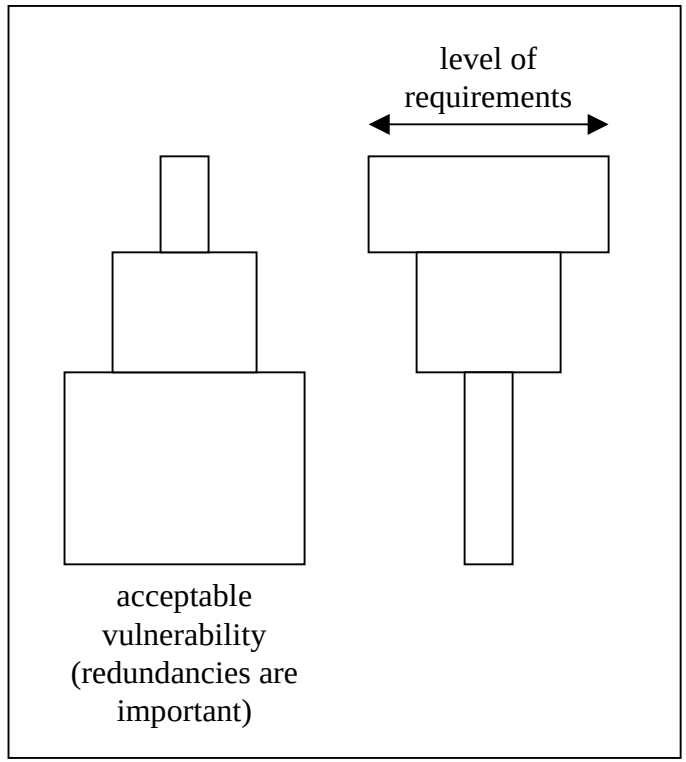
1: essential elements: e.g. command/control centres, main reservoirs, backbone distribution lines, etc.
2: important elements
3: less important elements: e.g. distribution systems to households, etc.

Acceptable vulnerability



number of elements

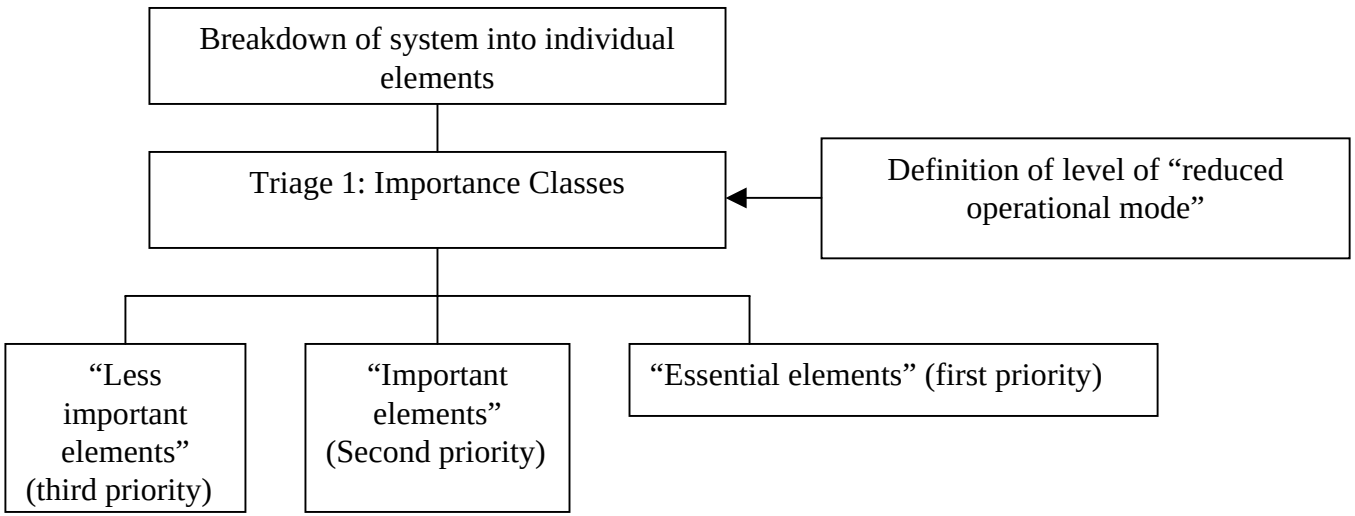
hazard level to be able to withstand



acceptable vulnerability (redundancies are important)

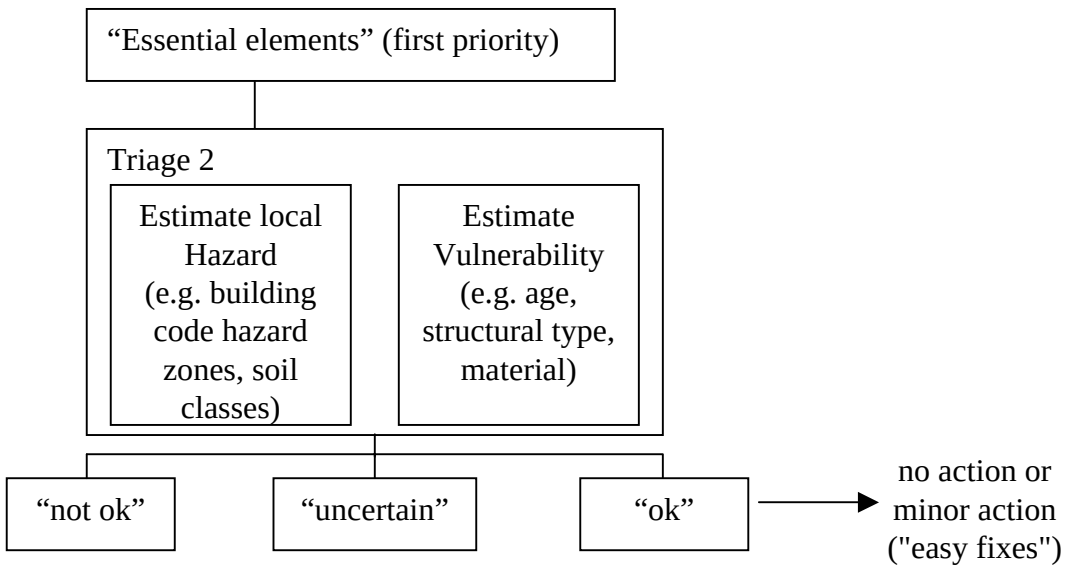
1: essential elements
2: important elements
3: less important elements

Measures to reduce the vulnerability of infrastructure systems (1)



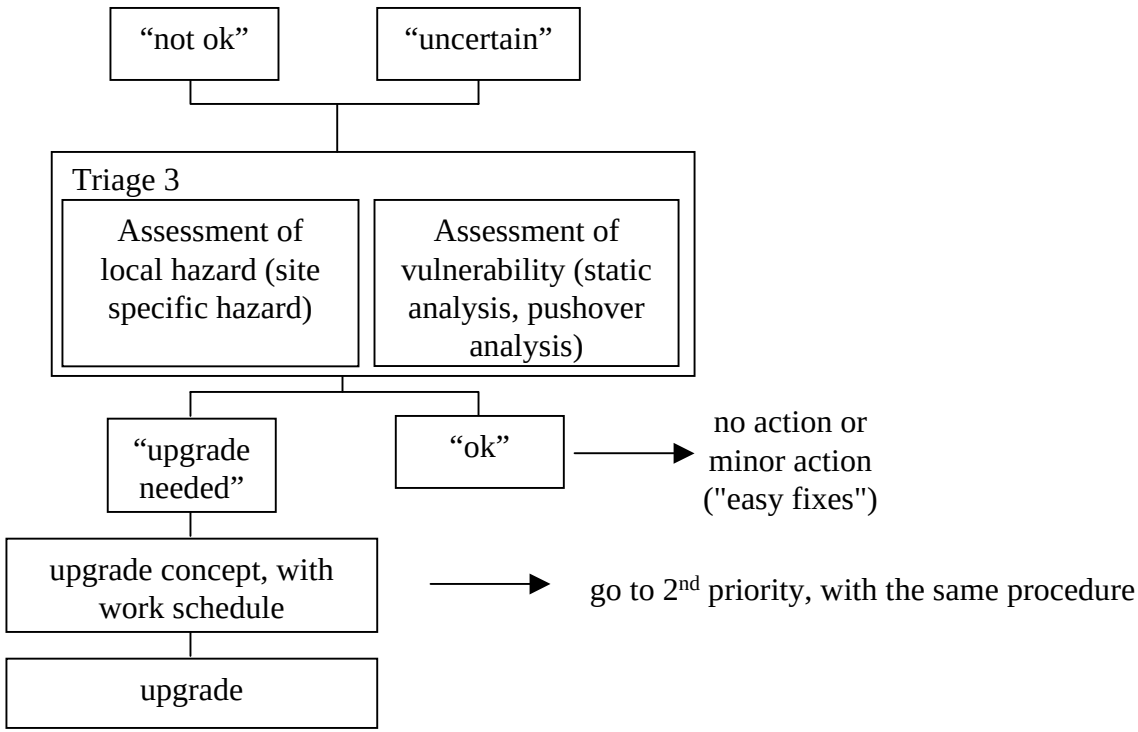
➔ Main responsibility: Utilities, earthquake engineers as counterpart

Measures to reduce the vulnerability of infrastructure systems (2)



➔ Responsibility: Earthquake engineers; not only structural, but also equipment, control and energy; ½ to 2 days work per element

Measures to reduce the vulnerability of infrastructure systems (3)



Measures for linear elements

Damage can not always be avoided!

Most important measures:
- geometrical layout
- Redundancies
- Capacity of repair organizations (often neglected)

Critical areas :
Areas with soil settlements and slope instabilities, liquefaction, lateral spreading

Measures for local elements

Robustness, i.e. not sensitive to

- overloading capability ➔ ductility
- construction tolerances
- maintenance

⇨ **Simple constructions!**

Measures for equipment / installations

- Avoiding a toppling and falling

  Fixations!

- Capability to withstand large deformations
- No excessive vibrations of the installations