

## Research Group REsilience of Structures [REST]

**Reference year:**

2025

**Scientific Coordinator:**

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### **Description of research lines:**

#### **1 – Resilience of reinforced concrete structures (Coordinator: Prof. Giuseppe Faella)**

Reinforced concrete had its greatest development in Italy in the years after World War II. It was believed that r/c could guarantee structural safety over time. About 70 years after that period, there is a growing awareness that this material also has its own life cycle. Today many buildings show a considerable degradation. The research aims at investigating the degradation phenomena, the parameters that accelerate degradation, the effects to be controlled, also by innovative techniques. Analysis of existing buildings and laboratory tests are involved.

#### **2. – Resilience of churches (Coordinator: Prof. Gianfranco De Matteis)**

This research line deals with studies aimed at analyzing the problems related to the assessment of seismic vulnerability and safeguarding of historic buildings. Through the identification of the prevailing historical-architectural and constructive characteristics, as well as through the recognition of the seismic capacity and the main fragilities connected to the behavior of structures, new predictive models of vulnerability are proposed, also aimed at simplifying the applications on territorial scale. Starting from the scientific background gathered on more complex buildings (churches), the study of techniques is currently aimed at analyzing two structural types that are immediately recognizable, such as bell towers and brick bridges. The methodology developed is aimed at: (i) planning territorial strategies for the mitigation of seismic risk, capable of ensuring adequate performance levels of structures; (ii) experimenting by devices and intervention techniques (including the ones innovative and based on metallic materials) capable of extending their residual life, in full respect of the architectural value of the assets considered.

#### **3 – Resilience of wood structures: From tradition a new renewable material to increase the safety of the existing (Coordinator: Prof. Giorgio Frunzio)**

Wood, in all its essences, has been used in civil construction, albeit dimensional limits, anisotropy and perishability when not adequately protected. In recent times, innovation allowed new products derived from wood such as glulam, CLT and all reconstituted products derived from processing and recycling waste. It is appropriate to deepen the knowledge about the properties of the materials that are gradually developing by the industry, also to test and code them. Finally, the possibility to strengthen existing buildings through timber elements and systems is valued. Such a technique allow reversible and replacement, rapid execution with reduced environmental impact. All these conditions are usually necessary in volumetric requalification/addition on recent buildings and Cultural Heritage.

#### **4 – Resilience of masonry structures (Coordinator: Prof. Mariateresa Guadagnuolo)**

The current substantial opportunities for transformation of / on the built induce to consolidate and strengthen the theme of composition research on a large part of the "minor" buildings that testify to a constant dialogue with the past and confirm the need for the project culture of "layering." The fabric of the historic centers is not represented by the mere tight coexistence of old and new

architecture, one next to the other, but proposes characters of resilience due to the successive stratifications of spatial stylistic and morphological-functional units that allow man and his habits and needs to adapt to the continuous transformations of contemporaneity.

The seismic safety of the existing masonry heritage is obviously fundamental, but as is known, the variety of calculation models proposed for such structures depends on the typological multiplicity of the artifacts and the type of verification that one wants to pursue. The research concerns the definition and development of models and methods for the evaluation of seismic safety through analyses on a territorial scale, with particular reference to churches, bell towers but also to buildings and urban aggregates. For the latter, linear and nonlinear kinematic analysis procedures will be analyzed, based on the macro-element approach, also for non-structural elements for the local analysis of wall portions and nonlinear static analyses for the analysis of the overall behavior.

### **5 – Numerical modelling of sustainability of materials and structures subjected to mechanical and chemical deterioration (Coordinator: Prof. Roberto Serpieri)**

This research line aims at achieving, by advanced numerical modelling methods, a deeper knowledge of the effect of mechanical and chemical deterioration over resilience and physical and functional integrity of materials and structures which deserve special attention due to their architectural value or due to their diffusion among the Italian building stock. Attention is also directed towards materials and structures which have been recently object of structural collapse with seemingly marked fragile kinematics (such as those occurred on August 14th 2018 to a segment of the Polcevera viaduct or on April 8th 2020 to a bridge on the Magra), and for which a contribution of mechanical and chemical deterioration may be argued. Research goals are primarily directed towards the life cycle assessment of structures and of the built environment within management policies for the qualification, preservation, and regeneration of the Italian building stock, with an ecosystemic and interdisciplinary approach that aims to achieve complete and congruent sustainability metrics to support the evaluation of operational proposals of design and construction to be deployed in the territories of Campania in the short, medium and long course of time.

### **Interaction with other University research groups in the last three years:**

The REST 2024 group interacts with the research group:

- **Structural and seismic safety of existing relevant constructions: building and bridges (SECURE)** Dipartimento di Architettura e Disegno Industriale.
- **StandardF-AU** of Dipartimento di Architettura e Disegno Industriale.
- **Knowledge , valorization and digital communicationn of the cultural heritage of the** Dipartimento di Architettura e Disegno Industriale.
- **LANDesign** of the l Dipartimento di Architettura e Disegno Industriale.

### **Participation in research projects during the last three years (2021-2023):**

**Title of the project:** GEstioNE del rischio SISmico per la valorizzazione turistica dei centri storici dei Mezzogiorno – GENESIS (codice progetto ARS01\_00883)

**Principal Investigator:** Prof. Enrico Spacone, Università degli Studi di Chieti-Pescara

**Program title:** Avviso del 13/07/2017 “Presentazione di progetti di ricerca industriale e sviluppo

sperimentale nelle 12 aree di Specializzazione individuate dal PNR 2015-2020”

**Description of the research project activities:** The main objectives of the research concern the development of a computer platform for the collection of information on the historical-cultural heritage, aimed at the simulation of damage scenarios for the management of emergency situations (territorial scale); at the planning of interventions for the reduction of seismic risk (urban scale); at the development of structural behavior models for the evaluation of static safety and seismic vulnerability as well as the interventions that may be necessary according to the previous analysis (building scale).

**Involved personnel:** Prof. Ing. Gianfranco De Matteis (Responsabile scientifico Unità di Ricerca), Ornella Zerlenga; Giuseppe Faella; Sergio Sibilio; Danila Jacazzi; Giorgio Frunzio; Riccardo Serraglio; Marina D'aprile; Giovanni Ciampi; Mariateresa Guadagnuolo; Corrado Chisari; Vincenzo Cirillo; Mattia Zizi.

**Partner institutions:** Proponente: Università degli Studi G. D'Annunzio di Chieti.

**Academic Partners:** Università degli Studi della Campania Luigi Vanvitelli, Università degli Studi dell'Aquila, Università degli Studi della Basilicata, Università degli Studi Mediterranea di Reggio Calabria, Università degli Studi di Enna Kore, Università Iuav di Venezia, Università degli Studi di Bergamo, Università di Pisa

**Industrial Partners:** Tab Consulting S.r.l. TAB Consulting, Asdea S.r.l. ASDEA, Zugaro Guido & C. S.r.l., Target Euro S.r.l., Kibernetes S.r.l., FIP Industriale S.P.A., PRO.GE.77 S.r.l., SISIA S.r.l. SISIA, BOVIAR S.r.l., Consorzio C.i.p.a.e. A R.l., BASF S.r.l., TELENIA S.r.l., Etna Hitech S.c.P.A., Fibre Net S.r.l.

**State of the project:** positively evaluated/funded/end date

**Submission date:** 9-11-2017/01-01-2023/30-06-2025.

**Title of the project:** WRENCH - Whispers of Time: Heritage as Narratives of Climate-Change

**Principal Investigator:** Prof. Marco Armiero (Autonomous University of Barcelona)

**Call title:** Collaborative Research Action (CRA) - Climate & Cultural Heritage (CCH) 2023

**Description of the research activities of the project:** WRENCH aims to address the effects of climate change on tangible and intangible heritage, while broadening the understanding of heritage to include narratives, narratives, and ephemeral legacies. WRENCH envisions cultural heritage as both something at risk and something that can tell a story about the risk we are all taking. WRENCH has the dual objective of (a) developing a transdisciplinary methodology involving environmental sciences, engineering and humanities to investigate the impact of climate change on tangible and intangible heritage; (b) use heritage as a storytelling tool to improve awareness of climate change.

**Involved Staff:** Corrado Chisari (Local Principal Investigator), Gianfranco De Matteis, Mattia Zizi, Michelangelo Scorpio, Sergio Sibilio

**Partner institutions:** Autonomous University of Barcelona (PI), Durham University, Orta Dogu Teknik Universitesi, Hidromod, Durham Castle, Diocesi di Ragusa - Chiesa Madre Duomo di San Giorgio, Consorzio “Coop4Art”

**State of the project:** approved

**Submission/starting/closing date:** 08-09-2023/30-06-2024/-

**Title of the project:** Evaluation of structural vulnerability and innovative intervention methods for the protection of masonry historical constructions of Italian infrastructural heritage (CUP: B61B21005470007)

**Principal Investigator:** Prof. Ing. Gianfranco De Matteis

**Program title:** Programma Operativo Nazionale Ricerca e Innovazione 2014-2020

**Description of the research project activities:** The research activities deal with the development of methodologies for the structural vulnerability assessment of historical masonry constructions. In particular, the methodologies refer to infrastructural constructions (bridges) and address the problem following both a large-scale and a single-construction approach. The activities entail: i. the development of methodologies for the structural vulnerability assessment at a large scale; ii. vulnerability assessment methodologies by means of Finite Element Models; iii. the proposal of innovative, low-invasive and reversible retrofitting techniques.

**Involved personnel:** Mattia Zizi, Gianfranco De Matteis

**Partner institutions:** Fabre Consortium

**State of the project:** funded

**Starting/closing date:** from 01/01/2022 to 31/12/2024

**Title of the project:** “Integrated PRocedure for assEssing and improVing the resiliENce of existing masonry bell Towers on a territorial scale” - PREVENT

**Scientific Coordinator:** Gianfranco De Matteis

**Call title:** VALERE 2019

**Description of the research activities of the project:** Enhancement and conservation of bell towers, with a multidisciplinary and multilevel approach, developed through three main research lines: Knowledge and survey (Zerlenga); Control and monitoring (Sibilio); Structural assessment and preservation (De Matteis). Such research lines develop independently but are strongly interconnected to each other. They converge in the fourth cross-cutting research line, which defines the main objective and result of the whole research, namely: Preservation and valorisation of exiting bell towers (All).

**Involved Staff:** Gianfranco De Matteis

**Partners:** Intra-University project competition

**Project status:** funded

**Submission date/Start/End of the project: start:** December 2<sup>nd</sup>, 2019/December, 2<sup>nd</sup>, 2022

**Title of the project:** Advanced procedures for SAFETy assessment of existing Masonry Arch Bridges – SAFE\_MAB

**Principal Investigator:** Mattia Zizi

**Call title:** Bando di selezione per il finanziamento di progetti di ricerca fondamentale ed applicata dedicato ai giovani ricercatori

**Description of the research activities of the project:** The SAFE\_MAB project will focus on existing Masonry Arch Bridges (MABs) by means of a multidisciplinary approach involving the scientific disciplines of Structural Engineering (ICAR/09), Structural Mechanics (ICAR/08) and Drawing (ICAR/17). The main aims of the SAFE\_MAB project proposal are to identify the defects mostly influencing the capacity in facing external loads of MABs and to propose innovative methodologies for their survey.

**Involved Staff:** Mariateresa Guadagnuolo (CO-PI), Giorgio Frunzio, Luciana Di Gennaro

**Partner institutions:** ---

**State of the project:** Positively evaluated/funded/ongoing

**Submission date/Start/End of the project:** 08-07-2022/03-10-2022/03-01-2024

**Title of the project:** TRAILED-LAB: Un Laboratorio Mobile a Servizio dei Comuni del Cratere

**Principal Investigator:** Prof. Giuseppe Brando, University “G. d’Annunzio” of Chieti-Pescara

**Call title:** Avviso per la selezione di progetti di promozione della ricerca, del trasferimento tecnologico e della formazione universitaria da finanziare nelle regioni Lazio, Abruzzo, Umbria e Marche interessate dagli eventi sismici del 2016

**Description of the research activities of the project:** "TRAILED-LAB" is a new research centre integrating mobile facilities for in-situ measurements of materials, structures and infrastructures, with fixed standard facilities. TRAILED-LAB aims at providing an advanced instrument for supporting reconstruction and decision-making processes, for both assessments of recovery interventions for seismically damaged buildings and infrastructures and addressing the choices on the re-use of construction materials of collapsed buildings.

**Involved Staff:** : Gianfranco De Matteis, Giorgio Frunzio, Corrado Chisari, Mariateresa Guadagnuolo, Mattia Zizi

**Partner institutions:** University "G. d'Annunzio" of Chieti-Pescara, University of Camerino, National Institute of Geophysics and Vulcanology -INGV

**State of the project:** funded

**Submission date:** 25-02-2022.

**Title of the project:** Structural Assessment and development of innovative saFEguard Measures fOr hisTOrical masONry towers\_SAFEMOTION

**Scientific Coordinator:** Gianfranco De Matteis

**Call title:** PRIN22-PNRR

**Description of the research activities of the project:** SAFE\_MOTION aims at developing innovative techniques and methods for investigation, assessment and retrofitting of historical masonry towers, in order to enhance their conservation, use, fruition and to extend their residual life. To reach the objective, complementary expertises of the research units (Rus) will be provided, namely in the fields of dynamic monitoring, identification and damage assessment, numerical modelling, structure testing and retrofitting design.

**Involved Staff:** Giorgio Frunzio, Mariateresa Guadagnuolo, Mattia Zizi

**Partners:** UNIPD, UNIUD

**Project status:** funded

**Submission date/Start/End of the project:** 30.11.2023/30.11.2025

**Scientific products during the last three years:**

*10 scientific publications in Class A journals and/or indexed in the Scopus/WoS databases::*

- [1] Massaro L., Di Gennaro L., Frunzio G., Sallicandro E., Serpieri R. (2024). Understanding past rules of the art in column-capreoli wood trusses. DEVELOPMENTS IN THE BUILT ENVIRONMENT, ISSN: 2666-1659, doi: 10.1016/j.dibe.2024.100472.
- [2] Serpieri R., Bossio A., Faella G., Frunzio G., Guadagnuolo M. (2023). Diagnostic reliability in the evaluation of degradation and carbonation in a pre-cast column after 20-year weathering, 5th International Conference on Structural Integrity and Durability, Procedia Structural Integrity, Volume 46, <https://doi.org/10.1016/j.prostr.2023.06.019>.
- [3] Massaro, L.; Di Gennaro, L.; Guadagnuolo, M.; Frunzio, G. (2023). Strengthening of masonry arches: The "Santa Maria delle Grazie" Church, COMPDYN Proceedings 2023. <https://doi.org/10.7712/120123.10567.20441>.
- [4] Guadagnuolo M., Aurilio M., Nuzzo M., Faella G. (2023). Historic chimney stacks: seismic assessment and kinematic analysis, Journal of Architectural Engineering, ASCE, 2023. doi.org/10.1061/(ASCE)AE.1943-5568.0000571.
- [5] Di Gennaro L, Guadagnuolo M, Monaco M. (2023). Rocking Analysis of Towers Subjected to

- Horizontal Forces. Buildings; 13(3):762. <https://doi.org/10.3390/buildings13030762>.
- [6] Massaro, L., Serpieri, R., Frunzio, G., & di Gennaro, L. (2023). Timber carpentry without steel connectors. in proceedings of COMPDYN, 9th ECCOMAS Thematic Conference on Computational Methods in Structural Dynamics and Earthquake Engineering, Athens, Greece, 12-14 June 2023.
- [7] Massaro, L.; Di Gennaro, L.; Guadagnuolo, M.; Frunzio, G. Strengthening of Masonry Arches: the "Santa Maria delle Grazie" Church, in proceedings of COMPDYN, 9th ECCOMAS Thematic Conference on Computational Methods in Structural Dynamics and Earthquake Engineering, Athens, Greece, 12-14 June 2023.
- [8] Guadagnuolo M., Aurilio M., Nuzzo M., Faella G., (2022). Historic chimney stacks: seismic assessment and kinematic analysis, Journal of Architectural Engineering, ASCE. [doi.org/10.1061/\(ASCE\)AE.1943-5568.0000571](https://doi.org/10.1061/(ASCE)AE.1943-5568.0000571).
- [9] Zizi, M., Chisari, C., Rouhi, J., & de Matteis, G. (2022). Comparative analysis on macroscale material models for the prediction of masonry in-plane behavior. Bulletin of Earthquake Engineering, 20(2), 963–996. <https://doi.org/10.1007/s10518-021-01275-x>
- [10] Chisari, C., Cacace, D., & de Matteis, G. (2022). A mechanics-based model for simplified seismic vulnerability assessment of masonry bell towers. Engineering Structures, 270. <https://doi.org/10.1016/j.engstruct.2022.114876>.

*Additional 10 scientific products:*

- [1] Bencivenga, P., Zizi, M., & de Matteis, G. (2022). Masonry Arch Bridges: Typical Features and Structural Issues. In Lecture Notes in Civil Engineering: Vol. 200 LNCE. [https://doi.org/10.1007/978-3-030-91877-4\\_62](https://doi.org/10.1007/978-3-030-91877-4_62).
- [2] Guadagnuolo M., Faella G., Frunzio G., Massaro L., Brigante D., (2022). The capacity of FRP anchors in concrete and masonry structures, XIX Convegno di Ingegneria sismica in Italia, Torino, Italy, September 11-15, 2022.
- [3] Guadagnuolo M., Di Gennaro L., Basile A., De Matteis G., (2022). Simplified methods for the evaluation of mechanical properties of tuff masonry walls in Campania (Italy), XIX Convegno Ingegneria sismica in Italia, Torino, Italy, September 11-15, 2022.
- [4] Di Gennaro L., Zizi M., Chisari C., Guadagnuolo M., Frunzio G., De Matteis G., (2024). Structural assessment of damaged masonry arch bridges: a parametric study based on limit analysis. In: International Association of Earthquake Engineering (IAEE) and the National Association of Earthquake Engineering (AEE), Proceedings 18th World Conference Earthquake Engineering WCEE2024, Milan (Italy), 30 June – 5 July 2024.
- [5] Massaro L., Di Gennaro L., Guadagnuolo M., Frunzio G. (2024). The use of engineered wood for volumetric additions to existing buildings. In: International Association of Earthquake Engineering (IAEE) and the National Association of Earthquake Engineering (AEE), Proceedings 18th World Conference Earthquake Engineering WCEE2024, Milan (Italy), 30 June – 5 July 2024.
- [6] Massaro L., Ottieri S., Frunzio G. & Damiani L. (2023). The static of temporary expositions. In Climate Change And Cultural Heritage, IV International Forum On Architecture And Urbanism (IFAU 2023), 22-23 June, Caserta.
- [7] Angelillo, M., Butterazzi, E., Di Gennaro, L., Frunzio, G., Massaro, L., & Cennamo, C. (2024, September). Structural characterization of the double-shell dome on the San Gennaro Chapel in Naples (in press). Italian Association of Theoretical and Applied Mechanics, XXVI AIMETA Congress.
- [8] Damiani L., Di Gennaro L., Frunzio G., Massaro L., Sallicandro E., Serpieri R. (2024). Enhancing past rules of the art for sustainable design of column-capreoli wood trusses. (in press). Italian Association of Theoretical and Applied Mechanics, XXVI AIMETA Congress.
- [9] Borrelli, M. (2023). Nuove Spazialità Museali in Architecture Open Source ISBN: 978-88-944172-3-4 prima edizione, Aprile 2023, prodotto disponibile per la consultazione sulla piattaforma digitale Calameo pag 122. <https://www.calameo.com/books/00399128672ac32fa8a20>.
- [10] Borrelli, Marino (2024) -DIECI CASE IN UN MAT BUILDING. DOI: 10.6093/978-88-85556-33-1.

In SUPERISOLA un borgo collettivo per dieci nuclei familiari - ISBN: 978-88-85556-33-1.

**Relationships with international and national Companies, Institutions, Research Centers, Universities during the last three years:**

- The group's research has relationships with the research activities of the research project "Studies and research on cultural and landscape heritage for the tourist development of the territorial areas of the Campania Region", funded by the Campania Region to the "Società Progetto Laocoonte S.c.p.a. - Research Institute". Lead scientist: Prof. Giuseppe Faella.
- The research work is linked with the research activities connected with the ReLUIS project DPC 2019-2021, concerning: WP2 (Inventory of existing structural and building types - CARTIS); WP4 (Risk maps and seismic damage scenarios - MARS); WP12 (Regulatory relating to civil and industrial steel construction). Lead scientist: Prof. Gianfranco DE MATTEIS
- Fabre Consortium "Research consortium for evaluation and monitoring of bridges, viaducts and other structures". Lead scientist: Prof. Gianfranco DE MATTEIS
- Agreement for research activities: Department of Civil Engineering, University of Salerno [Delibera del C.di Dip. n. 13 del 17/12/2020]. Lead scientist: Corrado CHISARI
- Agreement for research activities with "Laboratorio TecnoLab srl - Construction Materials Testing Laboratory" in Naples. Lead scientist: Mariateresa GUADAGNUOLO
- Memorandum of understanding with SUNTA srl technological advances for dynamic identification of masonry structures (2019\_to date);
- Relationships with ARISTOTELE UNIVERSITY OF THESSALONIKI (Greece) within the Erasmus+ Teachers' and PhD students' Mobility Programme.
- Relationships with Universidade NOVA de Lisboa (Portogallo) within the Erasmus+ Teachers' and PhD students' Mobility Programme.
- Relationships with Departamento de "Construcciones Arquitectónicas y su Control ". Universidad Politécnica de Madrid). ETSEM. ESPAÑA.

**Collaborations with Consortia, Scarl or other Institutions participated by the University of Campania L. Vanvitelli during the last three years:**

- The group's research interacts with the research activities of Benecon Scarl.
- Consortium FABRE "Research Consortium for assessment and monitoring of bridges, viaducts and other structures." (Consortium members: ENEA, University of Camerino; University of Campania "Luigi Vanvitelli"; University of Messina; University of Padova; University of Perugia; University of Pisa; Polytechnic of Milano; Polytechnic of Torino). Prof. Gianfranco De Matteis is Coordinator of the activities of the Consortium for the University of Campania "Luigi Vanvitelli", Member of Consortium Scientific Committee and Member of the Consortium Executive Board.

**ISI Web of Science Subject Categories:**

Engineering, Civil

Engineering, Mechanical  
Material Science, Characterization & Testing  
Material Science, Composite  
Construction & Building Technology

**Scientific-Disciplinary Sectors:**

CEAR-06A  
CEAR07-A  
CEAR08-D  
CEAR09-A  
CEAR-09C

**Keywords:**

Masonry  
Wood  
Vulnerability Cultural Heritage  
Seismic safety  
Churches  
Non-structural elements  
Consolidation interventions  
Bridges  
Steel Structures  
Experimental testing.

**ERC Categories:**

- PE8\_3 Civil engineering, maritime/hydraulic engineering, geotechnics, waste treatment
- PE8\_4 Computational engineering
- PE8\_8 Mechanical and manufacturing engineering (shaping, mounting, joining, separation)
- PE8\_9 Materials engineering (biomaterials, metals, ceramics, polymers, composites...)
- PE8\_12 Sustainable design (for recycling, for environment, eco-design)
- PE8\_16 Architectural engineering