M&MIMS24
Mathematics and Mechanics of Innovative Materials and Structures

2024 International Workshop
Mathematics and Mechanics of Innovative Materials and Structures **(M&MIMS24)**

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Ministry of Foreign Affairs and International Cooperation

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NEXTBUILDING

Current state of the research and future perspectives

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Next-generation green structures for natural disaster-proof buildings

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1. Units

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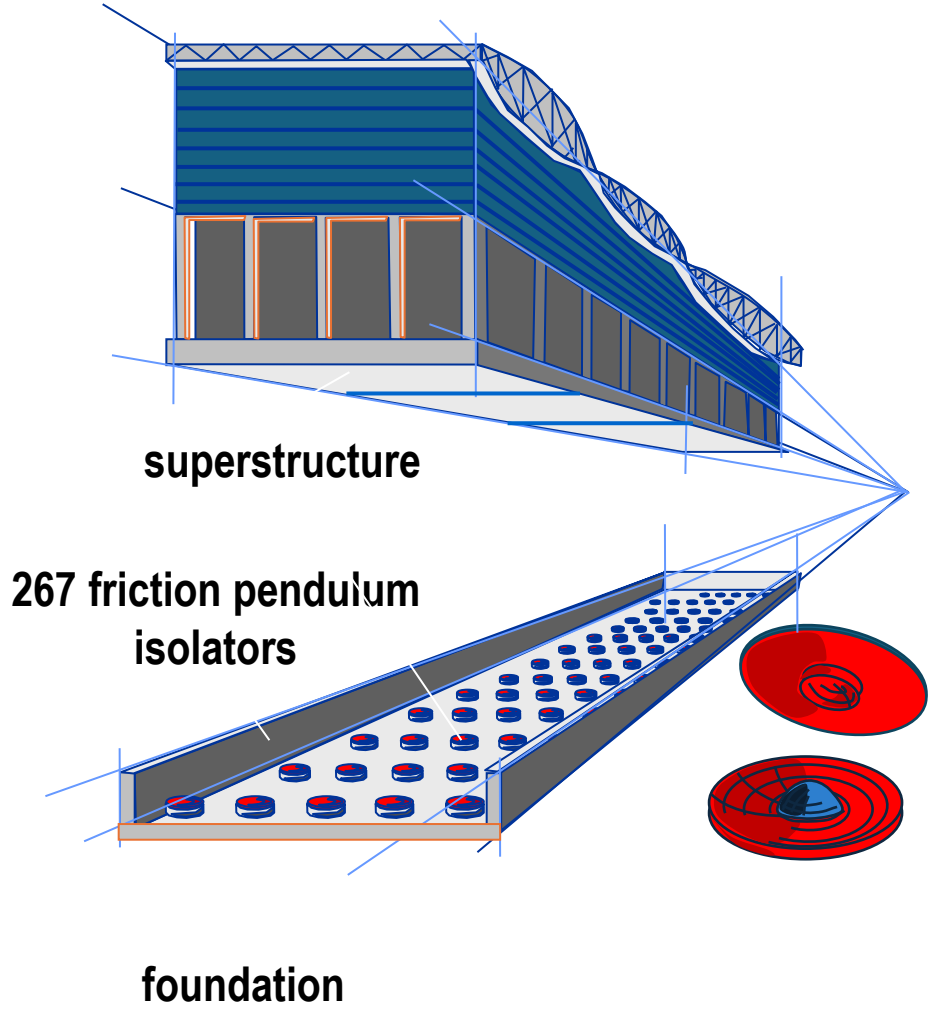
2. Project website

3. Description of the project

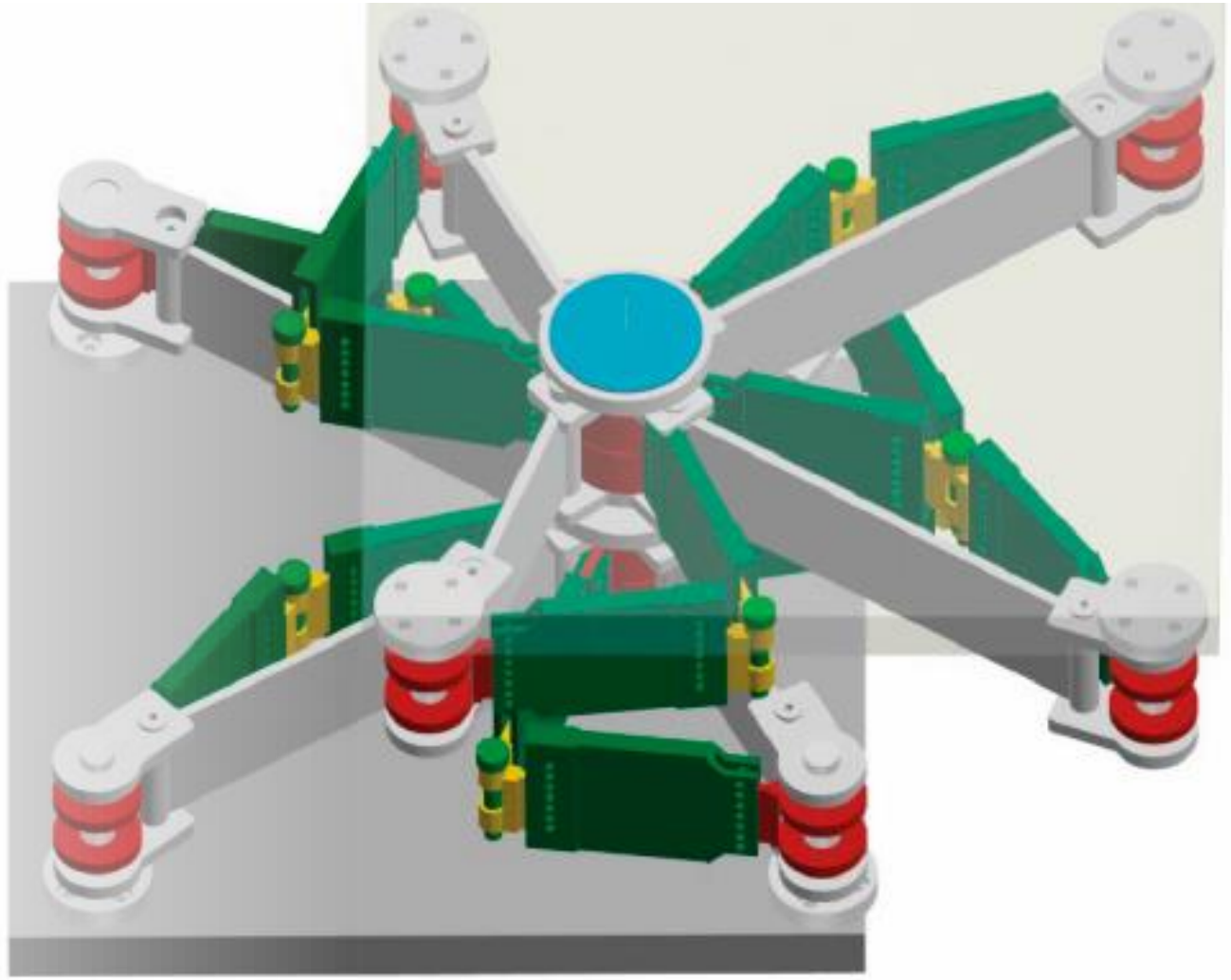
- The project develops innovative structural systems for next-generation buildings that are resistant to earthquakes and strong winds
- This combination of sustainable engineering, tensegrity structures, and mechanical metamaterials paves the way for radically new technological solutions for various building components



Example of a modern isolated structure in the San Francisco flight terminal

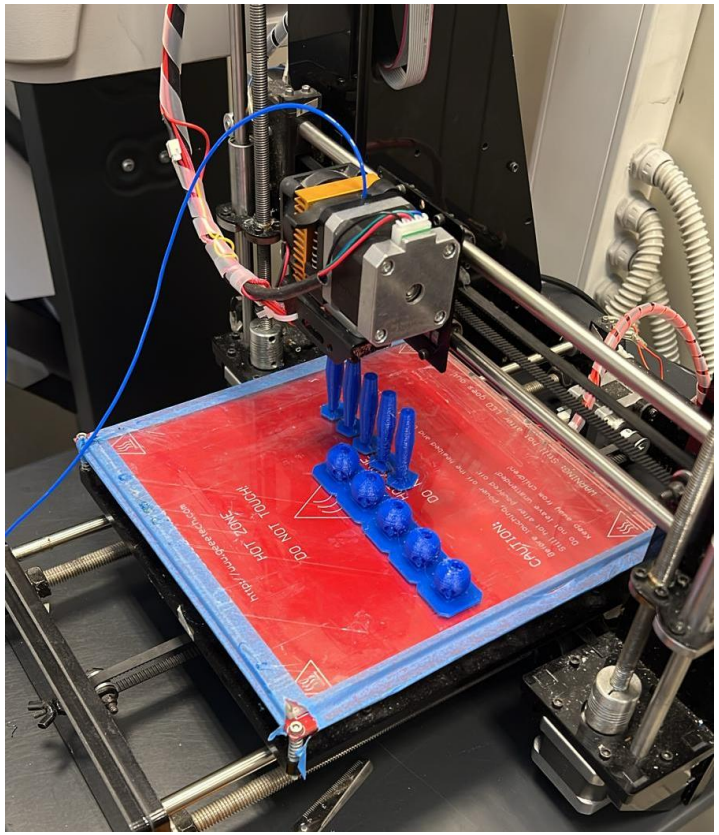
4. Goals achieved during the 1° year – 1/3

a) Experimental validation of mathematical and mechanical models for seismic isolation systems based on mechanical metamaterials ('metaisolators')

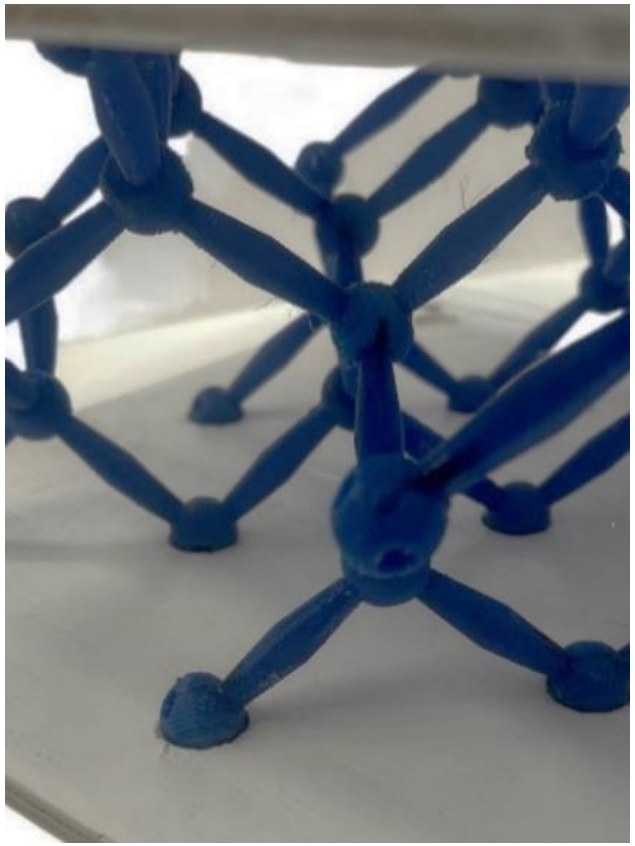


Sliding-stretching isolator (SSI)

4. Goals achieved during the 1° year – 2/3



3D Printer

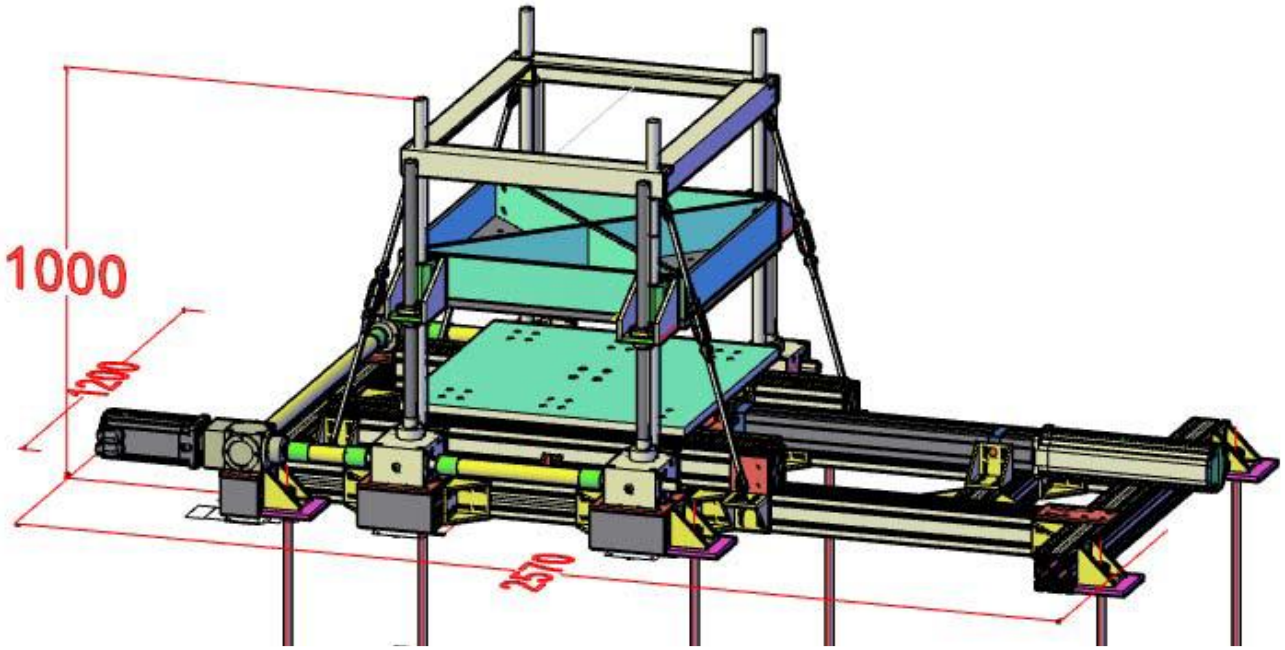


Experimental prototypes «Pentamode»

b) "Extensive experimental activities on prototypes of bio-inspired seismic isolation devices, manufactured using 3D printing technology with eco-sustainable materials

4. Goals achieved during the 1° year – 3/3

c) Mechanical modeling and experimental validation of a shake table built at the Structural Engineering Laboratory of the University of Salerno



Overall isometric view of a CAD model of the shake table

Photograph of the assembled shake table

5. PUBLICATIONS produced by the project in the 1° year

Amendola A.; de Castro Motta J.; Saccomandi G.; Vergori L.; 2023 A constitutive model for transversely isotropic dispersive materials. PROCEEDINGS OF THE ROYAL SOCIETY A, 2023, 20230374. ISSN:1471-2946, DOI: https://doi.org/10.1098/rspa.2023.0374

Germano, G., Qaderi, S., Adinolfi, V., De Castro Motta, J., Benzoni, G., Amendola, A., Ruzzene, M., Fraternali, F. Design and modeling of an in-house-built shake table setup for testing prototypes of innovative seismic isolators INGEGNERIA SISMICA/INTERNATIONAL JOURNAL OF EARTHQUAKE ENGINEERING. 2023, 40(1): 58-73. ISSN: 0393-1420.

Qaderi, S.; Adinolfi, V.; Germano, G.; Benzoni, G.; Luciano, R.; Fraternali, F. An Experimental and Mechanical Study of a Two-Layer, Bioinspired Seismic Isolator for Multistory Buildings. BUILDINGS. 2023; 13(9): 2272. ISSN: 2075-5309, DOI: 10.3390/buildings13092272.

Fraternali, F.; De Castro Motta, J. Mechanics of superelastic tensegrity braces for timber frames equipped with buckling-restrained devices. INTERNATIONAL JOURNAL OF SOLIDS AND STRUCTURES. 2023, 281: 112414. ISSN: 0020-7683, DOI: 10.1016/j.ijsolstr.2023.112414.

Fraternali, F., de Castro Motta, J., Germano, G., Babilio, E., Amendola, A. Mechanical response of tensegrity-origami solar modules. APPLICATIONS IN ENGINEERING SCIENCE. 2024, 17:100174, ISSN 2666-4968, Available online 19 December 2023, DOI: https://doi.org/10.1016/j.apples.2023.100174.

6. Research activities of the 2nd year – 1/2

The activities of the second year of the NEXTBUILDING project will continue in line with those carried out during the first year, within the scope of the two research lines (or "Work-Packages"/WP) "ISOLATE" and "BRACE".

The **ISOLATE WP** will continue research on seismic isolators based on mechanical metamaterials ("metaisolators") that feature bio-inspired architecture and are environmentally sustainable. New structural lattices of various types will be developed, inspired by 'pentamode' metamaterials, confined between terminal plates. The new devices will be constructed with eco-sustainable materials that do not require heavy industry, being partially or completely manufacturable with regular 3D printers.

The mechanical properties of these devices will depend primarily on their geometry and will be adaptable to the structure to be protected. The new devices will have bandgap-type vibration filtering properties**,** consisting of a matrix made of highly deformable material within which elements that transmit the vertical forces from the superstructure to the foundation can move.

6. Research activities of the 2nd year – 2/2

The **BRACE WP** will explore an innovative approach to designing support structures for new generation green and solar facades/roofs. These "green-tensegrities" will exhibit various architectures and utilize bio-based materials (e.g., wooden or bamboo struts and hemp, jute, kenaf, or sisal cables) to create unprecedented vertical green systems capable of storing carbon and resistant to earthquakes. The structures designed by this line are installed only once delivered to the construction site.

The solar facades/roof systems consist of "solar eyes" equipped with solar panels that can be opened and closed using simple mechanical or manual winches.

7. PUBLICATIONS produced by the project in the 2° year (as of July 11, 2024)

Amendola, A., de Castro Motta, J., & Fraternali, F. (2024). Discrete-to-continuum modeling of spider silk fiber composites. *International Journal of Non-Linear Mechanics*, *163*, 104735. Open Access

Placidi, L., de Castro Motta, J., & Fraternali, F. (2024). Bandgap structure of tensegrity mass–spring chains equipped with internal resonators. *Mechanics Research Communications*, *137*, 104273. Open Access

Fraternali, F., de Castro Motta, J., Germano, G., Babilio, E., & Amendola, A. (2024). Mechanical response of tensegrity-origami solar modules. *Applications in Engineering Science*, *17*, 100174. Open Access

Amendola, A., de Castro Motta, J., Saccomandi, G., & Vergori, L. (2024). A constitutive model for transversely isotropic dispersive materials. *Proceedings of the Royal Society A*, *480*(2281), 20230374. Open Access

THANK YOU FOR YOUR ATTENTION!