The Functional-Structural Rehabilitation of the Prince Caracciolo of Avellino Building Located in the Old Town of Naples "*UNESCO World Heritage Site*"

Beatrice Faggiano[1(✉)], Luigi Fiorino[1], Vincenzo Macillo[1], Giulia Bonelli[2], Claudio Rossi[3], and Federico M. Mazzolani[1]

[1] Department Structures for Engineering and Architecture District, University of Naples Federico II, Via Claudio 21, 80125 Naples, Italy
beatrice.faggiano@unina.it
[2] Bonelli Studio Architettura, Via D.Cimarosa 37, 80129 Naples, Italy
[3] PSE srl - Progetti di Sviluppo Engineering, Via Martucci 48, 80121 Naples, Italy

Abstract. The paper presents the functional and structural rehabilitation of an historical masonry building located in the old town of Naples, which is an UNESCO World Heritage Site. The building was initially built in the 16th century as monastery and in the 17th century it was achieved by the Prince Caracciolo of Avellino family, who made major modifications. The building has a rectangular plan with a length of about 50 m and width of about 10 m. It has 6 stories, one of which is below the street level; the pitched roof reaches a maximum height of about 26 m. Before the renovation intervention the building was very much degraded, presenting widespread cracks in the masonry walls and vaults and deteriorated wooden floors. The rehabilitation was dedicated on one hand to the retrofit of existing vertical and horizontal structures, on the other hand to adapt the building to the new use, as a Foundation of Contemporary Art. The paper briefly describes the state of the construction before the intervention and its recovery and transformation, with particular reference to the structural aspects.

Keywords: Rehabilitation of historical masonry building · State of conservation of historical masonry building · Structural retrofitting interventions

1 Introduction

The Prince Caracciolo of Avellino building was built in the XIV century, then modified in the XVII century up to the current configuration, consisting in two buildings that overcome the Anticaglia decuman of the historical center of Naples, giving rise to the urban square of Largo Avellino Dominici (2003). In the following XVIII to XX centuries some extensions (Catalani et al. 1845) and valuable decorations (Sigismondo 1989) were introduced in the building.

I. Vayas and F. M. Mazzolani (Eds.): PROHITECH 2021, LNCE 209, pp. 1138–1143, 2022.
https://doi.org/10.1007/978-3-030-90788-4_87

The building is included in the heart of the Greek-Roman town, near to the Donnaregina Church, the Cathedral of Naples, as well as the ancient Greek Neapolis theatre then Roman forum. In the area worldwide renown museums are located, like the National Museum Mann, the M.a.d.r.e. Museum, as well as the Academy of Beaux Arts.

The building is protected by the Italian Ministry of Culture and listed by UNESCO as World Heritage Site.

The Morra Greco Foundation for Contemporary Art, established since 2003 by the building owner dr. Maurizio Morra Greco, is located in the building. Due to the extended state of degradation of the building, the Foundation decided to proceed to the restauration of the building for the valorization and enhancement of the museum and exhibition activities, as well as for hosting the permanent exposition of the collection of more than 200 artworks of young artists, patrimony of the Foundation itself.

The works were realized in four years from 2015 to 2019 by the Brancaccio Costruzioni S.p.A company (Naples, Italy), the overall design was coordinated by PSE srl Engineering (Naples, Italy), taking advantage of a financial contribution for culture and tourism of the Regional Office of Campania (FESR, 2007–2013; www.fondazionemorragreco.com). Prof. Mazzolani was the responsible of the structural restoration design.

The restoration and reuse of the building gives also a new impulse to the requalification of the whole Neapolitan area.

2 The Original Building and the State of Conservation Before the Rehabilitation

Prince Caracciolo of Avellino building historically belongs to a larger building complex, with an open courtyard. It consists of a large wing building facing the East open courtyard. The building plan sizes are about 50 m along the North-South direction and about 10 m along the East-West direction (Fig. 1a). The building has 6 stories and it is about 24 m high. The main load bearing structure is a tuff masonry (Fig. 1b). The ground floor and first floor consist of barrel vaults, while the second floor is made up of pavilion vaults. The second mezzanine floor and third floors, the latter having with a relatively large span of about 8.5 m, are made of a wooden structure. In particular, sail vault ceilings are suspended at the lower surfaces of the third floor. The double pitched roof is made of wooden trusses covered with tiles or corrugated steel sheets. The building has a large staircase located on the South side, which reaches all floors except the basement floor. In addition, a small and narrow internal staircase connects the building from the basement to the first floor. Finally, a spiral staircase, located on the West elevation connects the building from the first to the third floor.

Over the years, the building has undergone several transformations and different uses. The condition of degradation was widespread and it affected both the envelope and the interior side of the building. In particular, both vertical and horizontal (vaults) masonry structures were affected by cracks with variable width and all wooden structures were greatly damaged by the ravage of time (Fig. 2).

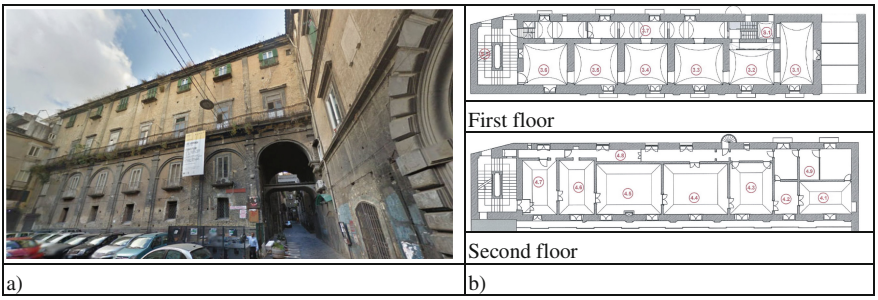

Fig. 1. The building before the rehabilitation: a) View from the East side; b) Some floor plans

Fig. 2. Typical damage in masonry and wooden structures.

3 The Functional-Structural Rehabilitation

The overall design was carried out according to the following phases: knowledge of the current state of the building through in situ geometrical and photographical surveys, including the site geotechnical investigations; evaluation of the structural capabilities of the building through numerical analysis on Finite Element models (FEM, before and after the interventions); identifications of the seismic vulnerability; selection of the type of intervention; design and execution.

In particular, the refurbishment of Prince Caracciolo of Avellino building had a twofold aim: the retrofitting with seismic upgrading of the existing structures and the integration of new structural parts related to the new functional purposes.

With regards to the retrofitting of existing structures the following interventions were designed and realized: repair of cracks in masonry based on their width; reinforcement of vaults; replacement of opening architraves with steel beams; installation of tie-rods in transversal structural walls; replacement or reinforcement of wood and concrete floors with new composite steel-concrete floors anchored to walls in order to obtain a rigid diaphragm effect; replacement of wood trusses of the roof with new steel trusses; reinforcement of spiral staircase by means of a bounding of steel plates; reinforcement with steel beams of the staircase between ground floor and basement; reinforcement of wood framed partition walls using steel frames.

Besides, the following new structural parts were designed and realized: two linear flying stairs, connecting the first to the third floor; steel frames to support new door openings in tuff masonry walls; a steel frame for the new lift shaft; a water reservoir and a transformer room both made of in reinforced concrete, located at the underground floor.

Some details of the new floor structure at the third level, in substitution of the wooden floor, are shown in Fig. 3. The new composite floors is made of steel beams collaborating with a lightweight concrete slab, cast on trapezoidal steel sheeting, by means of shear connectors. The diaphragm effect was obtained by a rigid ring along the perimetral structural walls, made of steel profile and anchored into the concrete slab.

Some details of the new linear flying stairs are shown in Fig. 4. They are made by a ribbed steel plate, which lightweight concrete steps are cast on; the stairs are also supported by steel profiles anchored in lateral existing masonry walls.

The new roof structure is shown in Fig. 5. The original wooden trusses were replaced by new ones made of CHS steel profiles, whereas the wooden beam floor was restored with particular attention to the supports to the masonries. It is now visible as ceiling of the third floor (see Fig. 7 b).

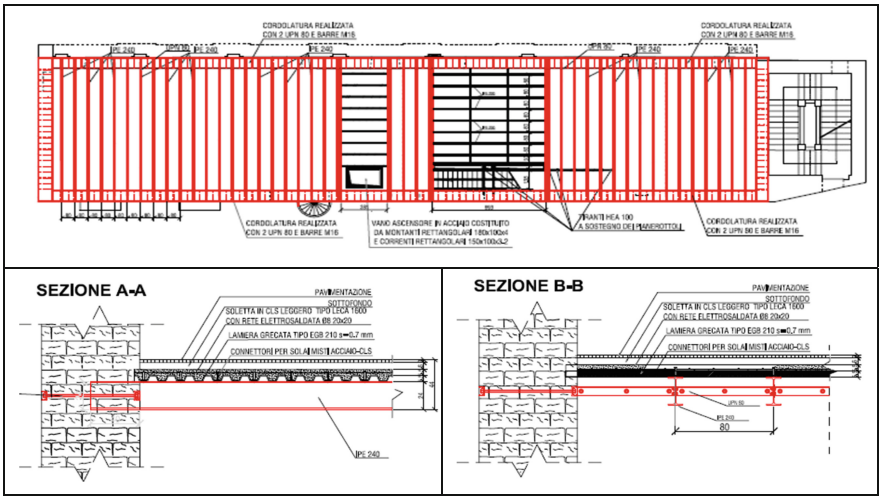

Fig. 3. Floor structures at the third level.

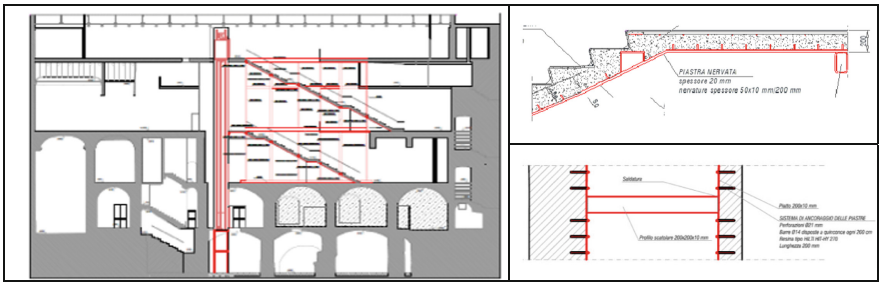

Fig. 4. New linear flying stairs.

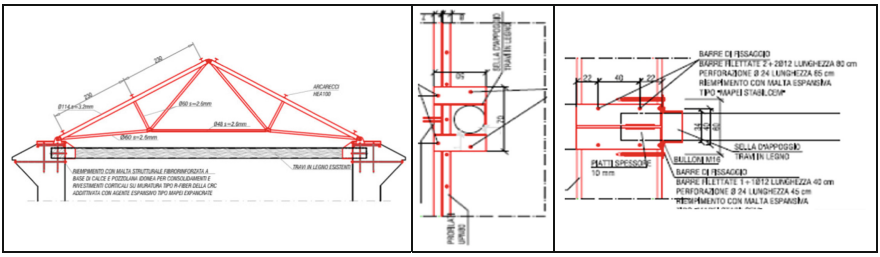

Fig. 5. New roof structure and detail of the support to masonry.

A linear dynamic analysis by a FEM model (Fig. 7), interpreting the structural behaviour before and after the interventions, was performed in order to evaluate the structural capabilities of the building in the current state and the enhancement of its seismic behavior after the interventions, with particular reference to the local safety checks in tuff masonry 'walls, to the evaluation of the global effects of rigid diaphragms given by new floors and to the effectiveness of the wall tie-rods (Fig. 6).

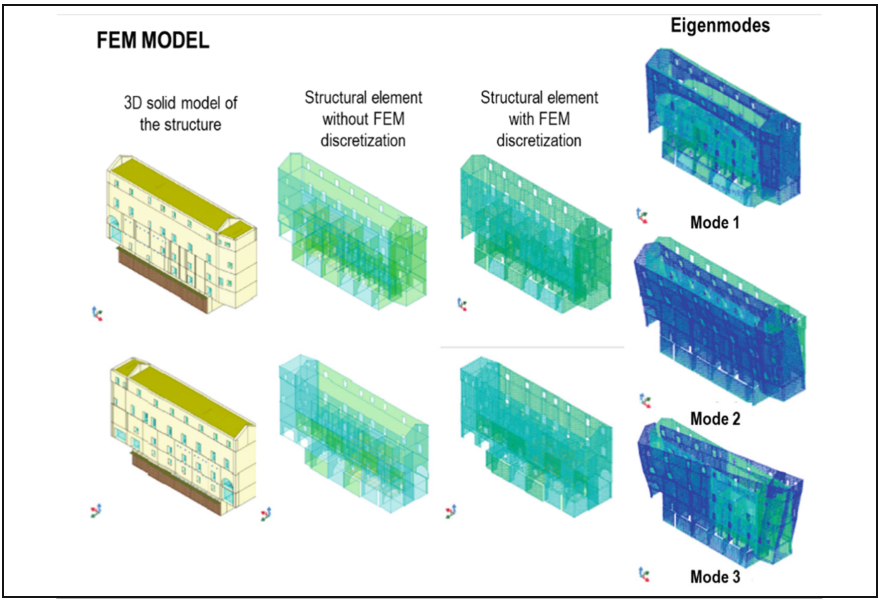

Fig. 6. FEM model and modes of vibration of the building.

4 The Building After the Rehabilitation Works

Hereafter some pictures of the renewal of the buildings are provided (Fig. 7).

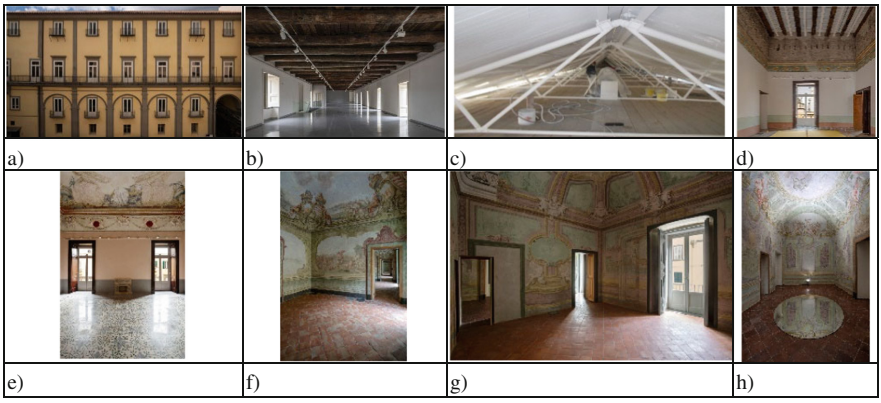

Fig. 7. a) The building East façade after restoration (fondazionemorragreco.com); b) the old timber beams in the upper hall (artribune.com); c) the new roof trusses; d) the ceiling of one of the halls (fondazionemorragreco.com); e, f, g, h) Some halls after restoration (fondazionemorragreco.com).

5 Conclusive Remarks

The functional-structural rehabilitation of the Prince Caracciolo of Avellino building is a very topical example of valorization of monumental built heritage, which combines principles of conservation and innovative technologies. This integration between ancient and modern environments, perfectly in line with the basic principles of the Restoration Charts, is even more apparent considering the destination of use to contemporary art exhibitions.

The comprehensive design allowed definitely to open two additional floors to the public for a total of 2000 square meters of exhibition space distributed over five levels, each revealing a remarkable variation of art-historical richness (www.fondazionemorragreco.com).

Acknowledgements. Fondazione Morra Greco is acknowledged for publishing.

References

Catalani, L.: I palazzi di Napoli, Napoli 1845, p. 64 (1845)

De Dominici, B.: Vite de pittori, scultori ed architetti napoletani, Napoli 2003, ed. a cura di F. Sricchia Santoro e A. Zezza, tomo I, p. 207 (2003)

Sigismondo, G.: Descrizione della città di Napoli e i suoi borghi, Napoli 1788-89, ristampa anastatica Forni (ed.) Bologna 1989, p. 137-138 (1989)