Abstract of Research Project
XXXV Cycle (A.Y. 2019-2020)

Name of fellow: Riccardo Liberotti

Name of UNIPG Supervisor: Full Professor Vittorio Gusella

International Partner Institution: University of Minho, Braga, Portugal

Name of International Co-Supervisor: Paulo B. Lourenço

Start Date: 1.11.2019 **End Date: 31.10.2022**

RESEARCH PROJECT (max 3 pages):

Defense of architectural and cultural heritage: A multidisciplinary approach for the structural retrofitting of masonry buildings

Introduction and state of the art

It is well known that the level of knowledge and the in-depth investigations regarding ancient masonry buildings are the mandatory conditions on which to base reliable structural safety assessments. Those evaluations derive from an articulated and rather complex process including, in general, historical investigations gathered by direct surveys of the building, also by means of experimental-test campaigns. In order to produce vulnerability evaluations on the safe side, the challenge to represent a correct interpretation of the seismic behaviour of the buildings, in their current state, becomes an essential prerequisite especially in historical constructions built with masonry elements often presenting structural peculiarities. Also possible interventions of structural strengthening derive from the knowledge of the constructive specificities and uniqueness of the buildings. The conceiving of such design actions, that as we know are never predictable or predefined, must prevent the dangerous factors related to the artifact's survival without jeopardize the role and the meaning they stood for during the centuries; on this nowadays new reinforcement methodologies are including the use of next-gen. composite materials that allow to fulfill the strengthening of ancient masonry structures in compliance with the environmental, cultural and social context where such building are placed. In a previous experience as research fellow at the D.I.C.A., through the PRIN 2015 funding scheme (project 2015 JW9NJT - Advanced mechanical modelling of new materials and structures for the solution of 2020 Horizon challenges), the features of one of these structural reinforcement, the FRCM (Fiber Reinforced Cementitious Matrix) composite system, has been studied. In these first months of the PhD they have been carried on in relation to the structural strengthening of Palazzo Murena [1], actual headquarters of the University of Perugia. This composite sistem proved many application in relation to masonry structures and in literature there are many experimentally studies [2,3] on masonry elements reinforced with FRCM systems, as well as modeling strategies based primarily on the finite element methods [4,5].

Research objectives

The aim of the present thesis is to consider and underline the essential interactions among the historical knowledge, the seismic vulnerability assessment, the investigation experimental tools, the preservation of the architectural quality and the strengthening design in regard to architectural heritage conservation with

a focus on the use of FRCM materials for which there are still no consolidated design rules and numerical modeling strategies.

Methodology

Actually is beign organized, in partnership with the Kimia S.p.a., an experimental campaign conducted in order to evaluate the incidence of those next-gen composite materials'application regarding the prevention of the dangerous in plane wall's collapse; a possible source of risks obeserved during the experience of Palazzo Murena. The tests will be conducted on some walls samples, and with the aim of bringing the specimens to failure, a steel contrast system has been designed to make a self-balanced assembly and the loads will be applied by mean of a hydraulic flat jack; furthermore a monitoring system has been coincived. Once the experimental tests have been carried out it is assumed I will spend a period abroad, on this I am still making arrangements with the University of Minho. In that span I will work on the creation of a finite element numerical model capable of describing the behavior of this type of materials; the complexity of this process consists in modeling the two phases (net and matrix) that make up the composite material, also with respect to the collapse modes. In the last year of work the design criteria with which to apply these reinforcements, in relation to real cases, will be analysed.

Expected results

The experimental results will clarify the behavior of the masonry elements reinforced with F.R.C.M. Those outcomes will be compared versus the ones obtained by the implementation of the numerical model for the composite material; in addition the data of the tests will be used to realize a proper calibration of such F.E.M. Subsequently the creation of design guidelines is envisaged, in order to strength the masonries regarding the bending and the shear actions without, besides, burden the existing masonry structures with the additional weight of structural gears non-canonical if compared to the genesis of the building; furthermore with different in-work implementation and to the life-cicle of the F.R.C.M. Therefore the integrated architectural-structural approach proposed is aimed at the tutelage of the building's architectural value by focusing potential interventions only on the elements of proved vulnerability so without involving valuable elements that could not be restored if it were damaged during the building work phase.

Bibliography

[1] R. Liberotti, F. Cluni and V. Gusella,"Vulnerability and seismic improvement of architectural heritage: the case of Palazzo Murena", Earthquakes and Structures, in press, (2019).

[2] C. D'Ambra, G.P Lignola, A. Prota, E. Sacco and F. Fabbrocino, "Experimental performance of FRCM retrofit on out-of-plane behaviour of clay brick walls", Composites Part B, 148, 198–206, (2018).

[3] F. G. Carozzi and C. Poggi, "Mechanical properties and debonding strength of Fabric Reinforced Cementitious Matrix (FRCM) systems for masonry strengthening", Composites: Part B, 70, 215–230, (2015).

[4] Bertolesi, E., G. Milani and C. Poggi, "Simple holonomic homogenization model for the non-linear static analysis of in-plane loaded masonry walls strengthened with FRCM composites", Composite and Structures, 158, 291–307, (2016).

[5] Pourfalah S., D.M. Cotsovos e B. Suryanto, "Modelling the out-of-plane behaviour of masonry walls retrofitted with engineered cementitious composites", Computers and Structures, 201, 58–79, (2018).