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From Research to Application of HBIM for Conservation Management Plan: The Experience of the School of Mathematics by Gio Ponti in Rome

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Abstract
Between 2019 and 2021, a multidisciplinary group, scientifically coordinated by Prof. Simona Salvo, conducted research on the Gio Ponti School of Mathematics - a work from 1935 located within the city of Rome - funded by The Getty Foundation under the "Keeping it Modern" project. After studying the building in all its aspects, the ultimate goal of this multidisciplinary experience was to develop a plan for scheduled conservation. Once the work was completed, all the data was collected in a technical report. Still, there was a spontaneous inquiry into which digital tool could be suitable for conveying its findings. It was decided to experiment and investigate the potential of the H-Bim model, which was, however, introduced ex-post compared to the research process. In conclusion, this contribution aims to address the result of this experience, highlighting the merits, potential, and limitations of HBIM modelling.

Keywords: *Rationalism in Italy, Conserving Contemporary Architecture, Conservation Management Plan, H-BIM.*

1. Introduction

In its critical-conservative sense, restoration is a "cultural act" (G. Carbonara) philologically founded and characterised by the dual purpose of preserving and revealing historical and formal values. Today, the object of restoration is an increasingly widespread heritage consisting of both material and immaterial assets. The values to be revealed and the instances to be considered seem to multiply. Numerous research contributions investigate modelling that can accommodate all these instances and serve the restoration project and its subsequent management and maintenance. Since the 1980s, there has been a need to develop modelling proposals aimed at providing useful information for the execution of the restoration intervention through the so-called "semantic graphing," meaning a model that contains within it information related to the state of conservation, as well as the proposed interventions (Lo Turco et al., 2017).

In this line of research, the concept of "formal modelling" developed by Fiorani and Acierno deserves attention, as it "aims to go beyond the simple establishment of a database on historical buildings, intending to offer a coherent support system for investigative activities and the design itself, excluding the reductionist and misleading objective of the expert system" (Fiorani, 2017).

The experimentation of computer tools capable of accommodating the needs of the disciplinary field of conservation that are queryable, interoperable and implementable proceeds in parallel with digital innovation and seems to find a valid response today in the H-BIM model.

Starting from these considerations, the present contribution does not intend to focus purely on modelling, which was carried out collaboratively and with the assistance of the BIM-Specialist Arch. Federica D'Orazio emphasises the need to experiment with and identify a structuring of the model itself that is as multidisciplinary as possible to achieve a level of completeness and exhaustiveness necessary to respond to the numerous instances of proper conservation.

2. Multidisciplinary Research on the School of Mathematics

Between 2019 and 2021, a multidisciplinary group scientifically coordinated by Prof. Simona Salvo (Professor of Architectural Restoration at the Department of History, Design, and Restoration of Sapienza University of Rome) conducted research on Gio Ponti's School of Mathematics, a 1935 work located within the university city of Rome. The Getty Foundation funded the research as part of the "Keeping it Modern" project.

The School of Mathematics, thanks to its unique volumetry, the attention to the choice of covering materials, furnishings, and decorative apparatus - although the latter is now lacking due to the loss of the monumental polychrome stained glass window, designed by Gio Ponti, that characterised the main facade, lost following the bombing of San Lorenzo on July 19, 1943 - represents a unique entity within the university city of Rome. Gio Ponti conceived the building in three pure volumes, characterised by formal, aesthetic, and functional autonomy: a prismatic representation volume, the *front body*, with a grand character, designed to house the monumental Mathematics Library and a series of rooms intended for the professors' life; two *curved wings* developed on two levels, illuminated by large ribbon windows that run along the curved walls and which once had opal thermal glass, the so-called "Termolux" consisting of two sheets of transparent drawn glass with an internal insertion of "Vetroflex" spun glass felt. The sheets were completely sealed at the edges by a special hermetic sealing putty. Its composition allowed for strong insulating capabilities and the filtering of incident rays, making the light optimal for the rooms intended for the drawing of descriptive geometry models in the School of Mathematics; finally, the last block is the *classroom tower*, a fan-shaped body with a daring structure - designed by Eng. G. Zadra - with portal concrete walls, hosting on three levels the stepped classrooms for the first two years of Engineering and Mathematics and, in the basement, the caretaker's house. These three blocks sit on a residual space, a horseshoe-shaped courtyard with irregular pavement and grass crevices (Figure 1).

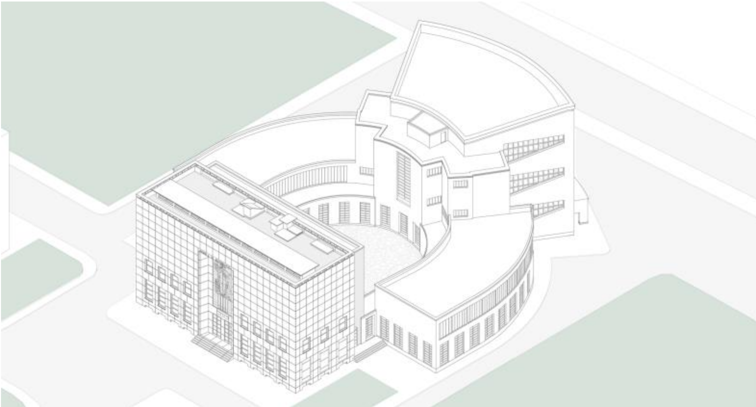

Figure 1. The School of The School of Mathematics in its original State (1935). The HBIM model was developed using Autodesk Revit 2021 ©: Cortesi, M. (2022)

However, as early as 1939, just six years after its inauguration, the building underwent a series of alterations that, in some ways, would become paradigmatic and would later be repeated in various parts of the building. Functional needs initially led to a transformation and internal subdivision of the spaces and later resulted in real expansions and extensions of the building's bodies. The safety regulation adjustments in the second half of the 1980s, with the insertion of fire escape stairs within the horseshoe-shaped courtyard, also obliterated the original conception of the building. Ponti's idea of pure volumes as finished crystals, not susceptible to additions or modifications, was undermined. The strengths of Ponti's project, such as the spatial crossings, both longitudinal, transversal, and vertical, and the junctions between building bodies differing in material and function, are those that, as we will see, suffered the greatest losses in value and meaning due to alterations, additions, and visual interruptions.
This multidisciplinary research experience allowed for the study of the building in all its aspects—its dimensional data, construction and transformation history, structures, systems, constituent materials, and furnishings—recognising its spatial, historical, and aesthetic values.
Based on this broad recognition, a technical report was prepared, including all the collected data and a conservation management plan. The interventions provided by the plan, conceived according to various categories of urgency, aim, on the one hand, to maintain the status quo, paying attention to the more fragile elements, such as coverings and finishes, and on the other hand, it also provides more strictly design-related guidelines that could partly lead to a reinterpretation of the building's obliterated values.

3. From research to the application of H-BIM

Upon concluding this process, it became natural to question which digital tool could be suitable for channelling its outcomes, for holding together data and results that are profoundly different from each other, such as cataloguing tables of archival documents, as well as geotechnical surveys, structural psychometric tests, chemical analyses, and polished sections of materials. Although all these aspects are highly specific, it was decided to experiment with and investigate the potential of H-BIM modelling to verify how such complex content and the synoptic conservation plan could be collected and made queryable in a computerised three-dimensional model.
It should be noted that the model was integrated ex-post concerning the research process. This resulted in rapid modelling of the construction elements. However, the level of detail and information collected for the building was not uniform, which led to a general inconsistency and the choice to maintain a less specific but uniform level of detail for the entire building.
Initially, it was decided to replicate the structuring of the research into multidisciplinary tasks in the organisation of the H-BIM model browser (Figure 2).

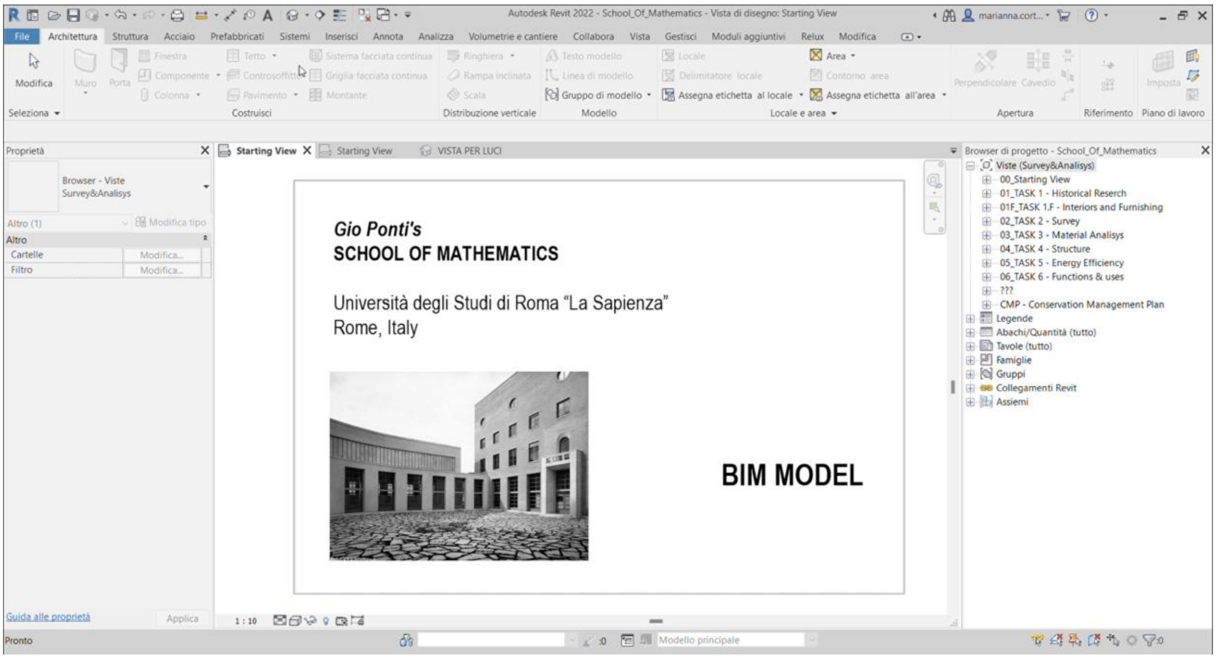

Figure 2. On the right is the organisation of the browser into multidisciplinary tasks. The HBIM model was developed using Autodesk Revit 2021 ©: Cortesi, M. (2022)

Once tasks defined the browser, the actual modelling began. The survey carried out with a 3D Laser Scanner by the Department of History, Design, and Restoration at Sapienza (see Attenni, Rossi 2022) had already highlighted a certain irregularity and uniqueness of the elements constituting the building. For instance, consider the pseudo-square slabs that cover the main facade, which increase and decrease in size according to the rhythmic axes that structure the entire facade, as well as the diverse constituent materials typical of the "autarchic" production of 1930s Italy.

The modelling of such a unique pre-existence in dimensions and construction characteristics required working not with standardised elements present in BIM software libraries but with parametric objects, the so-called "families." Thus, a methodology was devised to apply to complex forms through a "customised" modelling process for decomposable and parametric elements, with which data and parameters from the research were associated.

The model was developed for the entire building, while detailed aspects focused exclusively on the front body, as it was more extensively investigated during the research phase. This block is particularly interesting because it encapsulates those spatial crossings, expressed in the triple height of the library, and a conception of a total work of art that is reflected throughout the building and finds its greatest fulfilment here in terms of design solution and realisation. The front body, in addition to being of considerable architectural value, is also important for its contents: specifically, the library on the second-floor houses custom-designed integrated furniture and a noteworthy book collection, the so-called "Antique and Rare Book Fund" - approximately 2500 works published between 1482 and 1830, including Euclid's "Elements" from 1482 and Regiomontanus's "Almagestum Ptolomei" from 1496 - which requires particular microclimatic precautions also from a maintenance perspective in the scheduled conservation plan.

First, based on the survey of the current state, it was necessary to decompose the building into its constituent elements: the construction elements were parameterised and codified, and the different temporal phases of belonging were assigned to allow reading through a filter the original state of 1935 and the current state. In the browser section related to "interiors and furniture," the furnishings and all the doors were modelled as parametric objects, and schedules were developed and extractable in tables containing information about dimensions, materials, manufacturers, and conservation status. Similarly, in the browser section related to structures, the reinforced concrete columns and beams were modelled as decomposed elements, coded, and information from psychometric tests was inserted.

In the "Material Analysis" section, a particular focus was given to the reinforced concrete element crowning the flat roof of the front body. This element, a sort of *leitmotif* in Gio Ponti's architecture, comprised of voids, solids, and corner solutions, was decomposed according to its components and assigned archival information and data on its conservation status (chemical analyses and polished sections).

To graphically show the level of degradation of this particular element, a visual programming application – Dynamo – was used, allowing the automation of processes. By examining the script of this application in detail, there is an initial group where all the families of the reinforced concrete components are selected; each is assigned a degradation value according to tabulated values defined by the task responsible for analysing the construction elements and technical material investigations carried out at Sapienza's "AstreLabMat" material analysis laboratory. In the immediately following node, the quantified parameter is converted into colour. The degradation value is thus associated with a colour shade, allowing the visualisation of what was previously only quantitative data (Figures 3 and 4).

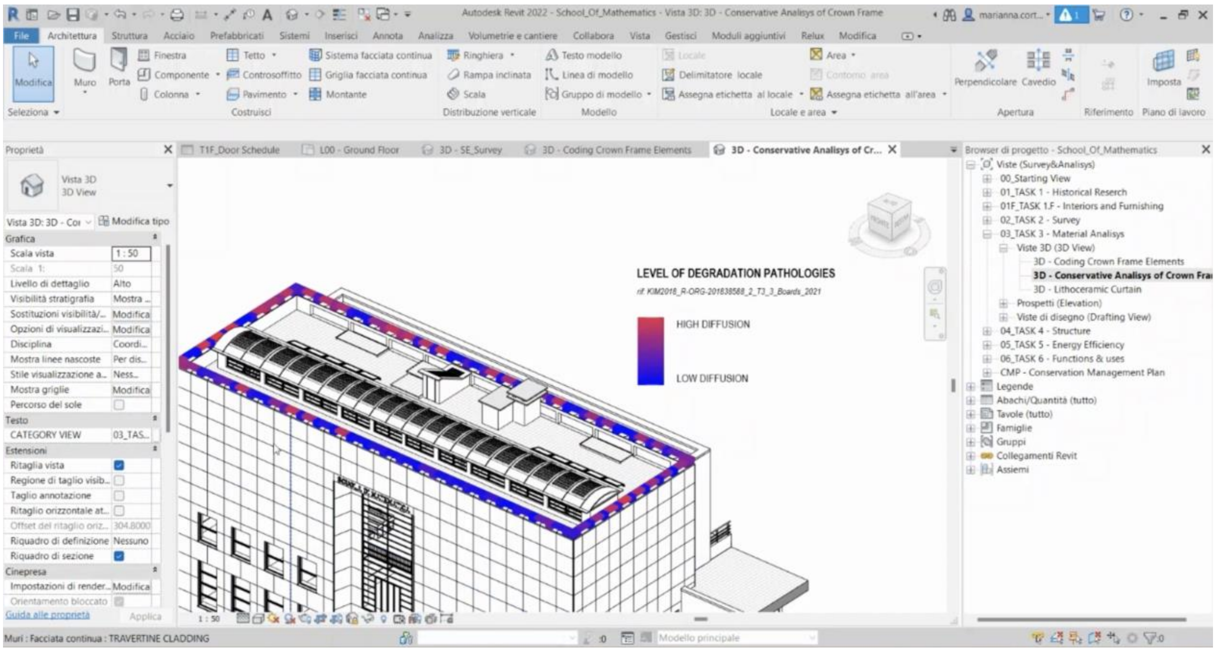

Figure 3. Deterioration of the concrete crown of the roof covering the front body at the current state: Cortesi, M. (2022)

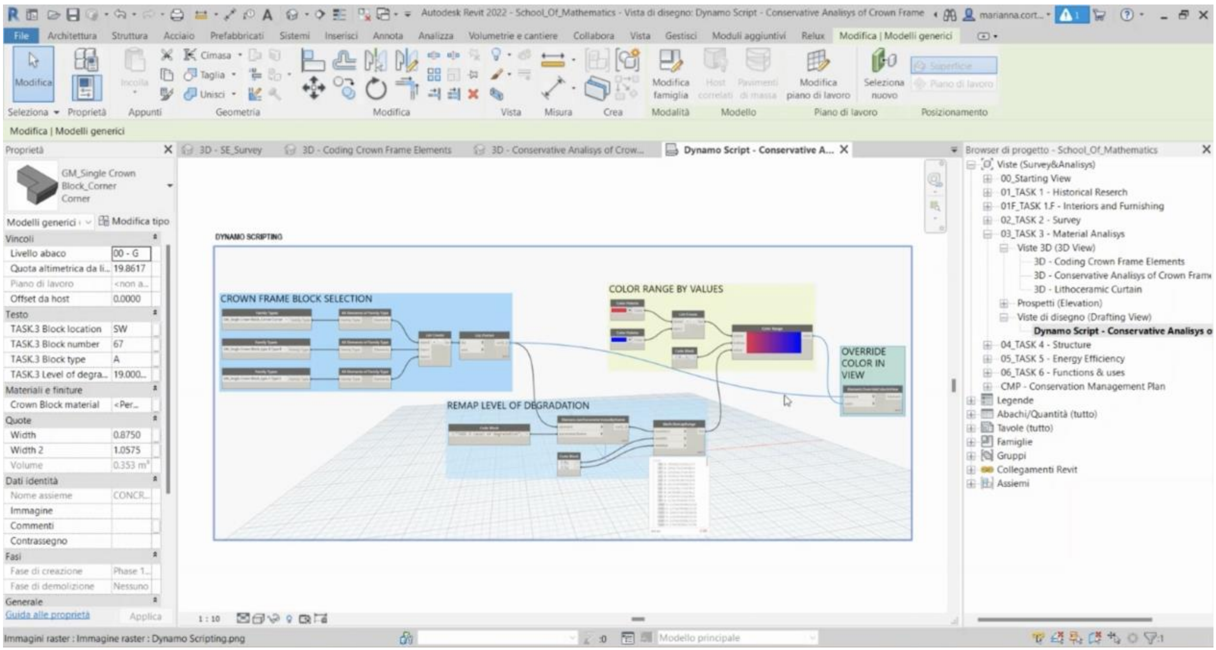

Figure 4. Dynamo script to visualise the level of degradation: Cortesi, M. (2022)

In a subsequent phase, to ensure that the model could also include the prescriptions of the conservation plan, each construction element was equipped with information regarding the interventions to be carried out according to different urgency categories defined in advance in the conservation management plan. Each category was associated with a colour, and it is possible to isolate one category over another through filters. The model thus becomes queryable, allowing the specific operation to be performed on each component to be read and updated once the intervention is completed (Figure 5).

Finally, in the browser section related to historical research, a virtual archive was created to contain all the links that refer to the numerous tables cataloguing documents and iconographic sources resulting from meticulous and extensive archival research.

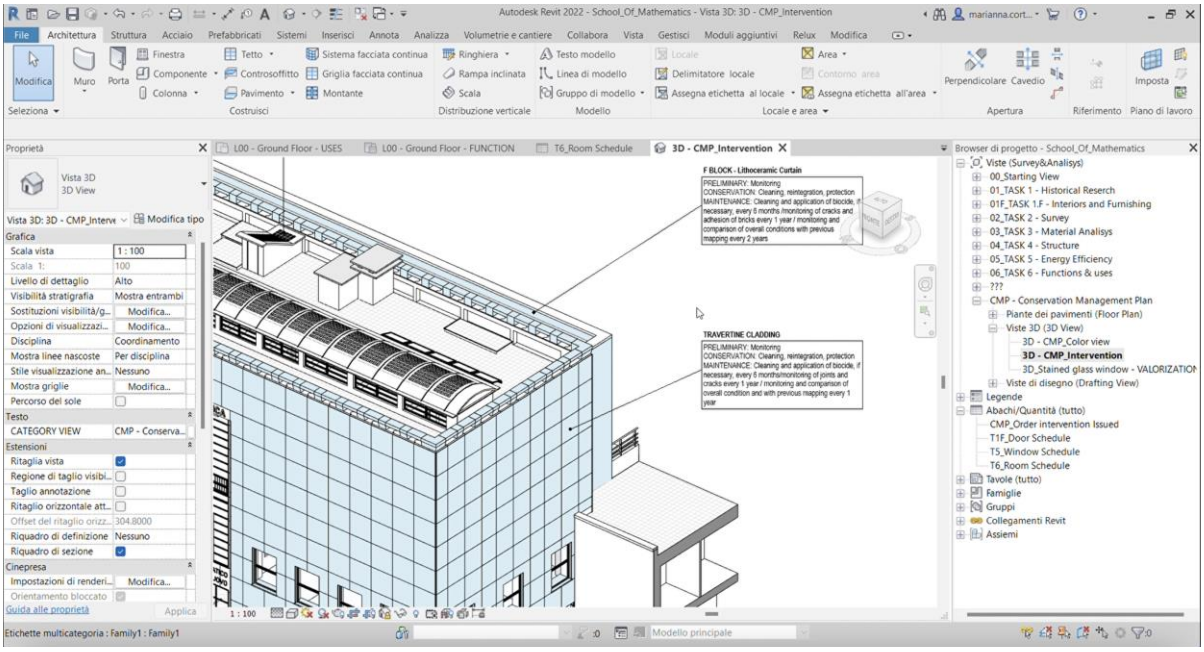

Figure 5. Conservation Management Plan. The HBIM model was developed using Autodesk Revit 2021 software ©: Cortesi, M. (2022)

4. Conclusion

In conclusion, this experience, which I recall as an early stage of reasoning without claims of completeness, highlights the merits, potential, and limitations of HBIM modelling. Among the qualities are the degree of synthesis, the detailed reading of continuously implementable information, interdisciplinary interpolation, and potential interoperability with other software. On the downside, a limitation in data interpretation emerges: the need to consult the model and the prescriptions of the conservation management plan presupposes a broad heterogeneous audience not always experienced in using H-BIM models. Therefore, it is necessary to experiment with the currently existing viewers, seeking an interface that is immediate, accessible to everyone, and capable of correctly displaying the complexity of the inserted data. In this sense, it is necessary to keep track and outline almost a *vademecum* that specifies first the method of structuring and organising the browser. Secondly, the properties of the elements, or the types of parameters assigned, bearing in mind that the reference standard UNI 11337 of 2017 defines the LOD for restoration but does not provide any indication on the definition of the parameters themselves, thus constituting a limitation in the design of H-BIM models.

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