The “Mandolesi Pavilion”: an information model for a process of integrating multidisciplinary knowledge

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Highlights

The Mandolesi Pavilion is an icon of innovation, a significantly important building from an architectural point of view and incorporates certain values, which invite reflections towards recovery work aimed at “conservation”. The high architectural value of the Pavilion outlines the need for a systemic management approach, capable of integrating and coordinating specialist and diverse but complementary competencies. In this context, the contribution provided by the BIM methodology is highly important, thanks to the use of “multicriteria” analyses.

Abstract

The Mining Engineering Pavilion was designed by Enrico Mandolesi in 1962. It represents an icon heralding the transition from masonry to reinforced concrete and the use of “new” materials. Its recovery may become an important starting point for integrating all scientific levels, from the construction history, which reconstructs the history of the project and that of the building site, up to the most sophisticated energy diagnoses that include the definition of an integrated information system on the building, to be used in cutting-edge style with the BIM approach or even with experimentation in a first-step evolution towards a cognitive building.

Keywords

Padiglione di Ingegneria Mineraria, Mining Engineering Pavilion, Enrico Mandolesi, Construction History, BIM, Recovery of Modern heritage

1. INTRODUCTION

When Enrico Mandolesi arrived in Cagliari in the mid-1950s, he found a rather underdeveloped academic scene in the architectural field, while, paradoxically, the city was a breeze of construction sites, especially related to the INACasa programme, which heralded the season of “Great Reconstruction” work after the widespread destruction from bombings in the war. In this context, professionals from the Roman school were active in the social housing sector, including Maurizio Sacripanti and many others like Adalberto Libera, whom Mandolesi was to collaborate intensely with over the following years. The Reconstruction took place in the form of a dialogue, with the terms dictated by the “Piano Fanfani” (Fanfani Plan), involving the traditional building site of the masonry house - with hollow-core concrete slabs - and the progressive
spread of the reinforced concrete frame, in the “domestic” version devoid of structural complexities, following the model of the Tiburtino district by Quaroni and Ridolfi. Mandolesi immediately burst onto the scene with a strong charge of innovation. In the academic field, he founded the Institute of Architecture and Urban Planning, training an entire generation of designers for 15 years and resolutely choosing to bring the Institute towards modernization of the relationship between project and construction. The constitution of the C6 (Study Centre on Industrialised Building) at the end of the 1950s says a lot about the direction that Mandolesi long sought to give to research: the progressive abandonment of the traditional construction method, with the study (even critical study) and the import of European prefabrication models. In those same years, conscious of the cultural reach of this battle, Mandolesi also encouraged a reflection on the philosophical and aesthetic principles of innovation. We now know that that path achieved contradicting results and that innovation soon went in other directions; nevertheless, today we can perhaps go back to that story and learn how to gain a better insight into the processes of the present through its contradictions.

During the 1960s, Mandolesi was able to experiment in Cagliari his approach to the project-construction relationship in a range of fairly diversified works. Among them, the INACasa district of La Palma marks the utmost expression of the Ridolfian integration between exposed reinforced concrete frame
and brick infill masonry, while the Engineering Pavilion is the point of arrival of a new, different and apparently opposing experimentation, which finds references in the post-Lecorbusierian brutalism and in the building industrialisation processes with a backdrop provided by the mega-structural experiments by leading professionals such as Kenzo Tange. The Pavilion will be 50 this year, a time that has obviously had its consequences in terms of physical obsolescence but also and more significantly in terms of functionality, plant engineering and what we now call “building sustainability” and “energy efficiency”. The recovery of this building opens a very inspiring research topic because it represents a “contemporary monument” that incorporates certain values, which invite reflections towards recovery work aimed at “conservation”. At the same time, just like the majority of contemporary buildings, it was designed and built for innovation and not for a “long life”. Therefore it highlights all the complexities (and even ambiguities) of a conservative approach intended as “deterministic”. The project research should bring out these complexities, resulting in the encounter-clash between different needs and cultural and specialist points of view, which are sometimes contradicting. These approaches, that are all legitimate and even necessary, should converge in designing scenarios (that may even be alternative), identifying the meeting points between the characters and the inherent potentials of the building and the conversion and adaptation hypotheses and needs.

Conceived as an icon of innovation, the Mandolesi Pavilion can become an important starting point for integrating all scientific levels, from the construction history, which reconstructs the culture, the conception, design and construction processes, up to the most sophisticated energy diagnoses, from the “unconventional” survey, to “non-destructive” diagnostics, the chemical and physical investigation of materials, the analyses on the structural behaviour and performance and ultimately, the definition of an integrated information system on the building, to be used in the most advanced way in the Building Information Modelling approach or even with experimentation in a first-step evolution towards a cognitive building.

2. PROJECT AND CONSTRUCTION

The building was designed by Enrico Mandolesi in 1962 and opened in 1970. It occupies the fifth and sixth lot of the floor plan, designed in 1944 by Salvatore Rattu for the pavilions of the Faculty of Engineering of Cagliari. The shape of the building, which in 1969 was awarded the Inarch Prize, is
significantly unique. On the pilotis level there are two floors in elevation with decisive projections; the base uses the level difference with the road to insert a basement that houses laboratories for large equipment and a large hexagonal double-height Great Hall. The upper floors are divided longitudinally into three functional areas: those on the edges, which correspond to the projecting parts, include study and research areas; while in the central strip, there are service blocks (toilets, staircase and lift) which define the beginning and the end of a sequence of areas for research and teaching activities, lit by six large cavaedia and two smaller ones.

The pilotis system along with the roof, which allude to the large garden terraces of Le Corbusier, constitute the leisure areas and serve as a mediator space between the two upper floors and the underground floor. Flexibility is the principal element of the programme, and is considered by the designer as “tangible sign of mobility, a fundamental characteristic of our age”.

The use of a reinforced concrete frame is therefore understandable, since it is capable of creating wide projections and providing a flexible internal distribution. In the upper floors, the structural pattern has a regular pitch. It consists of two rows of nine pillars, strongly recessed from the façade, which support two longitudinal “T”-shaped beams 90 metres long. Cantilever portions are 4 metres on the pilotis level and 5 metres on the roof level. This aspect, along with the slots below the slabs, that denounce the non-structural nature of the façade panels, emphasises the horizontality that governs the geometry of the building.
Figure 5. 1. reinforced concrete double floor slab, 60 cm; 2. “T”-shaped beam in reinforced concrete; 3. reinforced concrete double floor slab, 55 cm; 4. reinforced concrete pillar; 5. wall composed of solid bricks on the inside (half a brick double UNI), air space, insulating glass wool, prefabricated reinforced concrete panel th. 6 cm; 6. profiled iron windows; 7. profiled iron frame; 8. hollow-core concrete slab, 50 cm; 9. cantilever reinforced concrete ribs; 10. housing for technology system channels (graphic elaboration: G. Monni and M. Brandolini).
Staircases and lifts are made of exposed reinforced concrete septa, which are independent from the load bearing structure. The ramps consist of steps prefabricated in situ that are slotted in the septa and are lit and ventilated by small openings on the wall and by the cavaedia, towards which the distribution corridors overlook.

The construction works were assigned to the company of the Eng. Gallino from Genoa and the supervisor of works was Eng. Paolo Lixi, who played a crucial role in the articulated construction process. The original project was approved by the Technical Administrative Committee of the Public Works Department of Sardinia on 21 November 1962. The project was followed by eight variant appraisals that in some cases resolved issues, which had perhaps been underestimated during the design process, but often concerned the evolution of substantive technical solutions. The propensity of Enrico Mandolesi towards continuous experimentation is clearly manifested in the evolution of the project throughout the entire construction phase. The first appraisal was needed in 1964 and concerned the foundation structures. After the surveys carried out in 1963, they decided to replace the shallow foundation with boreholes. In 1966, Eng. Paolo Lixi pointed out the need for a complete review of the static calculations of the roof slab and that of the floor below, which were then carried out by Eng. Emidio Mencarelli.

The significant cantilever spans caused, in addition to the negative moment on the interlocking of the cantilever parts, significant recall negative moments on the slab of the central spans, that, in correspondence of the empty parts of the cavaedia, could have generated torques on the longitudinal large beams. The cover of the first floor was then substantially changed. In the cantilever parts, the 50 cm slab with air space was replaced with a slab of the same thickness but consisting of a double concrete slab reinforced along the two directions with the joists laid on top in situ. On the roof of the second floor, the cantilever parts and the slabs of the central strip, partitioned by the cavaedia, underwent the same modification with an increase of 5 cm. The slabs on the extreme ends of the building remained unchanged. Furthermore, we should point out the modification of the external infill masonry with the appraisal of 1966: to reduce loads on the cantilever parts and the resulting stress, the 15 cm thick reinforced concrete wall, provided within the project, was replaced by a wall consisting of only 6 cm thick prefabricated concrete slabs, with a layer of 3 cm of glass wool, an air gap of 17 cm and a layer on the inside made of solid square bricks 6x6x24, obtained by cutting in half the “double UNI” brick. In 1967, the fourth appraisal was approved, improving the technological systems and introducing interesting modifications in the internal and external
finishing. In particular, during the construction, Mandolesi decided to leave exposed the internal infill wall and all the internal partitions made with solid bricks, replacing the plaster and painting layers with a transparent protective varnish.

The design and construction processes of the Mandolesi Pavilion reveal the essence of the entire work, aimed at the integration between in-situ prefabrication techniques, enabling a quick and modular production of the components, and handicraft procedures. The accounting register shows that the construction company repeatedly asked, throughout the whole construction phase, for the recognition of the greater costs needed for the realisation of the double reinforced concrete floor slab. In fact, the absence of hollow flooring blocks required handicraft procedures such as the continuous assembly and disassembly of wooden banks for the concrete castings of the ribs and the use of buckets and trowels. Just like with the “Unité de Marseille”, the technically and formally unsatisfactory outcome of industrialised castings underwent “corrections” at the hands of skilled local professionals with handicraft procedures.

There are three types of “mono-block” windows: half-height, resting on the panels; full-height, fixed directly to the upper surface of the floor slab; full height with vertical shading blades in fired enamelled aluminium, which can be adjusted from the inside. The exterior windows and doors of the basement floor are different from those used on the façades of the upper floors. In the basement floor, there are iron-framed windows and doors with normal “national double-glazed glass”, and in the rest of the building there are frames in cold-processed steel provided with toughened glass. The pillars are shaped to look like twin elements, through an incision on the longitudinal sides, which in some cases continues on the inside and coincides with the expansion joint. The cutouts of the internal surfaces, also house the technological systems, that in this way are left visible but without being intrusive. Moreover. The exposed ribs in the bottom surface of the cantilever part that were prefabricated in-situ have a higher section at the joint to translate the shape of the moment trend diagram.

3. INNOVATIVE APPROACH TO THE RESTORATION AND MANAGEMENT OF THE MANDOLESI PAVILION: THE BIM METHOD

From the cognitive analysis, it emerged that the Mandolesi Pavilion is clearly a high-quality building due to the constructive experimentation and its iconic value. It is a kind of “missing link” between the portions of the complex of

1967 fu approvata la quarta perizia che permise, oltre al miglioramento degli impianti tecnologici, anche delle interessanti modifiche alle finiture interne ed esterne. In particolare, durante la costruzione Mandolesi decise di lasciare a vista la parete interna del tamponamento e tutte le trumezzature realizzate in mattoni pieni, sostituendo gli strati d’intonaco e tinteggiatura con una pittura di protezione trasparente.

L’iter progettuale e quello costruttivo del Padiglione Mandolesi rivelavano che si tratte di un cantiere incentrato sull’integrazione tra procedimenti di prefabbricazione a pieno d’opera, che hanno permesso una produzione rapida e modulare dei componenti, e procedimenti molto artigianali. Dal registro di contabilità si evince la richiesta insistente dell’impresa, tramite riserva riteruta per tutto il corso dei lavori, di riconoscimento dei maggiori oneri per la realizzazione del solaio a doppia soletta. L’assenza delle pignature impianti, procedure molto artigianali come il continuo montaggio e smontaggio di sponde di legno per il getto delle nervature e l’impiego di caldarelle e cazzuola. Proprio come nell’Unité di Marsiglia, l’esito tecnicamente e formalmente insoddisfacente del getto industrializzato fu quindi “corretto” da abili operatori locali con procedure del tutto artigianali.

I serramenti “monoblocco” sono di tre tipi: a mezza altezza, poggiati sui pannelli; a tutta altezza, fissati direttamente all’estradossolo del solaio; a tutta altezza con frangisole a lame verticali in alluminio smaltato a fuso, orientabili tramite un comando interno. Gli infissi esterni del piano seminterrato sono diversi da quelli utilizzati sulle facciate dei piani in elevazione. I primi sono in ferro finestrato e hanno “vetri doppi nazionali” mentre i secondi sono telai in profiliati in acciaio a freddo e provvisti di cristalli temperati. I pilastri sono conformati per apparire come elementi inferiore, tramite un’incisione riportata sui lati longitudinali, che in alcuni casi prosegue all’interno e coincide con il giunto di dilatazione. Le riseghe dei fronti interni accolgono inoltre il passaggio degli impianti, che in questo modo sono lasciati a vista ma senza ostenzioni. E ancora. Le nervature a vista presenti nell’intradosso dello sbalzo e prefabbricate a pieno d’opera, hanno una maggiore sezione in corrispondenza dell’incastramento per tradurre plasticamente l’andamento del diagramma dei momenti.

3. APPROCCIO INNOVATIVO AL RESTAURO E ALLA GESTIONE DEL PADIGLIONE MANDOLESI: LA METODOLOGIA BIM

Da quanto emerso dall’analisi conoscitiva, il Padiglione Mandolesi è un’opera di alto livello, sia per la sperimentazione costruttiva, sia per il valore iconico dell’edificio. Si tratta di una sorta di “anello di congiunzione” tra le porzioni del patrimonio dell’Ateneo dell’Università di Cagliari che appartengono alla grande tradizione muraria, che si spinge sino agli anni ’50 del ’900, e l’innovazione che si identifica con il passaggio dalla muratura al telaio spaziale ed all’uso dei “nuovi” materiali, a
the University of Cagliari that belong to the great “wall” tradition, which goes up to 1950s, and the innovation identified by the transition from the masonry structure to spatial frame and the use of “new” materials such as steel and reinforced concrete. However, half-a-century cannot go by without consequences, in terms of material degradation, regulatory misalignment, new answers to distribution requirements that are changing and inadequacy of the technology systems and energy consumption.

All this highlights the need for a conservative restoration of the Mandolesi Pavilion, preserving its meaning and (almost) historical value. These measures must be accompanied by a systemic approach capable of integrating and coordinating different but complementary skills and contributions (structural engineers, energy efficiency experts, plant engineers, restorer architects, technical physicists, etc.). In this context, the contribution of the Building Information Modelling/Management is essential. The structuring and management of a wide range of digital data and information about the status of the building creates the optimum conditions for conducting a “multicriteria” analysis that would allow the design and evaluation of different scenarios and intervention strategies, identifying the best combination that maximizes comprehensively the quality of the results. In this sense, BIM is the ideal ground for multi-disciplinary contributions, which are already widely considered as an important added value in the management and enhancement of existing buildings with high architectural value, such as the Mandolesi Pavilion.

Working on a BIM environment means having a parametric model of the building, with the integration of virtual items (“families”) that faithfully simulate those of the building. Therefore, the construction of the model of the Mandolesi Pavilion formed an important part of the work. However, before the development of the model, some important preparatory actions had to be made. Starting from the careful analysis of the propriety information, we proceeded with the selection of the subject for the parametric modelling. The BIM model, in fact, does not represent the universal container for every type of information, but must be conceived within a specific and focused programme. The deficiencies or inconsistencies found in the documentation were solved through sampling, concerning technological aspects, and through dimensional surveys regarding the size and geometry of the building. Therefore, the numerous on-site inspections were useful for integrating the data contained in the documentation or for assessing their reliability and coherence with the actual existing building. In addition, we carried out an analysis on the use and maintenance status of the structural components and building envelope. A
brief summary of this analysis will now follow, in order to assess the priorities for action.

The accurate study of the particle size composition of the castings and their perfect execution have ensured that the concrete envelope and load bearing structure of the Mandolesi Pavilion has been able to preserve itself without significant degradation. There are some exceptions in limited areas, where the over-shallow reinforcement cover has come off due to corrosion. The most significant “performance deficiencies” in the building are related to the extremely poor thermal inertia of the floor slabs and, above all, of the infill masonry, whose limits are explained by multiple factors such as the modest thickness of the prefabricated panels and of the glass wool insulation, the low heat retention of windows and doors and the considerable thickness of the air gap. Another important factor is the significant presence of thermal bridges due to the structural frame, which is often devoid of protection.

These aspects have certainly contributed to the reduction in the efficiency of the heating system, which was conceived in the project as a radiant system of coils within the floor screed, but which was replaced by a hot air system during construction, including a circuit of radiant panels and a thermo-ventilation system. The lack of routine maintenance has also compromised the delicate and complex system of shading blades, leading to the oxidation and blocking of the pins and also to the removal of some of the blades due to instability. The windows in cold-folded plate are in an advanced state of deterioration. The swelling of the frames, due to oxidation, caused in many cases the complete blocking of the fixture. Furthermore, the water infiltration through the flooring of the cavea has produced significant rising dampness at the base of the walls that define the corridors. The floors, made of terracotta tiles (10 x 10 cm), are often detached and cracked.

After the analysis of the use and maintenance status of the building, the work continued with the definition of a conceptual scheme for the decomposition of the building in categories of constructive objects (PBS), with the choice of alphanumeric content to be capitalised for each one of them and, therefore, with the definition of the detail level of the model. Finally, we selected a set of parameters required to “inform” the components of the model. This phase, which can be defined as pre-modelling, must be considered as crucial, as it determines the level of detail needed to achieve the set goals. Depending on the purpose, the model will have different characteristics, ranging from geometric ones to alphanumeric ones. In the specific case of the Mandolesi Pavilion, due to its particular architectural value, the pre-modelling phase achieved a rather high level of detail for each technical element.
The need to take advantage from a large volume of information is closely linked to the need to provide an appropriate information base for planning conservative restoration or maintenance interventions that respect the architectural peculiarities of the building in question.

The complexity of the modelling of the Mandolesi Pavilion is related to the irregularity of the particular elements of the building such as the pillars, beams with round edges and the internal staircase. The need to keep track of this irregularity has resulted in the almost exclusive use of the “local families” of the Revit software. We reproduced the particular shapes of the components of the building within the modelling frame, by using commands such as extrude, join and revolve. Local families can be created in the current project but they have the disadvantage of not being able to be used in other projects, and their repeated use also makes the model file heavy. Despite these disadvantages,
their use helped us to achieve work results that were essential for the approach to the management of the Mandolesi Pavilion: the accurate representation of the various building components, in terms of complexity and geometric peculiarity, avoiding excessive simplifications that would have caused the loss of precious details for the definition of the conservative restoration works. The created model allows us to record and manage the information relating to the architectural and historical aspects of the building, its current status, materials, techniques and constructive technologies used, the results of diagnostic surveys, the conditions of degradation in terms of type and severity, interventions and treatments performed, restrictions relating to its particular architectural value and degrees of freedom for new interventions.

Another important dynamic feature of the model is that it can be updated and integrated at any time in the life of the building. This aspect works towards resolving a further critical issue, namely the difficulty of ensuring the “information requirements” for the management of the building after the restoration works, creating the structure, which organises all the data and information, that is produced during any new intervention work and that is functional to the innovative management of the building.

4. CONCLUSIONS

As is well known, Italy’s enormous real estate heritage has become the major field for building investment and for the related projects and actions. It is a heritage that is often barely known and, in any case, extremely complex and diversified, whose recovery and management has until now been addressed in a rather casual and uninformed manner, with unsatisfactory and sometimes disastrous outcomes. The lack of documentation attesting the “as built” in buildings (building components, installations, etc.) associated with the poor activity in surveying their current status, considering the use (intended use and space dimensions, energy behaviour, actual consumption, etc.) and maintenance (conservation status of building components, age of the technological installations, previous maintenance work, compliance with current regulations, etc.) creates a profound inefficiency in planning, programming and controlling works of recovery, enhancement and/or re-functionalisation. This work comes from the realisation that overcoming these limits requires a real paradigm shift in the approach to a project for the recovery and management of a building - especially for a modern monument such as the Mandolesi Pavilion - based on an integrated and systemic knowledge programme. Therefore, we experimented in the use of Building Information Determination as a technique to support the approach to project and the management of objects that are part of a significant cultural heritage, that is, the Padiglione Mandolesi of the University of Cagliari, constitutes an important step in the direction of an integrated and systemic approach to the management of the Mandolesi Pavilion, which can be applied to other similar cases.
Modelling/Management (BIM) for structuring the cognitive process and for assessing enhancement and re-functionalisation scenarios. The Mandolesi Pavilion of the University of Cagliari is a highly stimulating architectural object for us as it emphasises the contradictions of the project culture related to historical heritage and helps to question “deterministic” paradigms, highlighting all the complexities (and even ambiguities) of the approach. In fact, as an “author building”, it incorporates values that require a conservative recovery approach, but at the same time, like most contemporary buildings, it was designed and built for innovation and not for “long duration”. This work represents the first and, as yet, partial prefiguration of an approach that develops from construction history, which is a powerful tool for highlighting the values and critical aspects of the building, and continues with advanced diagnostics on the dimensional survey, structures and energy performance of the building. Furthermore, through the application of the Building Information Modelling, the work begins to converge different (and sometimes contrasting) needs, skills and cultural and specialist points of view in designing different scenarios identifying the points of encounter between the characters and the intrinsic potential of the building and the assumptions/requirements of re-functionalisation and adaptation.

5. REFERENCES