Prove non distruttive su edifici storici e monumentali: Modelli numerici per la loro interpretazione

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Giornata seminariale Progetto RE-FRESCOS
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OUTLINE

- **Introduzione**
  - *Modellazione numerica della frattura (FEM, LM & DM)*
- **Prova con il martinetto piatto doppio**
  - *Caratterizzazione meccanica e crack pattern*
  - *Interpretazione e Scaling AE*
- **Prove di carico su strutture voltate**
  - Ex-Ospedale S. Giovanni
  - Modello di ponte a due campate soggetto a cedimenti
- **Prove di laboratorio a compressione su campioni**
  - *Simulazioni numeriche FEM*
  - *Simulazioni numeriche DM*

INTRODUZIONE: FEM

Meso-level model

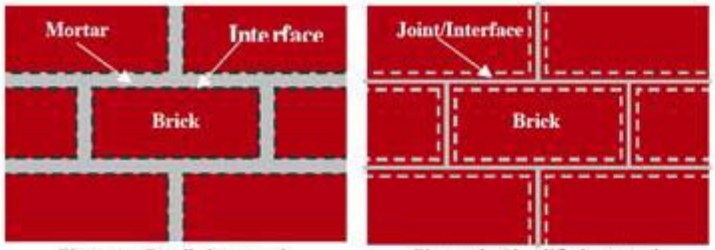


Figure 1a: Detailed approach

Figure 1b: Simplified approach

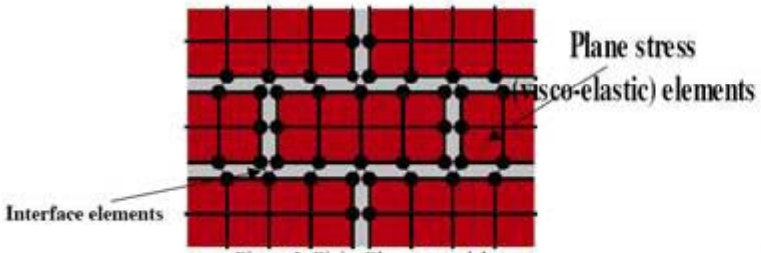


Figure 2: Finite Element model

Macro-level model

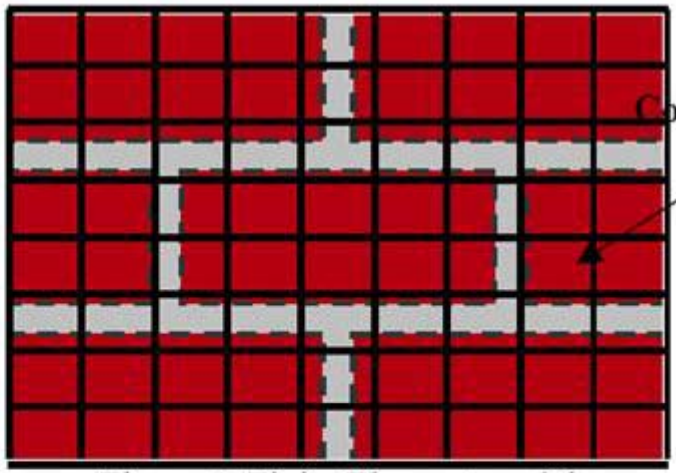


Figure 4: Finite Element model

Interface elements

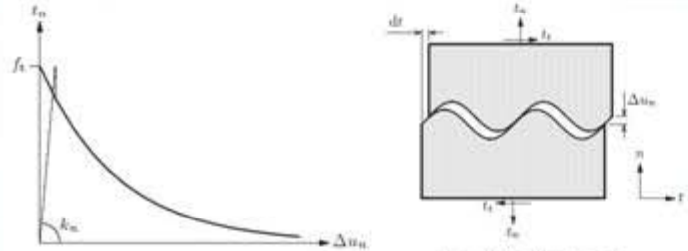


Figure 20.2: Discrete cracking

Figure 20.7: Rough crack

Plasticity (Rankine-Hill)

Smeared Crack Model

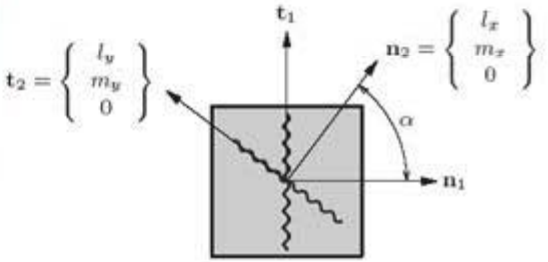
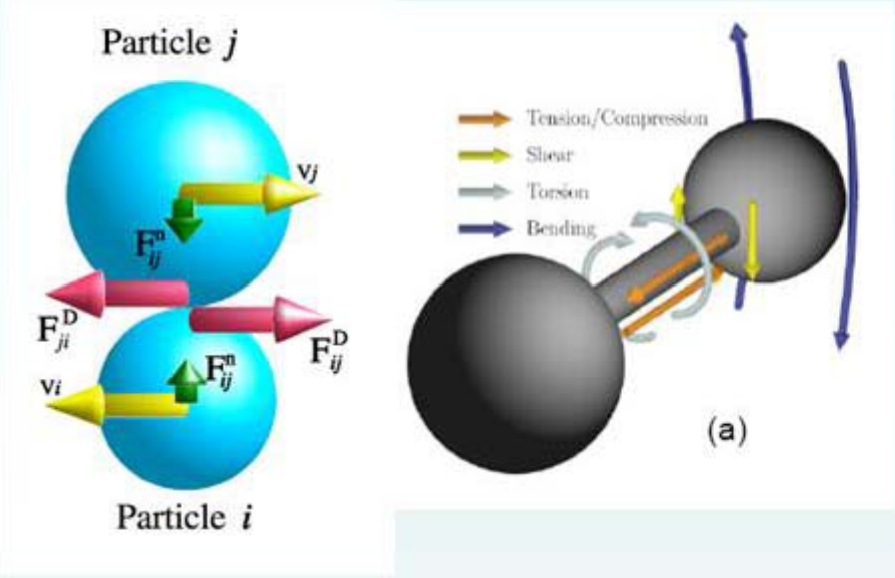
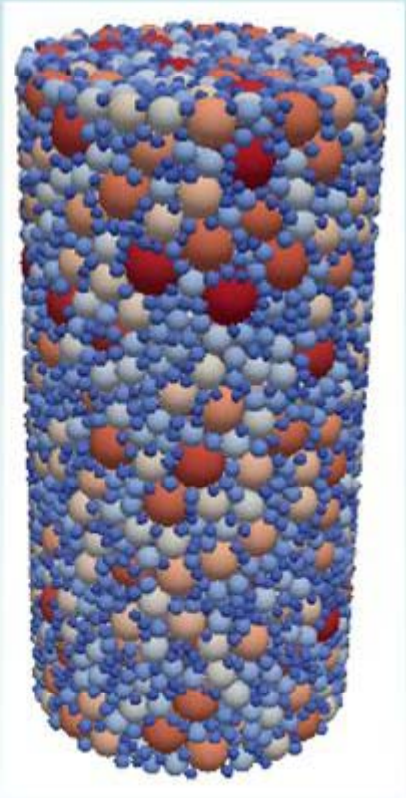
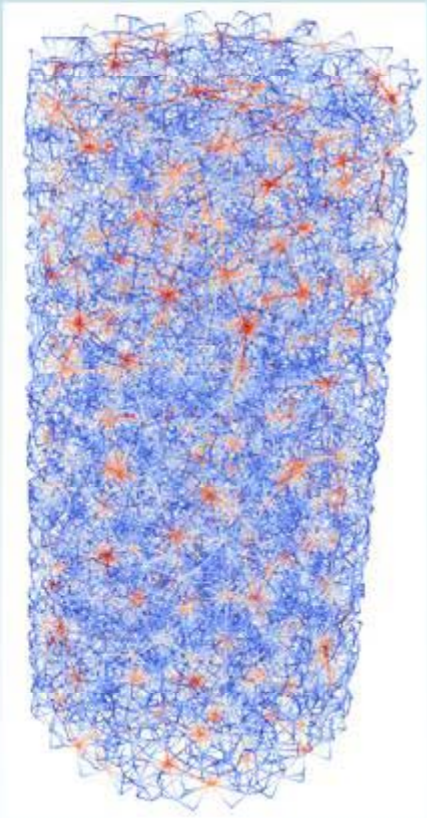


Figure 17.1: Multi-directional fixed crack model

INTRODUZIONE: DM

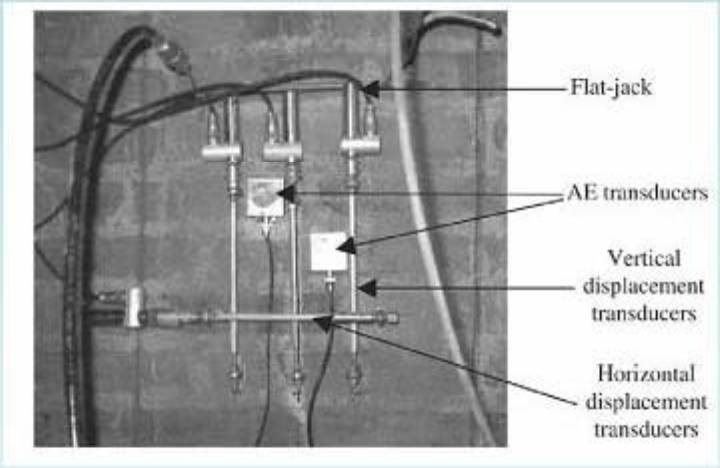




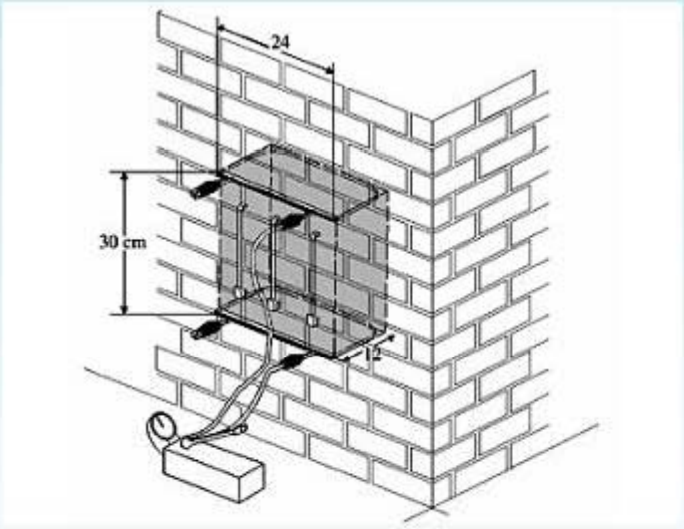


$$\frac{|F_n|}{F_n^{brk}} + \frac{|F_s|}{F_s^{brk}} + \frac{|F_b|}{F_b^{brk}} + \frac{|F_t|}{F_t^{brk}} > 1$$

PROVA CON IL MARTINETTO PIATTO DOPPIO

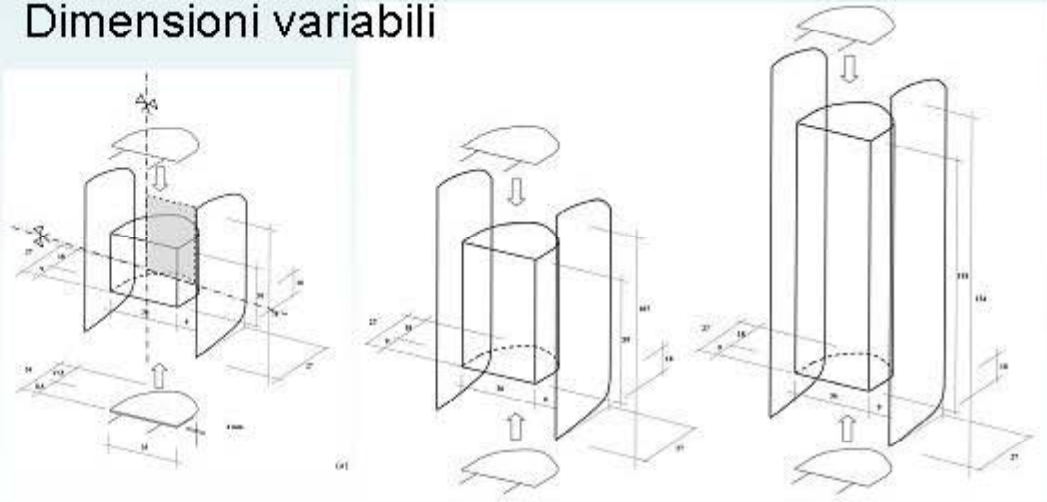


Monitoraggio AE

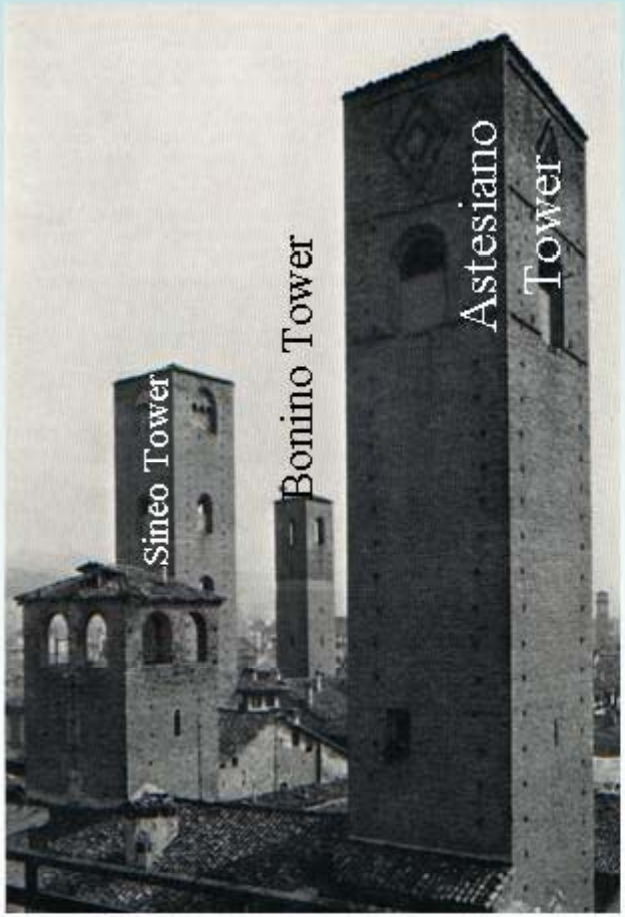


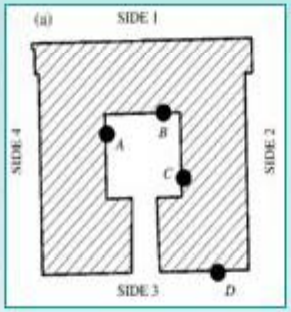
Schema di prova

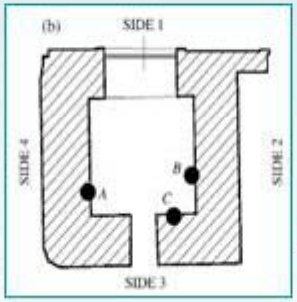
Dimensioni variabili

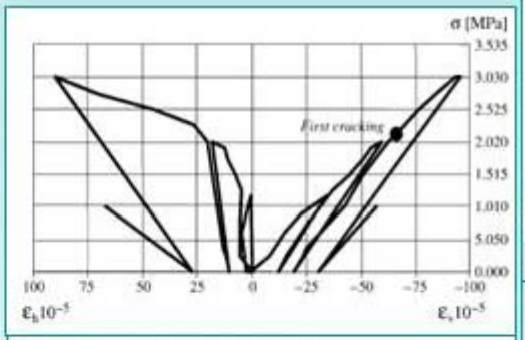


TORRI DI ALBA





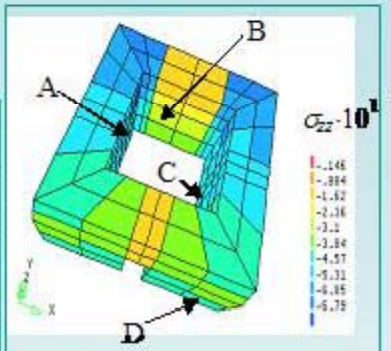


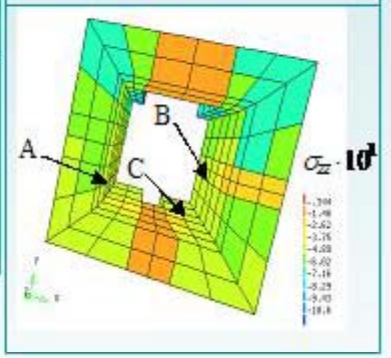


Results from single and double flat-jack tests

Points	Foundation floor		Ground floor	
	σ_z	E	σ_z	E
A	2.455	–	0.871	–
B	0.297	–	0.746	–
C	1.059	–	–	–
D	0.502	–	–	5000

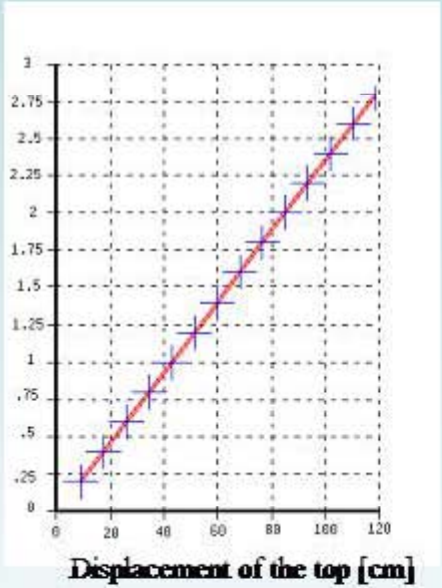
Average compressive stresses and Young's moduli are in MPa.

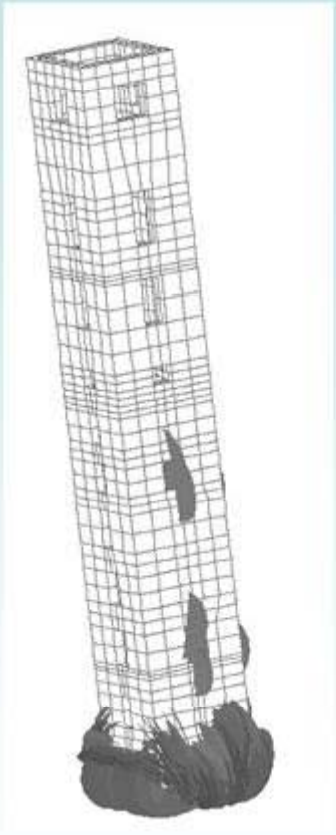




Monitoraggio con AE

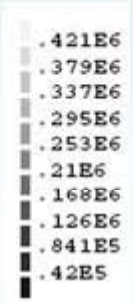
TORRI DI ALBA

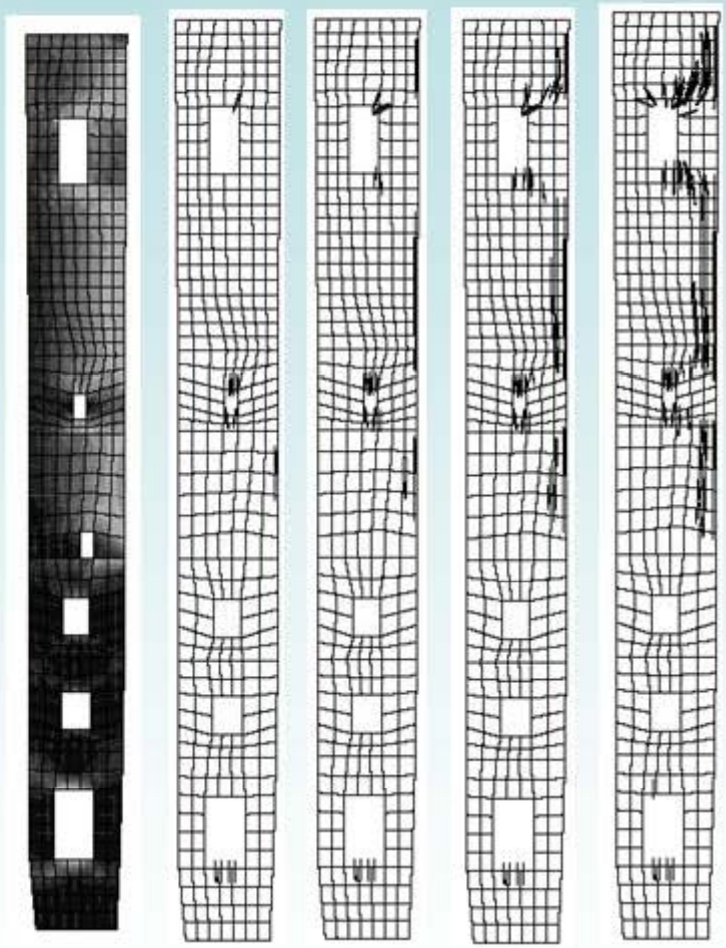




Evoluzione cedimenti

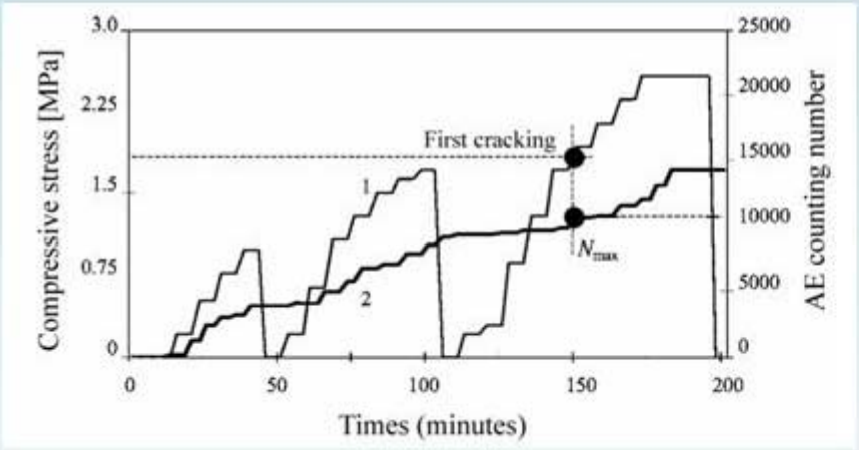
σ_1

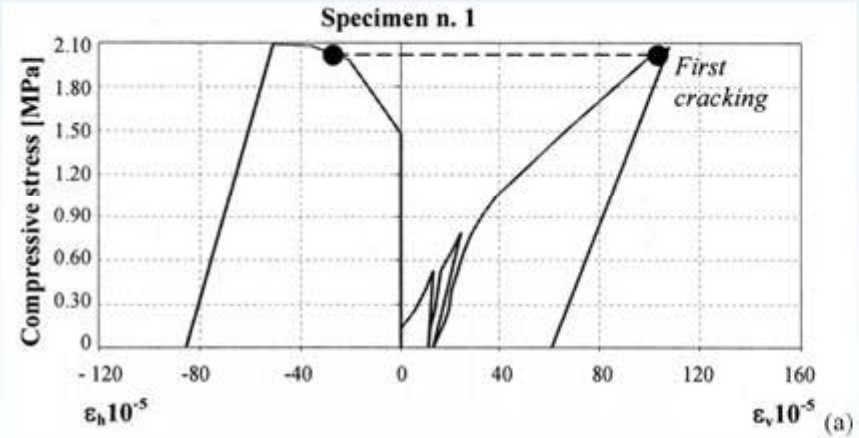




Frattura per escursione termica

PROVA CON IL MARTINETTO PIATTO DOPPIO





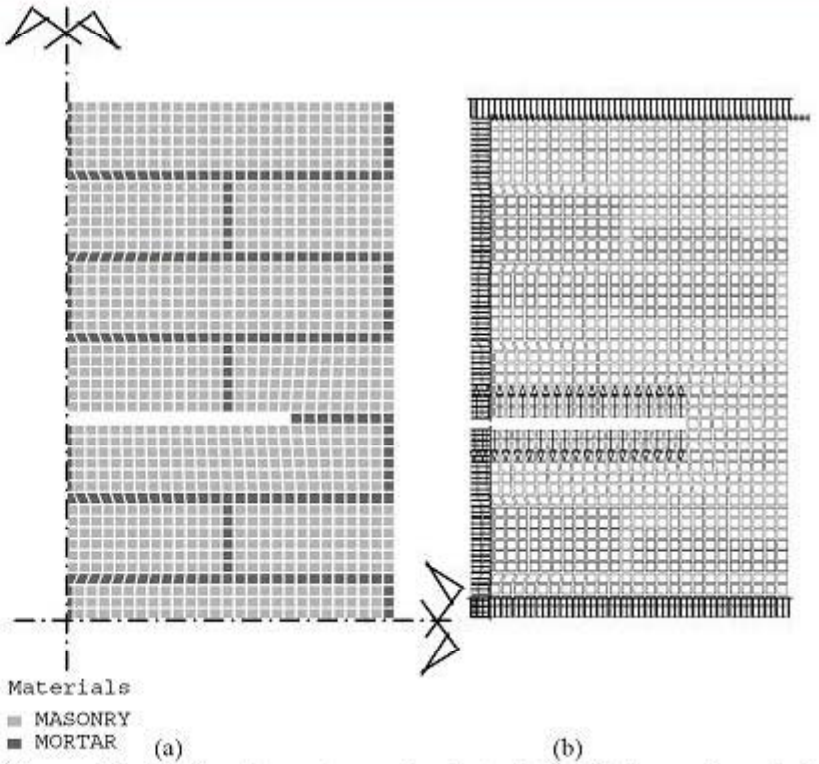
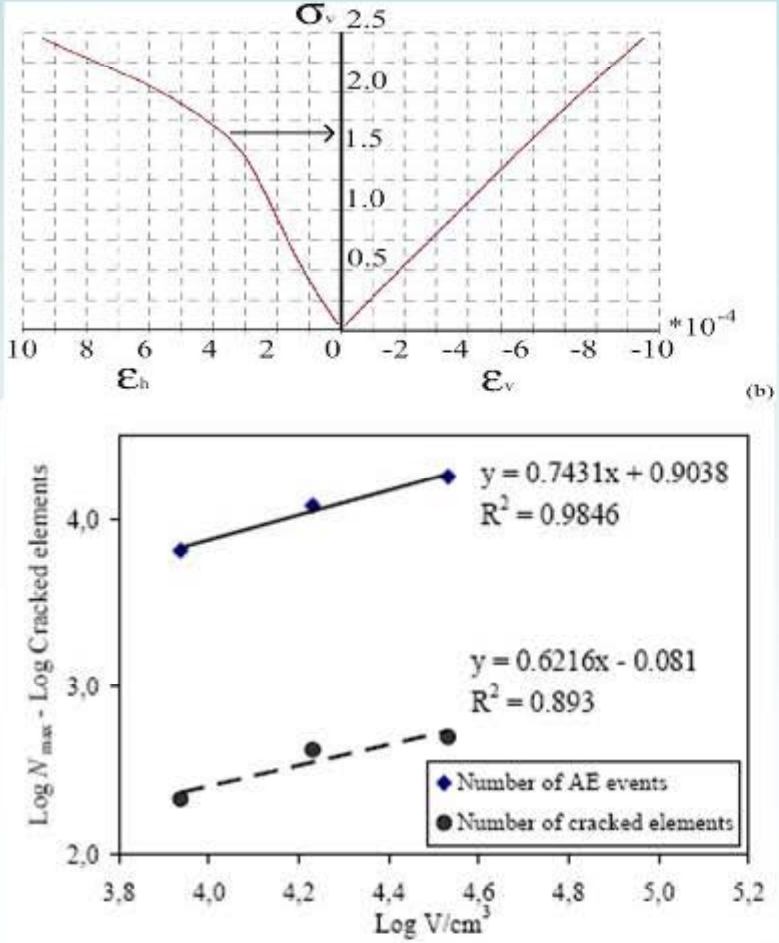
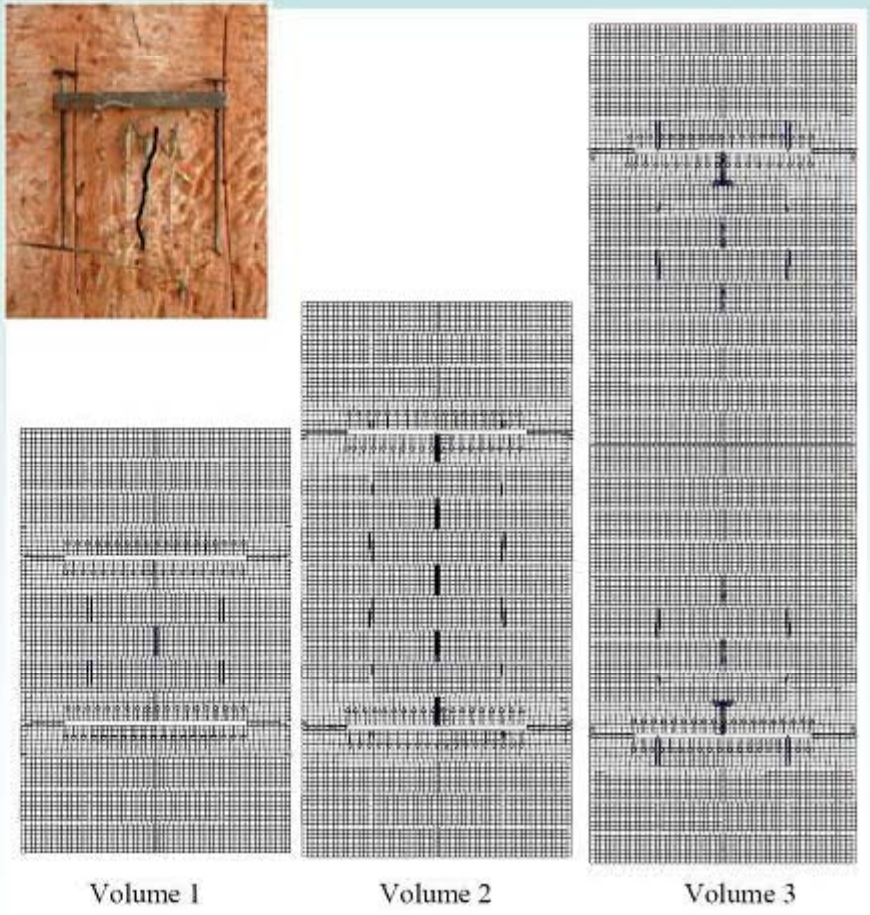


Figure 11. Finite element mesh adopted for Volume 1 exploiting symmetry (crf. Shaded area in Fig. 7a). Mesh and materials (a); loads and boundary conditions (b).

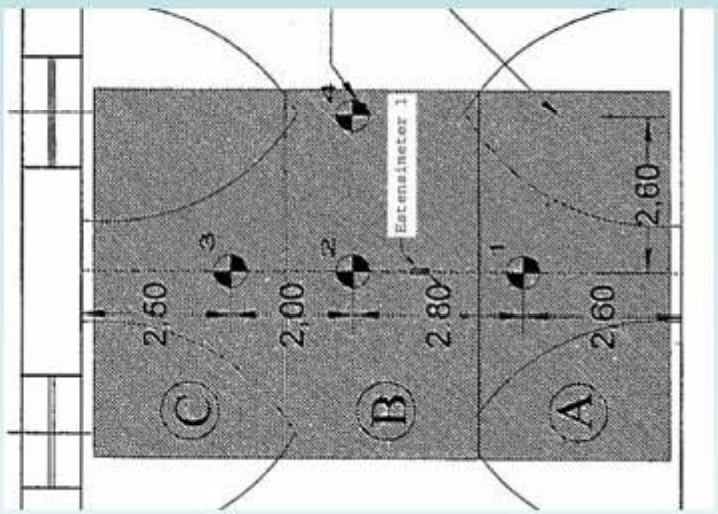
PROVA CON IL MARTINETTO PIATTO DOPPIO



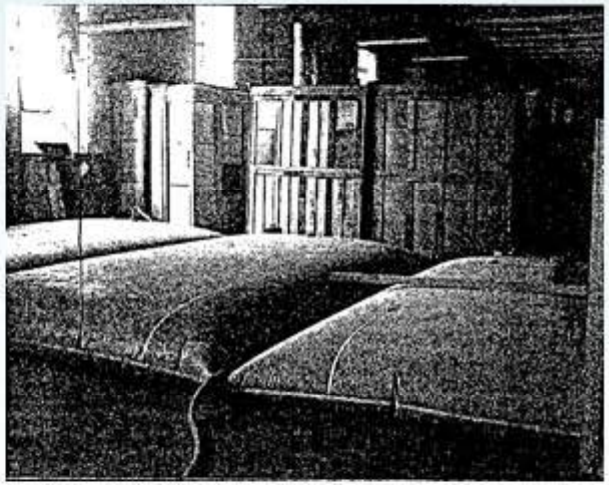


PROVE DI CARICO SU VOLTE

ExOspedale S. Giovanni

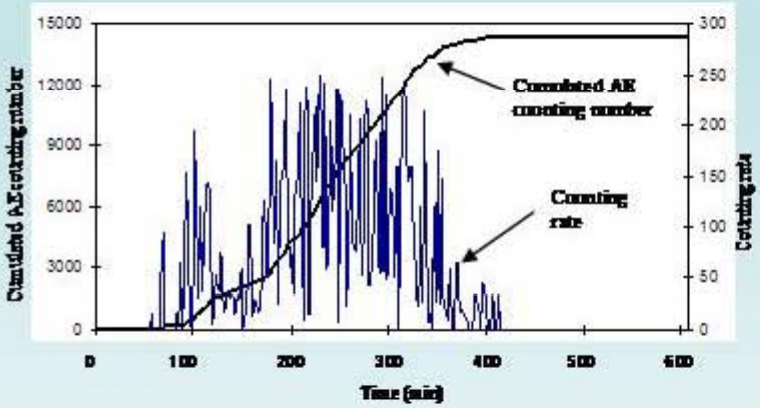


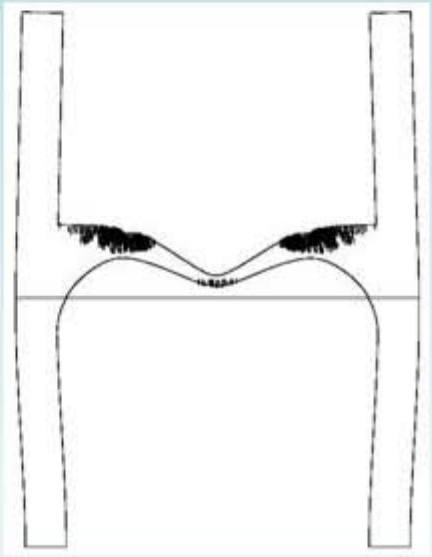
Schema di carico
e sensori AE

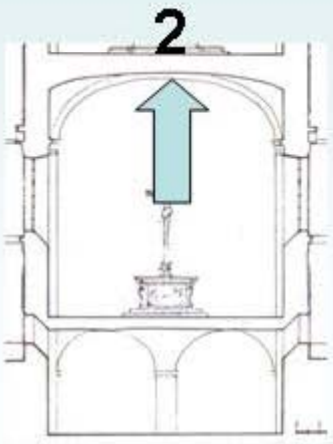


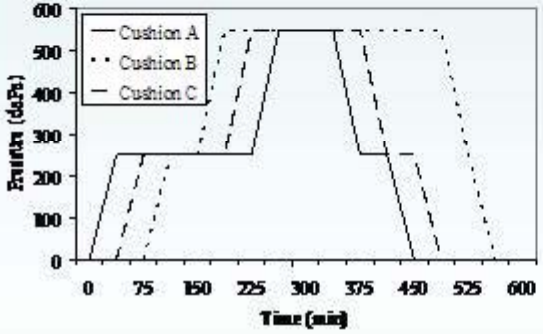
Cuscini
di carico

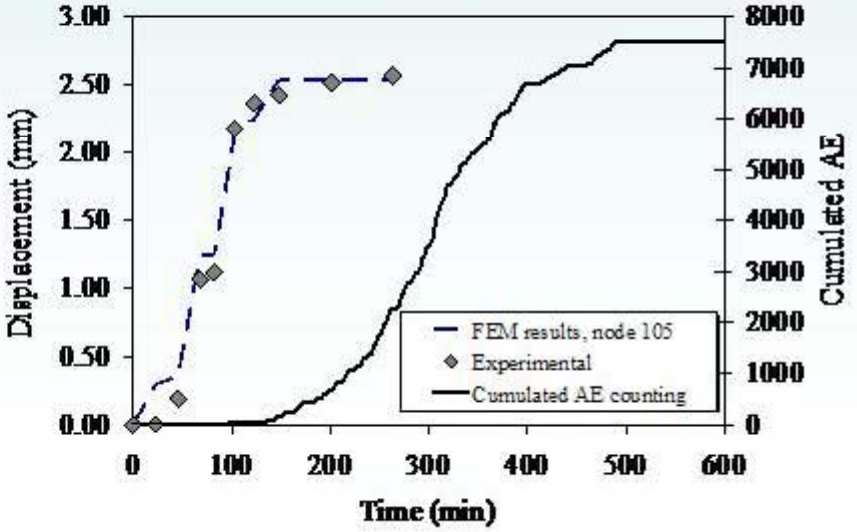
PROVE DI CARICO SU VOLTE











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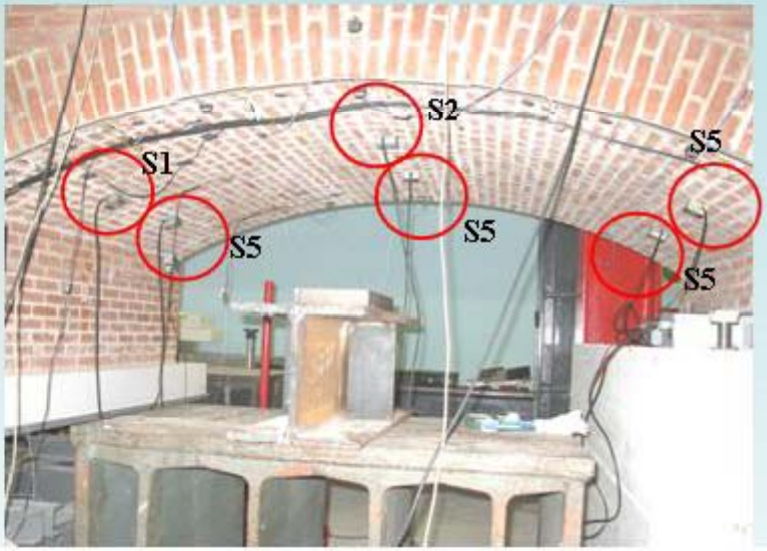
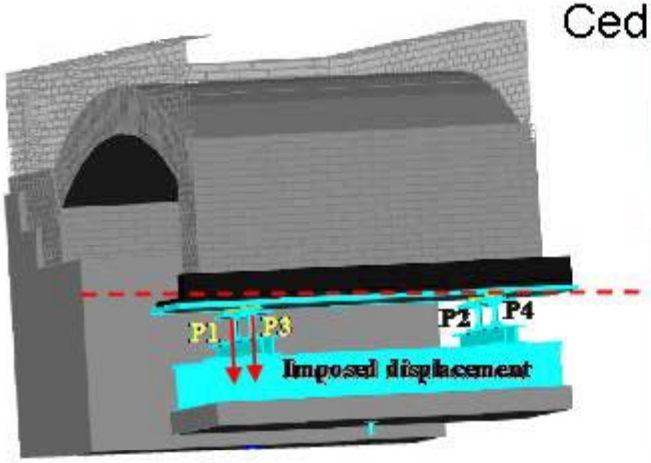
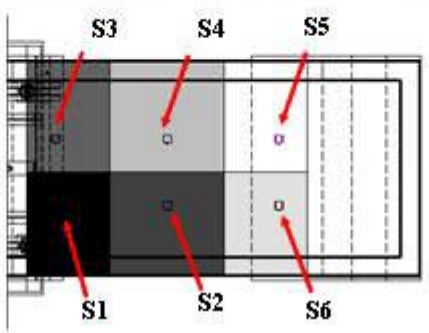
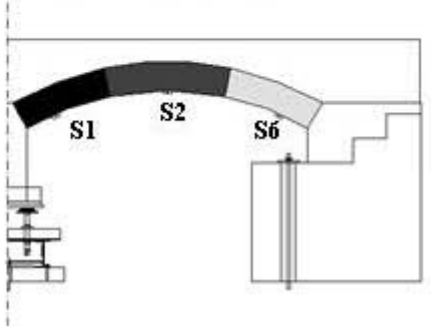
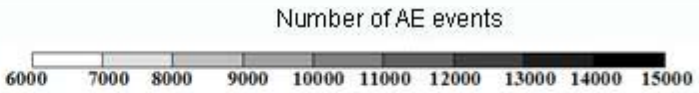


Cedimenti imposti









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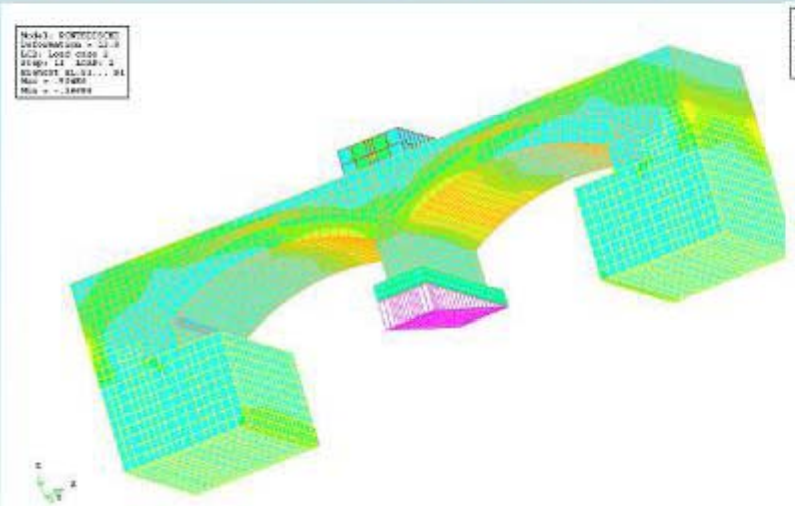
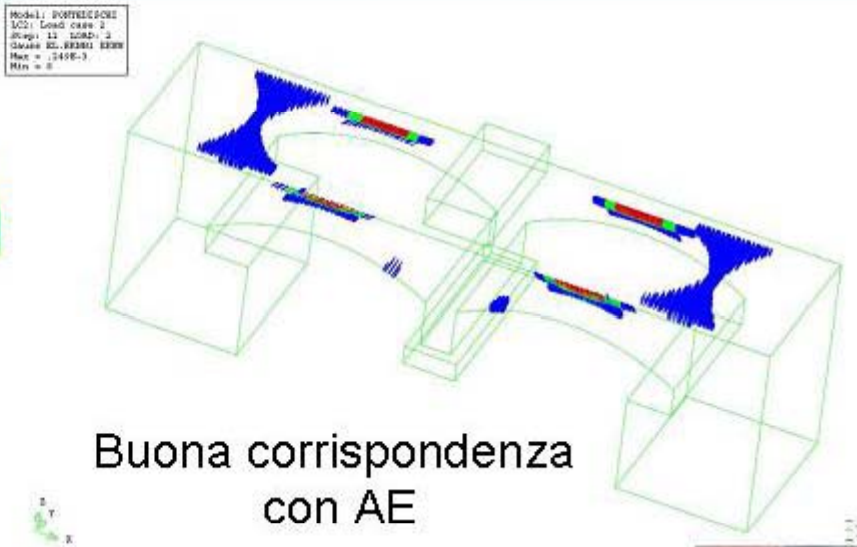
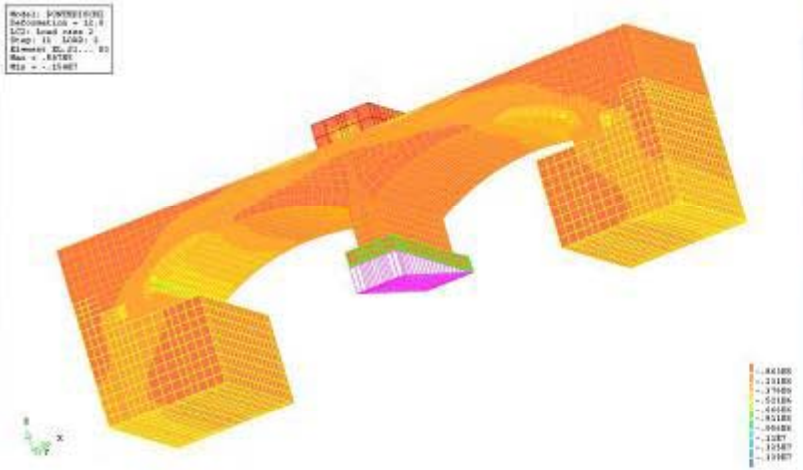
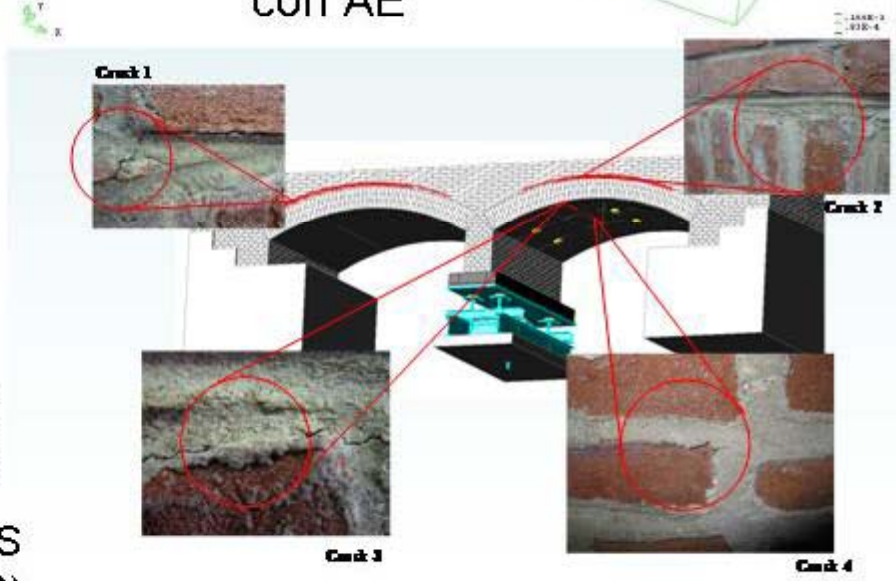


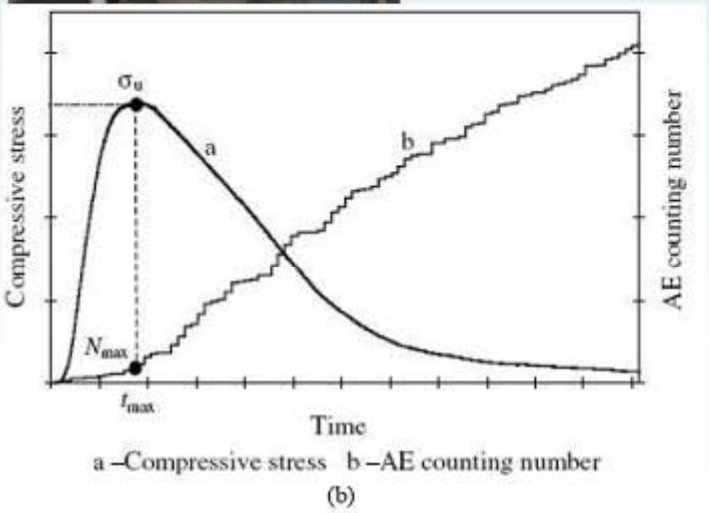


Buona corrispondenza con AE



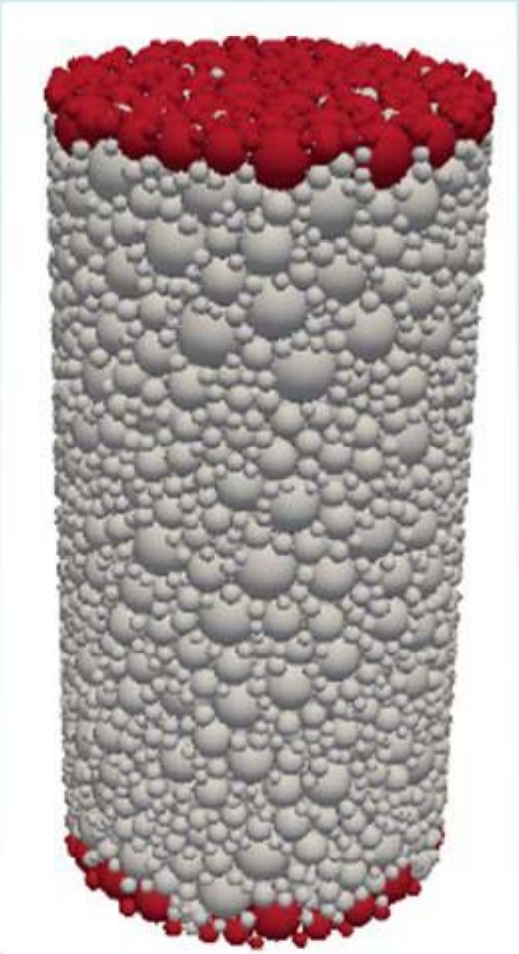


PROVE DI COMPRESSIONE

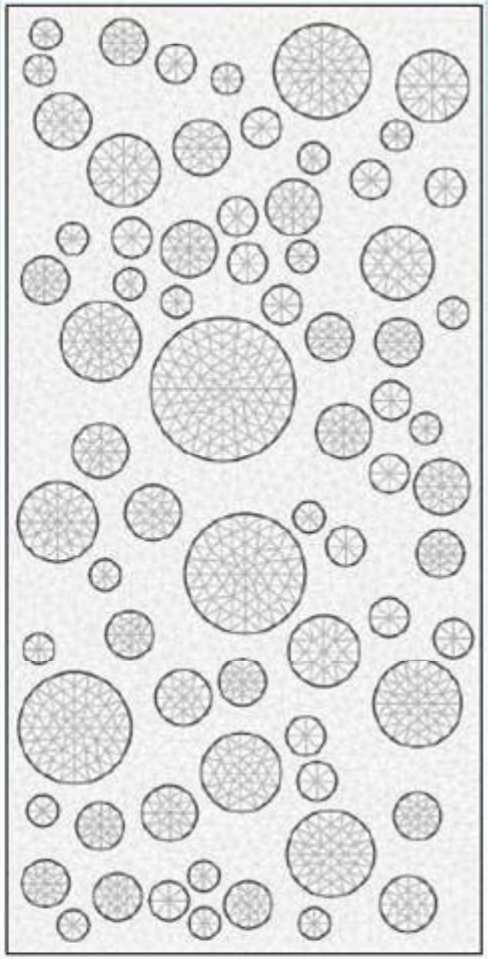


a –Compressive stress b –AE counting number
(b)

DE

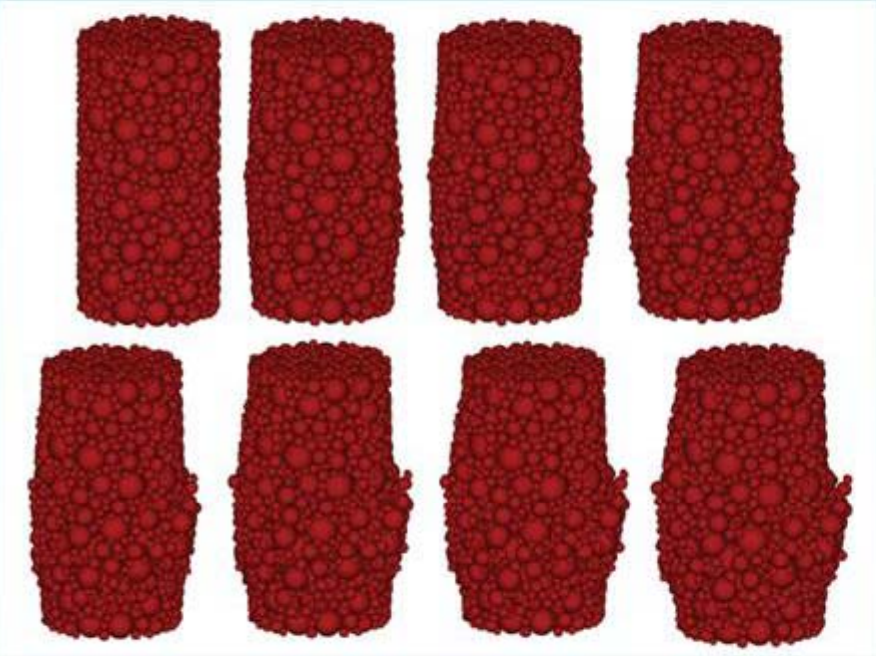


FEM

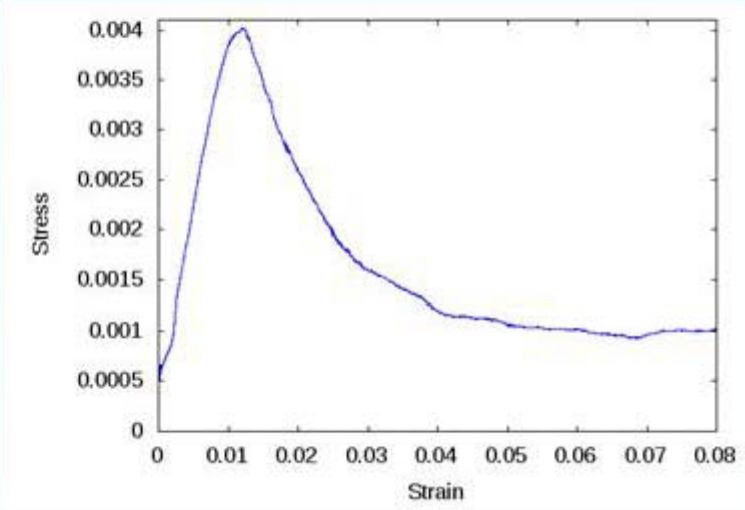


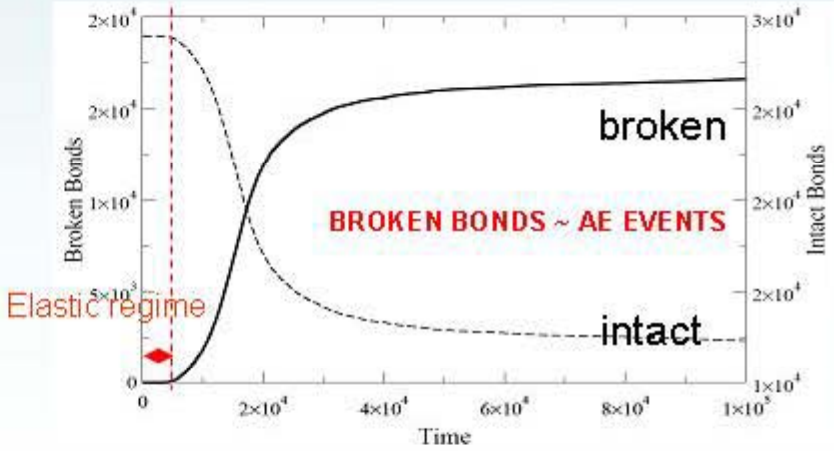
C23

PROVE DI COMPRESSIONE



Crack Pattern





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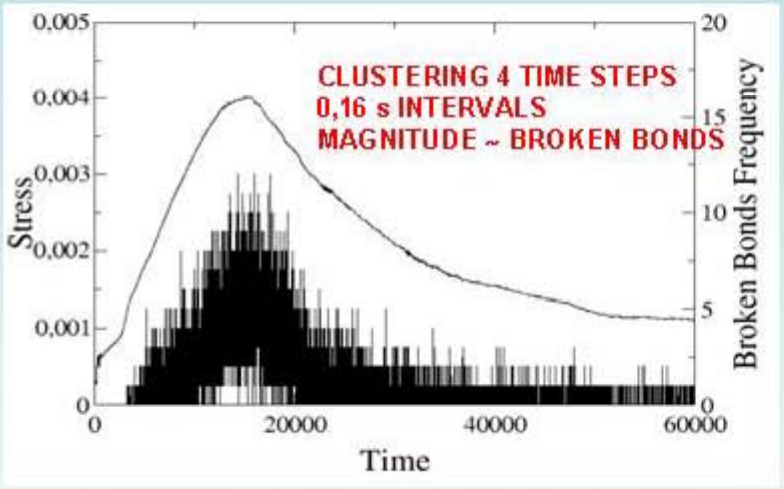

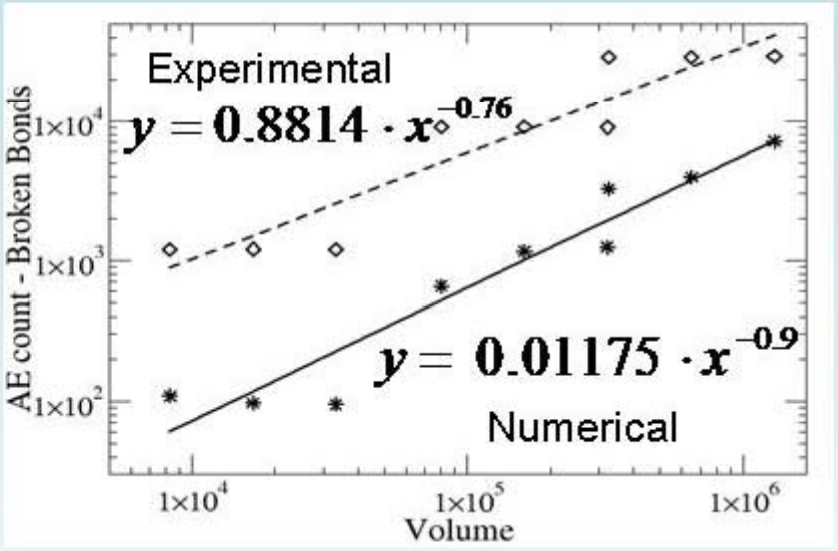

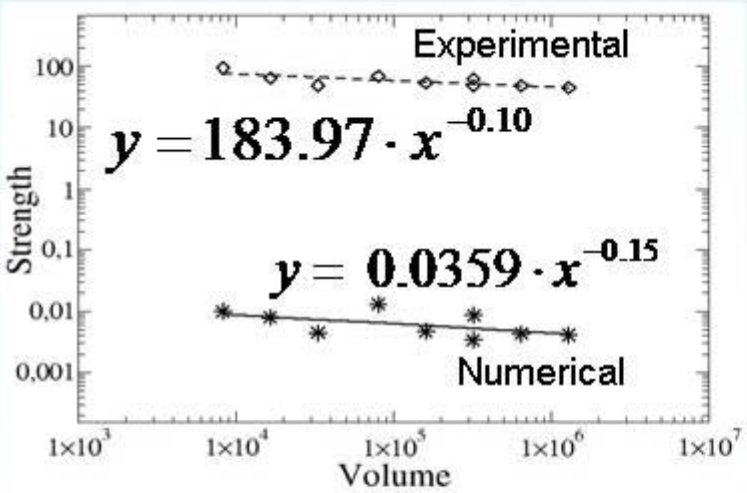

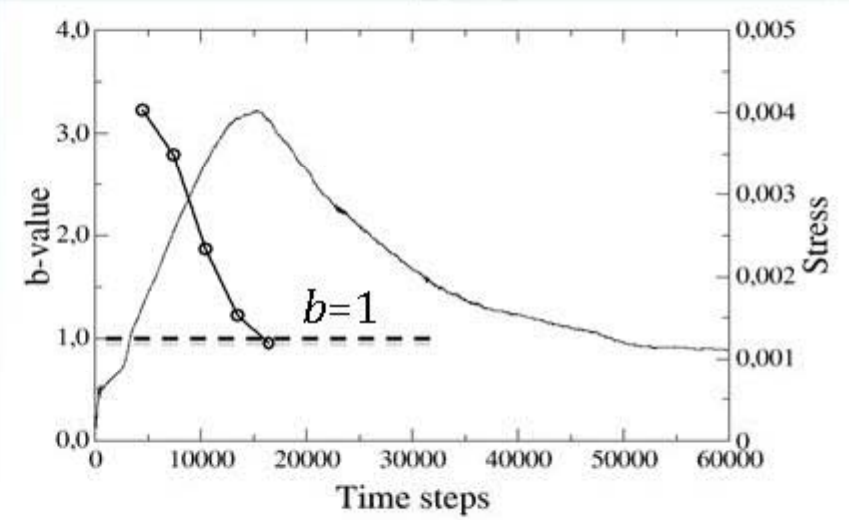

Giornata seminariale Progetto RE-FRESCOS
Giovedì 1 Luglio 2010, Aula Albenga (DISTR)

CONCLUSIONI

- Sono state illustrate le principali tecniche numeriche per la simulazione del danneggiamento in edifici storici e monumentali
- Tali tecniche sono state applicate all'interpretazione dei risultati sperimentali ottenuti con indegini non distruttive o moderatamente distruttive (martinetti piatti, prove di carico, Emissioni Acustiche)
- La modellazione numerica permette di valutare la stabilità del manufatto in esame, e di comprendere più a fondo i risultati sperimentali (NDT e/o laboratorio)
- I principali fenomeni considerati sono:
  - Risposta meccanica
  - Crack pattern
  - Scaling del numero di eventi di AE
  - Evoluzione del *b*-Value durante la prova

RIFERIMENTI BIBLIOGRAFICI

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