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Energy requalification of a historical building: A case study

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ABSTRACT

This paper illustrates an energy upgrading proposal of a historical building in Naples (Italy): Palazzo Fuga, better known as the Real Albergo dei Poveri which was built in the second half of the XVIII century.

The proposal consists of energy efficiency interventions on the building envelope and its plants. As energetic and thermal aspects are concerned, simulations were performed in order to size a photovoltaic system, considering lighting aspects, and to evaluate the improvement of the building energy performance. Furthermore, thermal and lighting measurements were performed with a double aim: to verify the factual state of the building and to calibrate the calculation tools to the particular situation. In this paper obtained results concerning the feasibility of interventions will be presented and discussed.

1. Introduction

The Real Albergo dei Poveri of Naples, a unique monument for its architecture, dimensions and volumetric organization, was built in the second half of the XVIII century from an idea of the King Carlo of Borbone. The building had to host, educate and rehabilitate the poorest of the reign. The original project, by the architect Ferdinando Fuga, contemplated the realization of a city in the city, but the building construction was interrupted in 1819: the realized part of the building, in Fig. 1, is only one half of the original project, but it seems imposing anyway and it looks like a realm than a welfare centre.

In the following the building was transformed, modified, partly demolished and occupied unlawfully; the peak of these events was in 1980 when a strong earthquake caused collapses and severe damages that made the building completely unfit for habitation. In the original project the building had to be bigger than the Reggia di Caserta; it had to be 600 m long and 150 m wide and it had to include five courtyards. A four aisles church had to be disposed in the central courtyard. When the building's construction was interrupted only three courtyards had already been built, the façade length was 364 m and the central church was only sketched.

The requalification project of the Real Albergo dei Poveri was included in the question of the rebirth and re-use of abandoned historical buildings (see Table 1). In particular, energetic aspects have represented a topic of a case study of the SARA (Sustainable Architecture Applied to Replicable Public Access Buildings) project.

A proper compromise between energy efficiency requirements and conservation of historical buildings is necessary to avoid conflicts and to obtain good energy performances in the respect of the buildings and monuments heritage [1,2].

The SARA project has interested only the big frontal body of the central courtyard. The body is composed of two parts, divided by a lateral corridor. "Little rooms" (6.2 m × 10 m) correspond to the old offices and to the ministers rooms are distributed on the seven levels of the body. The lateral part of the body was designed for dormitories and soup kitchen.

Experts and designers were asked to deal with:

- Renovation of the building aiming to reach high energy performance levels and fixed sustainability criteria, using traditional, natural, ecological and local materials.
- Use of high energy performance technologies aiming to reduce energy consumptions, in particular heating and lighting ones.
- Maximum use of daylight (in particular at the three top levels) aiming to reduce the energy demand for lighting, without neglecting the risk of overheating of environments during the summer.
- Collection and storage of rainwater for re-use of water aiming to reduce water needs of the buildings.
- Use of natural ventilation and low thermal transmittance of walls for indoor comfort both during winter and summer season

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Fig. 1. The Real Albergo dei Poveri.

Table 1
The Real Albergo dei Poveri in synthesis.

Age	250 years
Surface	103,000 m^2
Volume	830,000 m^3
Levels	From 2 to 9
Main courtyards	3 (6500 m^2, each)
Minor courtyards	6 (700 m^2, each)
Total width	140 m
Total length	384 m
Maximum height	42 m
Minimum height	15 m
Spaces	440
Corridors	9 km
Renovation costs	85 M€
New use	Youth city
Promoter	Municipality of Naples

without installing air conditioning systems, not compatible with the building structure.
- Integration of renewable energy systems, in particular in the cover at the last level.
- Monitoring of consumptions.

2. Feasibility study of interventions

All the hypotheses of intervention were compatible with the accordance that the Municipality of Naples took with the Government Department responsible for the environment and historical buildings. In particular the only elements of the building's envelope that could be modified were floors, roof and windows.

The feasibility study has focused on structures, plants and envelope of the building. In particular, concerning energy aspects, calculations were performed considering the hypothesis of a photovoltaic plant, daylight penetration, and thermal efficiency of the building.

At the factual situation, neither heating nor air conditioning systems work in the building. In agreement with the architectural project, a high performance plant was hypothesized, with floor radiant panels for heating. No air conditioning was considered during summer [3,4]. Natural ventilation was hypothesized for air change [5,6].

The analyses and calculation procedures will be described in the following sections. The start point was the respect of the monument with the aim to hand it down to future generations as an intact historical document [7,8].

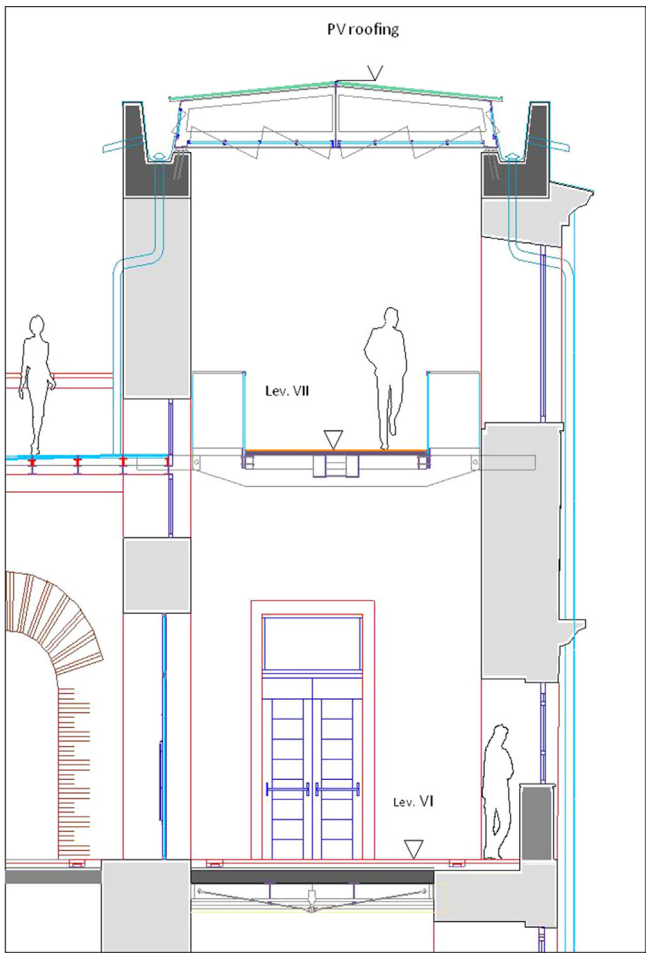

Fig. 2. Cross section of PV roof and levels VI and VII (from: Comune di Napoli).

3. The PV intervention

One of the most significant intervention hypotheses for the energy efficiency of the Real Albergo dei Poveri in Napoli is the design of a PV roofing at the top level (VII) of the AB lot, which is constituted by a big open space. The architectural project included the interior rebuilding of this level, by eliminating the floor and partially substituting it with a suspended footbridge (Fig. 2). The aim was to lighten the structure and to make visible the level below, creating a visual link between the two levels. Since the roof could be modified, the restorer architects proposed to place a transparent or a semi transparent roof in order to allow daylight entrance, in addition to the side windows. Furthermore daylight could pass through the holes aside the footbridge and reach the VI level. From a different point of view, considering energetic and sustainability's aspects, a PV roofing seemed a very effective solution.

Indeed, the realization of a PV roofing at Real Albergo dei Poveri in Naples assumes a great symbolic and demonstrative value.

The PV roofing covers the entire corridor, as shown in Fig. 2.

The orientation of the receiving surface has been strongly conditioned by a strict constraint: the non-invasively and non-visibility of the roofing by main points of view in the city, as required by the superintendence authority. The therefore obligated orientation has an azimut, γ of -41° (East) with respect to South and a tilt, β, of 4° and it is certainly not an optimal one.

No shading due to interference between modules is observed since they are disposed on a slightly inclined pitched roof; furthermore there are not buildings shading modules. According to the