DIGITAL INVENTORY OF CONTEMPORARY ARCHITECTURE IN FORTALEZA (CEARÁ, BRAZIL): THE MERCADO DOS PEIXES

INVENTARIO DIGITAL DE ARQUITECTURA CONTEMPORÁNEA EN FORTALEZA (CEARÁ-BRAZIL): EL MERCADO DOS PEIXES

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The production of contemporary architecture in Fortaleza is largely related to the increase in tourist activity, driven by the city's integration into global economic flows and the enhancement of its image. Among these works, the Mercado dos Peixes (2011–2016) stands out as the first construction within the Avenida Beira-Mar redevelopment project along Fortaleza's waterfront. This paper aims to discuss the importance of using building information modeling (BIM) in the digital modeling process of the Mercado dos Peixes, in order to contribute to its understanding, documentation, and critical analysis. The methodology is based on theoretical and practical principles linked to digital redesign through BIM, a powerful platform and tool for digital documentation and generating different representations and possibilities for analyzing architecture. The main product of the digital inventory is the parameterized modeling in BIM.

contemporary architecture, digital modeling, BIM, HBIM, digital twin, Fortaleza (Ceará)

La producción de arquitectura contemporánea en Fortaleza está relacionada en gran medida con el aumento de la actividad turística en el contexto de la inclusión de la ciudad en los flujos económicos mundiales y la valorización de la imagen de la ciudad. Entre estas obras destaca el Mercado dos Peixes (2011-2016), primera obra incluida en el proyecto de reurbanización de Beira-Mar, en el frente marítimo de Fortaleza. El objetivo de este trabajo es discutir la importancia del uso de BIM (*building information modeling*) en el proceso de modelado digital del Mercado dos Peixes, con el fin de contribuir a su comprensión, documentación y análisis crítico. La metodología se basa en supuestos teóricos y prácticos relacionados con el rediseño digital mediante el uso de BIM, que es una potente plataforma y herramienta para la documentación digital y la generación de diferentes representaciones y posibilidades de análisis de la arquitectura. El principal producto del inventario digital es la modelización parametrizada en BIM.

arquitectura contemporánea, modelización digital, BIM, HBIM, digital twin, Fortaleza (Ceará)

INTRODUCTION

The production of contemporary architecture in Fortaleza is largely related to productive and socio-spatial restructuring processes that have taken place in Ceará since the 1990s, with tourism playing an important role in integrating the city into global economic flows. In this context, the State has increasingly promoted large-scale urban interventions and the construction of facilities aimed at enhancing productivity, competitiveness, to boost the city's image. One such project is the Mercado dos Peixes (2011–2016), the first building developed under the Avenida Beira-Mar redevelopment project along Ceará's capital coastline. The facility houses 45 stalls for fish sales and provides restaurant services for tourists and locals, strategically located on the city's tourist waterfront.

The rare studies on contemporary architecture in Fortaleza —a city often overlooked in the historiography and debate on Brazil's contemporary architectural culture— underscore the importance of inventorying this recent production. This work is part of a larger research project that seeks to produce a digital inventory of contemporary architecture in Fortaleza, Ceará, through the use of digital technologies.

While there has been an increase in studies and the application of digital technologies in the process of architectural representation and design, as well as in the digital documentation of historic buildings from both before and after the Industrial Revolution, the use of these technologies to inventory contemporary architecture rare. This is not only because digital platforms are primarily tools used for design but also because contemporary architecture is a current production, with little historical distance.

In this context, the concept of digital twin emerges as a multidisciplinary technological paradigm with significant interpretative potential in the design, representation, documentation, and maintenance in the field of architecture and urbanism. Digital twin refers to a technology that integrates the digital and physical objects by mirroring data and information between them (Dezen-Kempter et al., 2020).

Theoretical reflections and applications of digital twin technology have been prominent in the industrial sector, particularly in aerospace and defense, where it is applied in design, production, manufacturing, and maintenance (Errandonea et al., 2020). More recently, its use has

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expanded to research on smart cities and built cultural heritage (Tao, et al., 2022).

Building information modeling (BIM), city information modeling (CIM), and historic building information modeling (HBIM) can be considered as virtual parameterization methods based on the concept of digital twin. These powerful platforms and tools facilitate digital modeling, the generation of different representations and, most importantly, the management of information, data, and critical analysis.

This work is situated at the intersection of digital design and representation technology and architectural theory and history, promoting necessary integration between these fields. It aims to foster theoretical and practical reflections that go beyond the operational and tool-like character of technology, valuing its foundations, social implications, and critical interpretations of architecture.

In the field of digital design and representation technology, numerous academic productions on computer-aided architectural design (CAAD) have emerged, with representations and associations across several continents, including ACADIA, ASCAAD, CAADRIA, eCAADe, SIGraDi, CAAD Futures, DDSS, and others. As a result of this wide range of academic production, it is worth highlighting CumInCAD, a cumulative index that aggregates CAAD publications, providing bibliographic information on over 12 300 journal and conference records.[1]

In Brazil, research on the use of digital technologies often finds a prominent platform for discussion and dissemination at the international conferences of the Sociedad Iberoamericana de Gráfica Digital (SIGraDi). These conferences have significantly contributed to highlighting the knowledge in this field produced by researchers, professors, and laboratories in both public and private higher education institutions.

In the fields of theory, history, and criticism, studies exploring technology as a research tool are still developing, particularly concerning built cultural heritage. Studies relating digital technologies to contemporary architectural theory, criticism, and history remain limited.

[1] https://papers.cumincad.org/about.html

Thus, this work aims to discuss the importance of using BIM in the digital modeling process of the Mercado dos Peixes, contributing to its understanding, documentation, and critical analysis, as well as to build a digital inventory of contemporary architecture in Fortaleza, Ceará.

The main product of the digital inventory is the parameterized modeling in the (H)BIM platform. This modeling is much more than a simple representation: it is a simulacrum, a virtual matrix with the potential to form an analog/digital research database, which brings together primary sources, images, drawings, documents, and vectorized or non-vectorized collections (Kos, 2002). The modeling will enable the generation of various representations, information and data management, and theoretical and critical analysis of the selected work through different byproducts resulting from the parametrization.

TOURISM, GREAT URBAN PROJECTS, AND CONTEMPORARY ARCHITECTURE IN FORTALEZA: THE CASE OF MERCADO DOS PEIXES

Nowadays, the implementation of great urban projects (GUPs) has served as a catalyst for enhancing places as tourist attractions. This strategy is widely used by public entities to boost urban productivity and competitiveness, closely linked to other dynamics such as the provision of infrastructure, development of the tertiary sector (commerce, services, and tourism), and real estate.

In Fortaleza, state-led initiatives, in collaboration with the private sector, have aimed to increase tourism through public policies. A notable milestone is the construction of the Dragão do Mar Centro de Arte e Cultura, inaugurated in 1999 (Paiva, 2010). This trend has intensified in recent decades, particularly with the boost from mega-events in Brazil, including Fortaleza's role as one of the host cities for the 2014 World Cup.

In this context, tourist attraction in Fortaleza is primarily related to sun, sand, and sea tourism, due to its location and proximity to the Equator, which guarantees favorable climatic and natural conditions for leisure practices related to modern maritimity (Dantas, 2004). Most urban, infrastructural, and architectural interventions take place along the waterfront, especially in the historically valued areas by real estate, such as the Praia de Iracema, Meireles, and Mucuripe neighborhoods.

> In the case of urban interventions, rehabilitating degraded areas —including seafronts, riverfronts, industrial and port complexes, heritage buildings, and historic areas such as old towns and neighborhoods— stands out and often presents a growing process of gentrification and touristification, giving rise to conflicts between the public and private sectors. (Paiva, 2014, p. 120)

Among the interventions aligned with significant GUP strategies, it is worth highlighting the "National Public Competition of Ideas for the General Redevelopment and Architectural, Urban Planning, and Landscaping Projects for Avenida Beira-Mar" in Fortaleza (2010), which was inaugurated in May 2022. Organized by the Fortaleza City Hall in partnership with the Instituto de Arquitetos do Brasil (IAB) – Ceará Section, this urban intervention represents one of the most recent strategies for enhancing tourist development along the city's coastline. The project covers a 3050-meter stretch of waterfront, with an average width of 100 meters, bordered to the west by Rui Barbosa Avenue and to the east by the Mercado dos Peixes (Figure 1).

Figure 1

3D modeling plan of the architectural, urban planning, and landscaping projects for Avenida Beira-Mar, with the Mercado dos Peixes located at the eastern end

Note. From: Modeling by Architect Esdras Santos.

The reconstruction of the Mercado dos Peixes, historically located at the end of Fortaleza's Beira-Mar promenade, on the famous Mucuripe Beach, marked a significant milestone in the initial phase of the seafront redevelopment process.

> Designed in 2011 and completed in 2016, the Mercado dos Peixes was the first project undertaken as part of the Beira-Mar redevelopment. This intervention preserved and improved the existing uses in the place, introducing a physical structure with 45 stalls that offer better hygiene and integration with the beach. The market's activity largely incorporates the fishing and sales

> practices historically associated with Mucuripe Beach, providing a source of employment and income for local residents. (Paiva et al., 2020, p. 12)

The new market project was developed by architects Ricardo Muratori, head of the Arcosanti Arquitetura office, Fausto Nilo, and Esdras Santos, with the collaboration of architect Luana Cavalcante. This team also won the aforementioned competition to revitalize Beira-Mar.

The idea for the project came from criticisms of the L-shaped layout of the previous building, one side of which obstructed sea views by using the seafront area for service purposes (Marquez, n.d.), as well as the precariousness of the old market. The old structure was demolished to make way for a new complex consisting of blocks perpendicular to the waterline, spaced by galleries that facilitate movements and enhance visual and physical integration with the coastal landscape. In addition, at the beach-facing end of the five pavilions, fish stands with restaurant services overlook a deck, creating a food square and terrace at the edge of the city (figures 2 and 3).[2]

Figure 2

Aerial photo of the Mercado dos Peixes

Note. From Mercado do Peixes. 3°43'20" sur, 38°28'41" oeste. Altura de la vista 664 metros, by Google Earth, 2020..

[2] While this article was being written, a large roof was built on the terrace, consisting of a wooden structure and metal tiles, which greatly compromised the quality of the initial proposal. The architects were certainly not consulted about this unsuccessful addition.

Figure 3

Panoramic view of the Mercado dos Peixes

Note. Photograph by Guido Milião (2016), Ricardo Muratori collection.

The formal unity of the Mercado dos Peixes is achieved through its curvilinear metal roof, composed of aluminum brises. According to Ricardo Muratori, these brises help to diffuse sunlight and create a fifth façade for those viewing the market from the adjacent vertical buildings on the waterfront (Marquez, n.d.).

It is also worth highlighting the varying dimensions of the pavilions that house the stalls. Adjusted to the irregular shape of the beach strip, this design resulted in a dynamic roof structure. The metal trusses supporting the roof are anchored by concrete porticos, which are aligned with the layout of the stalls.

The project adopts a contemporary architectural language while incorporating elements of the local architectural culture, such as valuing solutions suited to the climate and contextualized with the landscape. The large roof, designed to be separate from the blocks, reflects the idea of "open building" (de Holanda, 1976), a principle valued in modern architecture from the northeast region. Additionally, the project includes a block for the fishermen's association and a public car park.

The project appropriates architectural form as symbolic capital to emphasize the building's role as a means of enhancing the city's tourist image. Although the market exhibits a formalist character, particularly

in the design of the roof, its tectonic aspects are not hidden, revealing the authors' interest in exploring the technical and formal qualities of the materials and structure, which are prominently showcased (Figure 4).

Figure 4

Mercado dos Peixes roof

Note. Photograph by Fabrício Porto (2016), Ricardo Muratori collection.

For Muratori, the market's design seeks to translate an architectural language that aligns with Fortaleza's cosmopolitan and touristic character, moving away from a design approaches rooted in the values of traditional beach architecture. Although this approach of using architecture as a strategy to enhance the image of the city is questioned by Almeida and Silva Filho (2021, p. 14), who claim the clear contrast with the identity aspects of the local coastal territory, contributing to the deconstruction of traditional cultural ties with the landscape, it is important to point out that this supposed rupture has been ongoing since the waterfront's verticalization process in the early 1980s, marked by the production of multi-family residential buildings and various lodging establishments.

In the case of the Mercado dos Peixes, it is argued that beyond its architectural language, the problem lies not necessarily in the building's form but in the way the facility is used and appropriated. Immediately after its inauguration, the market failed to meet all the demand from traders and fishermen, who continue to operate improvised and informal sales structures that appear precarious when compared to the more established stalls of license holders.

As is typical of interventions aimed at increasing tourist attractiveness, it can be said that since its genesis, the new Mercado dos Peixes has initiated a process of gentrification in the area. This trend has been reinforced by the 18-year public-private partnership signed in 2020 between Fortaleza City Hall (PMF) and Parkfor Estacionamento Soluções e Serviços EIRELI, which has been the focus of public debate due to the refurbishments and implementation of more sophisticated services.

> The most recent conflict between the license holders and the facility's management is associated with the disconnection between the proposed new uses and the traditional fishing activity. Complaints have arisen regarding new construction works that began in 2021, including plans to add a bar area leased by a brewery, aimed at a higher-income public. (Almeida & Silva Filho, 2021, p. 16)

In general, these ongoing transformations in the market suggest a trend toward its privatization, as well as that of the surrounding public spaces, and perhaps even the coastal landscape itself. Digital modeling is an important tool for documenting and understanding the transformations the Mercado dos Peixes is undergoing.

METHODOLOGY: REDRAWING AS A DESIGN RESEARCH STRATEGY

The theoretical framework of this methodology addresses the debate on redrawing as an instrument for interpretation and research in architecture and urbanism. It specifically examines its relationship with digital tools in the process of surveying, digital documentation, intervention, management and modeling of information, and analysis of existing buildings using the BIM platform.

Drawing is an essential representation and expression of the theoretical and practical knowledge of architecture as a discipline. Consequently, redrawing can be considered as an interpretative tool not only for understanding the origin of a project but also for supporting historical, theoretical, and critical perspectives. As Gaston and Rovira (2007, p. 68) note, if the graphic representation grants the author access to the work, it can also facilitate access for those who later engage with it.

Redrawing is therefore an important tool for theoretical, historical, and critical research in architecture, as it represents a metalinguistic

practice, that is, a simulacrum of an intentional and directed project: a project of the project (Vázquez Ramos, 2016, p. 5). It enables deepening the building's conception, construction, and interventions.

The redrawing process has been enhanced and valued with the advent of new digital technologies affecting the entire architecture, engineering, construction, operation, and maintenance (AECOM) sector. Early impacts of digital technologies on architecture and urbanism are grounded in discussions by Picon (2004) about new hybrid materialities and Oxman's (2006) systematization of digital architecture, underlining a paradigm rupture concerning the generation of forms. These new technologies not only propose new alternatives but also overcome conventional representations such as drawings.

In the context of this accelerated technological evolution, with the advent of Industry 4.0, characterized by the convergence of physical, digital, and biological worlds (Schwab, 2016), different technologies —including virtual reality, mixed and/or augmented reality, artificial intelligence (AI), web technologies, GIS, CAD, BIM, HBIM, rapid prototyping, digital manufacturing, 3D laser scanning, and photogrammetry— significantly impact AECOM.

To a greater or lesser degree, these technologies are linked to the digital twin paradigm, with BIM being particularly relevant. As Isik and Achten state, "BIM has seemed like a central technology for the lifecycle, which also includes the design process, a tool of digital twin by many professionals" (2023, p. 5).

BIM has established itself as a leading design and representation platform in architecture. It offers an intelligent simulation of architectural artifacts, replacing traditional historical representations —rooted in knowledge since the Renaissance— with a central information model that prioritizes simulation and parameterization (Andrade & Ruschel, 2011).

For architectural documentation and theoretical, historical, and critical research, BIM significantly enhances redesign capabilities, enabling the virtual (re)construction of parametric models of historical or contemporary works.

Thus, HBIM emerges as an expansion of BIM technology, focusing not only on the documentation, analysis, conservation, intervention, maintenance, and management of built heritage but also —as

advocated in this paper— on the production of digital inventories of contemporary architecture. HBIM transcends the BIM environment and includes reverse engineering, which consists of mapping architectural elements using laser scanning and photogrammetry as the main resource (Murphy et al., 2009).

> In general, the aforementioned HBIM surveying processes have been increasingly used to document old buildings, likely because they are well-suited resources for digitizing complex and organic geometries, ornamental elements, and handcrafted details characteristic of this pre-industrial architectural collection. (Paiva, 2021, p. 10)

Due to the plurality of trends in contemporary architecture, although there is a prevailing interest in designing iconic forms, both minimalist and complex forms are being created (Paiva, 2014). Thus, for the redrawing of purer forms, the use of photogrammetry may be dispensable, whereas for modeling more complex formsthe full technological contribution of HBIM can be used.

In both cases, traditional surveying techniques and digital drawings produced in CAD are also important inputs for digital modeling and, in this research, for the production of a digital inventory of contemporary architecture in Fortaleza, Ceará, particularly the Mercado dos Peixes.

The practical assumptions of the methodology involve gathering analog sources such as project descriptive memoranda, access to websites, documents, collections, drawings, plans, photographs, projects, and interviews with architects. Parameterized digital modeling was carried out on the BIM platform (Archicad), which allows direct use of CAD drawings.

This work is part of ongoing research on the modeling and construction of a digital inventory of contemporary architecture in Fortaleza, Ceará [arq.con.ce]. The empirical dimension of the research builds on and reproduces the methodology used for digital modeling of modern architecture in Fortaleza (Paiva, 2021). It consists of systematizing iconographic sources of various examples to create a database of standardized information, compiled into building characterization sheets. However, the database is not restricted to such sheets, since these primary and secondary sources are linked to the virtual modeling in Archicad, which is the main process and product of the digital inventory.

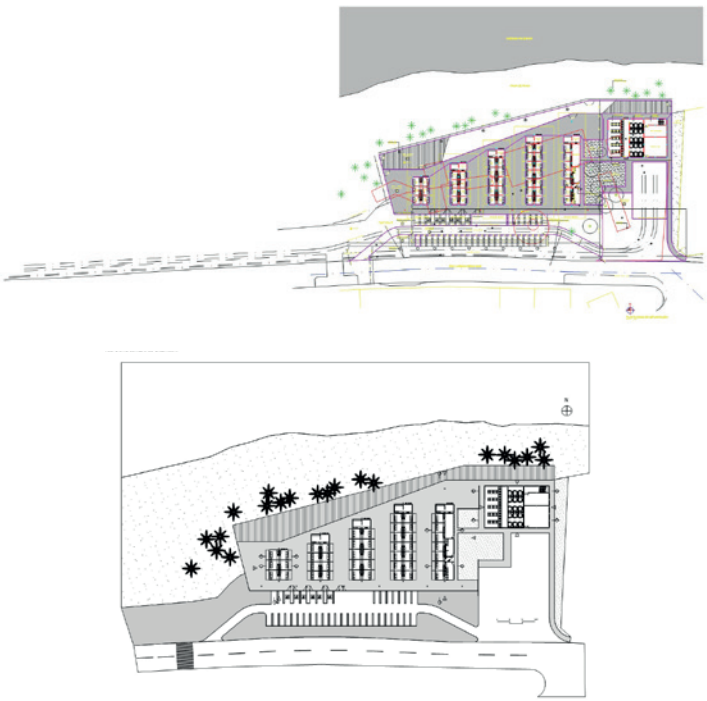
RESULTS: BEYOND THE 3D MODELING OF THE MERCADO DOS PEIXES

The BIM modeling process for the Mercado dos Peixes in Archicad software was based on AutoCAD drawings and began with an overview of the project, followed by the organization of the file base provided by one of the project's architect, Ricardo Muratori. The plans and construction details were divided into 15 .dwg files, the first two containing general plans of the project, nine files containing the plans, sections, and elevations of the building's six blocks, and the last four dedicated to external construction details and window frames.

After the initial assessment, the modeling process started by inserting the .dwg files into Archicad as worksheets, using them as a reference for modeling with the aid of the tracing tool. When necessary, direct checks in AutoCAD were performed to check for possible errors in importing the files. The 3D model was built mainly with the mesh tool for terrain modeling, alongside the wall, slab, pillar, beam, staircase, door, window, and morph tools for block modeling (Figure 5).

Figure 5

Screenshot of the matrix drawing of the original CAD project and the redesign (digital inventory) of the Mercado dos Peixes



The main product of the research is the digital model itself and the associated database. As a byproduct of this digital modeling, a characterization sheet is being created, containing information such as the building's name, use, architect, builder, date, land areas, location, map, coordinates, images, sources, and references. Also important is the compilation of original project drawings and new possibilities for representing the building, including diagrams, details, isometric views, and more (figures 6 and 7).

This set of analog and digital information enables various interpretations of the building, managing interventions and transformations, as well as providing comparative studies and parameters for architectural and urban analysis.

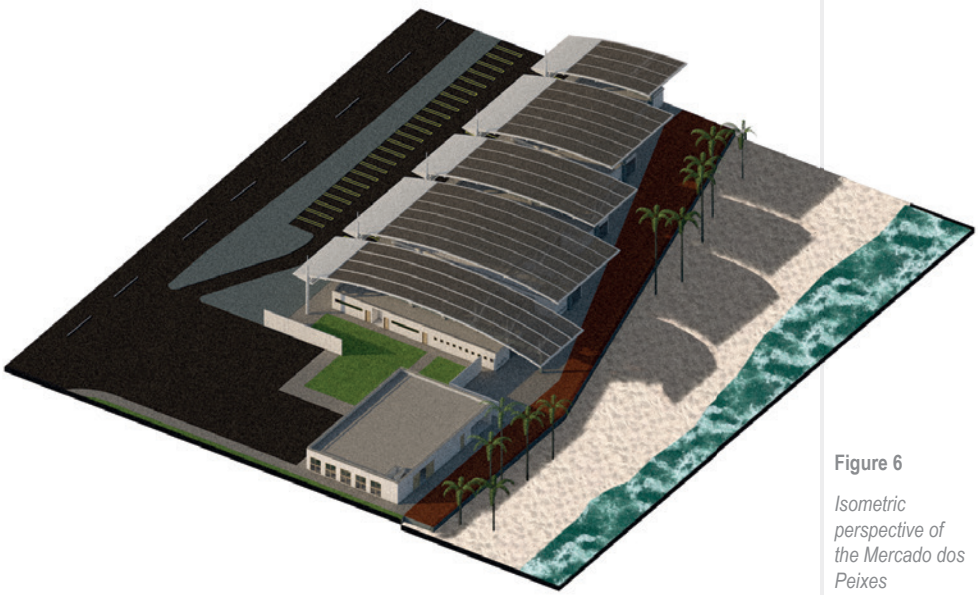


Figure 6

Isometric perspective of the Mercado dos Peixes

Figure 7

Images of the draft characterization sheet for the Mercado dos Peixes

FINAL REMARKS

The construction of the Mercado dos Peixes in Fortaleza has played a significant role in the recent redevelopment of the Beira-Mar waterfront, situated within a context characterized by a process of exacerbation of touristification in the metropolis on an international scale, prompted by mega-events (Paiva & Diógenes, 2024. p. 164). As such, it is an emblematic work for digital documentation and analysis.

The product of (re)drawing, transitioning from real to digital, extends beyond merely generating additional drawings and offers the possibility of virtual reconstruction of the object (digital twin). This enables its understanding and interpretation from a broader perspective: premises and ideas that influence the design and form, symbolic aspects of the building and its materialization (the work itself is also a representation), construction and structural solutions, bioclimatic strategies, relationship with its context and pre-existing landscape, interventions and renovations, maintenance management, among other factors.

In a way, this virtualization of architectural artifacts in AECOM has anticipated some aspects of what AI has produced in terms of simulations. BIM was a pioneer in creating virtual simulations of architecture, cities, and landscapes, with significant prospects for development through AI plugins, digital fabrication, virtual reality, and augmented reality.

The conceptual approach and results of this research contribute theoretically and critically to studies on contemporary architecture in its interface with digital technologies. It enhances our understanding of architecture as a cultural practice in the conception and construction of material artifacts that express and reproduce socio-spatial practices (economic, political, and cultural-ideological). Additionally, the research aids in identifying the agents involved in the production of architecture, their works, and their legacy, contributing to the field of design, theory, history, and criticism, with valuable didactic applications in teaching, research, and extension practices.

Specifically, in the field of architectural design, this research offers practical contributions to solving problems related to design activities and interventions in case studies. Consequently, it provides support for teaching and learning architectural design and establishes

theoretical and practical foundations that contributes to raising the level of discussion about the production of contemporary architecture in Ceará. Finally, it has the potential to serve as a reference for studies, consultations, and research in architecture and urbanism schools and graduate programs, as well as in the professional practice.

In summary, the digital inventory has substantial potential to improve the planning, intervention, and management processes of public buildings, contributing to socio-spatial development and contemporary architectural culture in Ceará. This is achieved through an integrated perspective that combines knowledge and approaches from theory, history, criticism, and design with digital technologies: an essential attitude for consolidating the discipline of architecture and urbanism.

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