Significant data and information in complex analysis of the architectural heritage, the Republican Museum of Itu, Brazil.

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Abstract – **Innovative digital tools make it possible to investigate and understand elements of architectural heritage based on considerations extracted from historical and physical analyses, and to use a large quantity of information acquired with technologically advanced tools (e.g, photogrammetry and image-based modeling systems). These tools allow us to investigate the form, reconstruct the process of designing, and study formal, proportional, and spatial features of archeological elements. The interrelation between theory, methods and application opens the possibility to achieve complete results as far as archaeological documentation, analysis and interpretation. On one hand, these high precision digital tools realistically show surface qualities; on the other hand, in the process of production of these models, it's possible to extend the knowledge of archaeological artefacts through the investigation of the material and its articulation with other components of the building, it offers a complex process of interpretation of historical aesthetical aspects, materials and surfaces.**

I. INTRODUCTION

Investigation about architectural heritage is an interdisciplinary field of research, where the process and methodology work are so important as the intended results. The complex life cycle of the building from its foundation to the main characteristics of the building, combining the material and the immaterial events, are fundamental to an accurate understanding and to the proper interpretation of the artefact [1]. In architectural heritage processes, the documentation and digital data acquisition of a cultural asset can support the process of interpretation and conservation of its image and history, in this field, the combination of different surveying techniques allows to better understand the changes in aesthetical aspects of the building's architectural design , materials, surfaces and spaces, with better definition of some constructive elements, geometrical and semantic information.

The representation, analysis, interpretation, and communication of archaeological heritage includes a wide range of interdisciplinary subjects and competences, that play a key role, "deeply influencing decisions and actions of the different specialists involved in investigation, conservation and fruition processes" [1]. The conservation process, according to ICOMOS charter (2003), must follow principles for the analysis and conservation of architectural heritage. These artifacts, by "their very nature and history (material and assembly), present a number of challenges in diagnosis and restoration that limit the application of modern legal codes and buildings standards". These recommendations are necessary to "ensure rational methods of analysis and repair methods appropriate to the cultural context" [2].

Digital photogrammetry is an important technique in this experience of investigation, since it offers geometric information. This high precision digital tool is explorable and measurable, gathered by taking advantage of the potentialities of technologically, from a large scale to a small one.

The research presented in this paper is currently in development and uses as a case study the the main façade of the Republican Museum "Convenção de Itu" (MRCI) at University of Sao Paulo (USP). It is a historic building in the city of Itu (Sao Paulo, Brazil) of Luso-Brazilian architecture with rammed earth construction and brick

masonry, its main façade and the ground floor entrance hall are covered in historic tiles.

The research is based on MRCI architectural documentation and historical images and aims to provide knowledge and information about the main façade of the building design in different moments, with its complex history, involving a large amount of semantic data [1], that requires the organization of the building's investigations and interventions in precise steps, "corresponding respectively to the searches for significant data and information" [2].

All this information is important to understand, at the urban scale, some aspects of the Architectural and Cultural Landscape, and it offers specific building understanding in restoration processes, maintenance actions and conservation criteria.

II. REPUBLICAN MUSEUM "CONVENÇÃO DE ITU"

The case study is the Republican Museum "Convenção de Itu" (MRCI), located in the city of Itu (state of São Paulo, Brazil). The building was initially a two-story single house residence, in 1824. The historic townhouse is considered heritage because it was the place where, on April 18, 1873, the Republican Convention of Itu was held. Throughout the history of the building, it has undergone transformations and architectural interventions, which represent an aesthetic renewal of the cities of the coffee cycle and related to an economy of agro-industrial production in the interior of São Paulo, corresponding to the desires of the local elite in the search for modernization, in the period marked between the middle of the 19th century and the first half of the 20th century.

Fig.1. Photograph of the MRCI main façade and the process of drone images acquisition for photogrammetry with the marker's points.

The building, considered representative of the configuration of the republican political regime in Brazil, was acquired by the Government of the State of São Paulo

in 1922, when an intervention project and programmatic transformation was carried out, with the musealization of the internal spaces, and a project for the construction of the garden. The Museum of Itu was founded in 1923 and installed in a building considered cultural heritage, an important historical landmark and national memory. The Museum consists of a garden designed and built in 1920, by Pedro Amirat, and executed by Carlos Neuhof, later marble statues and a fountain were installed. The construction of the building of the Museum's historic building was carried out with rammed earth and brick masonry, floors and staircases in wood and a timber framed roof with trusses and ceramic tiles. Its main façade was covered in glazed tiles in 1867. Later, in the1940s, the ground floor entrance area was also covered with glazed tiles illustrated with the historical and cultural narrative of the city, by commission from its director Afonso Taunay (1917 – 1946) to the ceramist Antônio Luiz Gagni. The Museum is a scientific, cultural and educational institution of the University of São Paulo, and covers the theme related to the republican movement, the first phase of the Brazilian Republic, and the history of the city of Itu and its region.

The historic building of the Museum is recognized as a cultural asset with legal protection by the federal and state bodies, with the listing in 1967 by the Brazilian National Historical and Artistic Heritage Institute (IPHAN) and, in 1981, by the Council for the Defense of Historical, Archaeological Heritage, Artistic and Tourist (CONDEPHAAT). Under heritage protection, interventions in the building must follow the specific guidelines, an issue that requires knowledge of the characteristics of the listing, and constant dialogue with the public preservation agencies.

III. DIGITAL DOCUMENTATION PRODUCTION PROCESS, METHODOLOGY OF RESEARCH.

A research project was developed from 2021 to 2022, funded by the University of São Paulo, to document, survey, and create a digital model of the building using digital tools with the goal of producing Heritage Building Information Modeling (HBIM) documentation and developing a Digital Twin for release on the Museum's Centennial in 2023. This research was based on the application of reverse engineering of built structures through the creation of an integrated protocol for documentation, management, and digital dissemination of the built heritage, combining techniques such as terrestrial laser scanning, photogrammetry, technical-construction surveys, non-destructive testing, and the systematization of information into HBIM models and a Digital Twin.

Based on the results of this previous research, this new work develops an investigation about the main MRCI façade to extend knowledge of its archaeological aspects, through analysis and interpretation of historical aesthetical aspects, materials and surfaces.

A. Digital Timeline, the Heritage Building Data Inventory production

In the development of a document database structured as a timeline, data inventory procedures [3] were employed as part of a pilot study to assist in the creation of the parametric object library and building model for MRCI's heritage building preservation and renovation projects.

The process of surveying, systematizing, and analyzing documents is crucial during the initial stages of building reconnaissance and interpretation, field surveys and data acquisition, and the development of HBIM and Digital Twin (DT) models. Beyond geometric data, accurate historical information is essential to gain a comprehensive understanding of the building. This includes investigating materials used in different construction phases, structural behavior, and physical integrity.

The MRCI building underwent various transformations, starting as a single-family residence and later becoming a museum. One of the main challenges in inventorying data for the MRCI building was dealing with primary sources, cross-referencing information from historic and social studies, city maps, and existing documents. The research also involved consulting National and Local Conservation Bodies and the city's Master Plan provisions for heritage preservation. These guidelines informed conservation, restoration, and monitoring actions.

The Heritage Building Data Inventory plays a critical role in collecting data for digital models. It aids in survey planning and supports strategic actions. Documenting and defining the asset is the first step toward studying its design, construction characteristics, and conservation status [4].

HBIM Models and DTs require information about different construction stages over the years. To achieve this, it was necessary to document spatial changes in the MRCI building throughout its two centuries of existence. This process considered new construction elements, material changes, and gaps in historical information. Documentation maintained by administrative entities responsible for the museum and its building were also consulted. However, the original building's foundation date and physical characteristics at that time remain unknown.

The historical documentation of the building was organized into an interactive timeline to support the development of the HBIM parametric object library and model [5]. This involved extensive data curation, structuring topics and events related to the building's history, architectural interventions, institutional management, relevant legislation, urban context, and the creation of the museum's garden.
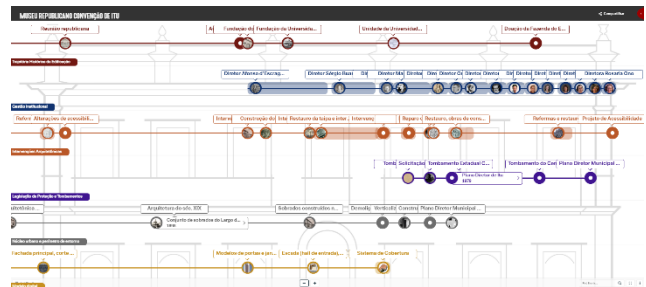

Fig. 2. The digital timeline of the MRCI events produced to support the development of the HBIM model, MRCI/MP/USP. Available on:
https://www.timelinefy.com/timelines/2681

As a result of the previous research, a descriptive and up-to-date timeline of the MRCI building was obtained, including events and topics throughout the building's life cycle, as well as considerations regarding the survey, inventory, and curation of documentation related to a heritage asset, addressing contemporary questions. This timeline enabled information management, ensuring consistency for the interpretation of the research about the main façade.

B. Historical documentation of restoration works.

Fig.3. Photograph of the MRCI rear façade and the architectural restoration works from the 1970s.

The images of the restoration process in the 1970s, expose the modification in the character of the interior façade of the building"s first floor, with the replacement of the historic door and windows, which were closed with bricks and replaced by a door with a different design.

This information was gathered from a single historic image of the IPHAN's report about the restoration work of the rear façade, with access to the interior garden of the building. During the restoration works, in the 1970s, brickwork areas were left exposed, allowing the historical documental investigation about the pre-existence of arches in doors and windows, that were covered by bricks in successive renovation and redesign façade works.

C. Digital documentation processes.

The research activity involving the examination and comparison of documentation, information, and data related to MRCI resulted in a digital timeline aimed at better understanding architectural, urban, administrative, legal, and heritage preservation aspects, as well as construction techniques and materials, among others. To achieve an ideal understanding of the building as an architectural entity, an investigative process was necessary to analyze and manage various documents, information, and data, incorporating methodologies and assimilating document survey processes related to the historic building.

Fig. 4. Drone photography of the MRCI main façade, MRCI/MP/USP.

The drone images expose some damage in the main façade and reveals that probably there was the replacement of the original windows by windows with a different design. In this case, it's possible to extend knowledge through analysis of the façade material surface and its articulation with other materials of the building, it provides a more complex process of interpretation of historical geometric and aesthetical aspects about the main façade and the preexistent arches at the top of the windows.
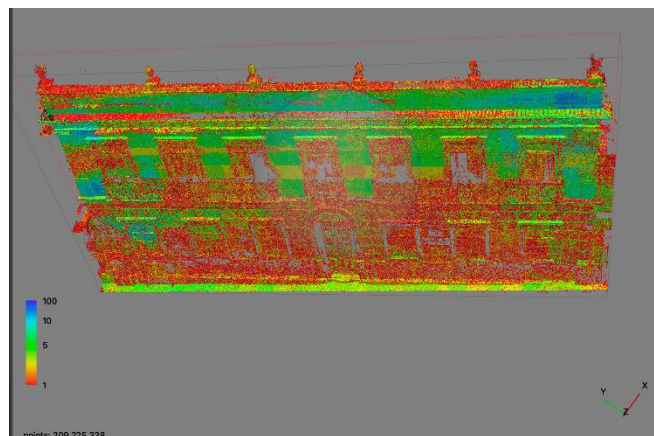

Fig. 5. Photogrammetry software arranging images generate dense cloud of the MRCI main façade, MRCI/MP/USP.

Fig. 6. Photogrammetry software arranging images generate dense cloud and texture data of the MRCI main façade, MRCI/MP/USP.

Fig. 7. Photogrammetry orthoimage of the main facade of the MRCI, MRCI/MP/USP.

The photogrammetry process provided a more accurate geometrical information of the façade, exposing the features of the old windows arches design, probably redesigned with the insertion of the new parapet in 1867. This investigation is important in a system of multidisciplinary activities, as the conservation process

requires information with "accuracy and the completeness of the built heritage knowledge representation" in the activity of "investigation, intervention, conservation and maintenance phases" [1].

IV. RESULTS

The architectural heritage conservation and restoration project's first phase is structured in an extensive examination and documentation process with geometrical and non-geometrical data. Digital technologies contribute as an increasingly important approach and methodology for the acquisition of information , inspection managementand diagnostics, able to provide information about the key decisions that takes precedent over the others, as it offers tools that allow the investigation of the form, support the reconstruction process of the design and enable the study of formal aspects of windows, doors and street façade, considered the main façade of the building in the case of this study.

The interrelation between theory, methods and application opens the possibility to achieve complete results as far as the documentation, analysis and interpretation of archaeology, specific building understanding in restoration processes, maintenance actions and conservation criteria.

V. CONCLUSION

The case study offered an opportunity to analyze the use of historical information and digital tools, associated, producing digital documentation to assist in the management of future interventions and in the maintenance of the building, to study and record the modifications, interventions and maintenance (preventive and corrective) works in the building throughout its lifecycle. The research was an opportunity to systematize historical information, data and documentation, and will allow a more adequate management of the heritage asset, in addition to making the information available to a wider audience. The research aimed to offer important contributions to the construction of a digital inventory methodology, data management and historical heritage information. Additionally it can assist in the construction of preservation actions and policies for historic buildings of cultural value, in order to contribute to the social and economic development, and to the quality of life of our communities, through actions that support, structure and promote the knowledge of cultural heritage and its preservation, contributing to the Sustainable Development Goals (SDGs) of the United Nations (UN) 2030 Agenda in the field of arts and culture.

Innovative digital tools, which are constantly being developed, make it possible to understand the key elements of archaeological heritage. Combined with historical and physical analysis, these tools allow the investigation of formal and spatial features of different archeological elements of the buildings. The combination of different surveying techniques allows the better understanding of the changes in the building and provides appropriate technical reference in the reuse and conservation interventions in the building. Thus, the study contributes to ensuring the authenticity of the conservation actions over time in heritage buildings.

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IMAGE CREDITS

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