



Rete dei Laboratori Universitari  
di Ingegneria Sismica e Strutturale

# Convegno ReLUIs

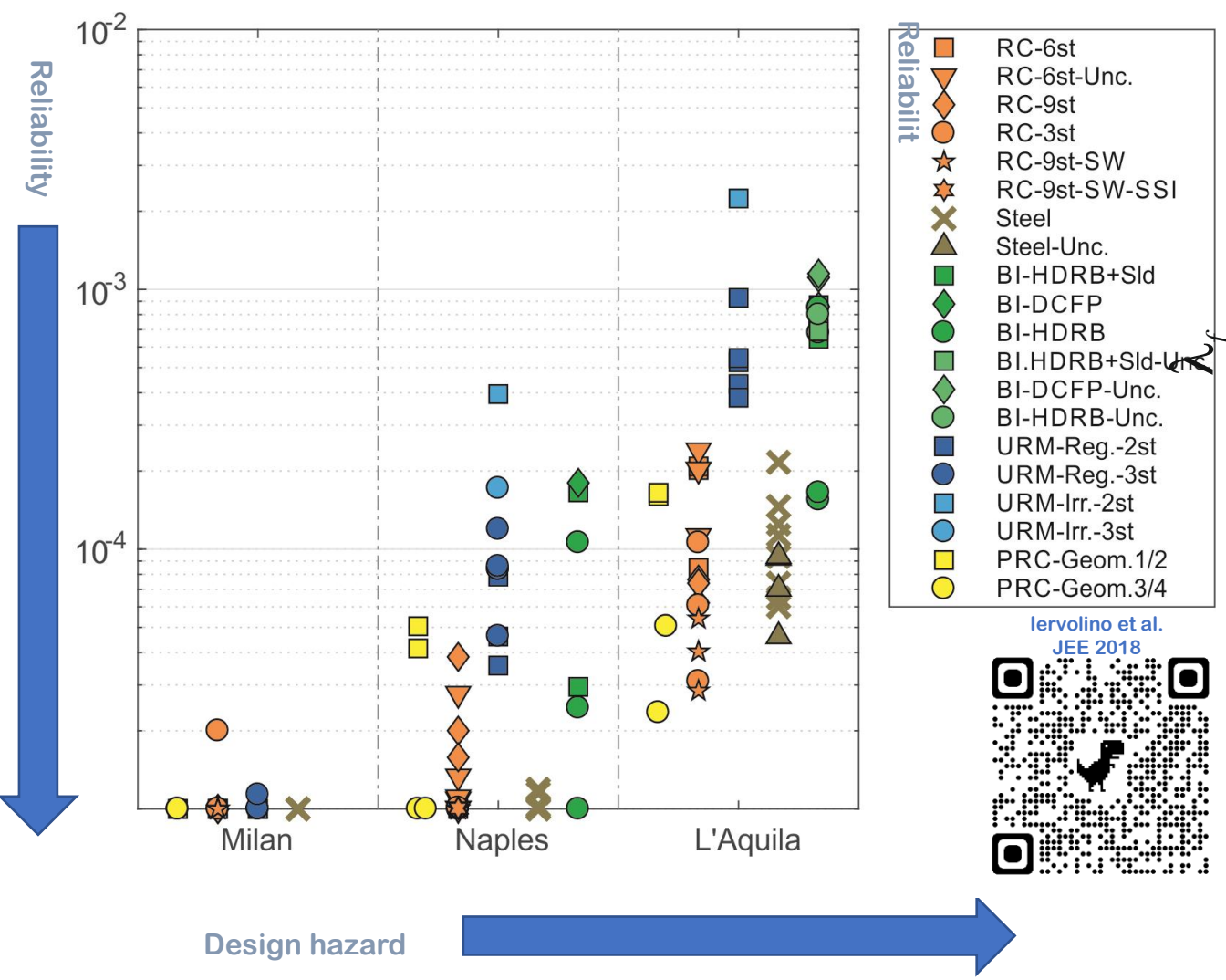


**Progetto DPC\_ReLUIs 2022-2024**  
**Esposizione delle attività svolte e prospettive**

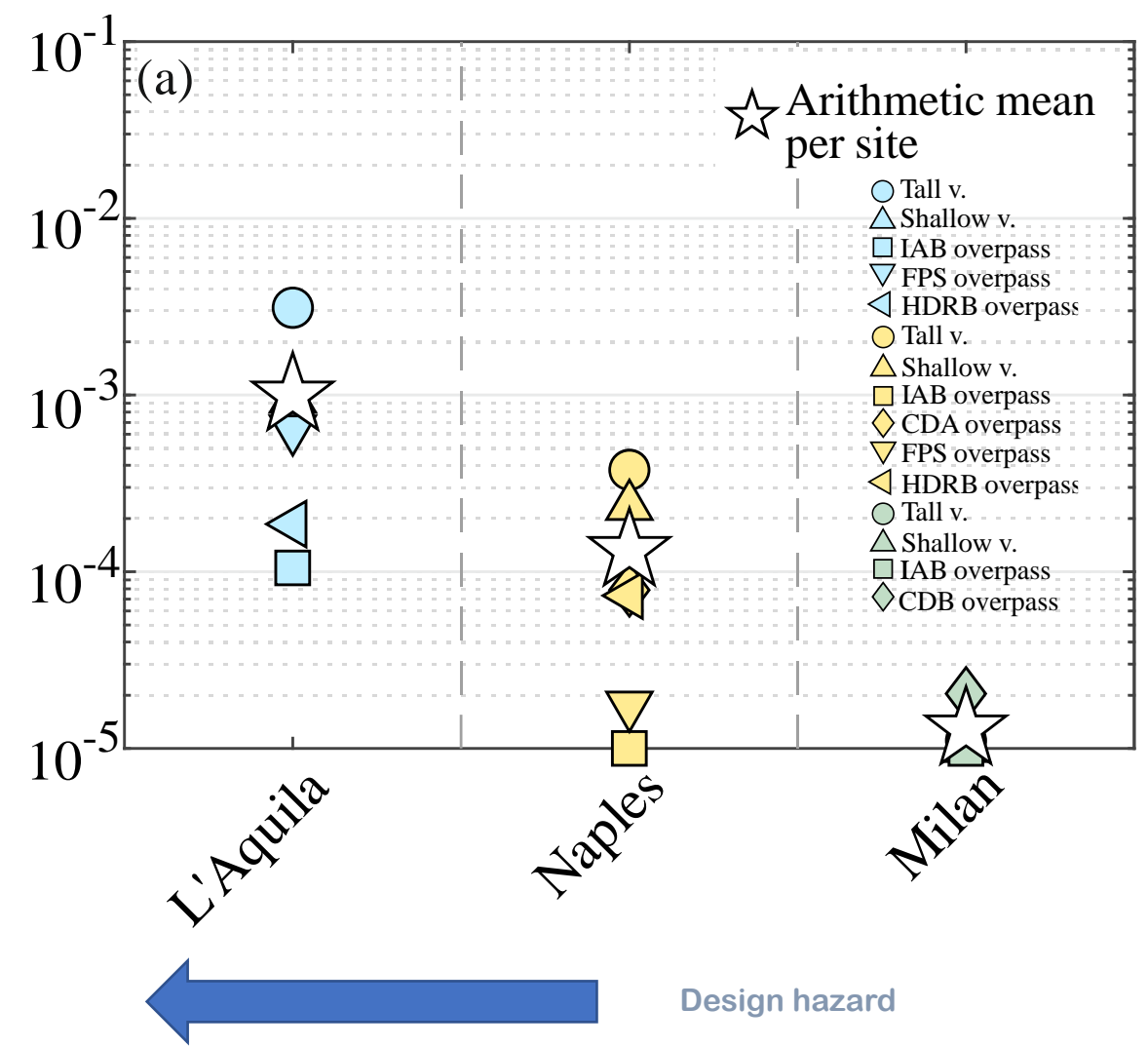
**Roma, 7 novembre 2023**

**WP 3 – RINTC**  
**Iunio Iervolino**

## Code-conforming buildings

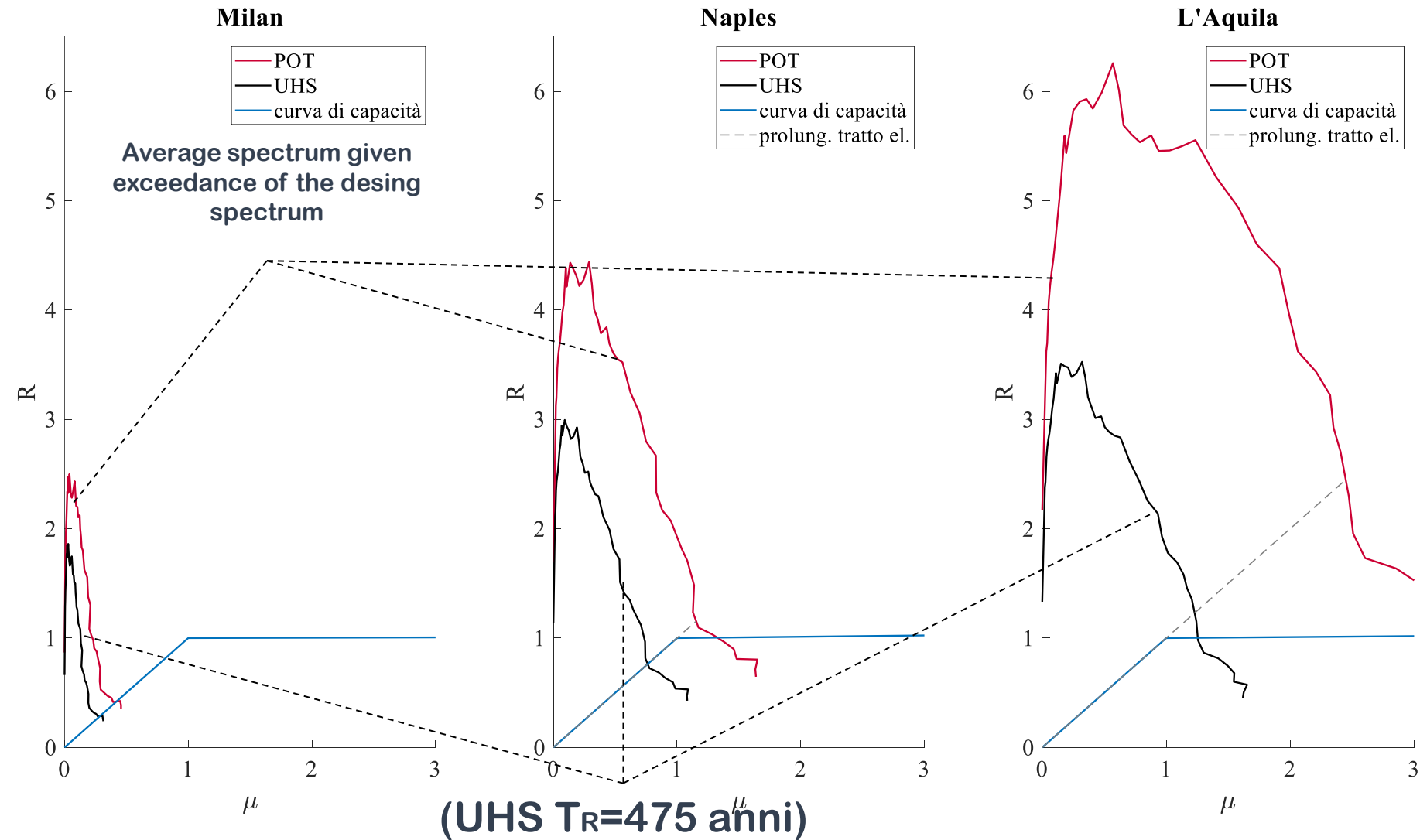
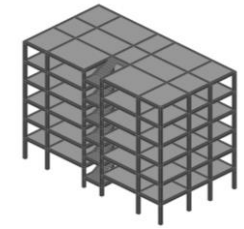


## Code-conforming bridges



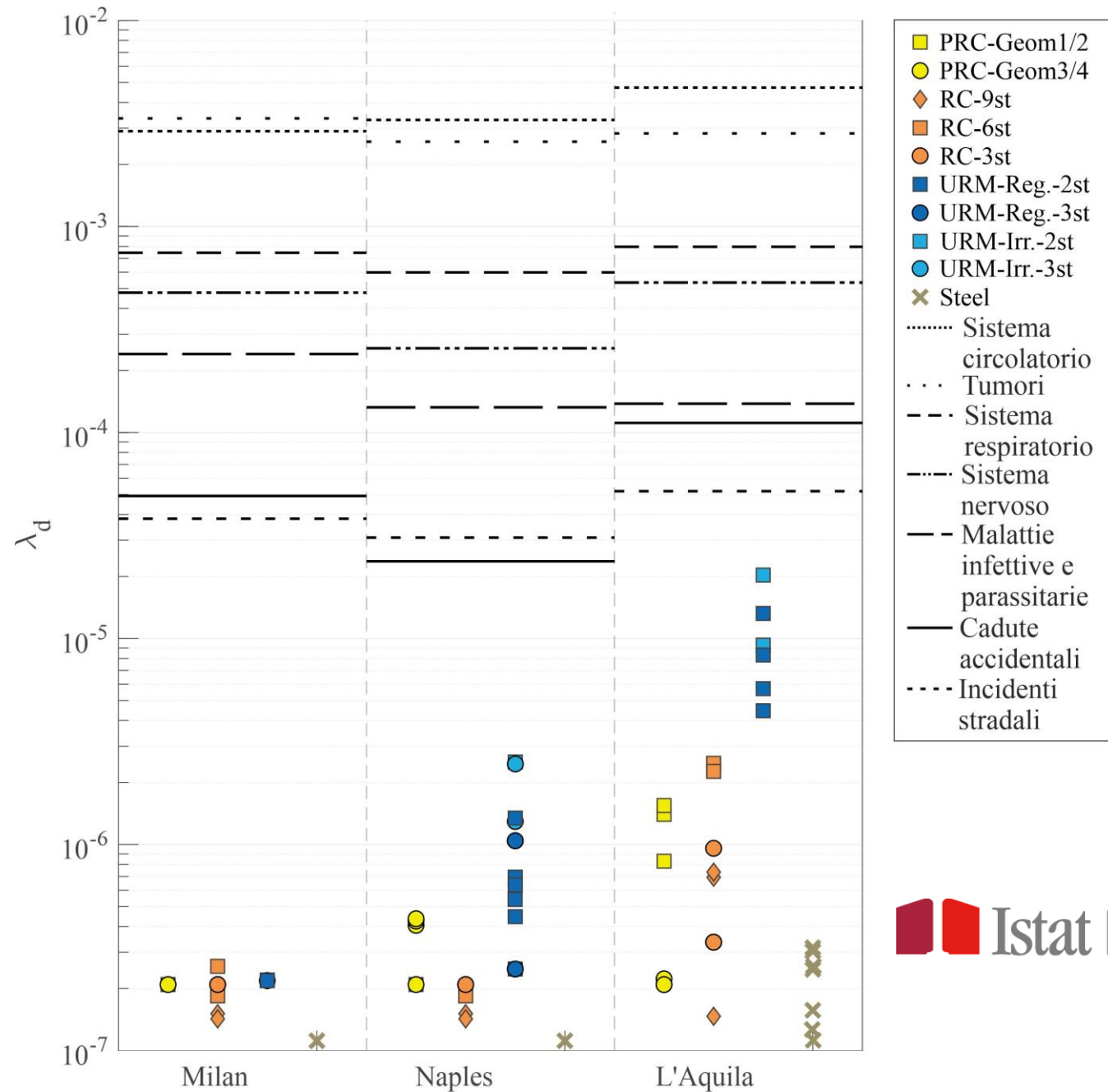
# Why reliability decreases with increasing hazard?

Baltzopoulos et al. (2021)

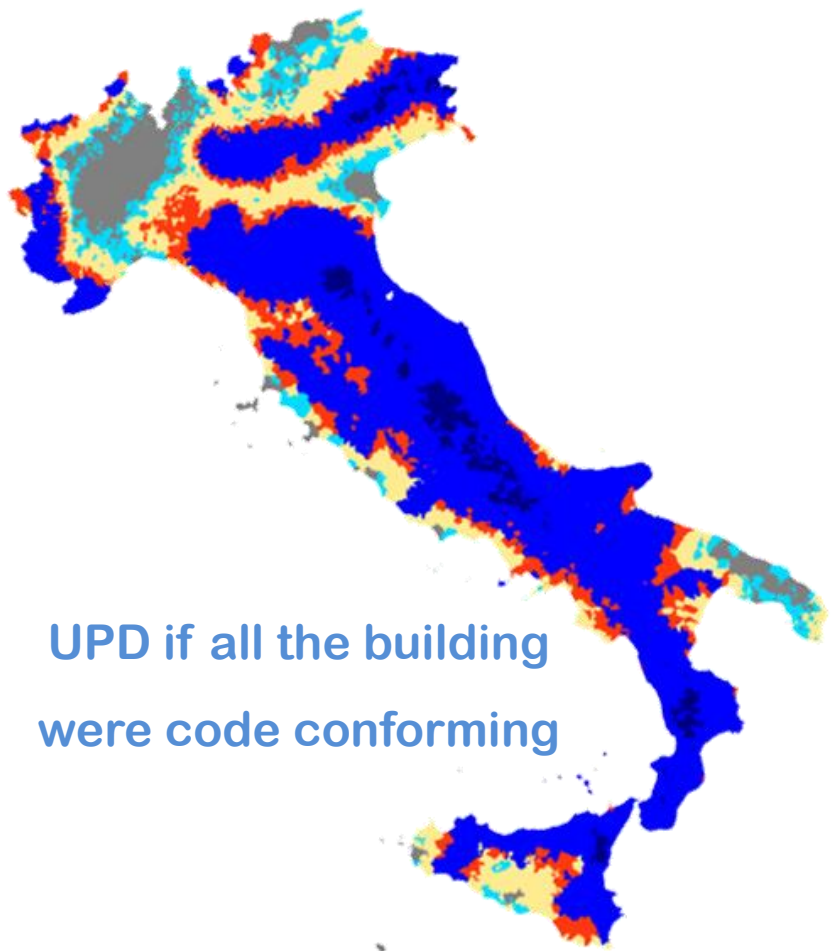


# Fatality rates

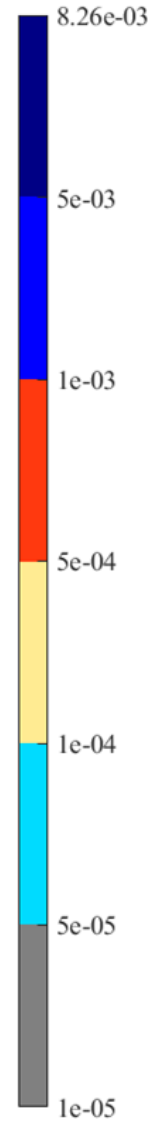
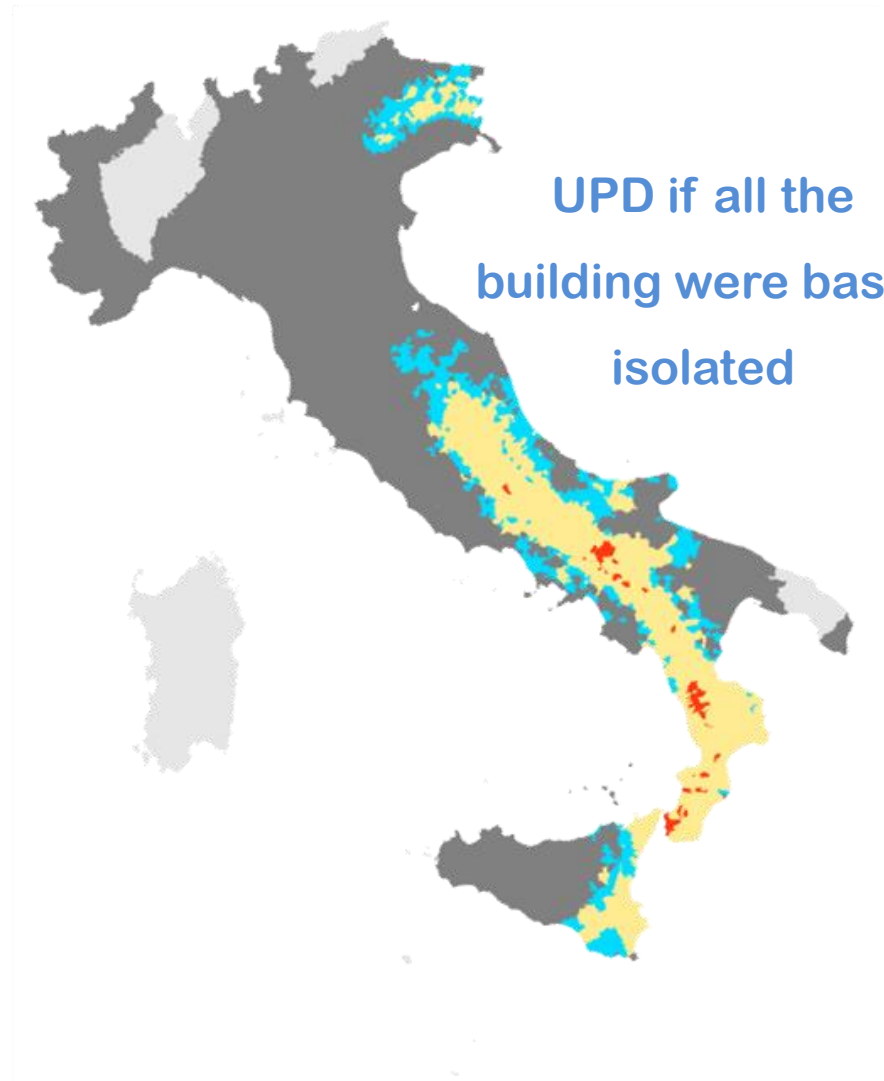
Iervolino I., Pacifico A. (2021)  
Fatality rates implied by the Italian  
seismic code. EESD, 50:3083-3089.



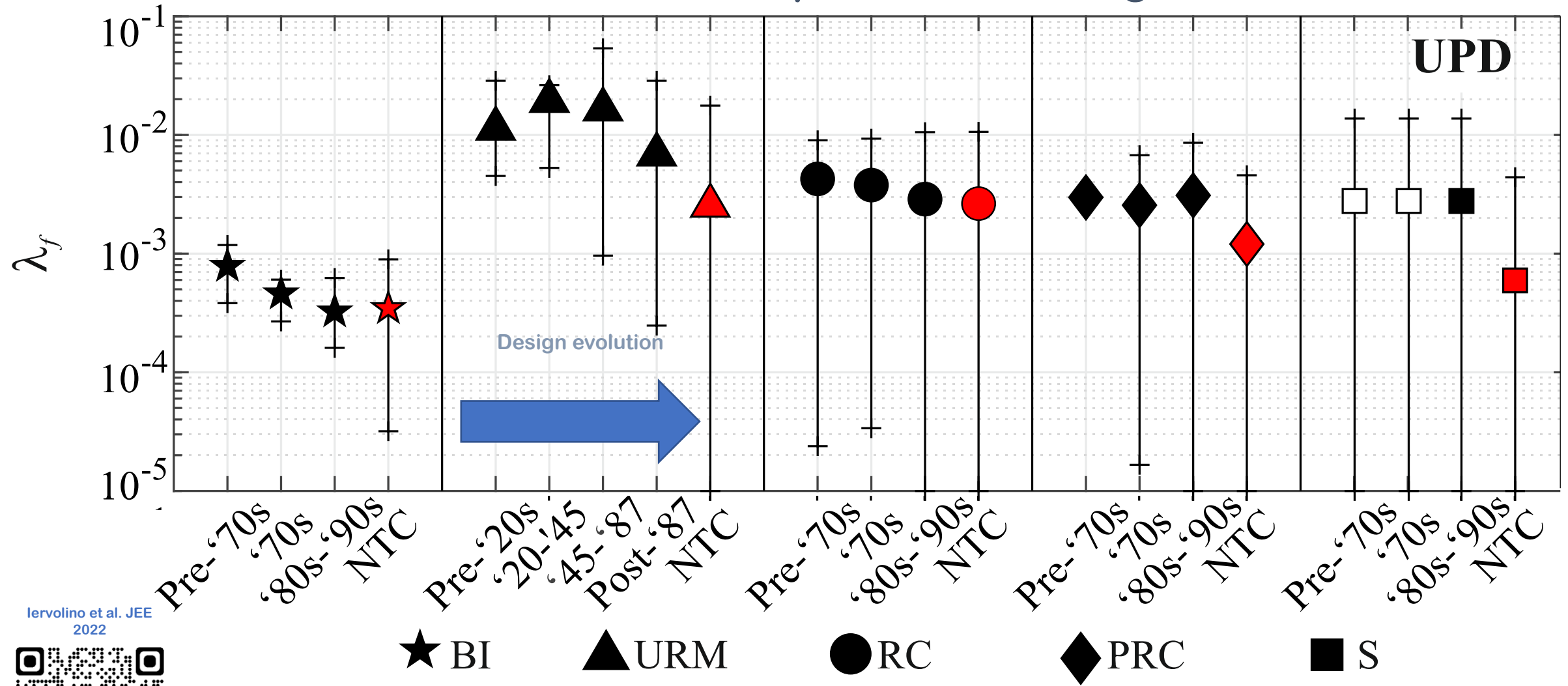
# Ideal risk maps (risk if all the building were code-conforming)



Pacifico et al. (2022)



## Low-code and pre-code buildings

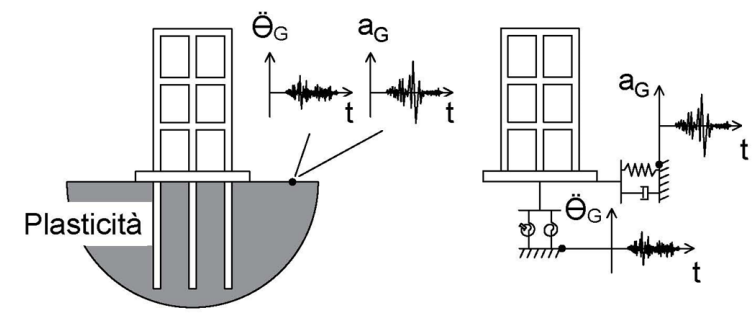
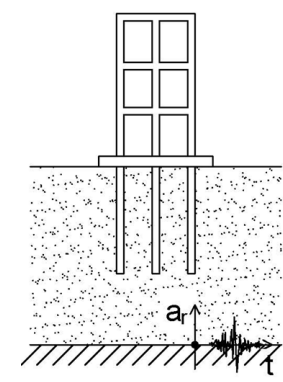
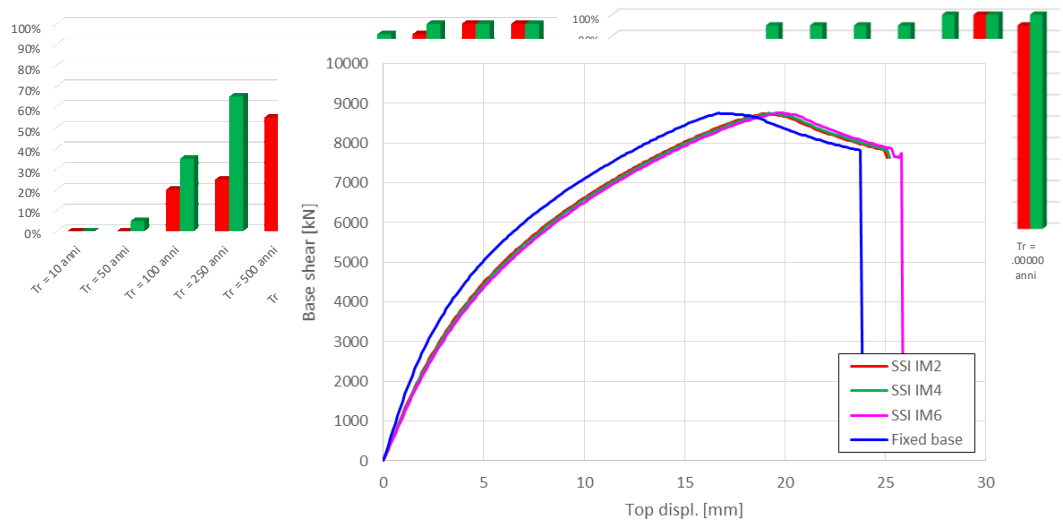
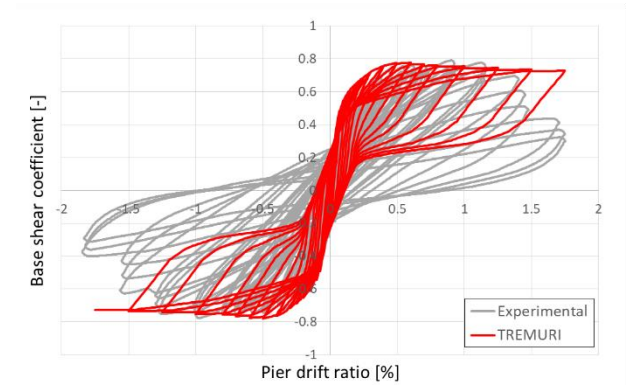
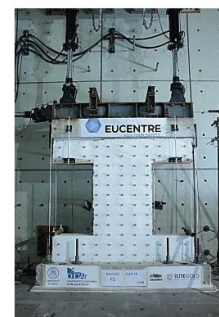
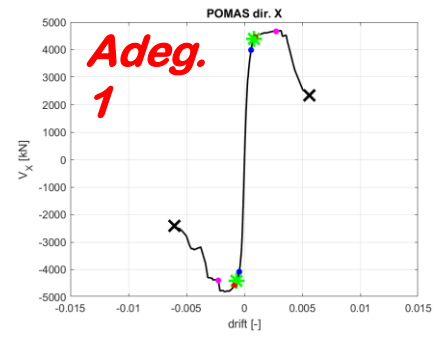
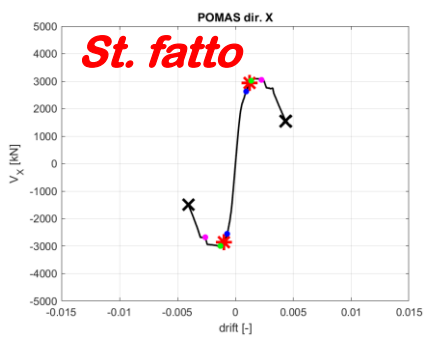
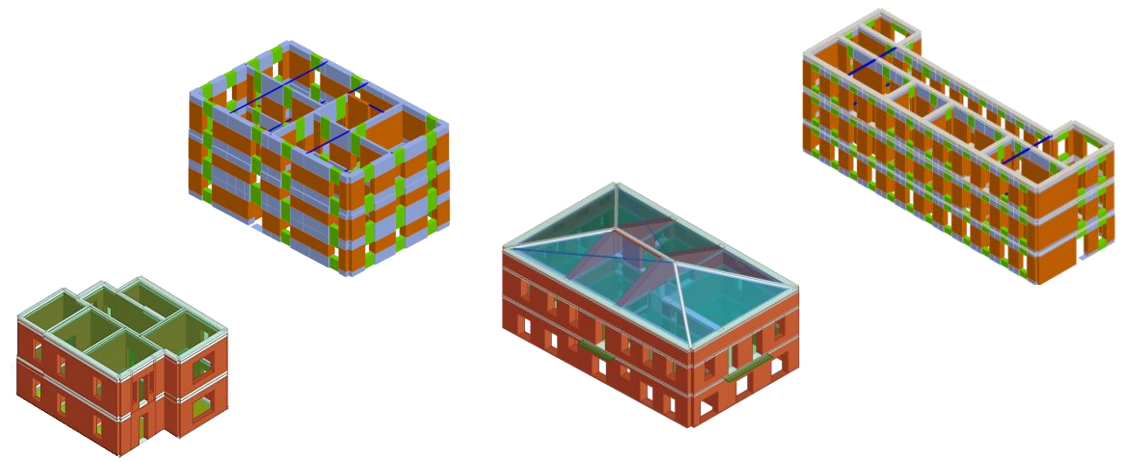


Iervolino et al. JEE 2022



# URM

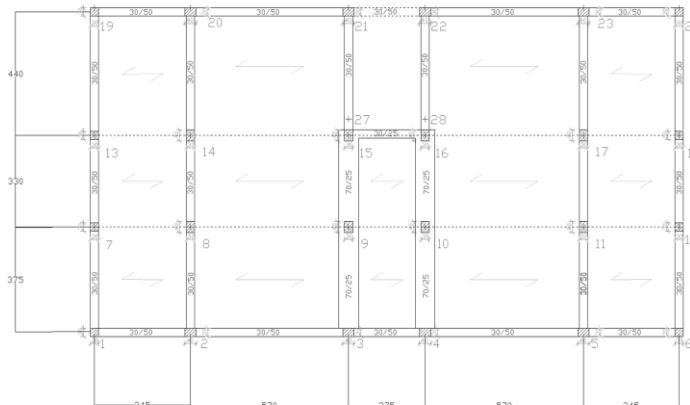
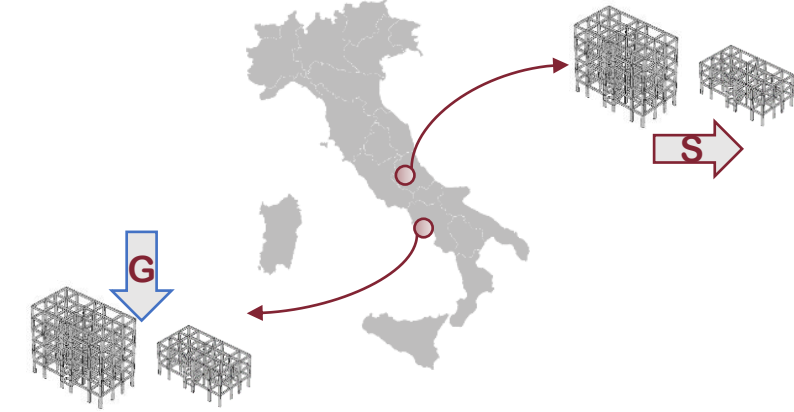
- Edifici esistenti con progettazione di adeguamenti (cap./dem. obiettivo di 0.8 e 1): irrigidimento solai, aggiunta cordoli c.a. o catene, iniezioni di miscele leganti, ristilatura, placcaggi con FRCM, esoscheletri in acciaio



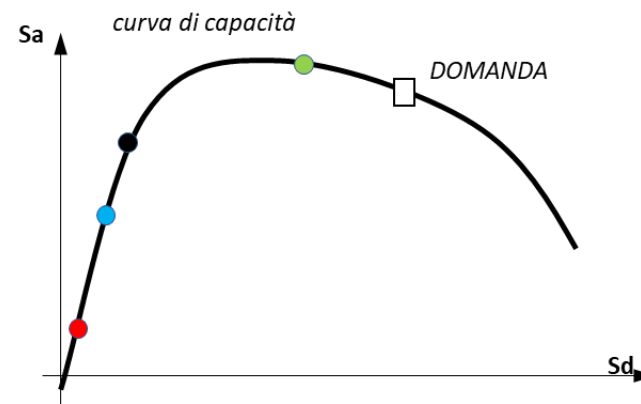
# CA

## Sommario:

- Edifici 1950-60 di 3 e 6 piani a Napoli (progettazione non sismica) e L'Aquila (progettazione «sismica»)
- Valutazione sicurezza attuale (rapporto capacità/domanda circa 0.3)
- Strategie di intervento
  - I. Eliminazione crisi fragili (o duttili precoci)
  - II. Esoscheletri metallici → progettati per adeguamento a L'Aquila
- Modelli capacità (analisi pushover)



Tipico comportamento edifici AS-BUILT



- PRIMA crisi di NODO a trazione diagonale
- PRIMA crisi di COLONNA a taglio-trazione
- PRIMA crisi di NODO a compressione diagonale
- PRIMA crisi duttile

### HP di modellazione

- elementi trave/colonna tutti duttili
- nodi rigidi

Generalmente la capacità è condizionata dalla crisi a trazione diagonale del nodo.

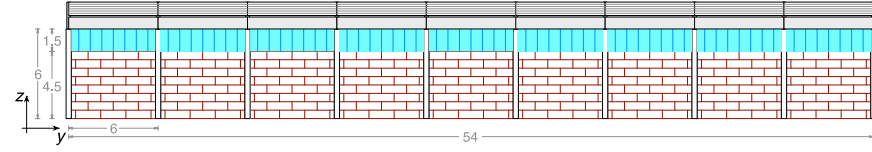
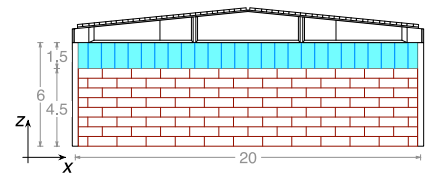
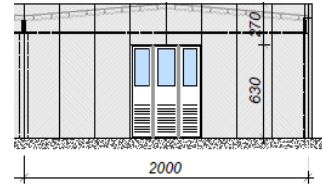
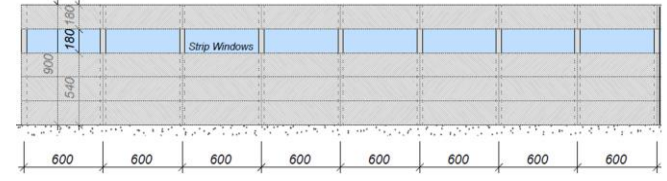


# Precast

**OBIETTIVO DEL TASK:** Valutare il rischio sismico a valle di interventi di miglioramento sismico locali e globali condotti su edifici prefabbricati di varie «epoche» normative **Unibg** **Eucentre**

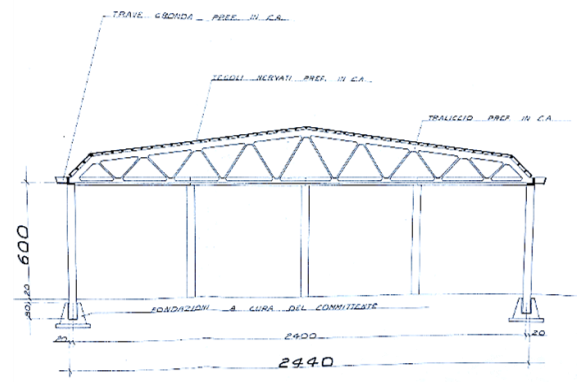


**L'AQUILA**

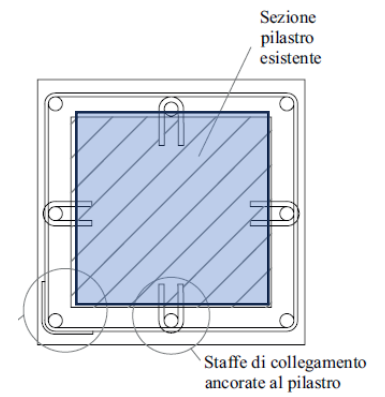
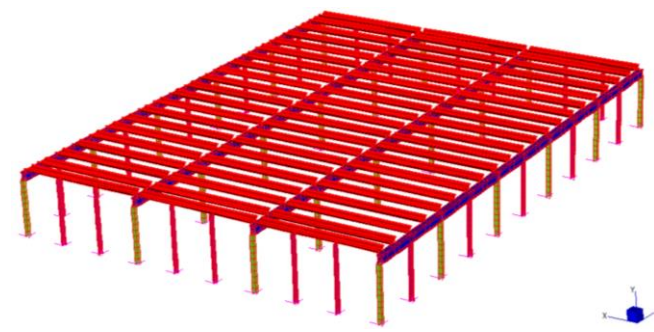


**MILANO**

**UniNa-Magliulo**



**Uni Insubria + Polimi**



## OBIETTIVI DEL TASK:

Valutare il rischio sismico implicito relativo alle prescrizioni per EC8 V2.

Evidenziare quali sono le richieste / i dettagli che portano a scostamento dimensionale degli elementi strutturali rispetto a EC8 e NTC18

«Application checks – SC8»

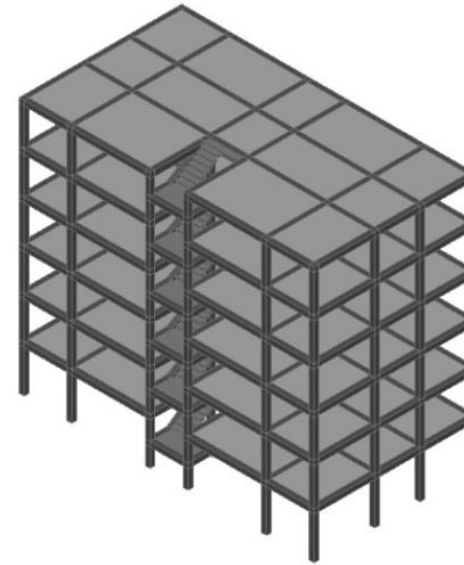


**L'AQUILA**



**MILANO**

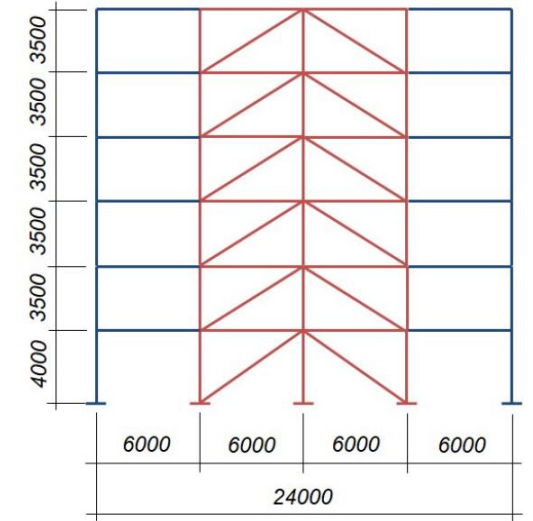
## RC: Moment Resisting Frames



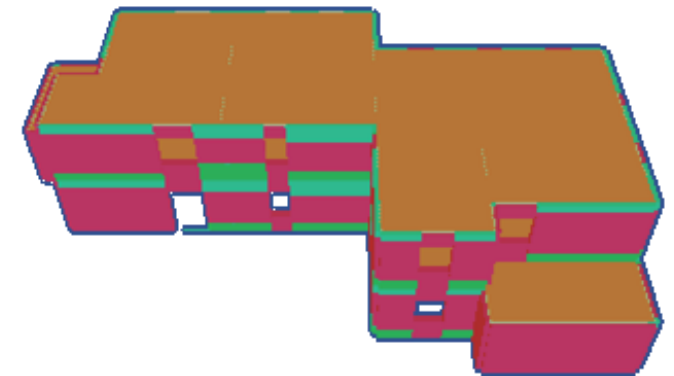
## Precast concrete



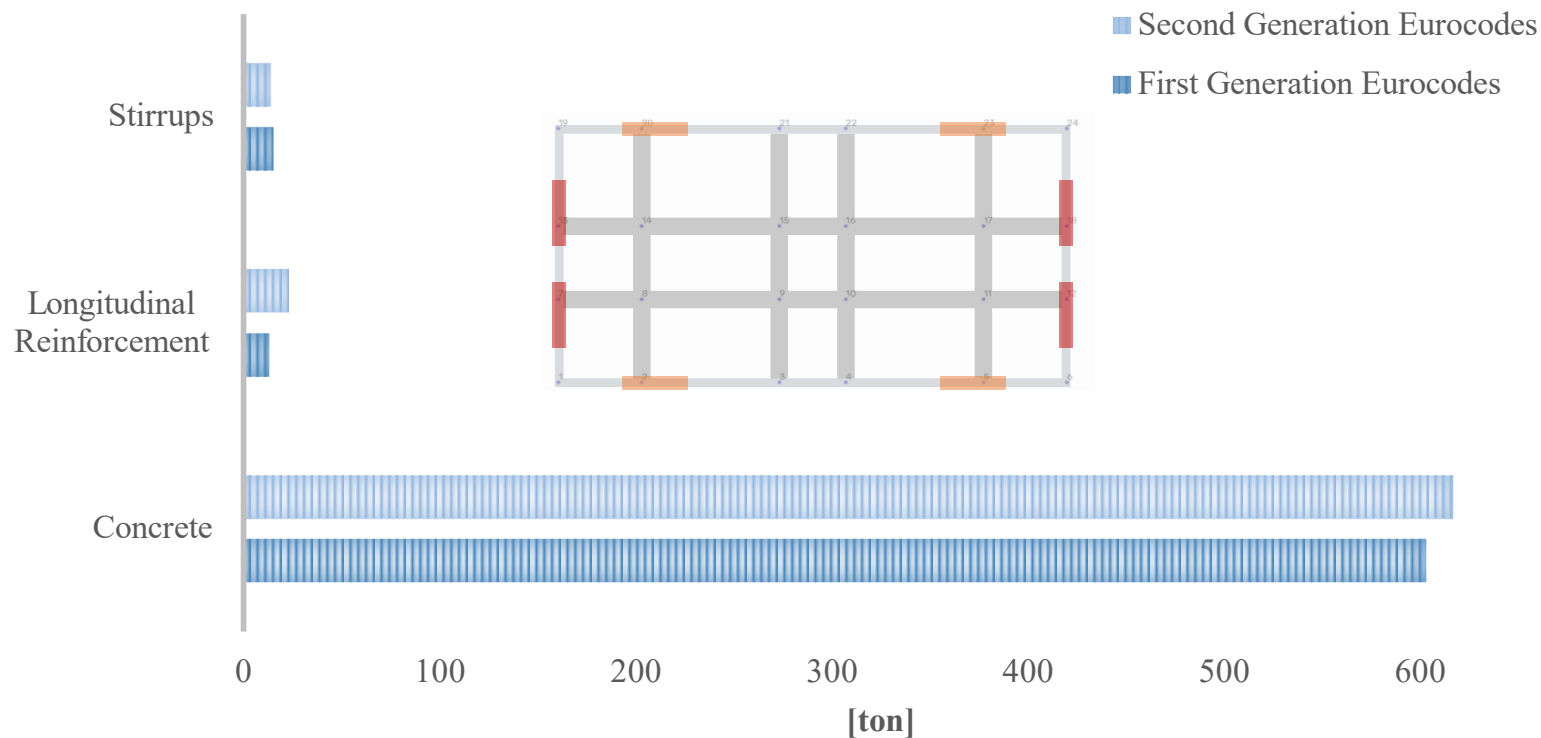
## Steel: Concentric braced Frame



## Masonry



# L'AQUILA: UNCOUPLED WALL STRUCTURES



CONCRETE  
**+2.3%**

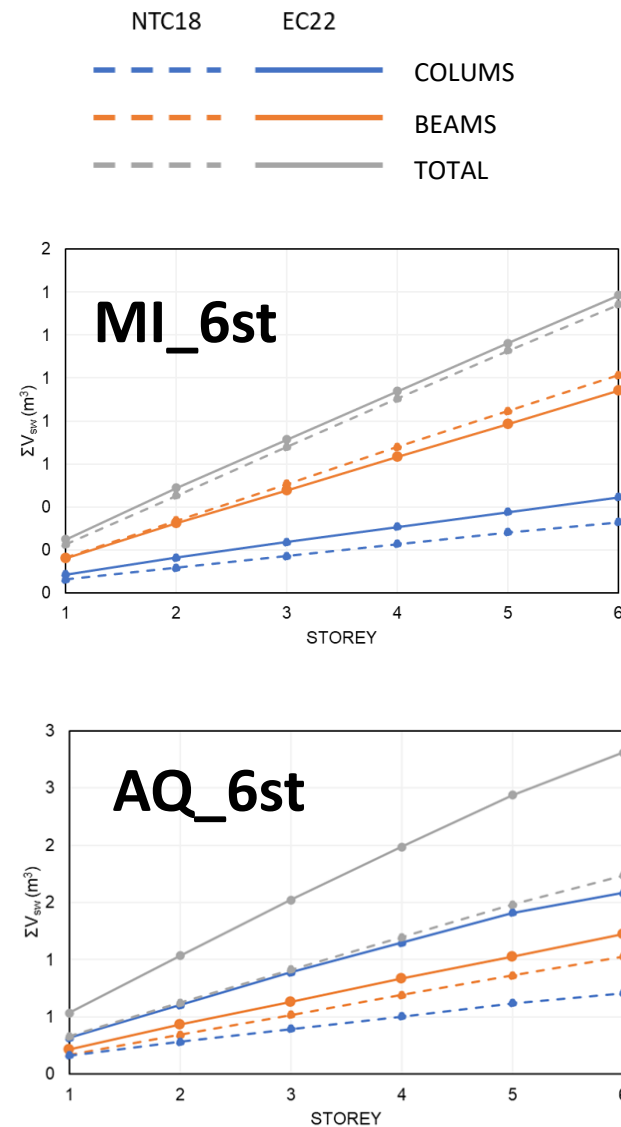
LONGITUDINAL  
REINFORCEMENT  
**+74.8%**

STIRRUPS  
**-10.0%**

# RC MRF STRUCTURES

The increase of materials volumes is negligible in low seismicity zones

The increase of materials volumes is significant in high seismicity zones



# OBIETTIVI

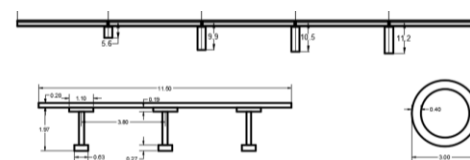
Valutazione dell'affidabilità sismica di ponti progettati secondo normative precedenti a quelle attualmente in vigore.

Tipologie strutturali già studiate nel triennio 2019-2021, con opportuni adattamenti.

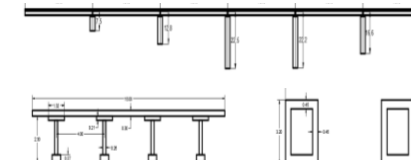
L'obiettivo è confrontare l'affidabilità sismica di opere d'arte esistenti tra le più diffuse sulla rete stradale italiana realizzate a partire dalla seconda metà del secolo scorso.



01 – Viadotto Sideroni  
Osservatorio Sismico



02 – UniRoma T2B



03 – UniRoma T2A



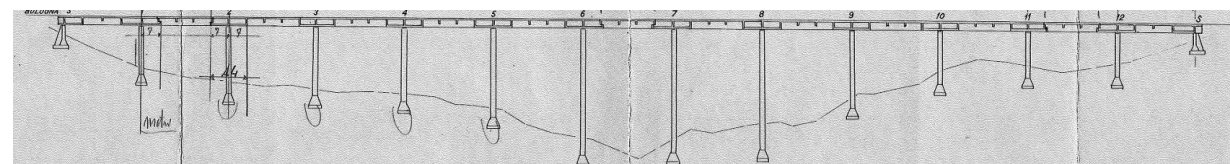
06 – Viadotto Cesio  
Osservatorio Sismico



05 – Miano-Agnano



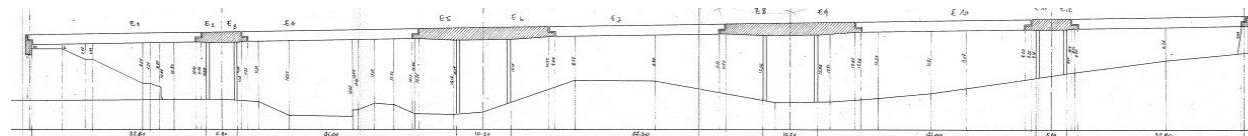
04 – Viadotto Rotolo



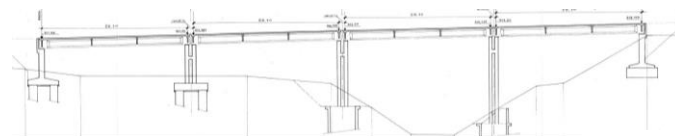
07 – UNIPV #1



11 – Ponte Lambro



09 – UNIPV #3



08 – UNIPV #2



10 – UNIPV #5



12 - Viadotto Chiaravalle



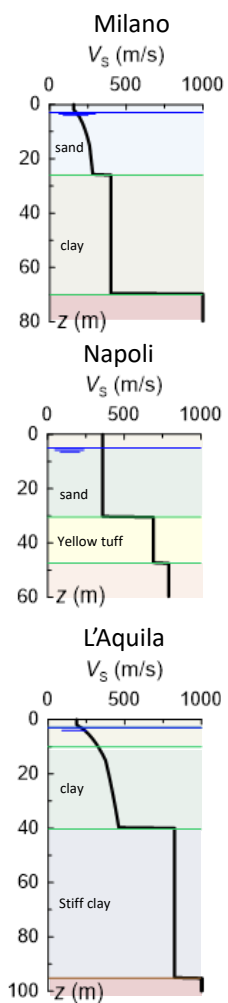
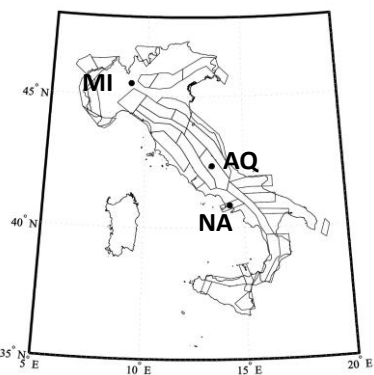
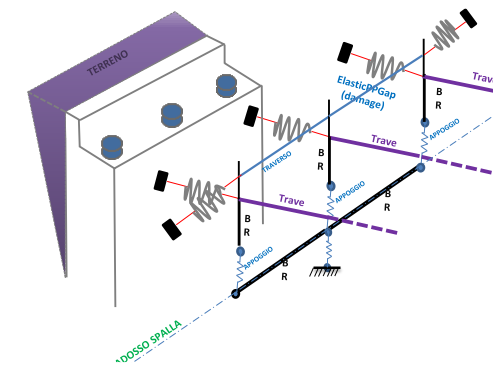
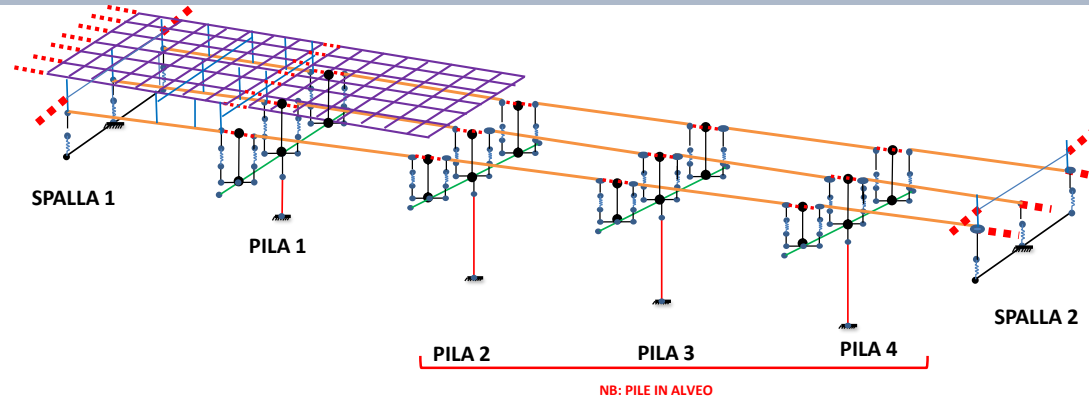
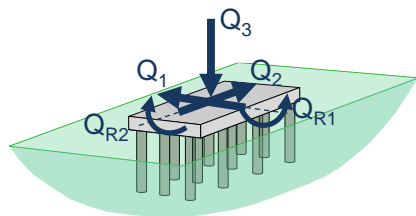
13 - Ponte Gresal



14a - Viadotto Nizza

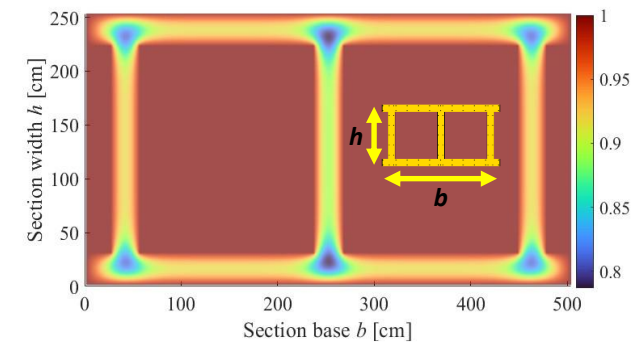
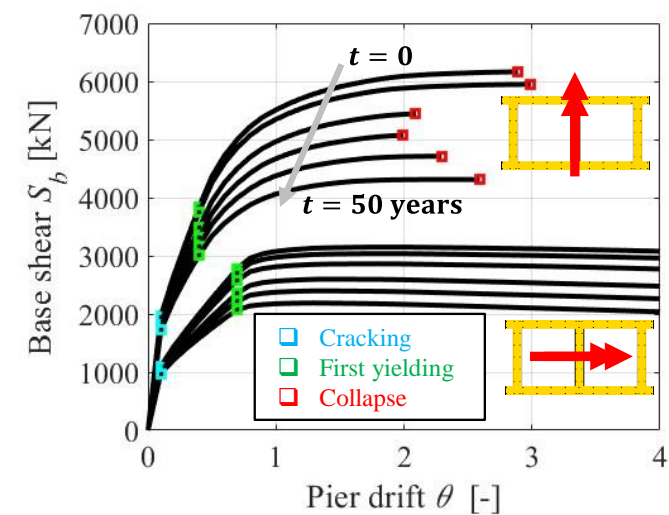
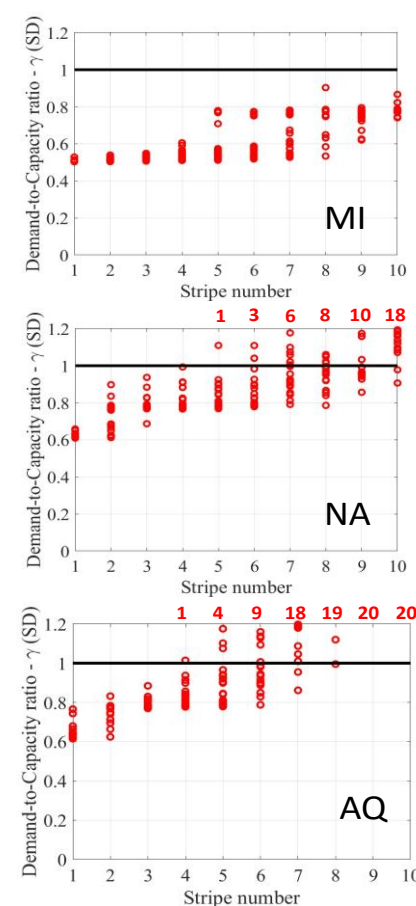
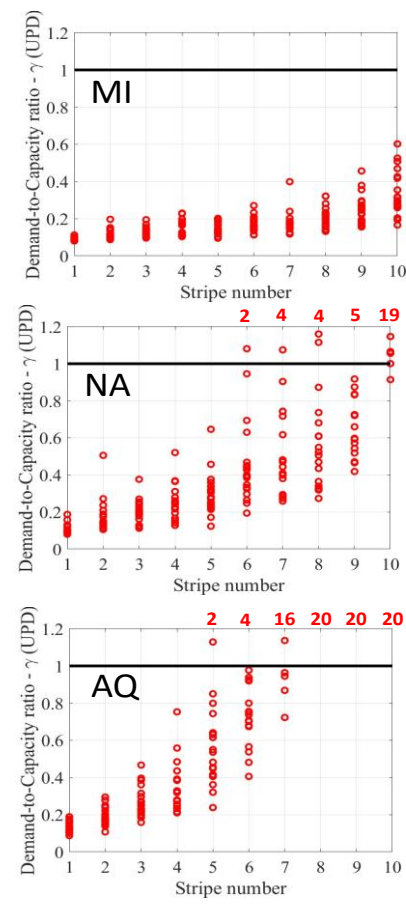


14b - Viadotto Acquasanta



### USABILITY PREVENTING DAMAGE (UPD)

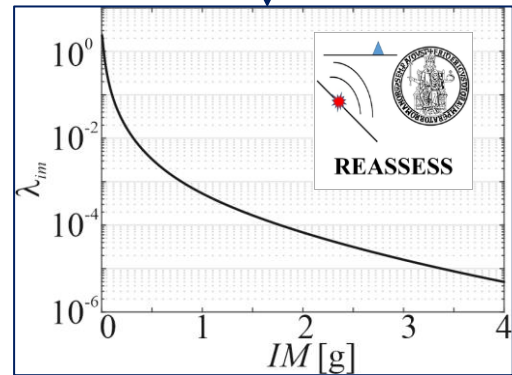
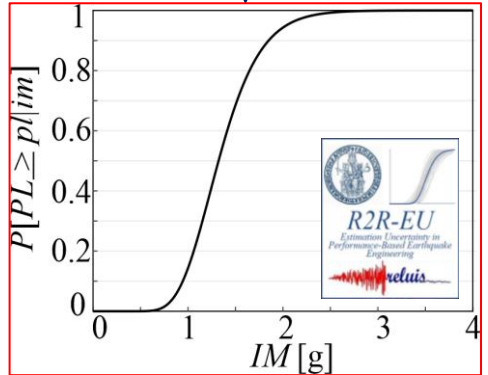
### SEVERE DAMAGE (SD)



$$\lambda_{E,pl} = \sum_{st} \lambda_{E,pl|st} \cdot P[st] = \sum_{st} \sum_i \left\{ \int_{im} P[PL^{(st)} \geq pl|z] \cdot \left| d\lambda_{E,im|\theta_i}(z) \right| \right\} \cdot P[\theta_i] \cdot P[st]$$

Tasso di fallimento medio per municipalità

**Obiettivo: Mappe di rischio degli edifici esistenti confrontabili con le mappe di rischio ideale**



Probabilità che un edificio qualunque della municipalità sia fondato su ciascun tipo di suolo.

Probabilità che un edificio qualunque della municipalità appartenga a ciascuna tipologia strutturale considerata

URM - pre '20	1p	2p	3p	4p+
NC	-	-	AQ CT	NA RM
ZU	-	-	-	-

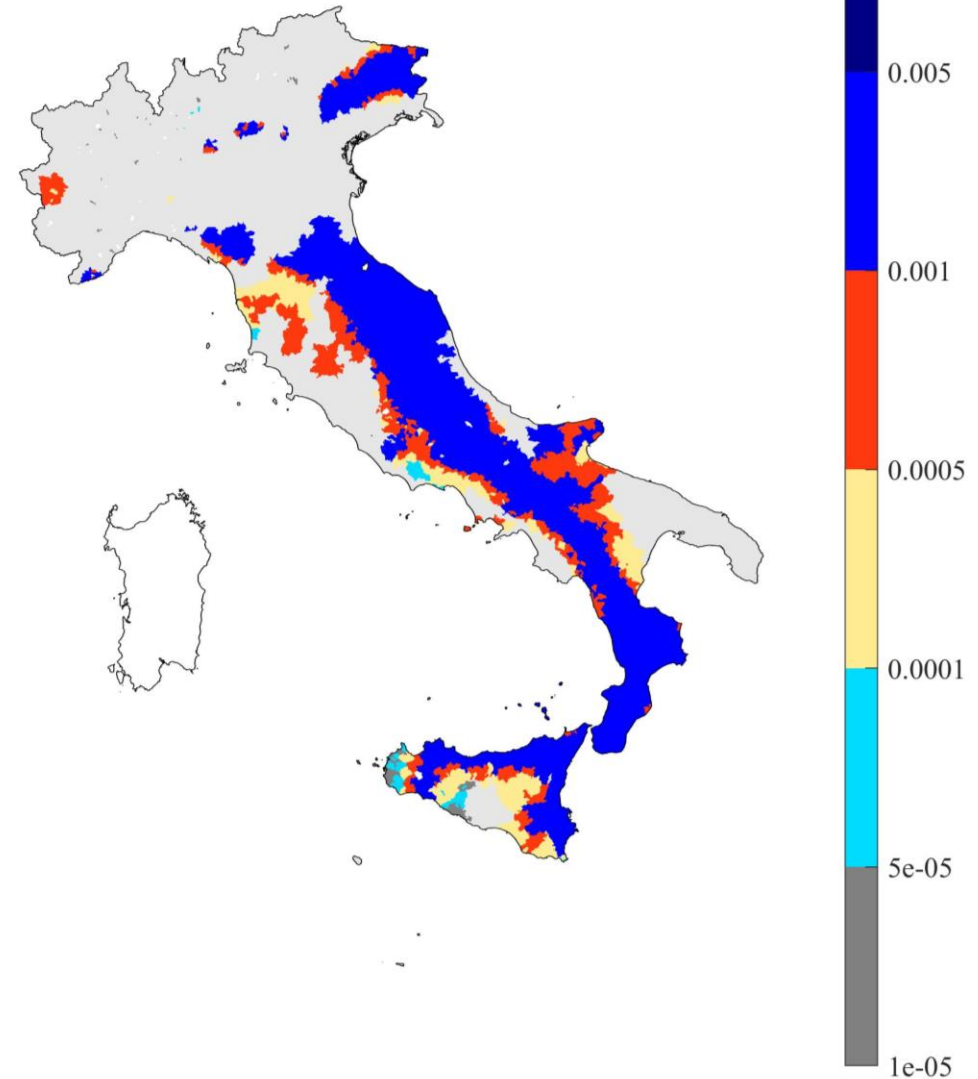
URM - ('20-'45)	1p	2p	3p	4p+
NC	-	-	-	MI
ZS 2	-	AQ	AQ AQ	-
ZS 1	-	-	-	-

RC - ('50-'60)	1p	2p	3p	4p+
NC	-	-	CT NA MI	CT NA MI
ZS2	-	-	AQ	AQ
ZS1	-	-	-	-

RC - (70s)	1p	2p	3p	4p+
NC	-	-	CT NA MI	CT NA MI
ZS2	-	-	AQ	AQ
ZS1	-	-	-	-

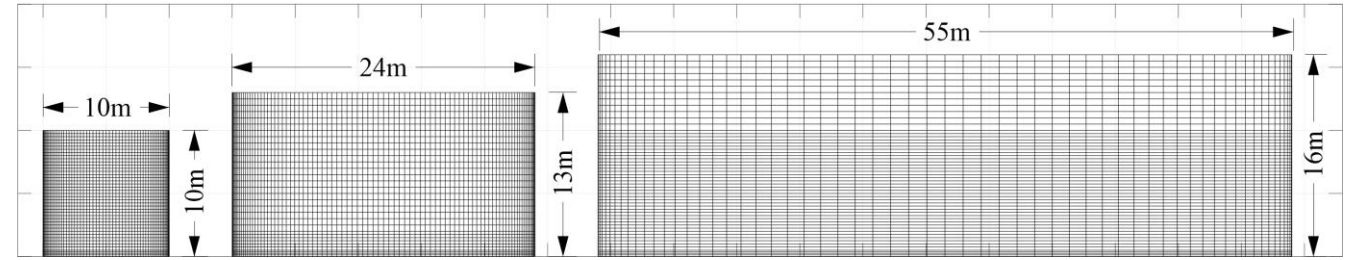
## ***Global collapse - URM – post'45***

- In riferimento alle strutture in muratura, è stato possibile calcolare mappe di rischio che tengono conto degli edifici esistenti di epoca post '45 di due e tre piani
- Per gli edifici in c.a., saranno prodotte mappe di rischio riferite agli edifici post '50 di tre e quattro piani

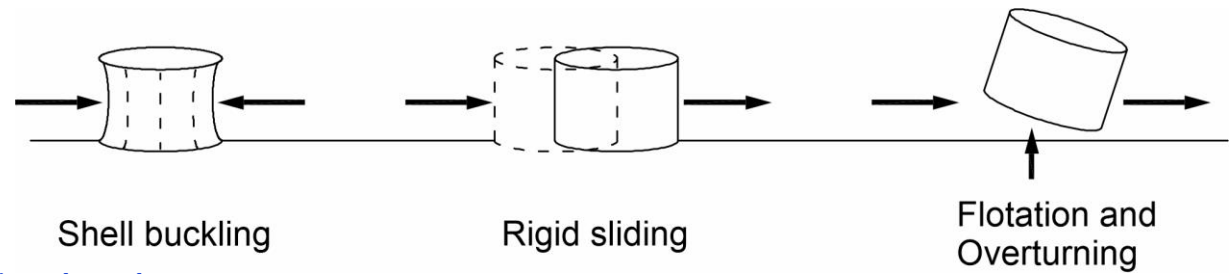


# Tsunami fragility functions for anchored atmospheric storage tanks

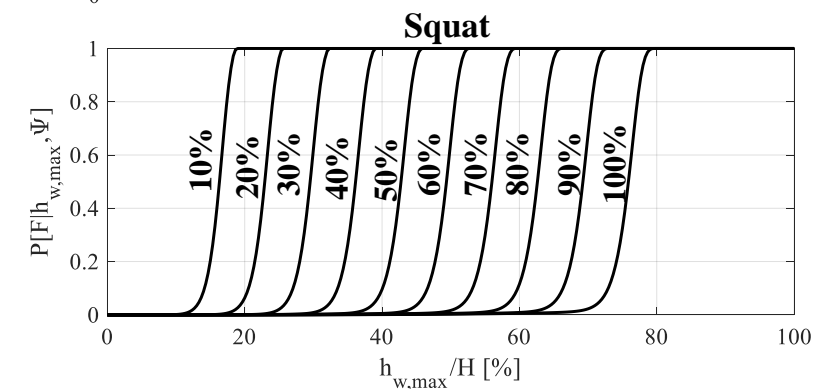
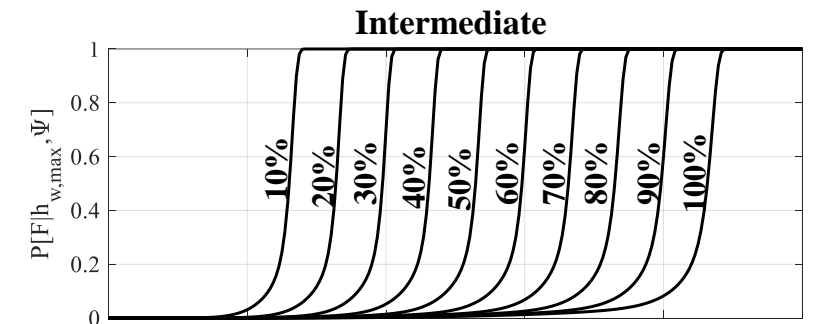
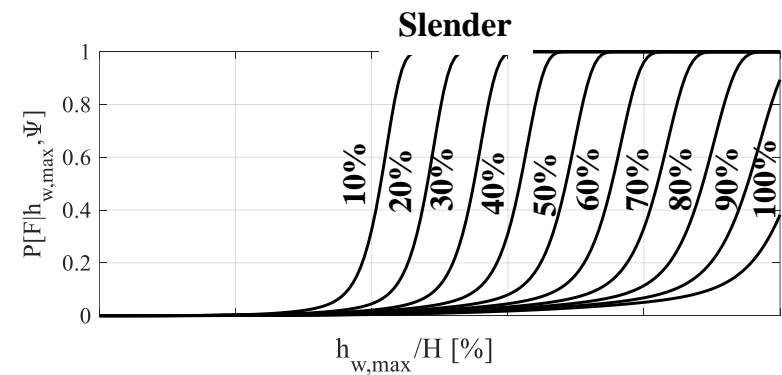
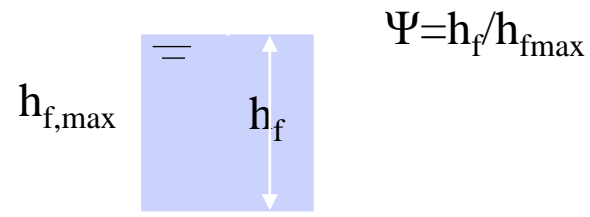
*FEM models*



*Failure modes*



*Fragility functions per filling level, as a function of max wave height*

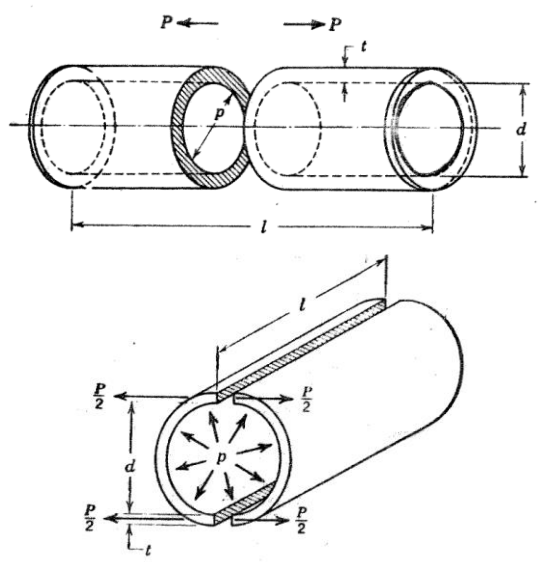
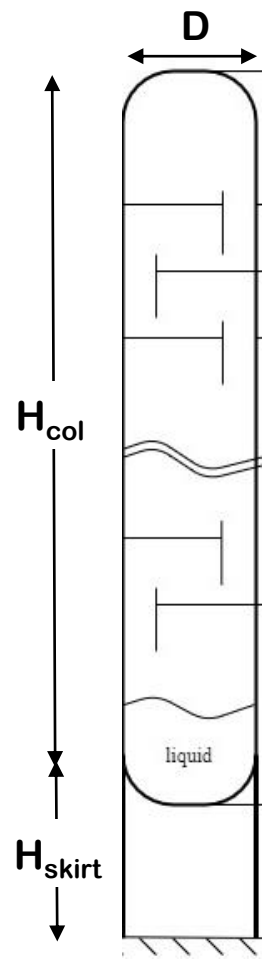




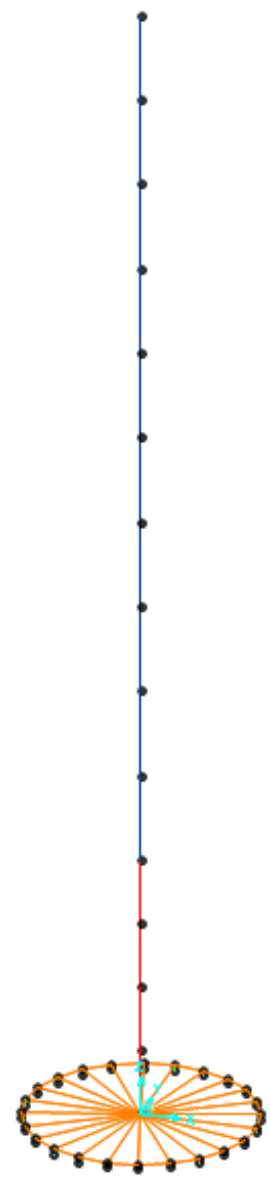
*European Standards for design:*

- EN 13445-3:2021 - Design
- EN 1998-1:2013 – Seismic action
- EN 1991-1-4:2010 – Wind action

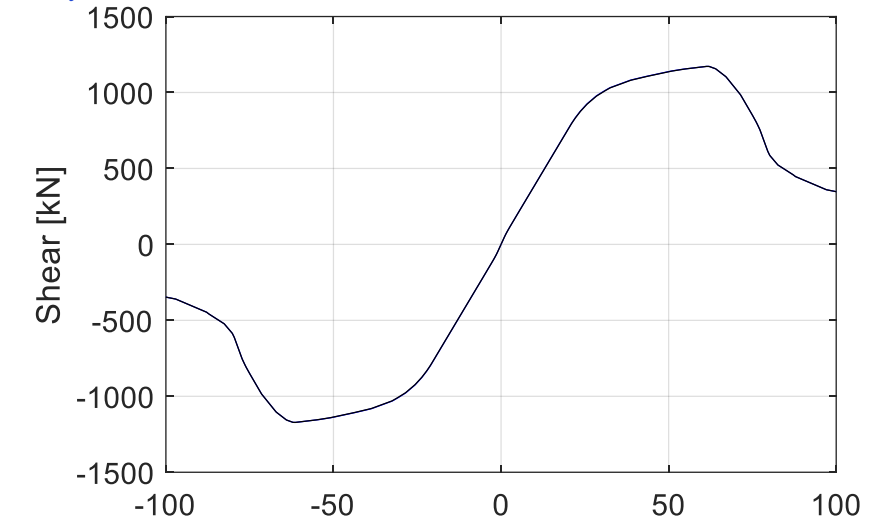
**Seismic fragility functions for process towers**



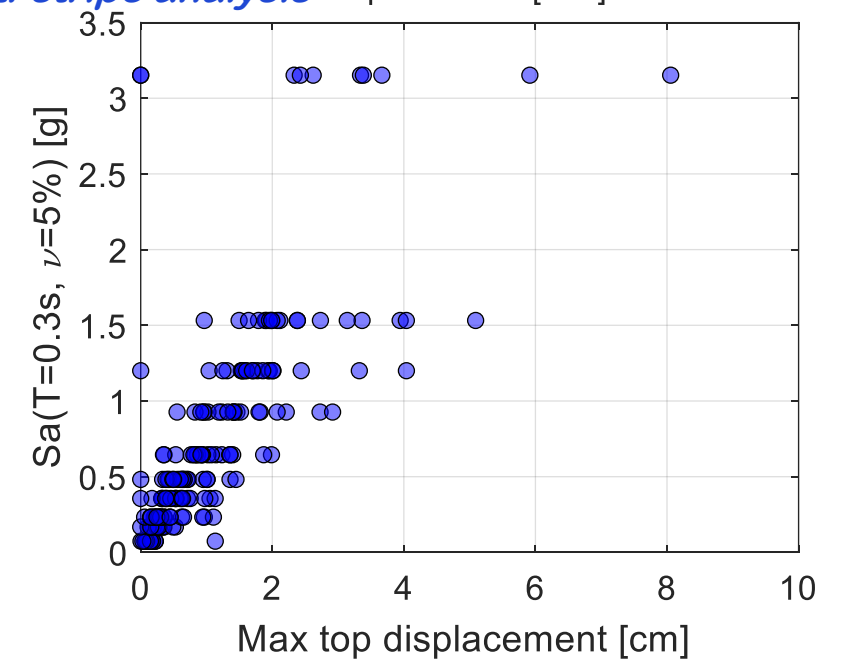
- Design of archetype structures
- Numerical modelling
- Dynamic analysis



*Static pushover curve*



*Multi-stripe analysis*





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# Convegno ReLUIs



**Progetto DPC\_ReLUIs 2022-2024**  
**Esposizione delle attività svolte e prospettive**

**Roma, 7 novembre 2023**

**WP 3 – RINTC**  
**Iunio Iervolino**