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The BIM representation for documentation and historical-critical analysis of the Modernist heritage

La rappresentazione BIM per la documentazione e l'analisi storico-critica del patrimonio modernista

BIM - Building Information Modeling applied to the historical-critical analysis and representation of the architectural heritage is becoming more and more an essential means for the understanding of design processes and changes over time, as well as a basic instrument for knowledge and as an aid for the design of conservation, maintenance, restoration and enhancement projects.
The paper analyses BIM applications to the Indian and Brazilian modernist heritage, through the works of the greatest architects of the period, investigated through a detailed methodology, also representative, which opens to further researches and reinterpretations.

Il BIM - Building Information Modeling per l'analisi storico-critica e la rappresentazione del patrimonio architettonico si configura, sempre più, come veicolo fondamentale per la comprensione dei processi progettuali e di trasformazione nel tempo, nonché come strumento privilegiato per la conoscenza e come ausilio per il progetto di conservazione, manutenzione, restauro e valorizzazione.
In particolare, il presente contributo approfondisce l'applicazione del BIM al patrimonio modernista indiano e brasiliano, attraverso le opere dei maggiori architetti del periodo, analizzati con una precisa metodologia, anche rappresentativa, che apre a una molteplicità di spunti per ulteriori ricerche e reinterpretazioni.

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INTRODUCTION

The paper proposes a critical approach to the process of knowledge aimed at the documentation of the Brazilian and Indian architecture of the twentieth century through Building Information Modeling, with particular reference to the examples of Brazilian and Indian housing of the twentieth century. The potential in the digital management of architectural modeling applied to "survey of the project" fits into the great theme of the international research on modern architecture, which began several decades ago but has already involved many historians to thoroughly understand a period in the history of architecture characterized by multiple shades.

Despite the wide use in architecture of modernist precepts in countries once called developing (identified today by the international community as the *Global South Countries*), the historical-critical architecture approach tends to focus on the development of this trend for the more in the West. With the exception of the work of a small number of famous architects, in fact, so far little attention has been devoted to modern architecture in countries far from Europe, the places where it was considered reductively as a minor form of Western modernism.

Starting from the end of the nineteenth century, in a broad panorama of nationalist movements and newly independent colonies, the modernist architecture articulates with hybrid architectural approaches. This approach is aimed at responding to the increasing technical design challenges in different ways, in some cases by means of technological innovations, in others inspired by the regional vernacular solutions through interpretation of modern architecture principles: a wealth of extraordinary buildings to document, protect and value, and from which to draw insights.

Through the works of the greatest architects of the period, by João Batista Vilanova Artigas, Oscar Niemeyer Paulo Mendes da Rocha for the Brazilian architecture, and Le Corbusier, Charles Correa, Balkrishna Doshi and Pierre Jeanneret in India, it is possible to browse a history of architecture from the search of the national identity to specific local features.

The knowledge of buildings selected and analyzed according to a specific methodology, also representative, opens to a multiplicity of ideas for further research and reinterpretations. The implementation of three-dimensional digital models is focused on an accurate representation in BIM environment, integrating the geometry information with details concerning materials, construction phases, technical characteristics and by linking the building with environmental features. The consistency in the construction of the digital model and two-dimensional representations starting from the BIM model, drives to a definition of the *Level of Detail* based on knowledge objectives and documentation and representation output. The morphological analysis applied to digital modeling of Brazilian and Indian architecture of twentieth century stems from the formal and geometric knowledge through a process of "deconstruction" of architecture, and comes in a digital "reconstruction" of the building, aimed at knowledge, conservation and enhancement of heritage. The outcomes exploit different levels of knowledge, both formal and substantive: 2D representations and render from modeling in BIM environment, media for the analysis and representation of architecture, are an effective tool for knowledge but also an aid to the project of conservation, maintenance, restoration and enhancement.

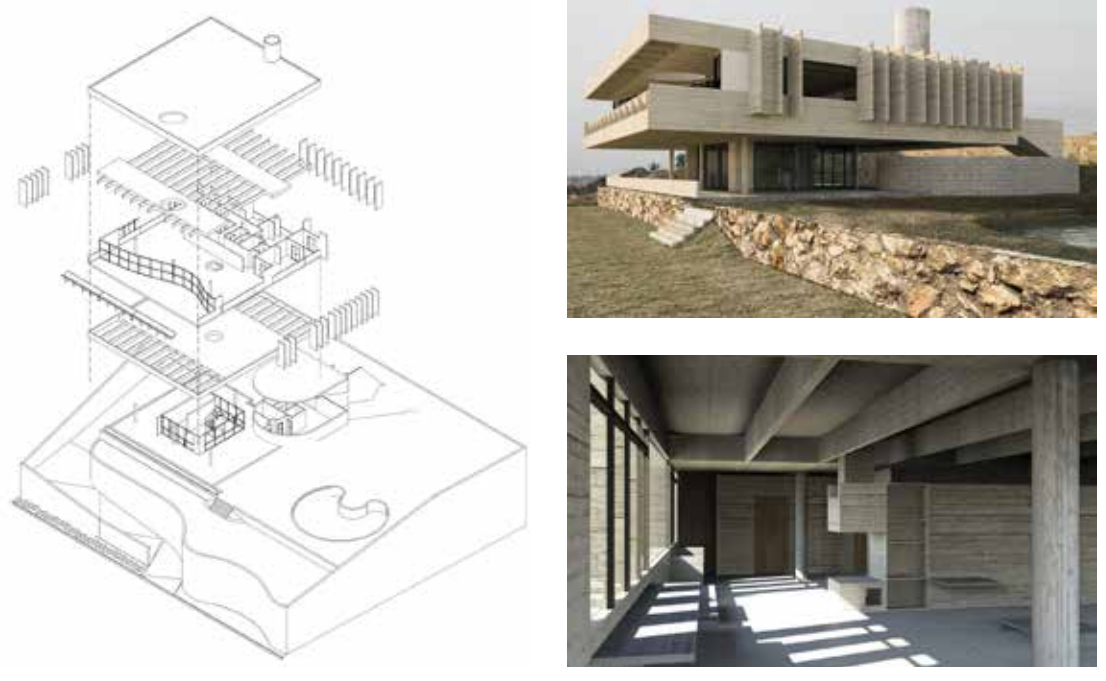

Figure 1 - Ruy Ohtake, axonometric cross section and render of Residência Nadir Zacharias, 1970, São Paulo

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RESEARCH FIELD: THE MODERNIST HERITAGE

Among the international researches developed by the Department of Architecture of the University of Ferrara, modern architecture has been for years a significant topic also thanks to various agreements both with Brazilian and Indians institutes, aimed at the documentation of heritage for its preservation and enhancement.

Currently the twentieth century architectures in Brazil and India (as well as in many other countries) are in danger, from the conservative point of view, and risk of loss: these buildings (in many cases designed by renowned local and international professionals) are facing a sort of "silent destruction". Day after day are slowly changed in terms of materials, volumes, surfaces, colors or even demolished.

Although often still used as public buildings or private residences, these architectures are usually in bad conditions and their state of conservation is rather lacking. This is partly due to widespread opinion that modern architecture is not a "heritage" to be preserved. In fact, modern buildings are "affected" to all those apparent minor changes compared with those belonging to previous historical periods.

Figure 2 - Charles Correa, Gandhi Ashram, Ahmedabad, India, 1963. Front view, perspective cross sections and render

In order to preserve this huge heritage is essential to know and understand their history and design principles underlying the implementation of this architecture made very often in detail, in addition to the plasticity of the volumes, and construction and technological details that are often the most interesting part of the their architectural features.

Modern architecture is, for historical and architectural importance, concepts, shapes, construction materials and technological solutions, the ideal field of survey to explore the integration of BIM techniques aimed at the preservation and enhancement of heritage. Thanks to the integrated survey procedures (including the survey of the project as "backward procedure") and modeling of architectural components, the BIM becomes a tool for historical and critical analysis of the modernist heritage in its design processes, creation, modification and transformation, and as a basis for the conservation and restoration design, maintenance and enhancement procedures.

THE BRAZILIAN MODERNISM

"The Brazilian modernist architecture is a mystery to be revealed", said Lauro Cavalcanti in *Quando o Brasil era moderno*, basic document written in 2001 [1] which gave new impulse to the enhancement of a built heritage too often underestimated. The influence of Brazilian modernism is expressed not only in architecture, but also through the social impact of some works by the leading Brazilian architects. For an emerging country such as Brazil then was, modernism could be defined to all effects as a renaissance, in terms of innovation, revisiting concepts and classical approaches in architecture, hybrid architectural approaches.

If the beginning of the style is universally recognized in the project by Gregori Warchavchik for its modernist house in São Paulo (1928), it is equally indubitable that the high point of excellence has been achieved in the works for the new capital Brasilia in the early years Sixty.

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Figure 3 - Charles Correa, Gandhi Ashram, Ahmedabad, 1963. Exploded axonometric view and render

The reasons behind the development of this successful period are in different factors hardly summarized in a few lines. We can certainly mention the influence of European immigration (escaping from poverty caused by World War II), the need of the government to modernize Brazil making it look like a new entity (while hiding the problems related to the dictatorial regime), the great need for housing and new buildings [2].
Starting from the exponents of the passage between the Beaux Arts and the modernist approach, i.e. Gregori Warchavchik, Lucio Costa and Osvaldo Bratke [3], it is possible to identify architects with leading roles such as like Oscar Niemeyer [4], long-lived genius who went through all the stages of the International style and which remains probably the best known figure in the international field [5]. Among others, Affonso Eduardo Reidy [6], whose concise and pure architectural language remains to this day unique in the built environment of Rio de Janeiro. Rino Levi [7], a master at creating comfortable spaces and intimate atmosphere. Lina Bo Bardi [8], one of the few to incorporate vernacular solutions within the modernist poetry. Vilanova Artigas, author of works that marked the beginning of the architectural language linked to the reinforced concrete (and its strong social impact). João Filgueiras, David Liberskind, Joaquim Guedes and Paulo Mendes da Rocha [9], led the Modernism to the present day, in a way not without controversy and obstacles but always of the highest quality, research and technological innovation.
This legacy of extraordinary buildings to be enhanced, preserved and protected, and from which to draw for thought, is an asset [10] to which the digital control of the modeling procedures becomes a means to a more thorough management of different knowledge' levels, with an emphasis on representative possibilities in terms of project documentation.

THE INDIAN MODERNISM

The years after World War II have been the period during which many countries gained independence as former European colonies. Among them India, through the Prime Minister Nehru who followed in the footsteps traced by Gandhi, sought the political and social emancipation through the dream of a modern and functional country. In architecture, this has been turned through new and unexplored possibilities, futuristic visions and sometimes utopian that fascinated dozens of architects. The United States were seen as well as a symbol of modernity, and for that, aided by the excellent knowledge of the English language, many young people decided to follow Wright's footsteps and move to America to study from the masters.
Thus was born the first generation of Indian modernist architects, talented young people that after several years of training in the United States in professional offices and universities, came back India with new ideas and completely different styles from the traditional ones [11].
Was not long before the occurrence of hybridization of European modernist ideals with the complicated socio-Indian cultural context: between 1945 and 1970 architects and engineers as Habib Rahman, Achyut Kanvinde, Gautam and Gira Sarabhai, Charles Correa and Hasmukh Chandubhai Patel turned the concepts learned in American universities into buildings with a strong Indian background.
A second generation of modernist architects emerged, however, from the strong contribution in terms of cultural impact that masters such as Le Corbusier and Louis Kahn were able to make through their work in Southeast Asia.
In India the buildings by Le Corbusier, Pierre Jeanneret and Kahn were real workshops where several young Indian architects were "bred" living in close contact with the teachers and operating as local architect for them during long absences from construction sites. Among these Rajinder Kumar, Kulbushan Jain and especially Balkrishna Doshi brought a significant contribution to the development of architecture where regionalism took precedence over purely modernist functional aspects [12] and established the foundations for the contemporary Indian architecture.

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Figure 4 - Eduardo De Almeida, Residencia Max Define, 1978-79, São Paulo. Perspective cross section

Figure 5 - Eduardo De Almeida, Residencia Max Define, 1978-79, São Paulo. Outdoor render

SURVEY OF THE PROJECT AND 3D MODELLING IN BIM ENVIRONMENT

The overall methodology has resulted from the selection of the most representative buildings of the Brazilian and Indian modernism, in order to document and analyze, through the digital model, a large series of works by the great masters of modernism in Brazil and India, by means of a broad typological, compositional and technological-constructive variety.

The preliminary role of "survey of the project" was the starting point to define the cognitive support, geometrically corrected, for the implementation of the digital model.

In-depth study of bibliographic and documentary sources, environmental analysis, the determination of the correct scale ratios, the metric and dimensional data, spatial rules and interpretive criteria, allowed producing representations as preliminary support to modeling in BIM environment.

The analysis of the selected projects, with a number of variables that depend on the availability of more or less comprehensive bibliographic and documentary sources, was drafted by determining:

- a scale ratio, suitable to identify dimensionally the construction;
- one or more reference planes, needed to find out elevations identifying the plans of horizontal and vertical section and their relationships;
- possibility of dimensioning of the structural elements;
- formal and proportional elements needed to define the vertical connection systems;
- a description of architectural details, also detectable by photographic images;
- descriptive elements to represent the surrounding area and the environmental and urban context;
- qualitative factors suitable for describing surface materials and colors;
- the morphology of the roofs coherent with the planimetric system.

The critical-interpretative value of the analysis of the architectural components in analyzed buildings has been draw through preliminary representations by means of sketches and schemes, allowing to extrapolate a series of issues also related to the transformation processes in time.

DIGITAL MODELS FOR THE REPRESENTATION OF THE MODERNIST HERITAGE

Digital models for the representation of modernist buildings made use of the potential that Building Information Modeling provides within the digital "check".

The relationship between the knowledge process and the model resulting from the implementation of advanced information systems becomes therefore increasingly articulated in relation to a partial reverse of the traditional survey process. Part of the critical approach of understanding and verification of reality is moved in the post-processing of the representation [13] where the semantic-dimensional verification, discretized in architectural components, becomes an integral part of the analytical-descriptive process.

On the other hand the application of Building Information Modeling to the existing heritage and historic architecture is the topic, for some years, of several papers from the scientific community [14]. The so-called H-BIM (*Historic* or *Heritage Building Information Modellig*) primarily focuses on survey, on the description of the state of conservation of materials and sites, to better plan aware restoration projects [15, 18] or to deepen their knowledge in order to implement conservation and enhancement strategies.

The application of this research topic focused on modern architecture on the fields of survey, representation and analysis of architecture considers the "characteristics" of the drawing (either as a digital model as a two-dimensional extractions aimed at representation in orthographic projection) strategic for documentation of the project and for its analysis.

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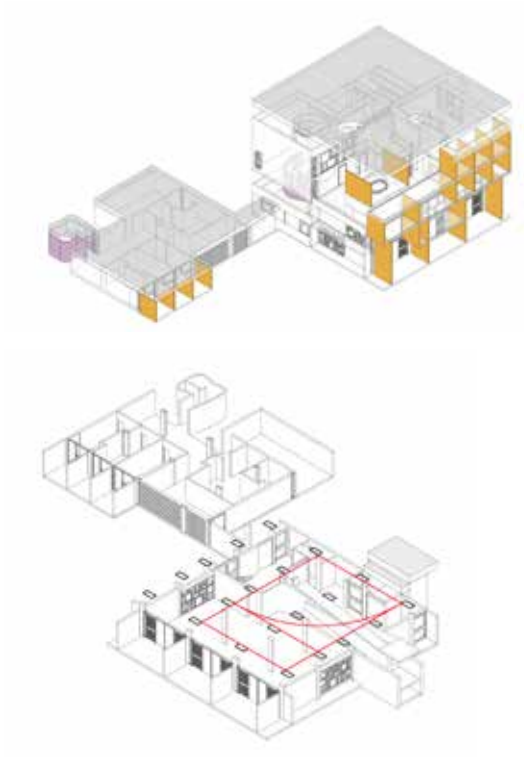

Figure 6 - Le Corbusier, Shodhan House, 1951-1956, Ahmedabad, India. Axonometric view and analysis drawings

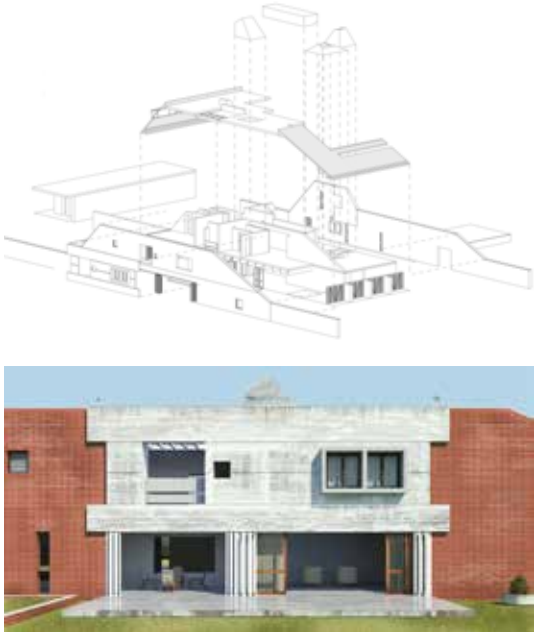

Figure 7 - Charles Correa, Ramkrishna House, Ahmedabad, India 1962-1964. Exploded axonometric view and render

CONCLUSION

The methodology of the "survey of the project" was used to develop three-dimensional architectural models geometrically consistent from which also extract two-dimensional canonical representations. Some characteristics (typological, dimensional, contextual, formal, distributive, functional) of the analyzed architectures, both in the Brazilian modernism examples and in the Indian case studies, led to a series of assessments related to both design aspects (proportions, relationship with the context, color and material analysis, etc.) and linked to the state of conservation of architecture.

Each building has been the subject of a "removal and assembly" process (geometrical and conceptual) to get inside knowledge (not only formal) of architectural experience of the twentieth century.

The representation does not become, therefore, only a means of communication but a tool of thought and project [19]. In this direction, talking about the graphic rendering of architectural design often sounds like a reduction, where it is not a real misunderstanding.

The application of Building Information Modeling tools allow a freer level of process than the projective geometry criteria, allowing new interpretations that arise from geometric and formal knowledge and awareness, reaching all the accurate consistency for a BIM environment digitally and physically in the solid models [20].

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NOTES

[1] L. A. de Paiva Cavalcanti, 2001.

[2] Williams, R. J., 2009.

[3] Warchavchik G., 2006.

[4] F. Maietti, M. Balzani, 2015.

[5] Weinstraub A., Hess A., 2012.

[6] Bonduki N., Portinho C., 2000.

[7] Anelli R., Guerra A., Kon N., 2001.

[8] De Oliveira O., 2014.

[9] Artigas R., 2000.

[10] Acayaba M., 2011.

[11] Lang, J. T., 2002.

[12] Scriver, P., Srivastava, 2015.

[13] Brusaporci S., 2013.

[14] M. Murphy, E. McGovern, S. Pavia, 2009.

[15] S. Garagnani, 2015.

[16] S. Logothetis, A. Delinasiou, E. Stylianidis, 2015.

[17] M. Murphy, E. McGovern, S. Pavia, 2011.

[18] S. Garagnani, 2012.

[19] M. Unali, 2009.

[20] The topic of this paper is a research field developed by the DIAPReM center of Department of Architecture, University of Ferrara, even through PhD Courses and international workshops, which includes teaching experiences within the integrated course of Surveying II and Techniques of Representation, AA 2015-2016, Professors Marcello Balzani, Federica Maietti, Riccardo Rubini.

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