Gian Piero Lignola
University of Naples
ReLUIS Laboratories University Network of Seismic Engineering

Preliminary studies on tsunami effects on buildings

Ministero dello Sviluppo Economico
DGS-UNMIG
CLYPEA INNOVATION NETWORK FOR FUTURE ENERGY
OMC 2019 27-29 March 2019 RAVENNA ITALY
www.omc2019.it
OFFSHORE MEDITERRANEAN CONFERENCE & EXHIBITION

INPUT

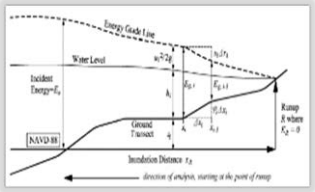
Inundation depth, **h**, along the coastline

- Constant
- Random
- From refined simulations

LARGE SCALE VULNERABILITY ANALYSIS

1. Knowledge of buildings features in coastal areas

- masonry/reinforced concrete
- number of storeys
- area



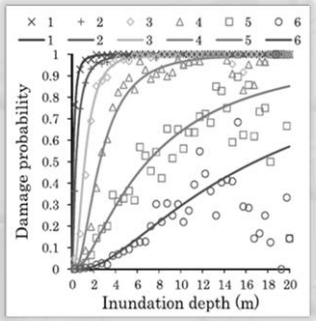
2. Simulation of an inundation scenario

Inundation depth trend:

- constant
- linear
- Energy Grade Line [EGL]

3. Definition of buildings fragility functions

- empirical
- analytical



4. Damage prediction

- Reconstruction costs
- Human losses

OUTPUT

Damage scenario for a tsunami event

Ministero dello Sviluppo Economico

DGS-UNMIG

CLYPEA INNOVATION NETWORK FOR FUTURE ENERGY

EMPIRICAL FRAGILITY FUNCTIONS

Based on post-tsunami surveys

- *"The 2004 Indian Ocean tsunami"*

Sumatra (Indonesia)

Victims: 250 000

- *"The 2009 South Pacific tsunami"*

Samoa

Victims : 200

- *"The 2011 Great East Japan tsunami"*

Tohoku (Japan)

Victims : 16 000

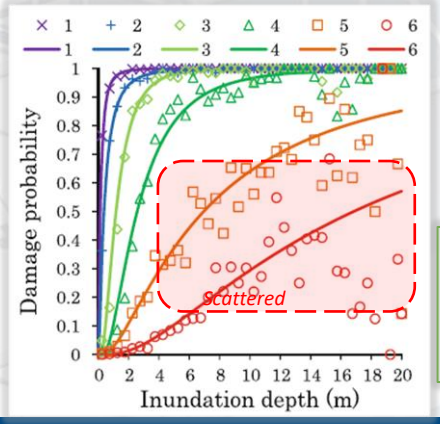
Sumatra - 2004

Tohoku- 2011

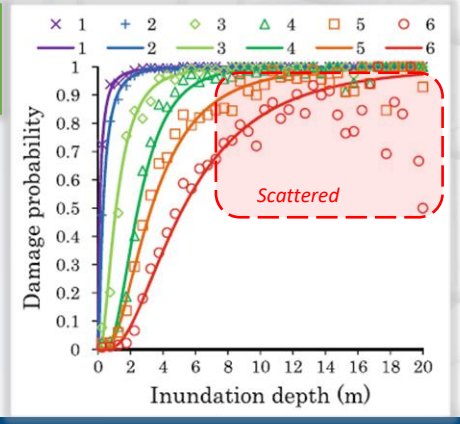
The 2011 Great East Japan tsunami

Fragility functions strictly related to local building typologies

Masonry buildings



Reinforced concrete buildings



Ministero dello Sviluppo Economico

DGS-UNMIG

CLYPEA INNOVATION NETWORK FOR FUTURE ENERGY

KNOWLEDGE OF BUILDINGS IN COASTAL AREA

ISTAT data

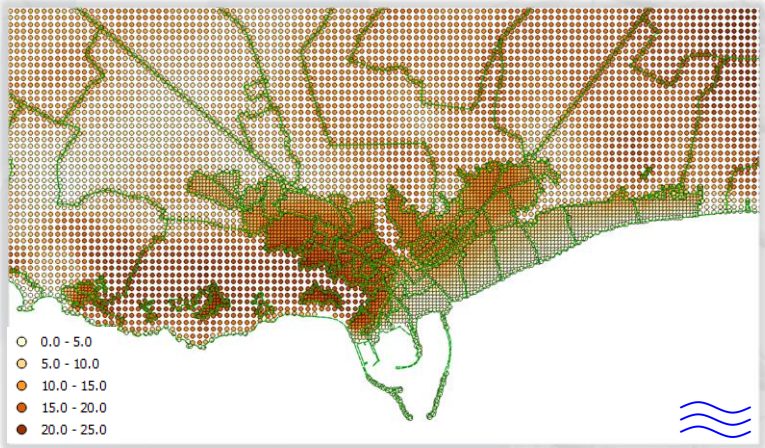
In-situ surveys

→ **GIS platform**

- Definition of a grid with spacing 50m in urban areas and 100m in rural areas
- Geolocalizations of grid centres
- Altitude assigned at grid centres

Italy ≈ 1 400 000 grid centres

DTM 20m [GEOPORTALE]



h = 25 m *[TSUMAPS]*
L = 5 km [fascia inondata]

Ministero dello Sviluppo Economico

DGS-UNMIG

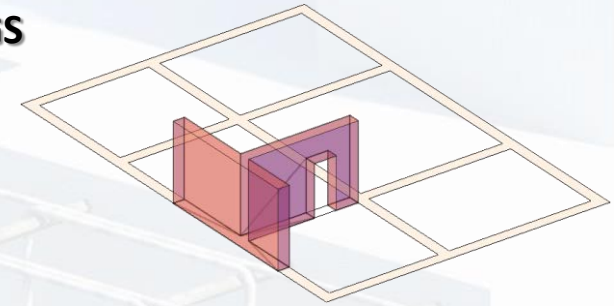
CLYPEA® INNOVATION NETWORK FOR FUTURE ENERGY

ANALYTICAL FRAGILITY FUNCTIONS

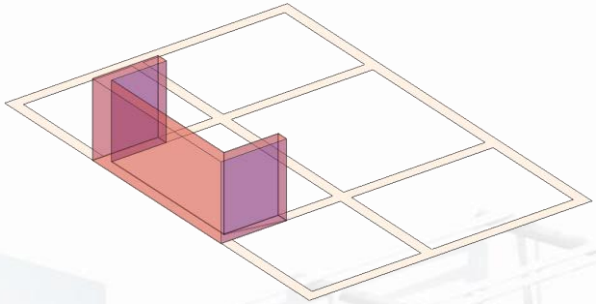
Based on structural models and numerical analysis

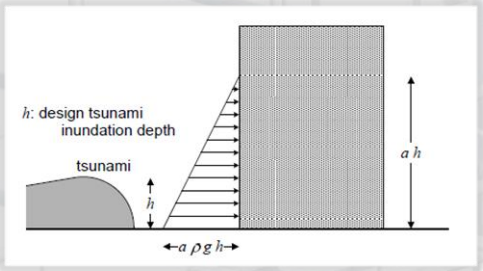
MASONRY BUILDINGS

In-plane mechanism



Out-of-plane mechanism





Structural Design Method of Buildings for Tsunami Resistance - *SDMBTR (Japan)*

Global behavior

REINFORCED CONCRETE BUILDINGS

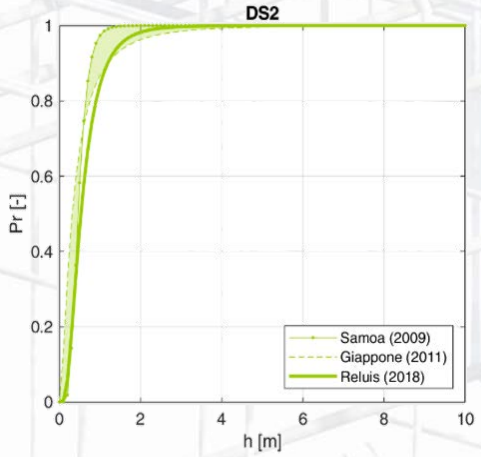
ANALYTICAL FRAGILITY FUNCTIONS

Based on structural models and numerical analysis

Definition of vulnerability classes for Italian buildings

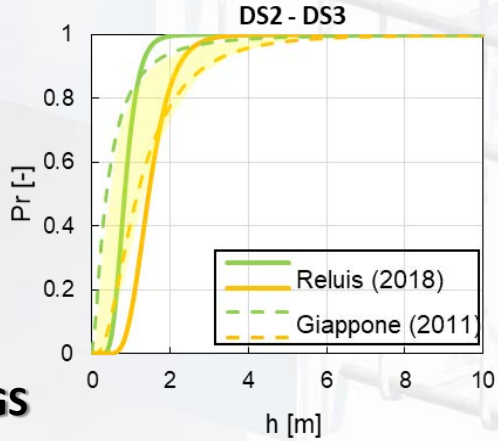
- **Number of storey:**
  - Low-rise (n < 3)
  - Medium rise (n ≥ 3)
- **Design code:**
  - Gravity load
  - Seismic load
- **Age of construction:**
  - *Pre 1919 (masonry only)*
  - Pre 1980
  - Post 1980

Comparison with empirical fragility curves



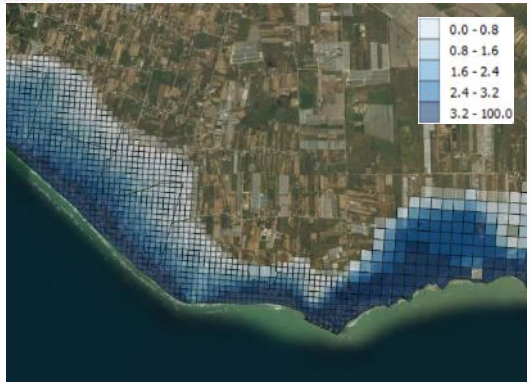
Masonry

Reinforced Concrete



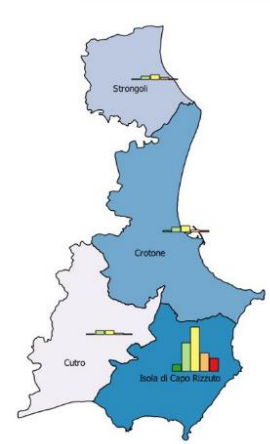
SEISMIC POST 1980 BUILDINGS

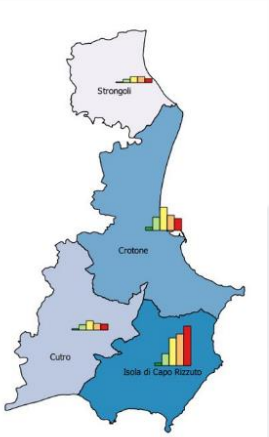
Inundation map for Ispica (RG)

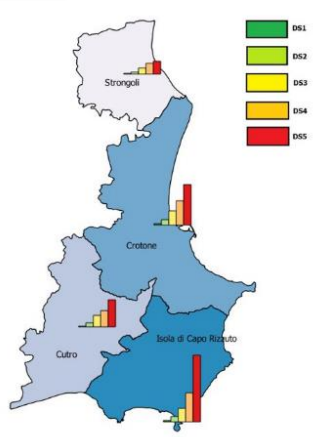


Inundation depth at coastline: 2m 5m 10m

Damaged buildings at urban level







Inundation depth at coastline: 2m 5m 10m

Ministero dello Sviluppo Economico

DGS-UNMIG

CLYPEA INNOVATION NETWORK FOR FUTURE ENERGY

CONCLUSIVE REMARKS

- A tool for the large scale analysis of tsunami vulnerability was developed for Italian coastal areas;
- New refined methods for assessing the structural vulnerability of masonry and reinforced concrete structures under tsunami loading were proposed;
- A simplified model for the tsunami loading was adopted, neglecting the effects of load pattern and of other components of tsunami loading (debris impact, buoyancy forces, etc.). These components of tsunami loading will be investigated in future research;
- Preliminar analytical fragility functions were derived for predicting damage scenarios and a quite good match was found with empirical ones, but further research is needed especially for high damage levels.

THANK YOU FOR YOUR ATTENTION!