3D MODELLING FOR VALORIZING 20TH CENTURY ARCHITECTURAL ARCHIVES: THE CASE OF THE UNBUILT PROJECT FOR A THEATRE IN CAGLIARI BY CARLO MOLLINO

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ABSTRACT:
The issue of conservation and valorisation of Cultural Heritage involves today 20th century architectural archives, that come to us with their often considerable amount of materials, where the predominance of the design drawings arises. Interpretation, fruition and sharing of archival materials aimed to deepening the knowledge of contemporary masters and architectural movements address the works of many international scholars. In particular, using the continuous innovations of digital modelling tools, a field of this research is developing reconstruction and new interpretations of masters' unbuilt projects. The rise of H-BIM for modelling architectural heritage, has been flanked by some experiments really aimed to represent unbuilt architectures.
This is the case presented in this paper: the unbuilt project for the "Teatro Comunale" in Cagliari, designed by Carlo Mollino between 1964 and 1965. The building has been digitally modelled and the potentialities of BIM tools are today in phase of evaluation, also in light of the aim to create a collection of reconstructive models of Mollino's projects, to be shared on-line. In particular, in this phase of the research, we are exploring the potentiality of BIM aimed to evidencing the reliability of reconstructive modelling based on different documentary sources.

1. INTRODUCTION

The architectural archives are unique and significant sources for the scientific research aimed to understanding Architecture in all its aspects connected with multiple disciplines (history of architecture, conservation, design theory, history of representation…).
In recent years a culture of conservation has been developed also regarding 20th century archives, on which the case study of the present research is based. These archives come to us with their often considerable amount of materials, where the predominance of the design drawings arises. Valorisation, interpretation, fruition and sharing of archival materials aimed to deepening the knowledge of contemporary masters and architectural movements address the works of many international scholars.
In particular, using the continuous innovations of digital modelling tools, a field of this research is developing reconstruction and new interpretations of masters' unbuilt projects.
At the end of 20th century, some scholars undertook this path. It was the case of Novitski, who created digital reconstructive models of 27 unrealized projects ranging from antiquity to contemporary architecture (Novitski, 1998), and Larson, who digitally rebuilt several unbuilt projects by Louis Kahn (Larson, 2000).
Thereafter, a lot of following reconstructive modelling works was realized, and also the fourth dimension was introduced.
The software used in the process of reconstructive modelling and animation were mainly CAD, 3D computer graphics, and motion graphics, while the render techniques ranged from photorealism to conceptual, and the views from the cutting photos to the abstract visualizations in orthographic and axonometric projections, or in cut-away sections.
In more recent years, simultaneously with the rising of H-BIM for modelling architectural heritage, some experiments aimed to represent unbuilt architectures are exploiting BIM potentialities in this field.
The case study presented in this paper follows this path.
It concerns the unbuilt project for the "Teatro Comunale" in Cagliari, designed by Carlo Mollino between 1964 and 1965 (Figure 1).
The building has been digitally modelled by Revit and some features and potentialities of BIM tools are today in phase of evaluation, also in light of the aim to create a collection of reconstructive models of Mollino's projects, currently in progress, to be shared on-line.
In particular, in this phase of the research, we are exploring the potentiality of BIM aimed to evidencing the reliability of reconstructive modelling based on different documentary sources.
For this reason, the case study could assume the role as a prototype for the creation of future reconstructive models belonging to the collection.

2. ISSUES OF VALORIZATION OF ARCHITECTURAL ARCHIVES BY DIGITAL MODELLING

Focusing on 20th century architectural archives of the pre-digital era, they contain different materials: not only drawings – that, in any case, are at the center of the projectual activities -, but also technical reports, correspondence, pictures, photomontages, scale models, audio and video recordings. The value of these archives is justified by the real meaning they take: being a proof of a phase in the design process that ended with the construction or remained on paper.

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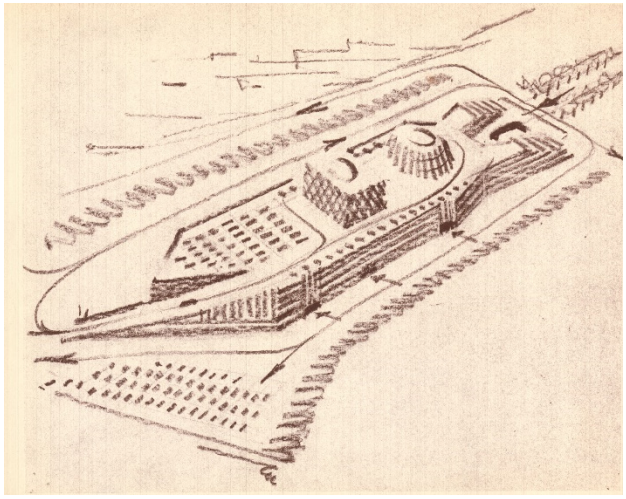

Figure 1. Mollino, Teatro Comunale in Cagliari (1964-1965), sketch. Source: Archivi BCA "Roberto Gabetti", Politecnico di Torino. Fondo Carlo Mollino.

Iconographic projectual documents can be classified as cartographic material, survey drawings, sketches, preparatory and/or demonstrative drawings, final drawings, construction drawings, detail drawings; to which pictures, photomontages and plastic models are added. These materials could be grouped as bases for the ideation phase or as products during the projectual phases (definition, execution, construction, communication, maintenance, management) (Figure 2). They could be also made for different purposes: architectural competitions, contracts, engagements, promotions, publications; and for different customers: private or public. But this list does not encompass all possibilities due to which the designer takes paper and pencil to elaborate a design thought. Indeed, there is a wide scope in the activity of the designer that pushes him to use drawing as a language and method to study and explore new formal, constructive, and technological solutions to the architectural problems, regardless of their necessity, or possibility of being built.

Reconstructive digital modelling of these archival sources starts from the graphical analysis, that is a real survey work applied to the entirety of design drawings produced during the projectual process.

Indeed, it implies: the search for the traces on paper due to the use of technical drawing instruments, the hypotheses of reconstruction of the archival drawings sequence, the check of the consistency between the scale drawings, and the proposals of integration of the missing data. Moreover, graphical analysis aims to recognize geometric structures, proportional criteria, modular patterns underlying the concept of the project.

After doing this, each project has to be decomposed e.g. identifying its levels, its technological elements, its functions… (Pagnano, 1974)

The results of graphical analysis could be collected in a digital model, and the practice of decomposition is crucial, addressing the successive choice of modelling strategies.

Transforming several drawings into a digital model is a process which changes one model into another and deserves some attention, because it is not only a simple variation without alteration of contents, but it modifies, from time to time, the wealth of the model, and its expressive potentiality (Migliari, 2004). The transformations of the models are moved by the interpretative intent of the scholar, and they converge, therefore, toward an abstract model that identifies the project idea. Graphical analysis and digital modelling offer new life to objects that become explorable, sectionable and decomposable, and allow the scholars to propose new interpretations of the architects' work, also in relation with the historical context and physical environment, in which they had to be built. Moreover, the rise of architectural animation opens the way for more effective visualizations of unbuilt architectures. Indeed, the setting of a path into the modelled space constitutes a specific prerogative of digital modelling, which goes beyond the static constraint imposed by the traditional methods of representation on paper.

The animation, as a tool for digital reconstruction, quickly highlighted its potential in enabling the exploration and dynamic perception of never existing buildings, and representing different hypotheses, thematic analyses, decompositions, and construction phases. Agreeing the statements of the Charter of London (2009), in this kind of digital reconstructions the knowledge they represent should distinguish between evidence and hypothesis, and between different levels of probability.

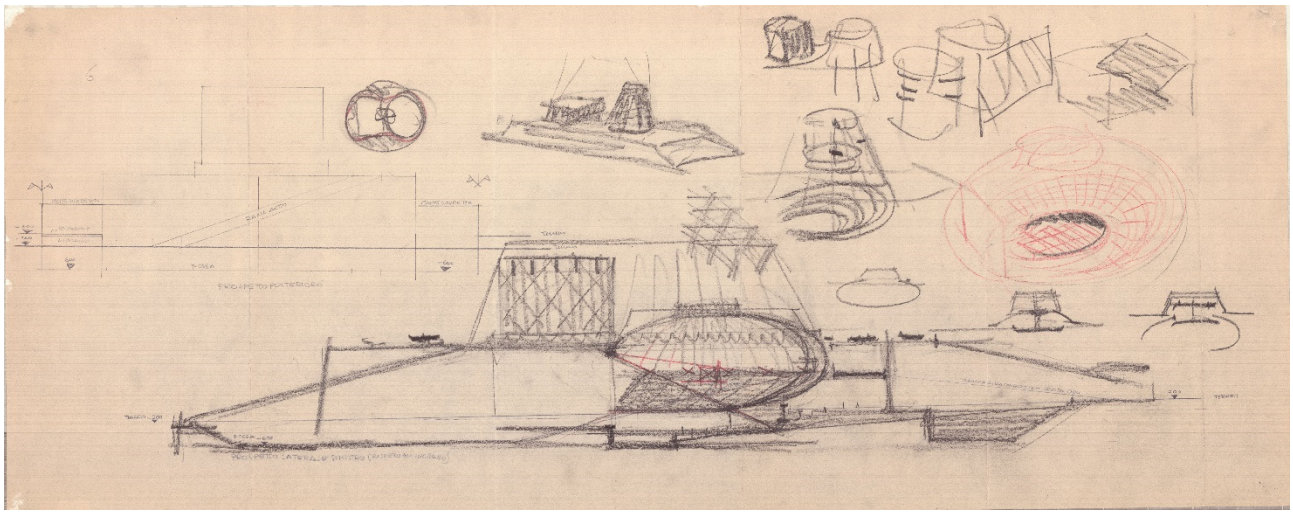

Figure 2. Mollino, Teatro Comunale in Cagliari (1964-1965), ideation sketches and longitudinal section. Source: Archivi BCA "Roberto Gabetti", Politecnico di Torino. Fondo Carlo Mollino.

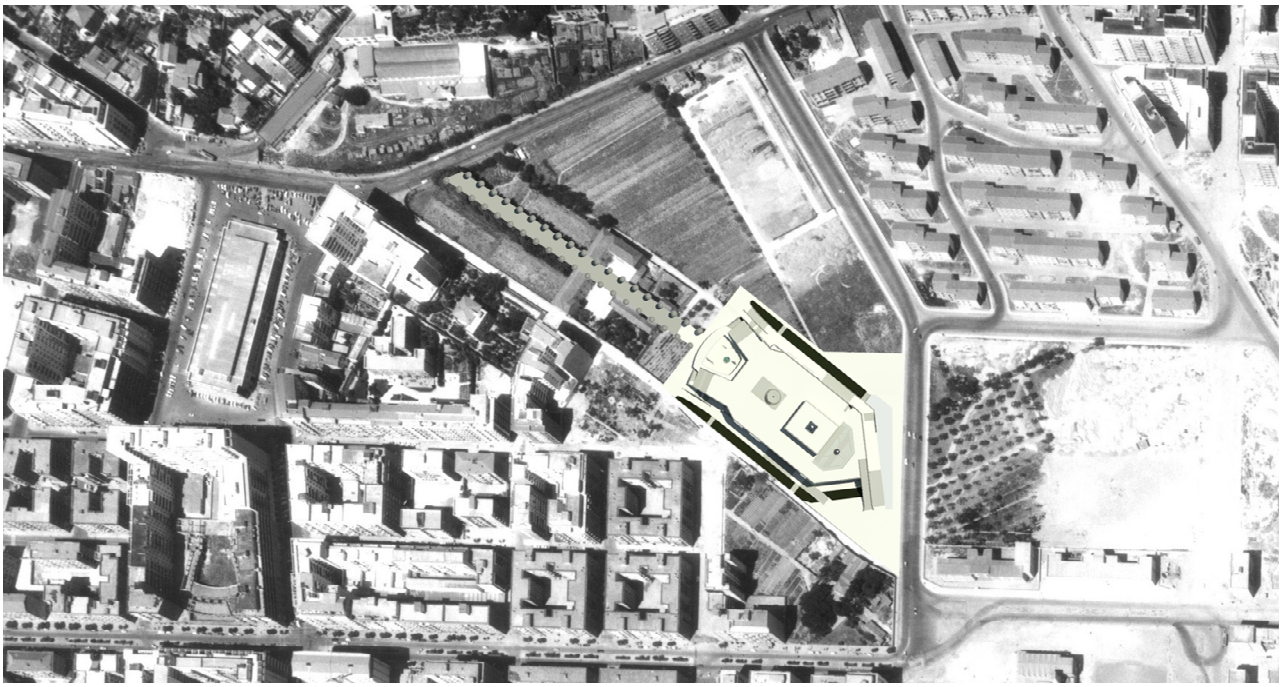

Figure 3. Photo-montage of BIM model of Mollino’s Teatro Comunale in Cagliari into an aerial view of the Sixties. Modelling: F. Capaldi.

Being in the case of hypothetical reconstruction of a cultural heritage, it should be clear the extent and nature of any factual uncertainty (Charter of London 2009, 4.4). Moreover, “documentation of the evaluative, analytical, deductive, interpretative and creative decision made in the course of computer-based visualisation should be disseminated in such a way that the relationship between research sources, implicit knowledge, explicit reasoning, and visualisation-based outcomes can be understood” (Charter of London 2009, 4.6).

3. BIM MODELLING FOR REPRESENTING UNBUILT ARCHITECTURES: STATE OF ART

In more recent years, simultaneously with the rising of H-BIM for modelling architectural heritage, some experiments aimed to represent unbuilt, no longer existing, and partially built architectures. In particular, it was mainly applied for creating 3D semantic models of the architectural designs presented in the Renaissance treatises, and for modelling partially existing buildings (integrating survey of the rests and documentary sources). These kinds of case studies, characterized by the need of integration of different sources, highlight the issue of transparency of the reconstructive process and result (Parisi et al. 2019).

In the following will be developed the reference to several case studies that faced this issue.

The research of Apollonio, Gaiani, Sun (Apollonio et al. 2013) was based on Palladio’s treatise, exploiting BIM potentialities in regard to the semantic construction of the digital model, the object-based parametric modelling, the multiple data enrichment to the geometric model, and the displaying of uncertainties. This last issue was faced aiming to allow transparency of information to users, and to demonstrate the solutions chosen for representing uncertainties and lacks. The scholars defined 8 levels of progressive uncertainty of reconstruction process. The progression goes from the reconstruction based original designs to the reconstructive conjectures failing references. The uncertainty display used the density slicing color code.

This research refers to sources comparable to those of our case study, but the de-composition criteria are based on the architectural orders that rule Renaissance architecture.

Another research on this line, carried out by the same Apollonio with Giovannini (Apollonio et al. 2015) deepened the issues of validation of 3D modelling reconstruction process, exchange and reuse of information, and collaboration between experts. It concerned the digital reconstruction of Porta Aurea in Ravenna documented by fragment and ruins, and different iconographic and textual documents. In this case was proposed a gradient color scale for visualizing the uncertainty in a progression that goes from reconstruction based on laser scanning survey of archaeological fragments to reconstruction failing references.

Few years later, Bianchini and Nicastro (Bianchini et al. 2018) defined a new parameter in the process of integration of BIM with survey, communication and management of built Cultural Heritage. This parameter is the Level of Reliability (LOR), intended to measuring and explaining the consistency and transparency of digital objects, resulting from critical analysis and interpretation of Cultural Heritage. The methodology has been applied to two architectural complexes inside Sapienza Main Campus in Rome. The coding of LOR has to consider both the geometric reliability of digital objects and their ontological correspondence to the real buildings they intend to describe.

Despite the difference between the case study developed in this research and that we are carrying out, the interest of this research is in the possibility of generalization of the method, applicable to very different case study in the field of Cultural Heritage.

4. CASE STUDY

One of the author of this proposal previously carried out researches on reconstructive modelling of minor architectures of the Fascist period in Piedmont, and today is involved in studies on contemporary archival drawings, and supervisions of some Master Theses about digital reconstruction of Carlo Mollino´s projects with professor Sergio Pace, an architectural historian.

Mollino (1905-1973) was an architect and designer active from the thirties until his death.
Dozens and dozens of drawings (preserved by the Archives of the Central Library of Architecture "Roberto Gabetti", Politecnico di Torino) characterize his projects, regardless of the vocation to be built. Indeed, among more than 130 architectural projects, only around twenty have been realized.
The graphical documentation of unrealized projects, including the ideal ones, often does not imply incompleteness or minor detailing; rather, alternative solutions are explored, and sometimes they are carried out up to the large-scale details and completed with ideas for art installations and furnishings. This ability of Carlo Mollino to check the entire design process derived from his experience of working with his father, Eugenio died in 1953, a civil engineer and designer of remarkable buildings.
Among Mollino's unbuilt projects, many refer to the residential typology, mainly holiday homes (single-family houses and condominiums), public buildings, theatrical and entertainment buildings (theaters, auditoriums, dancings, and cinemas).
About ten, among Mollino’s projects, were previously analyzed using 3D models, and choosing different software and modelling strategies in response to the different features of the specific project analyzed.
The project of “Teatro Comunale” in Cagliari (1964-65), third classified at the architectural competition announced by the municipality, could be a paradigmatic example from which organize a reconstructive methodology that pays attention to the transparency of the reconstructive process.
The project concerned a theater for almost two hundred people that had to be in the original request of the municipality a sort of multifunctional theater able to welcome interests of every social class of citizens (Figure 3).
Even if there were some critical architectural description of the project most of the information came from the archive documents; in particular, the documentation includes: the nine plates presented for the competition, all drawn in scale 1:100 except for the seventh plate that was lost during the years, but remained its copy, out of scale, in the project report; two copies of the competition notice in which the architect pinned some of his ideas for the functional distribution.
Next to this three fundamental type of documents the archive includes also a collection of about thirty sketches, detail drawings and structural hypotheses.
The use of 1:100 scale allows to understand the general volumes and functions in each part of the theater that is divided in six main level in elevation and in four areas: back area, stage area, audience area and entrance area. In particular, the entrance area is defined by the author in two design variants that where considered separately in the 3D model reconstruction to create and compare two different reality of the same unbuilt project.

5. WORKING METHODOLOGY

The case of “Teatro Comunale” in Cagliari is a good test field for the application of BIM methodologies also in light of the project to create a collection of reconstructive models of Mollino’s projects, currently in progress, to be shared on-line.
In addition to the qualities tested by previous scholars, there are many other reasons for experimenting BIM for reconstructing Mollino’s projects.
In general, by addressing the question of the reconstruction of unrealized projects, we want to pay attention to the role of the “re-constructor”, or rather, the “re-creator”, who analyzes, integrates, interprets and realizes a real re-project of the work.
The criteria he assumes for decomposition are answered appropriately in the BIM tools (Figures 4, 5).

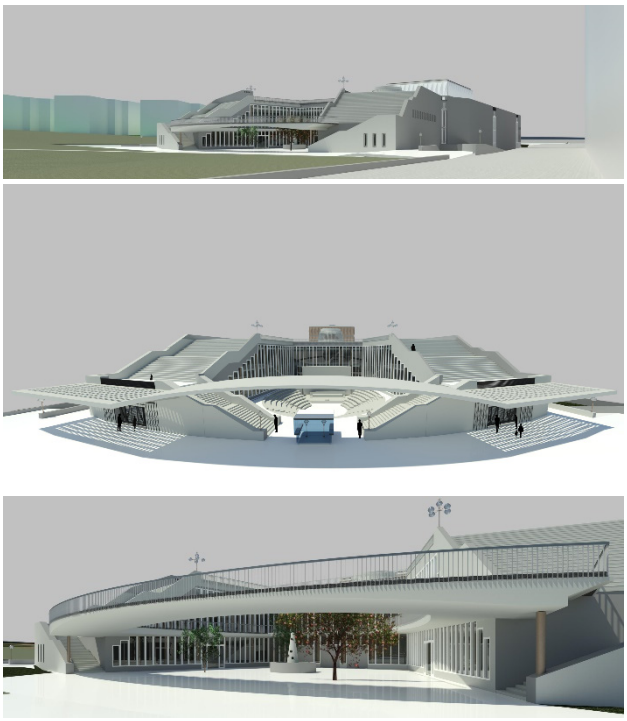

Figure 4. Reconstructive BIM model of Mollino’s Teatro Comunale in Cagliari, external veiws. Modelling: F. Capaldi.

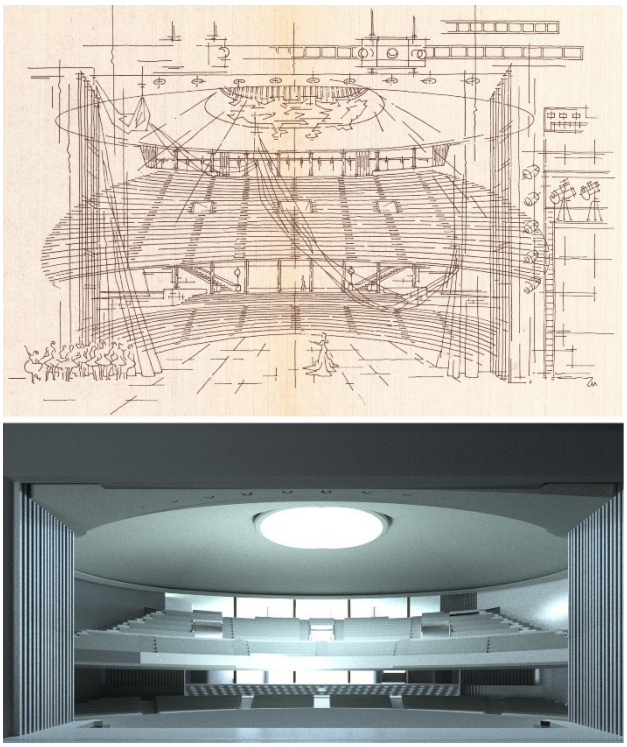

Figure 5. Mollino, Teatro Comunale in Cagliari sketch. Source: Archivi BCA "Roberto Gabetti", Politecnico di Torino. Fondo Carlo Mollino. Reconstructive BIM model of Mollino’s Teatro Comunale in Cagliari, internal veiws. Modelling: F. Capaldi.

Moreover, as emerged during the operational phases of the case here proposed, his working process includes rethinking, discoveries and hypotheses of alternative solutions to which BIM guarantees a good level of interactivity and, above all, the

possibility of considering the time dimension in the evolution of the project. Specifically, as we have seen, the overall architectural work of Mollino develops with a certain typological homogeneity. Within a type, shaping solutions, elements, materials, fixed furniture are used, which can be compared with those of the realized buildings, for creating families of objects.
The same design method of Mollino, which frequently starts from three-dimensional images and visions, can be interpreted thanks to this software that allow you to extract sections to be compared with the technical drawings made later, as already verified.
Finally, the analysis of the relationship between the project, the urban tissue, and the environmental context in which the building should have arisen is facilitated by BIM geo-referencing, which can show what the current layout of the artifact would be in the context and form the basis for regressive readings of the tissue up to the time of construction. The results of the ongoing research and considerations about future enhancements will be developed in the proposed paper. Approaching to an unbuilt architecture such as the one here analysed needs a sort of philological approach that can’t be supported by a real building. The development of a digital reconstruction has only as its foundations the archive documents. The so called philological approach start from the classification of the archive documents in a way that follows the design process. Excluding some sketches that shows the first ideas and that have to be placed upstream the entire work, the documents have been divided into six levels of analysis (Figure 6):

1. Project plans, starting from the basement floors to the roof.
2. Elevations and sections
3. Competition notice and project report
4. Architectural details and drawings
5. Design views and sketches from different point of view around the theater
6. Descriptions and documents from books and papers about the author and the project itself, if they can be found.

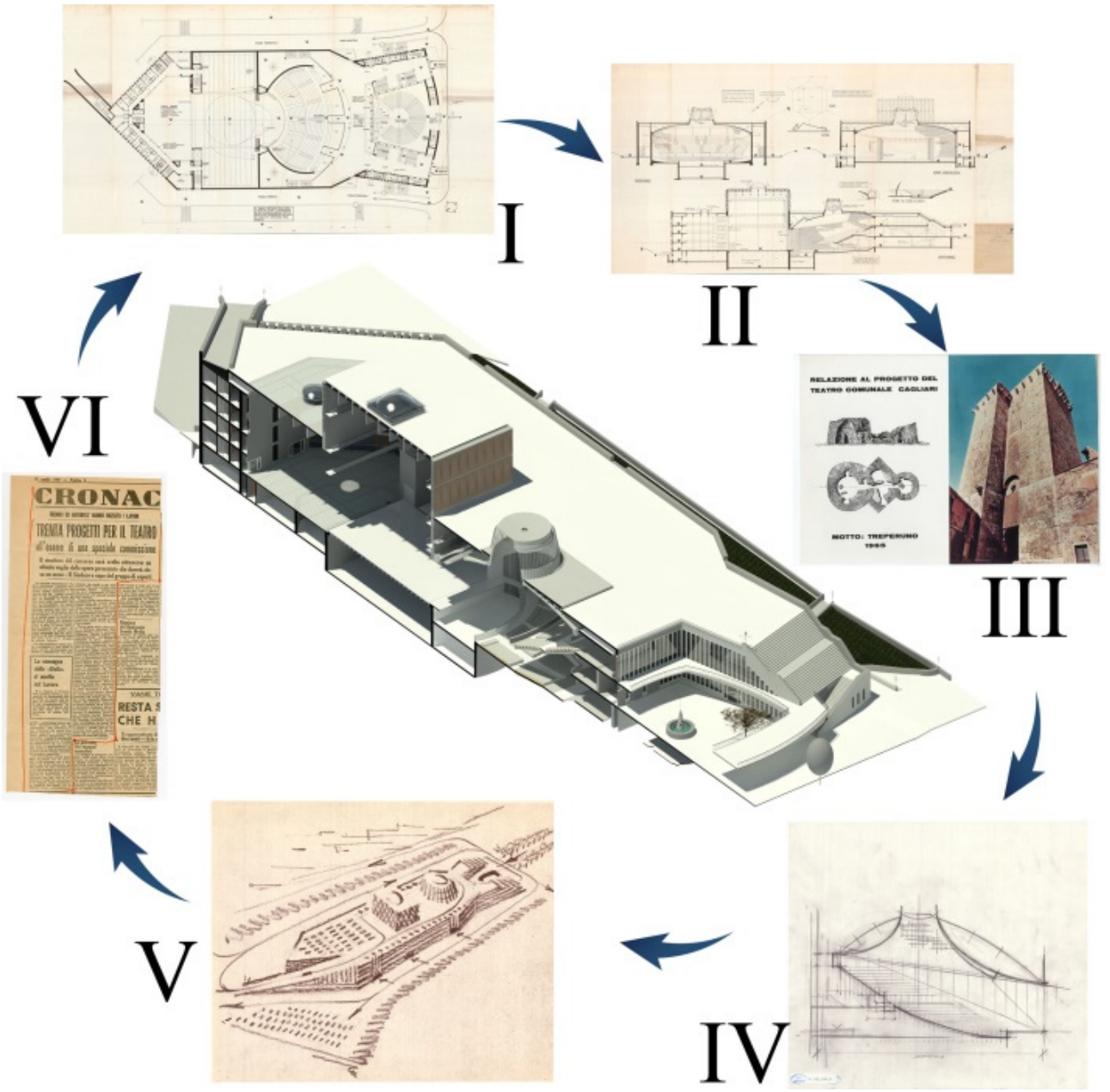

Figure 6. Level of analysis.

Each level adds a quantity of information that, joined with the previous, increase the level of reliability or compliance of the reconstruction with the original design. The first and second levels are the ones that define the model by its three-dimensional representation. The third and fourth confirm or correct what it is designed in plans, sections, and elevations as a check for the addition of a second level of knowledge describing parts and technical details of project.

Finally, the last two levels show the project in its entirety but are also the fulcrum of the interpretation of the re-creator, because they are based on undefined dimensions and similitudes with other projects of the author or of the specific period in which the project is made.

The approach based on the six levels of analysis is applied first in the composition and classification of archives documents and then it is used as an application in the BIM technology, but it has to be add with a second type of levels that are the different floors of the project used to assign a specific position of plans, sections, and elevations in a three-dimensional space comparable with the reality. Using this method, at each floor and part of the software space corresponds the sum of the reliability of the levels of analysis found from archive documents.

Due to the classification exposed it is possible to define the level of compliance between the model created and the documents and information analyzed. Defining keywords of the elements used to specify a project and applying them to the object of the research, it is possible to determine a class of correspondence that can be applied in the construction of the model to find a total class of reliability of the reconstruction made and of the parts analyzed.

6. EXPERIMENTS AND RESULTS

The work made for the reconstruction of "Teatro Comunale" in Cagliari wants to be a way to connect the use of BIM technologies with the possibility of a continuous modification during time that start from the definition of a level of reliability that can be modify adding more information and applying the method here proposed.

Starting from the definition of the six levels of analysis for each level were defined the presence or the absence of elements typically present in an architectural project; in particular, it was created a matrix using which it is possible to assign a class from 0 to 6 of reliability, also called LOR, Level of Reliability (Bianchini et al. 2018).

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LEVEL I - project plans and territorial framework							
	drawing	text	function	dimensions	details	paths	class result
first level basement							4
b. stage area	1	1	1	0	0	1	4
second level basement							4
a. back area	1	1	1	0	0	1	4
orchestra pit level							4
c. audience area	1	1	1	0	0	1	4
d. entrance area	1	1	1	0	0	1	4
stage area level							4,5
a. back area	1	1	1	1	1	1	6
b. stage area	1	0,5	1	0,5	0	1	4
c. audience area	1	1	1	0,5	0	0	3,5
third level basement							3
a. back area	1	0	1	0	0	1	3
d. entrance area	1	1	1	0,5	0	0	3,5
ground level							3
a. back area	1	1	1	1	0	1	5
c. audience area	1	0	1	0	0	0	2
d. entrance area	1	1	1	0	0	0	3
first floor level							3
a. back area	1	1	1	1	0	0	4
c. audience area	1	0,5	1	0	0	0	2,5
d. entrance area	1	0	1	0	0	0	2
parking floor level							1
a. back area	1	0	0	0	0	0	1
b. stage area	1	0	0	0	0	0	1
c. audience area	1	0	0	0	0	0	1
d. entrance area	1	0	0	0	0	0	1
stage pit level							1
b. stage area	1	0	0	0	0	0	1
LEVEL I _LOR final result							3

Table 1. Level 1: table with gradient colours

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The six elements designed are presence or absence of: drawing, text, function, dimensions, details and paths; for each voice is assigned a value of 0 (absence) or 1 (presence) with the addition of value 0,5 for the incomplete elements (Table 1, Table 2). As said, the archive documents were previously divided into six levels of analysis to which it is added a second division dictated by the project different levels, and a third of the specific areas of the theater.
For each area the matrix returns a LOR value and the average of them defines the reliability of each floor for the different levels of analysis.
Even if the final LOR value it is dictated by a second average between the different levels, this kind of partition allows to understand where there is a lack of information in documents of the project and so where it is more useful to concentrate the research of new information and application that can upgrade the final result of the reconstruction.
The matrix defines a scale of twelve possible LOR value to which it is assigned a different gradient colour from the clearer to the darker, that represents the higher value. The application on model shows that the general level of reliability of the reconstruction it is about 2/2,5, that it is understandable thinking it is an unbuilt architecture on which the certainty of true-likeness is impossible.

LOR colour gradient scale	
0	
0,5	
1	
1,5	
2	
2,5	
3	
3,5	
4	
4,5	
5	
5,5	
6	

Table 2. gradient colours scheme and LOR values

The result shows also that the levels on which it is necessary an interpretation are the fifth and the sixth where there is the lack of technical details and dimensions (Figure 7). The future application of the work can be the finding of more details and specifications on single elements of the project; in fact, even if the general shape of the building is totally defined, it is difficult to recreate materials and environments in details.

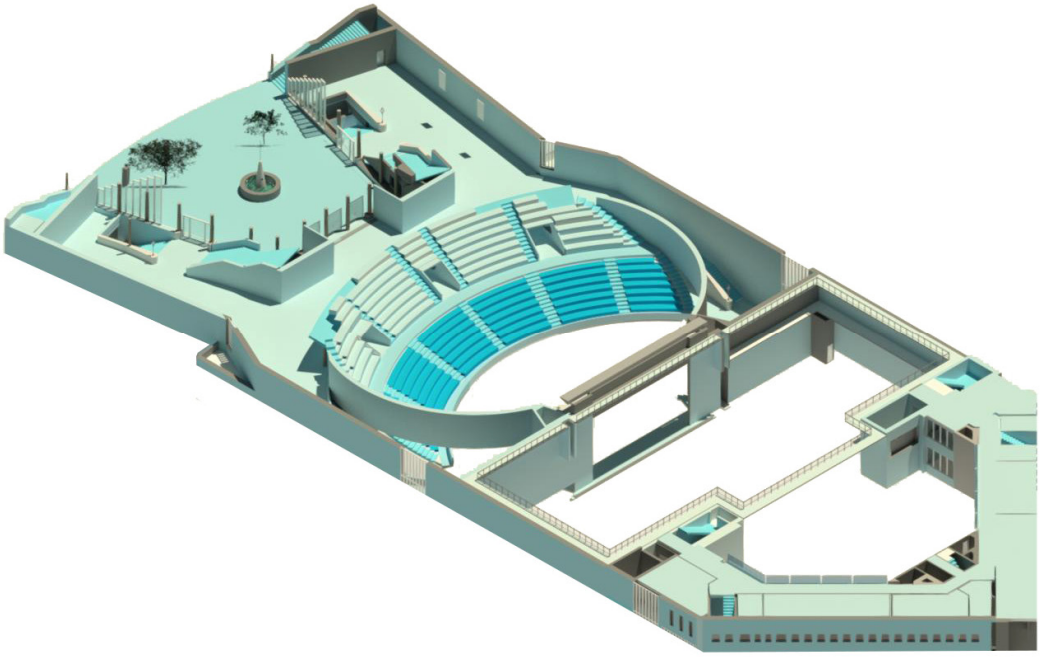

Figure 7. Application of the level of reliability on ground floor. Modelling: F. Capaldi.

7. CONCLUSIONS

As said, several digital reconstructions of unbuilt or demolished projects by Mollino, based on the rich archive materials, have been realized. A prototype of website, called DIMO (Digital Interactive MOllino), and containing a selection of digitized archive drawings, some general and bibliographic reference and, mainly, the reconstructive digital models interactively explorable, is currently in progress (Spallone et al. 2017). The need of sharing, not only the results of the reconstructive process, but also the level of reliability of the re-creation of parts and elements of the project and the related possibility of enrich the models thank to new findings and interpretations, led us to try to test a methodology inspired by the above mentioned researches on historical heritage. The difference between the present case study and those that inspired our proposal consists in two main aspects: the source, that is an archival fund composed by a lot of drawings and documents, and the feature of the designed building, that belongs to the contemporary architecture. These considerations led us to choose to consider the architectural levels as layers of analysis, instead of the single architectural elements and the architectural orders.
The comparison with the materials that describe the others projects by Mollino let us to think that the established methodology could be generalized to the entire archive and contribute to its enhancement.

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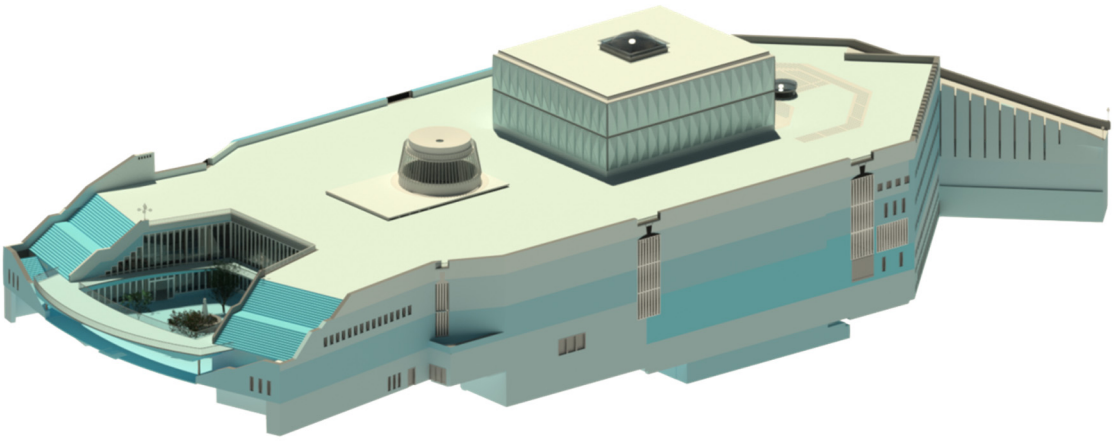

Figure 8. Application of the level of reliability on the reconstructive model. Modelling: F. Capaldi.

This paper is a development of the research project on reconstructive digital modelling carried out by Roberta Spallone since 2015. The case study, previously analysed by Francesco Capaldi within his MSc thesis (supervisor: Roberta Spallone, advisor: Sergio Pace), has been enhanced for the aims of the present research. Roberta Spallone wrote paragraphs 1., 2., 3., 7., Francesco Capaldi wrote paragraphs 5, 6. Paragraph 4. was written together by Roberta Spallone and Francesco Capaldi.

REFERENCES

Apollonio, F.I., Gaiani, M., and Sun, Z., 2013. 3D modeling and data enrichment in digital reconstruction of architectural heritage. In: *ISPRS Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, Vol. XL-5/W2, pp. 43-48. https://doi.org/10.5194/isprsarchives-XL-5-W2-43-2013.

Apollonio, F.I., and Giovannini, E. C., 2015. A paradata documentation methodology for the Uncertainty Visualization in digital reconstruction of CH artifacts. *Scires-it*, V(1), pp. 1-24. http://www.sciresit.it/article/view/11415.

Bianchini, C., and Nicastro, S., 2018. La definizione del Level of Reliability: un contributo alla trasparenza dei processi di Historic-BIM – The definition of the Level of Reliability: a contribution to the transparency of Historical-BIM processes. *Dn–Building Information Modeling. Data & Semantics*, 2, pp. 45-59. http://www.dienne.org/2018/10/06/bianchini/.

Larson, K., 2000. *Louis I. Kahn: unbuilt masterworks*. The Monacelli Press, New York.

Migliari, R. (ed.), 2004. *Drawing as Model*. Edizioni Kappa, Roma.

Novitski, B.J., 1998. *Rendering real and imagined buildings: the art of computer modeling from the palace of Kublai Khan to Le Corbusier’s villas*. Rockport Publisher, Gloucester.

Pagnano, G.,1975. *La lettura critica: analisi di cinque opere di Adolf Loos*. Istituto Dipartimentale di Architettura e Urbanistica dell’Università di Catania, Catania.

Parisi, P., Lo Turco, M., and Giovannini, E. C., 2019. - In: *ISPRS Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, Vol. XLII-2/W9, pp. 581-588. https://doi.org/10.5194/isprs-archives-XLII-2-W9-581-2019.

Spallone, R., and Carota, F., 2017. Digital Interactive MOllino. A Collection of 3D Models from Carlo Mollino Design Drawings. In: Amoruso, G. (ed.), *Putting Tradition into Practice: Heritage, Place and Design*. Springer, Cham, pp. 607-617.

The London Charter for the Computer-Based Visualisation of Cultural Heritage, Draft 2.1, 7 February 2009. http://www.londoncharter.org/ (1 June 2019).

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