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PIANO NAZIONALE DI RIPRESA E RESILIENZA

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MUR Ministero dell'Università e della Ricerca

VITALITY

Piezoresistive and piezoelectric cements: a disruptive step towards sustainable and smart infrastructures

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ABRUZZO

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  - Production process
  - Strain sensing capabilities
  - Damage sensing capabilities
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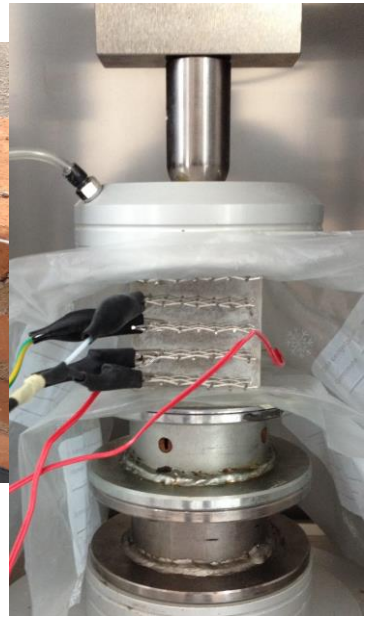
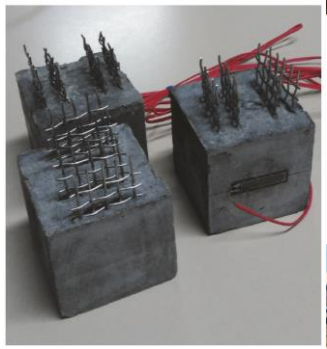
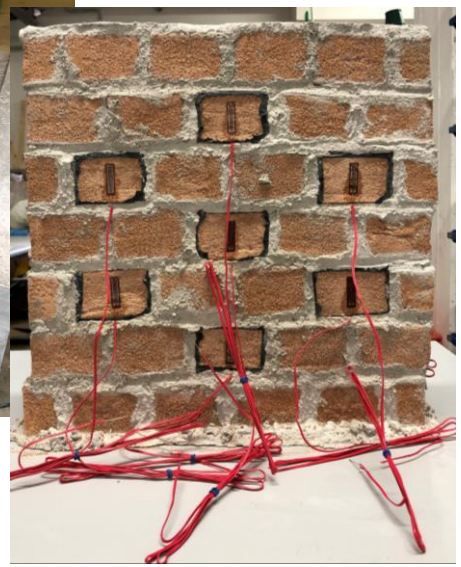






Background and Motivations

- Absence of seismic design
- Material deterioration (aging)
- Damage due to excessive loading conditions
- Differential foundation settlements
- Natural hazards
- Scarce maintenance

Structural pathologies can negatively influence the structural performance of constructions

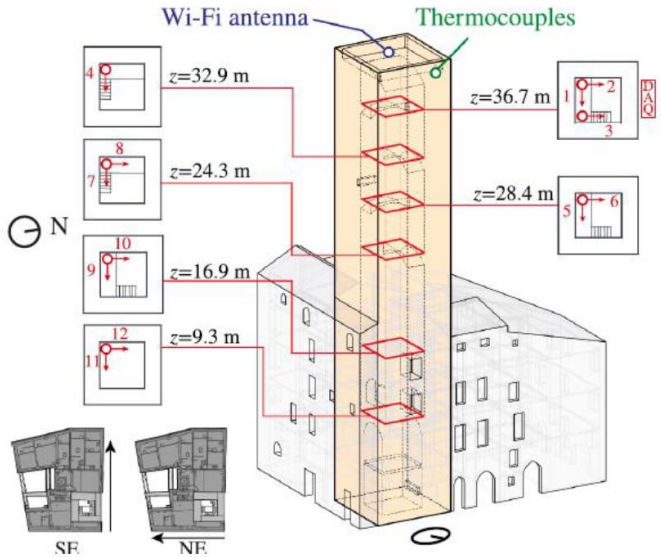
Background and Motivations

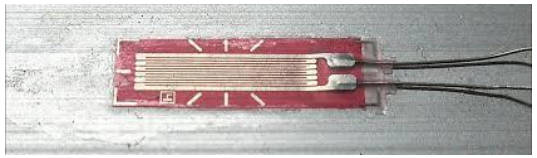
SHM approaches can be employed to monitor the structural performance of a construction during its operating conditions.

Actually, the large-scale deployment of SHM systems to concrete/masonry constructions is quite limited nowadays.

Issues in sensor deployment:

- Traditional sensors are commonly attached externally;
- Scarce/low durability in time;
- Limited scalability of the traditional sensing technologies;
- Historical value of the building being monitored;
- High cost;
- And more…

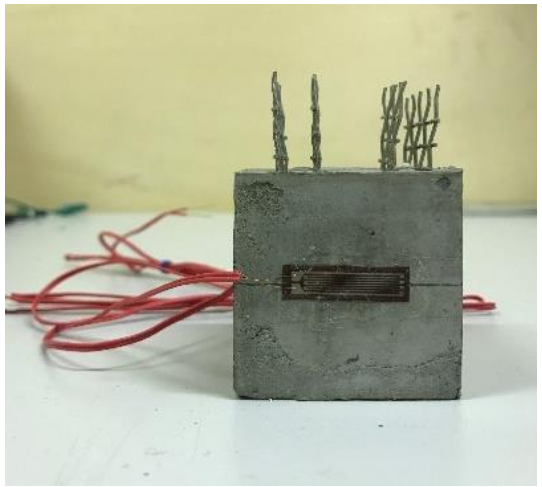


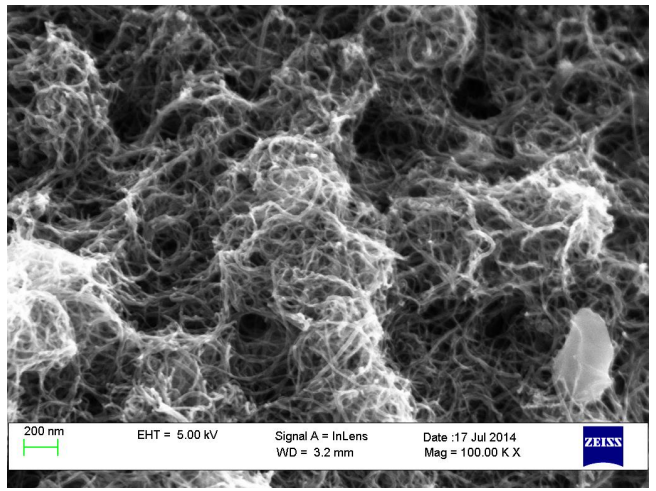


Smart Construction Materials

Why smart materials?

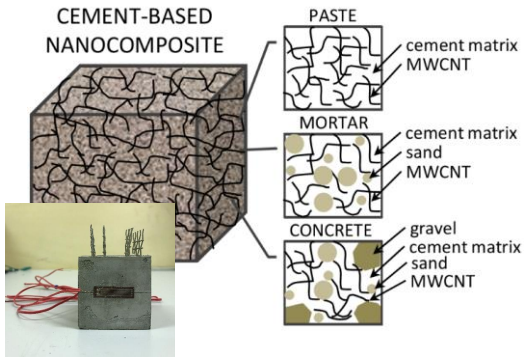
- Define construction materials that generate a direct response to damage
- Sensors are naturally integrated in the monitored structure (the construction material is a sensor itself)
- Novel functionalities and enhanced performance (possibility of also monitoring air temperature, humidity, etc.)



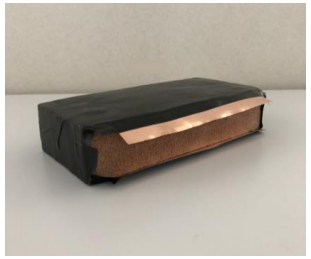


Smart Construction Materials

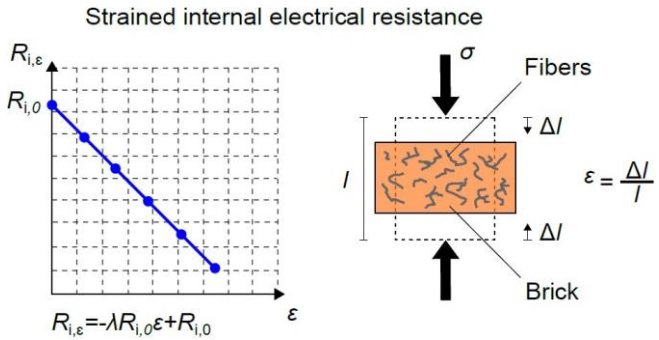
The physics of self-sensing

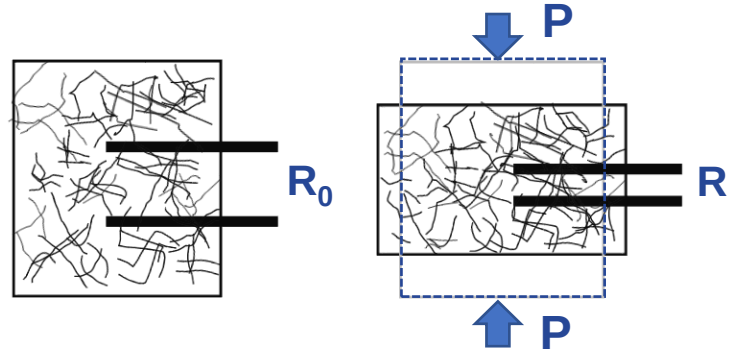


Smart concrete sensors



Smart bricks





Piezoresistive sensors

The piezoresistive material/sensor produces changes in its electrical resistance when mechanically strained.

They have to be powered.

$$\frac{\Delta R_i}{R_{i,0}} = \frac{R_{i,\epsilon} - R_{i,0}}{R_{i,0}} = -\lambda\epsilon$$

Relative change in electrical resistance

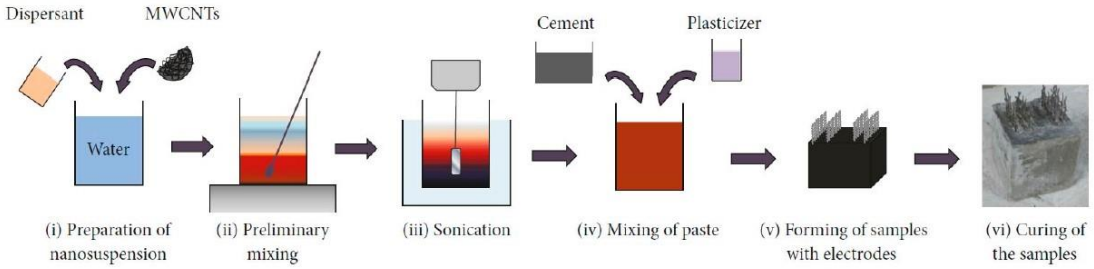
Gauge factor

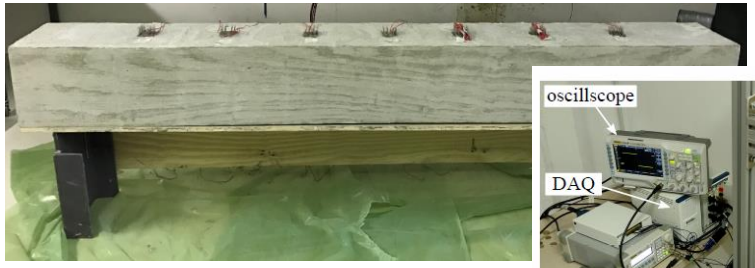
Strain

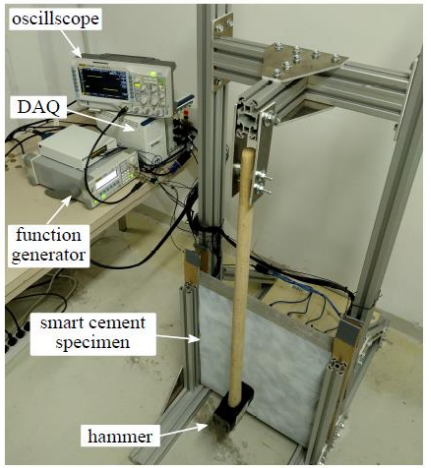
Smart Construction Materials

Production process

Smart concrete sensors







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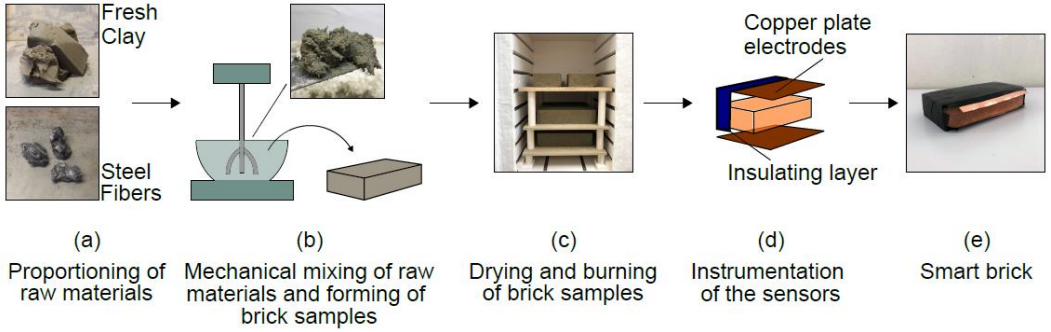
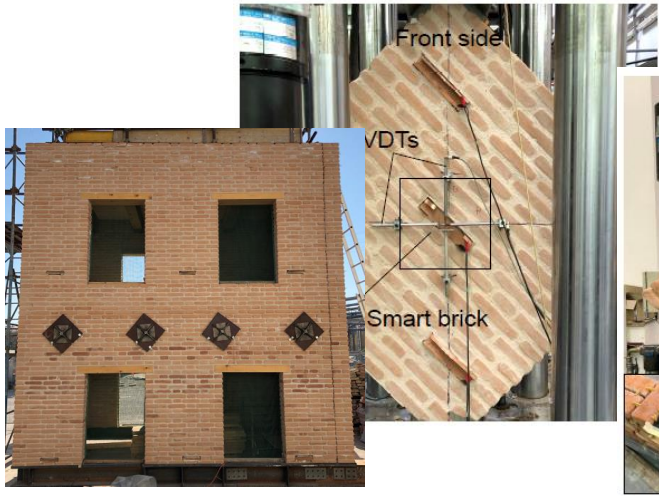
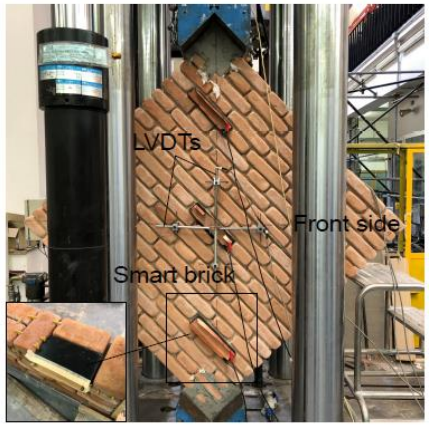


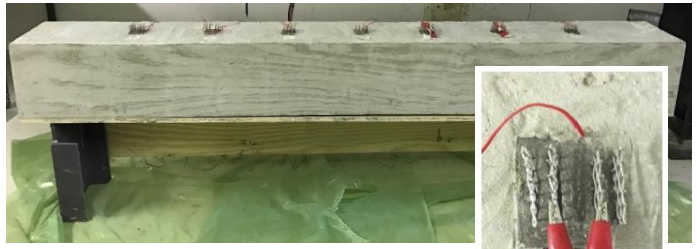


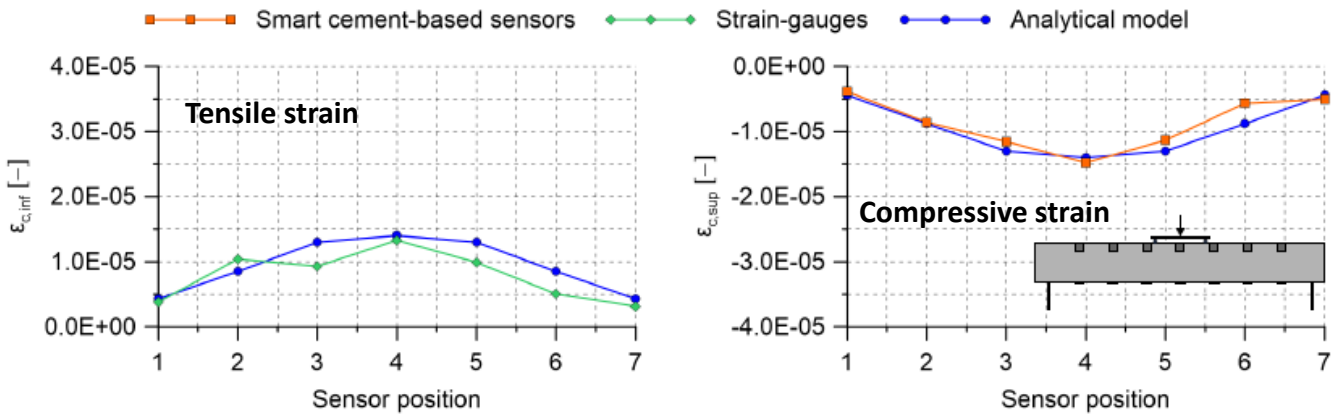


Smart Construction Materials

Strain sensing capabilities

Smart concrete sensors





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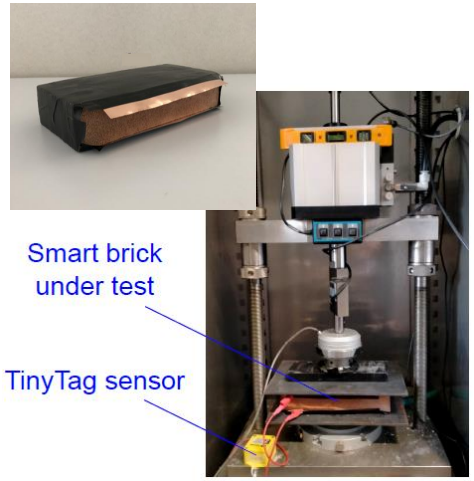
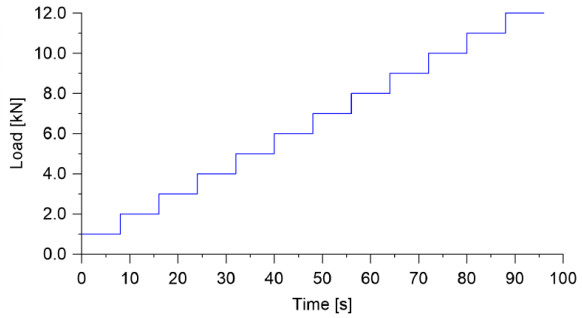
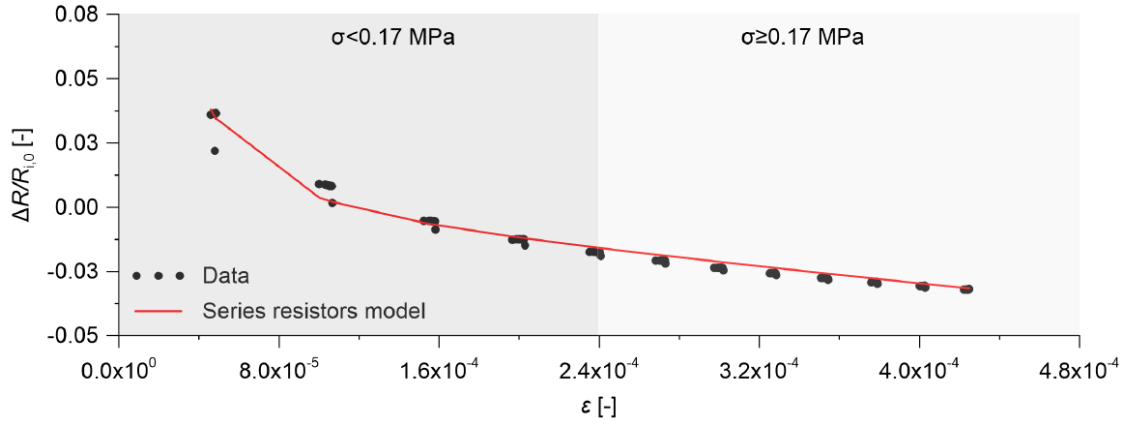


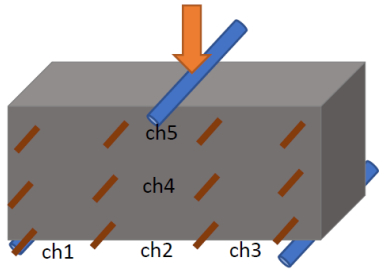


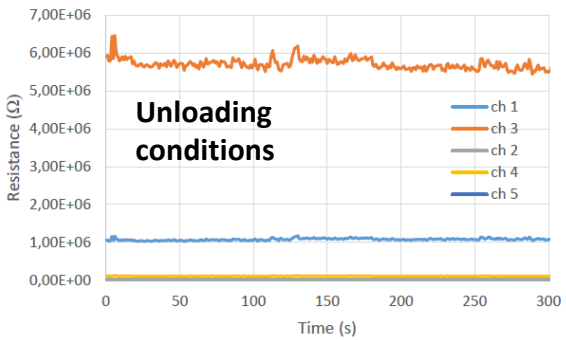


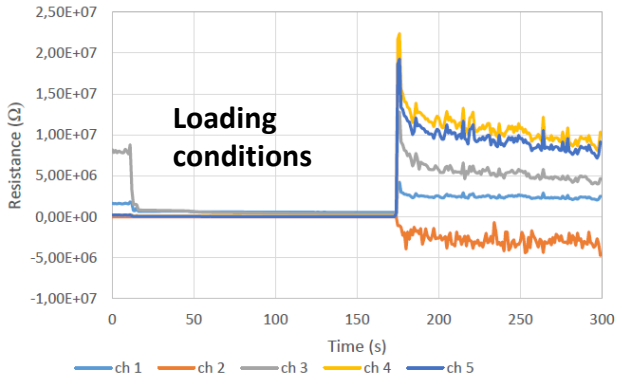
Smart Construction Materials

Damage sensing capabilities

Smart concrete sensors







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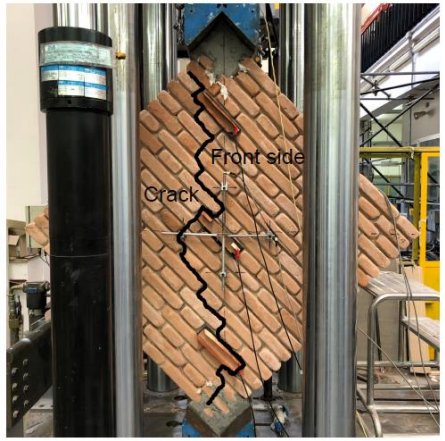
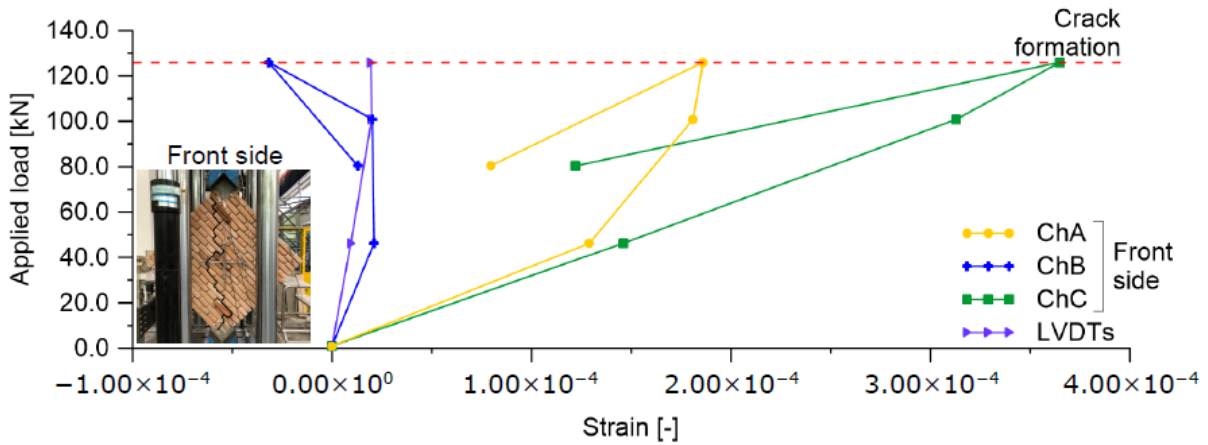
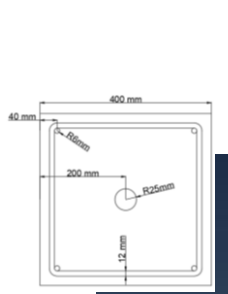


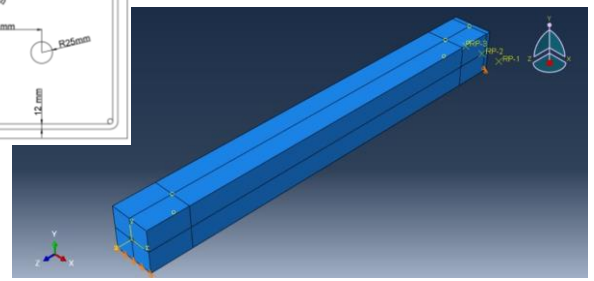


Ongoing Research Activities

- Literature review on the state-of-the-art of piezoelectric smart concrete sensors for SHM applications;
- Literature review on the state-of-the-art of the 3D printing of smart concrete sensors for SHM applications;
- First laboratory attempts to produce/test piezoelectric smart concrete sensors;
- Field tests to evaluate the effectiveness of smart construction materials for SHM;
- Execution of numerical simulations to explore possible use of smart concrete sensors for SHM of reinforced concrete structural elements/constructions;
- Study of the structural response of buildings and bridges subjected to static/dynamic excitations during their operating conditions.

Esempio tratto da: Asprone, D., Auricchio, F., Menna, C., & Mercuri, V. (2018). 3D printing of reinforced concrete elements: Technology and design approach. Construction and Building Materials, 165, 218-231.





Dissemination Activities

- Plenary session at the 19th International Conference on Construction Pathologies and Repair (CINPAR 2023) held in Sobral (Ceará), Brazil.

  Structural Health Monitoring of Masonry Constructions using Smart Bricks: Recent Developments and Monitoring Strategies

- EuroDyn Delft 2023 - XII International Conference on Structural Dynamics, Delft University of Technology.

  Vibration-based assessment of the structural integrity of a masonry wall system with single opening subjected to progressive damage induced by out-of-plane loading conditions

- EUROSTRUCT Vienna 2023 - 2nd Conference of the European Association on quality control of bridges and structures, Vienna, University of Natural Resources and Life-Sciences (BOKU).

  A New Methodology for the Prioritization of Visual Inspections of Bridges and Viaducts

  Winner of the "Best Paper Award" – Young Researcher

Dissemination Activities

Meoni, A., Fabiani, C., D'Alessandro, A., Pisello, A. L., & Ubertini, F. (2023, June). Smart-Earth Multifunctional Cement Composites for Sustainable Constructions: Thermal and Sensing Characterization. In International RILEM Conference on Synergising expertise towards sustainability and robustness of CBMs and concrete structures (pp. 1199-1208). Cham: Springer Nature Switzerland; https://doi.org/10.1007/978-3-031-33211-1_107

Meoni, A., García-Macías, E., Venanzi, I. and Ubertini, F. (2023), A New Methodology for the Prioritization of Visual Inspections of Bridges and Viaducts. ce/papers, 6: 753-759; https://doi.org/10.1002/cepa.2064

Farneti, E., **Meoni, A.**, Natali, A., Celati, S., Frascella, C., Lupi, M.C., Cavalagli, N., Venanzi, I., Salvatore, W. and Ubertini, F. (2023), STRUCTURAL HEALTH MONITORING OF CURVED ROADWAY BRIDGES THROUGH SATELLITE RADAR INTERFEROMETRY AND COLLAPSE SIMULATION. ce/papers, 6: 907-916. https://doi.org/10.1002/cepa.2201

Meoni, A., Galassi Sconocchia, G., Mariani, F., Ierimonti, L., Castellani, M., Tomassini, E., Venanzi, I., & Ubertini, F. (2023). Characterization of the static and dynamic response of a post-tensioned concrete box girder bridge with vertically prestressed joints showing vertical deflections due to concrete creep deformation. In XII International Conference on Structural Dynamics 2023, in press.

D'Alessandro, A., Birgin, H. B., **Meoni, A.**, & Ubertini, F. (2020). Smart graphite cementitious composites for weigh-in-motion and monitoring of bridges. In Italian Concrete Days Conference 2020, in press.

Thank You for Your Attention

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