VIDEO ARTICLE

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Seismic Upgrading of Existing Buildings using Non-Invasive Solutions based on Advanced Materials

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Graphical Abstract

Abstract

The existing reinforced concrete (RC) and masonry structures may be affected by strong signals of deterioration and they often need to be upgraded to meet new mandatory seismic design requirements or to allow a change of use of the building. Applications of advanced materials for retrofitting and upgrading existing structures have been rapidly grown in past years because of their several advantages with respect to traditional strengthening systems. Often seismic upgrading involve buildings partially or completely occupied and short-term disruption of occupants becomes a crucial aspect and controls the design. These remarks have introduced new challenges in the development of novel advanced material-based strengthening solutions for seismic upgrade of

deficient existing buildings that can be applied wholly from the exterior of the building. The experimental validation of such solutions and the relevant calibration of reliable design formulations is a crucial aspect for future seismic risk mitigation. The study outlines the basic principles of advanced material-based seismic upgrading strategies on existing RC and masonry structures in order to avoid the most common brittle and premature failure modes. In particular, the use of composite materials (i.e., Fiber Reinforced Polymers, FRP, and Fiber-reinforced concrete, FRC) as a non-invasive solution is investigated by means of full-scale experimental programs aimed at: increase the shear capacity of partially confined beam–column joints of RC structure (on which, typically, shear transverse reinforcement is missing or lacking); avoiding out-of-plane mechanisms in masonry buildings with poor connections between orthogonal bearing walls. The strengthening phases and the details of the proposed strengthening layout are described. Details on the experimental investigations on full scale specimens or real subassemblies aimed at confirming the effectiveness of advance material-based upgrade strategies are presented and discussed with due attention to the calibration of reliable design formulations. The experimental outcomes confirmed the effectiveness of the proposed FRP-strengthening solutions (i.e., FRP sheets or FRC thin jacketing on RC joint panels and grouted anchors made by hollow CFRP pultruded carbon tubes wrapped with longitudinal and spiral stainless steel fabrics bars on T-shaped masonry wall with a poor connection between orthogonal walls) to significantly increase the shear capacity of RC joint subassembly and the out of plane capacity of masonry wall connections. The strengthening solutions did not change the initial stiffness of the structural subassemblies and they resulted suitable for application in a local strengthening strategy framework.
Finally, an insight on the main still open issues and future perspective for future investigations on the use of advanced materials for seismic upgrade is presented.

Keywords: Advanced materials, FRP, FRC, and CFRP pultruded carbon tubes; seismic upgrade; beam–column joints, masonry walls, brittle failure modes.

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Biography of Presenting Author

Marco Di Ludovico is Associate Professor of Structural Engineering at the University of Naples Federico II where he is currently responsible for quality control of Full-Scale Tests Laboratory of the Department of Structures for Engineering and Architecture (DiSt) at CeSMA - Center of Advanced Measurement Services. He holds the courses of Structural Engineering Part II, and Materials and Structures Mechanics. He is author of more than 250 scientific papers published on journals or proceedings of national and international conferences. The research activities deal with theoretical and experimental aspects on the following topics: non-linear behavior of reinforced concrete and masonry structures; structural vulnerability, post-earthquake damage and repair costs; repair, strengthening and seismic retrofit of concrete and masonry structures with composites; response of reinforced concrete buildings under tsunami-induced loads; protection of historical monumental buildings.

He was member of Working Group by CSLLPP - Public Works National Council - for the revision of the Circular n° 617 02/02/2009 - Instructions for the application of the Italian Building Technical Code (DM14/01/2008). He currently participates to the following National and International Scientific Bodies: Working Group "Learning from Earthquakes (LFE)" by Earthquake Engineering Research Institute (EERI); EAEE (European Association for Earthquake Engineering) Working Group 1 (EC8) Future Directions for Eurocode 8; *fib* (Federation International du Beton) TG 9.3 "FRP Reinforcement", Task Group 5.1 'FRP Reinforcement for Concrete Structures'; CNR (Italian National Research Council) working groups on the development of technical documents on the use of composite materials.

He is editorial board member of Journals: Buildings MDPI, Journal of Architectural Environment & Structural Engineering Research (JAESER) and Current Trends in Civil & Structural Engineering (CTCSE). He is member of reviewer panels of the most relevant journal publication in the field of earthquake and structural engineering. He is Guest Editor of Special Issues: Heritage (ISSN 2571-9408) - Special Issue: "Assessment and Protection of Cultural Heritage Masonry Structures" section "Cultural Heritage"; Buildings (ISSN 2075-5309) - Special Issue "Sustainable and Green Construction Materials: Opportunities for New and Existing Structures.

He is co-founder of the company SEISMART, Sustainable Engineering Innovative Solutions & Materials for Anti-seismic Reliable Techniques (www.seismart.it), Spinoff Company of the University of Naples Federico II.

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