



Recommendation for restoration of Modern buildings with stone cladding and steel windows: A multi-disciplinary approach on a significant case study

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HIGHLIGHTS

- ▶ Holistic approach for Modern heritage safeguard.
- ▶ Deep historical-constructive analysis and diagnostic experimental investigation.
- ▶ Hypotheses for conservation for thin stone cladding and steel window frames.
- ▶ Elimination of protective elements (copings) causes inefficient draining.
- ▶ Rising damp and differential thermal expansion.

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ABSTRACT

The paper reports the results of a multi-disciplinary study carried out on a significant example of Modernist architecture, dating back to the Fascist period in Italy.

The buildings of that period are as laboratories for architectural innovation and are characterized by the adoption of new constructive and technological solutions for the elimination of the decorative and functional element in order to obtain pure volumes. This characteristic feature caused in a great number of Modern buildings design errors and the deterioration of the unprotected elements.

In order to safeguard this heritage it is necessary to have a thorough understanding of the materials and the techniques used. This can be achieved only through a multi-disciplinary approach on relevant case studies.

The current study was carried out on the characteristic construction components of the main façade of a selected building, the stone cladding and the steel windows, to have a more thorough awareness of the techniques used and to verify the state of conservation. It was also possible to hypothesise conservation actions coherent with the material culture.

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1. Introduction

For the first time the Modernism paid particular attention to the technical aspects of construction and for this reason each building became as a type of laboratory where new architectural forms and construction techniques were experimented.

In 1991, during a European Council meeting in Rome, the Committee of Ministers came to a decision about the need for a better awareness of this heritage, by drawing attention not only to the works of the most famous designers but also to less well-known examples which have significance for the history and architecture of the period [1].

The present research was carried out on a significant case study (the Municipal Building of Corridonia) and it was focused on the characteristic construction components of the main facade that embody the principal aspects of technological innovation: the stone cladding and the steel window frames.

This case study and the most important construction features of the building were chosen after carrying out a thorough historical and critical research study on the national and regional Modernist heritage, which led to the cataloguing of 45 buildings constructed between 1928 and 1944 and the identification of the new techniques [2].

The aim was to conserve the historical testimony of the method of construction, verify the state of conservation and supply useful indications for the maintenance and restoration of the most interesting technical and stylistic features of the building so that the historical significance of the building can be preserved and its future maintenance ensured. The remedial measures could be

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adopted in a great number of buildings of the modernist Italian architecture characterized by a widespread use of thin stone claddings and steel window frames.

A study of international literature on the experimental analysis of buildings of historical significance, has highlighted the presence of methodological researches or detailed surveys on case studies.

Some researchers present methodological works on the development of analytical models for the prediction of the service life of stone cladding [3] or on the identification of experimental methods for diagnosing the state of deterioration [4]. Some authors propose reviews based on experiences on a great number of buildings [5,6] or analyse the applicability of particular diagnostic techniques, such as thermography [7].

Other researchers focus on the investigation of case studies by experimentally analysing samples collected during restoration work. Most of these papers deal with the analysis of plasters [8–12], mortars [11,12] or windows metallic elements [13] in historical buildings dating back to the pre-industrial period.

There are few experimental studies on the durability of the new constructive techniques which were introduced after the end of 19th century (as a result of the profound changes due to industrialization) and generally concern modern cement-based plasters [14]. The most interesting studies on this heritage are about the technological and historical analysis and restoration projects on the work of pioneers [15–18].

In the present work a multi-disciplinary approach was adopted [19,20] that involved a detailed historical analysis; an on-site experimental campaign and laboratory tests; the identification of remedial measures for the physical conservation of the fabric; new tests on the remedial measures adopted.

2. The case study

The Municipal Building in Corridonia (1936) is one of a series of works commissioned by the Fascist regime in order to “re-found” the town of Montolmo, the birthplace of Filippo Corridoni (its name was subsequently changed to Corridonia), a decorated military who died during the First Mundial war.

On that occasion an architectural and sculptural complex with a large square (Fig. 1a) was realized in the historical centre with the focal point being the monument to Filippo Corridoni, and in which the Municipal Building is the scenic background for the sculpture. Apart from the historical reasons this case study was chosen because cultural significance is embodied in the building fabrics from two points of view:

- Aesthetic, because the complex is “forced” in a historical centre, creating a slash in the stratified context that evokes the paintings of Methaphysical artists (such as De Chirico). The relationship between the new complex and its surrounding setting is unusual if compared with the demolition of entire urban areas which occurred in other Italian towns.
- Technological, because novel constructive solutions were experimented in two components that have a great impact on the appearance of the building: the cladding of the whole façade with thin layers of travertine (which was usually limited to the basement) which led to the development of new details for the connection of the external stone boards with supporting masonry, architraves, etc.; the use of steel window frames in a public building (generally used for covered markets) for purely aesthetic reasons, although the systems for opening the windows are typical of wooden frames.

The design of the Municipal Building, for the trickiness of the work involved (which was monitored personally by Benito Musso-

lini) was assigned to technicians who were trusted by the “Podestà”: the engineer Pirro Francalancia and the architect Giuseppe Marrani.

The building has a two storey central volume and two lateral wings connected by a colonnade on the same level as the square. The presence of typical features of Fascist architecture can be noticed on the main façade: the cladding with thin travertine slabs covers both the flat and the linear components giving the surface a homogeneous and abstract appearance; very thin steel window casing which “disappears” in the disposition of volumes and contributes to the overall simplification of the decoration; the central balcony (which acted as a podium during public assemblies) and the visible pilastrades; the “colossal order” openings which cut into the surface and create a contrast between projecting volumes and cavities.

The complex has traditional load-bearing masonry and reinforced-concrete floor slabs. The wall is made of solid brick masonry using $6 \times 13 \times 27$ cm bricks. Reinforced concrete is used for beams and for the architraves.

3. Stages, materials and methods

This research study was carried out through a historical and critical investigation and experimental analyses on the external façades of the building. The different stages can be summarised as follows:

- Historical investigation on the Modern heritage through the analysis of the documentation concerning: design criteria, construction and diagnostic techniques.
- Historical investigation on the case study through the analysis of the historic material from archives, original drawings and technical papers (measurement of items of work, final records, final estimates) as well as photographs of the building site.
- Photographic survey in order to map the visible damage to the facade, highlighting the areas where the stone cladding has become detached from the support surface.
- Non-destructive experimental investigation:
 - *Magneto metric investigation (Pachometer)* to detect hidden ferromagnetic materials. It was possible to identify the position size and arrangement of the anchoring straps and the metal clamps supporting the steel window frames.
 - *Thermographic investigation* to identify the presence of thermal dispersion or cracking (with higher thermal inertia and different conductivity).
 - *Percussion with hammer* to map the different levels of detachment of the slabs. The surfaces were tapped with a hammer and the resulting sound was qualitatively evaluated (a hollow sound allows the detection of not adherent areas).
- Semi-destructive or destructive experimental investigation:
 - *Small specimens and endoscopic observations* to verify: the presence of detachment and the condition of the mortar in the interspace; the distance of the travertine slab from the support surface; the configuration of the strap anchors. It was also possible to extract a fastener of a window frame from the wall adjacent to the window.
 - *X-ray diffractometry analysis* on representative samples to determine the physical characteristics of the materials used, to identify crystalline compounds and any possible deleterious components. In particular this test was carried out on samples taken from the glazing putty and from the masonry lateral to the window frames (in contact with the anchoring fasteners).
- Analysis of deterioration. The results were collected in a deterioration mapping of the façade. Identification of the probable causes and the possible conservation actions (by analysing the available literature and contacting the manufacturers).
- Guidelines for the physical conservation and performance tests. Restoration was planned in order to retain the cultural significance of the building and retarding the natural deterioration processes. To test the performance of the restoration work on the original window frames, the research involved the intervention on a window and the subsequent assessment of the air tightness through the Blower Door Test.

4. Results regarding the cladding

4.1. Construction analysis based on historical and experimental analyses

The details regarding the specific anchor design of the slabs are not visible from the outside and are not mentioned in the executive design, having probably been decided on site during the construc-

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