RECENT MUSEUM EXPANSIONS HOUSED IN HISTORIC BUILDINGS IN SÃO PAULO CITY, BRAZIL

AMPLIACIONES RECIENTES DE MUSEOS ALOJADOS EN EDIFICIOS HISTÓRICOS EN LA CIUDAD DE SÃO PAULO, BRASIL

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ABSTRACT
Museums are expanding their role beyond collections and have made efforts to improve the experience of visitors. In this sense, the article aims to understand the expansion of relevant museums installed in historic buildings and provide a critical analysis of the recent expansion with exhibition spaces in the city from São Paulo. To this end, a comparative analysis is adopted whose scope includes verifying similarities that develop in a specific socio cultural scenario and reading the scenario based on different criteria at 1) macro, 2) meso and 3) micro scales. The results are expected to demonstrate whether (or not) criteria related to the integral context, accessibility and inclusion, flexibility and adaptability, environmental and heritage dimensions are met. The practical implications of this study are related to the conditions for the development of general expansion planning in museums and the identification of emerging needs present in historic buildings that house museums.

Keywords
Adaptation, built heritage, museum architecture, operation and maintenance, user requirements

RESUMEN
Actualmente, los museos están ampliando su papel más allá de las colecciones y se han esforzado por mejorar la experiencia de los visitantes. En este sentido, el artículo pretende comprender el fenómeno de expansión de museos relevantes instalados en edificios históricos y brindar un análisis crítico de la reciente expansión de espacios expositivos en la ciudad de São Paulo, Brasil. Para ello, se adopta un análisis comparativo, cuyo alcance incluye verificar las similitudes que se desarrollan en un escenario sociocultural específico y leer el escenario a partir de distintos criterios en diferentes escalas (macro, meso y micro). Se espera que los resultados demuestren si se cumplen o no criterios relacionados con el contexto integral, accesibilidad e inclusión, flexibilidad y adaptabilidad, y sostenibilidad (dimensiones ambiental y patrimonial). Las implicaciones prácticas de este estudio están relacionadas con las condiciones para el desarrollo de la planificación general de expansión de los museos y la identificación de necesidades emergentes presentes en los edificios históricos que los albergan.

Palabras clave
Adecuación, patrimonio construido, arquitectura del museo, operación y mantenimiento, necesidades del usuario.

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INTRODUCTION

The 2023 Agenda (United Nations [UN], 2015), highlights the need for change in the relationship between humans and the environment, addressing topics such as climate change, consumption and generation of solid waste, and socioeconomic issues, among others (Sposito, & Scalisi, 2021). Adaptive reuse (AR) is one way of rethinking the future of cities, promoting sustainable urban regeneration based on a balance between form, function, and attractiveness of the city (Djebbour, & Biara, 2020) and it can act as a social catalyst (Arias, 2023). When dealing specifically with converting existing buildings into museums, it is important to establish the interaction between built heritage, museum, and city, in light of the space-time relationship (Barranha et al., 2017).

The preservation of built heritage has been a topic of discussion since the 19th century. The Venice Charter (ICOMOS, 1964) and the Burra Charter (Australia ICOMOS, 2013) have been the main guides for building conservation processes (Misirlisoy & Gunce, 2016), together with the Charter of Krakow (ICOMOS, 2000) and the ICOMOS Charter (ICOMOS, 2003), which offer an approach based on minimal intervention and reversibility (Barranha et al., 2017). These actions align with the ideas of: 1) extending the useful life of buildings (Pieczka, & Wowrzeczka, 2021); 2) reusing the energy embodied in the building (Ali et al., 2018); 3) minimizing solid waste (Ali et al., 2018); and 4) complying with the rules and regulations in force (Alhojaly et al., 2022).

On the one hand, an old building has its own peculiar characteristics and requires a specific approach to maintenance that considers the restrictions and needs of its users (Ali et al., 2018). On the other hand, maintaining facilities for both an original and old building and its expansions can incur significant costs. The challenge is to promote the conservation of historic buildings with socio-cultural value for the society in which they are part of, while also maintaining annexes and modern or contemporary buildings (primarily for storage but also to add exhibition rooms). In the case of developing countries such as Brazil, and under the impact of climate change, the challenge becomes an even greater task. For this purpose, the Facility Management (FM) function in cultural institutions is required. In this strategic and advanced approach, FM integrates people, places, and processes, aiming to enhance productivity and the well-being of users (International Organization for Standardization [ISO], 2017).

Indeed, FM —widely recognized in office and industrial buildings— should be introduced to a significant number of cultural institutions in Latin America. However, some museums in this region may be considered as exceptions due to their management focus on maintaining their buildings, collections, and their highly qualified teams.

The modernization process of a building should aim to implement measures that reduce future operational and maintenance costs (Pieczka, & Wowrzeczka, 2021). This includes addressing the uncertainties of hygrothermal variations pursued by collection conservators, which can even have an impact on inter-institutional loans (Taylor, & Boersma, 2018). Furthermore, significant changes to urban environments where these institutions (museums) are located, particularly concerning road systems and means of transportation, can potentially cause damage to old buildings and the collections they house. This damage may result from carbon dioxide emissions and ground vibrations caused by heavy vehicles or large numbers of vehicles.

According to Misirlisoy & Gunce (2016, p. 149), “making contemporary museums is a challenging, creative, complex and collaborative activity in the 21st century”. Currently, museums not only house exhibitions, but also extend their role to enhance and make more enjoyable the visitor’s experience. The first aspect is the museum journey, understood as the guiding thread between the exterior and interior architecture, accompanying and guiding visitors during their visit, activating a variety of sensations (Saraoui et al., 2018).

In this context, this article, as part of its main author’s ongoing doctoral research, aims to understand the expansion phenomenon of relevant museums housed in historic buildings located in the city of São Paulo, Brazil. The specific objectives aim to: 1) describe the socio-

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historical contexts of the museums studied; 2) present the main similarities and differences between the three cases; and 3) highlight the messages present in expansion projects. For this, a comparative analysis is adopted, the scope of which includes the horizontal axis (similar phenomena that develop in a specific socio-cultural scenario); the vertical axis (tracing the phenomenon through the macro, meso and micro scales; and the transversal existence (traces phenomena and cases over time) (Bartlett, & Vavrus, 2017).

The research problem addresses the physical limitations and preservation assumptions historic buildings that house museums have. Thus, the research hypothesis is: Are the recent expansions of museums, housed in historic buildings, located in the city of São Paulo, Brazil, essentially different from each other? To answer this question, a comparative explanatory analysis between three cases will be adopted.

The main aspects of the proposed comparative analysis cover the historical-empirical descriptive view of the cases in their respective socio-historical contexts, the presentation of their similarities and differences in relation to the *tertium comparationis* (i.e. the quality that two comparable things have in common), and the disclosure of the communication codes present in the projects (Shahrokh, & Miri, 2019). Initially, the research was delimited based on geo-socio-cultural, physical, and environmental aspects. Next, a survey of the state-of-the-art regarding strategies of 1) contextual integration; 2) 'architectural' accessibility and inclusion; 3) flexibility and adaptability; and 4) sustainability was carried out.

Finally, this study hopes to contribute with practical implications focused on the conditions for developing a general planning for the expansion of museum institutions, and the emerging needs imposed on relevant museums housed in historic buildings located in developing countries.

STATE OF THE ART

Table 1 summarizes the theoretical framework adopted in this research and grouped together with the strategies: 1) Contextual integration, 2) 'Architectural' accessibility and inclusion, 3) flexibility and adaptability, and 4) Sustainability.

Table 1
Summary of strategies

Strategy	Description	Author(s)
Contextual Integration	The expansion should take into account the architectural and historical context of São Paulo city. The design should harmoniously blend with the existing urban fabric, preserving the city's cultural heritage while still providing a contemporary and innovative setting for the museum.	Almeida, & Sena (2023); Bortoluci (2020); Duarte, & Gonçalves (2022); Silva, & Ornstein (2022); Sousa et al. (2023).
Accessibility and Inclusion	The expansion should prioritize accessibility for all visitors, including people with disabilities, elderly people, and those from diverse backgrounds. This can be achieved by incorporating universal design principles and providing amenities such as wheelchair ramps, tactile exhibits, and multilingual signage.	Filová et al. (2022); Koustriava, & Koutsmani (2023); Lynch, & Proverbs (2019); Marín-Nicolás et al. (2023); Ravi et al. (2021).
Flexibility and Adaptability	The expansion should be designed with flexibility in mind to accommodate diverse exhibitions and events. Spaces should allow for easy reconfiguration to cater to different types of art, installations, and performances. This ensures that the museum remains dynamic and relevant to the changing needs and interests of the public.	Askar et al. (2021); Becker et al. (2023); Becker et al. (2024); Hamida et al. (2022); Hamida et al. (2023); Ottenhaus et al. (2023).
Sustainability	The expansion should prioritize sustainable design principles to minimize the environmental impact. This can include the use of renewable energy sources, energy-efficient systems, and materials with low carbon footprints. The integration of green spaces and outdoor areas can also enhance the overall sustainability and aesthetic appeal of the expanded museum.	Carvalho, & Camacho (2023); Fresneda-Fuentes et al. (2022); Silva, & Ornstein (2022).

Source. The authors.

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Contextual integration

According to Silva & Ornstein (2022), Brazil has near 3,900 museums, of which 17.5 % are located in the state of São Paulo. In the country, the museum sector has relevant legislation, such as the National Museum Policy (2003), the Museum Statute (2009), the National Museum Sector Plan (2010), and the National Museum Education Policy (2018). Specifically in the city of São Paulo, there are initiatives by the Municipal Department of Culture aimed at museums, with emphasis on the platform, with an information georeferencing system applied to cultural facilities and their respective territories (Almeida, & Sena, 2021).

At the same time, the city of São Paulo became more populous throughout the 20th century. From 2.6 million inhabitants during the 1950s, it rose to 9 million in the 1970s. In this period, architecture contributed to discussions about modernization and a field of aesthetic, material and political dispute (Bortoluci, 2020). Today the city is reaching around 11 million inhabitants, and that kind of dispute still remains current, but is associated with the contemporary demand regarding technical and financial procedures to operate and maintain large museum institutions in developed countries, whether public or private ones.

On the other hand, studies indicate that many districts and places with a higher vegetation index point to lower surface temperatures compared to other built typologies (Duarte, & Gonçalves, 2022). This urban and building context can contribute positively to the microclimate near squares and parks in the immediate vicinity of some historic buildings and those that house museums, and even mitigate the impact of climate change into these buildings. It is from this technical-legal and urban perspective that the three case studies are inserted.

Accessibility and Inclusion

Filová et al. (2022) present the main requirements for adopting Universal Design in museums. Such as: equitable use; flexibility of use; simple and intuitive use; perceivable information; fault tolerance; low physical effort, size, and space for approach and use.

The method was applied to 52 museums visited, located in Central Europe. In this sense, Marín-Nicolás et al. (2023) presents an index for improving accessibility based on the removal of architectural barriers. While Lynch & Proverbs (2019) discuss the challenges and barriers to making historic buildings accessible to people with disabilities. Along the same path, Koustriava & Koutsmani (2023) exhaustively research 30 museums between Great Britain and Greece to identify the level of special accessibility.

About the elderly, specifically, Ravi et al. (2021) present a description of this population's experiences in buildings, including accessibility and adequate infrastructure, such as physical environment, safety, walkability, among others.

Flexibility and Adaptability

The evolution of interpretations of concepts and paradigms related to the adaptability of buildings was addressed by Askar et al. (2021). On the other hand, Hamida et al. (2022) carry out an extensive literature review on the incorporation of circularity (i.e., extending the useful life of a product or a building by decreasing the incorporation of new materials and associated energy) and adaptability in buildings through 10 design and operation indicators. They are: 1) configuration flexibility, 2) disassembly of products, 3) multi-usability of assets, 4) design regularity, 5) functional convertibility, 6) reversibility of materials, 7) building maintenance capacity, 8) resource recovery, 9) volume scalability, and 10) ability to readjust assets. In addition, Hamida et al. (2023) apply the adaptability of circular buildings in adaptive reuse (i.e., adapting an existing building to a new use). This study provides evidence of the application of 'configuration flexibility', 'product disassembly', and 'material reversibility'.

Becker et al. (2023) carried out an investigation into Design for Adaptability in driving further adaptation and reuse of buildings. Based on Becker et al. (2024) used quantitative methods to evaluate the adaptive potential of projects through the application of Analytic Hierarchy Process (AHP).

Sustainability

Carvalho & Camacho (2023) discuss the results of a nationwide project in Portugal with the challenges of generating recommendations at a public policy level for museums, palaces, and monuments, considering sustainability issues. In this context, museums were understood as fundamental pillar agents of change and culture for sustainable development, especially in a post-pandemic and climate emergency scenario. In this sense, Silva & Ornstein (2022) present individual initiatives introduced by Brazilian museums to address climate-related issues, considering exhibitions, educational activities, the building and its operation and maintenance. Such as, the São Paulo Museum of Art, the Museum of Tomorrow, the Museum of the Portuguese Language and the Rio Art Museum, among others.

METHODOLOGY

According to Knight (2001), "a comparative case study is a research approach to formulate or assess generalizations that extend across multiple cases." The selection of cases was careful, taking into account the similarities of the multiple experiment (Yin, 2018). Thus,

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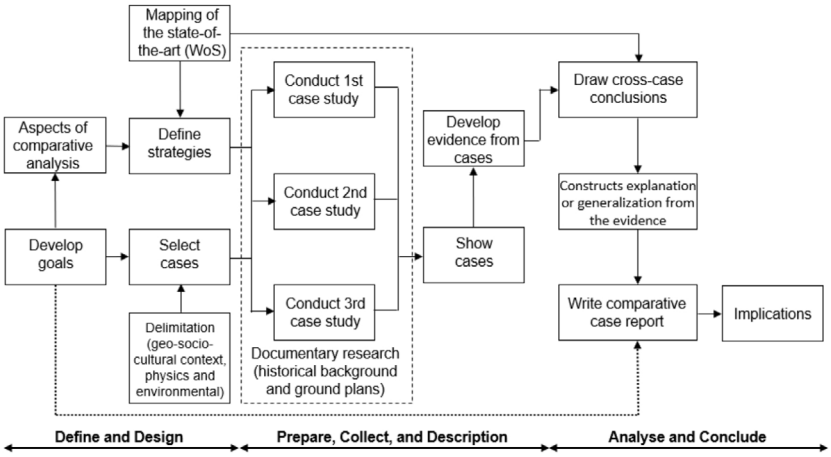
the study was initially conducted by developing the state-of-the-art, via Web of Science (WoS), which allowed the grouping of articles based on the above strategies. At the same time, the delimitations for choosing the cases were defined. These choices were made based on the geo-socio-cultural, physical and environmental context.

This comparative study can be illustrated by the following flowchart (Figure 1):

Figure 1
Flowchart for comparative study



Source. The authors.

The three case studies were selected due to 1) the location in the city of São Paulo; 2) buildings protected by heritage entities; 3) all of them are currently expanding their exhibition spaces; 4) all of them use the underground floor so as not to interfere with the image of the built heritage; and 5) receiving architectural interventions. These delimitations allowed the selection of three case studies.

A documentary research (texts, iconography and audio-visuals) was carried out, and multiple case studies were used to demonstrate the coexistence of the 'object-module' (the ideational principle of construction) and the 'module-measure' (metric ratio between the parts) in the adapted and expanded historic buildings that house exhibitions for the general public. These concepts were presented by Argan (2000).

This step was carried out in the archives of the three museums, the Municipal Historical Archive (city of São Paulo), and the Institute of Astronomy, Geophysics, and Atmospheric Sciences at the University of São Paulo (IAG-USP) to identify photographs that highlighted the different phases of the evolution process of the place and the buildings that comprise the case studies. To highlight the physical aspects (systems-subsystems), success factors related to architecture/physics and structure/technical were used, systematized by Vafaie, Remoy & Gruis (2023).

RESULTS

The scope of this comparative analysis contains the axes: 1) horizontal, 2) transversal; and 3) vertical, according to Bartlett & Vavrus (2017). In this way, it will be possible to understand the geo-socio-cultural context, physical and environmental aspects of the three cases under study.

Horizontal axial

Currently, Brazil has 3,956 museums. The State of São Paulo has 674 museums, 174 of which are in the city of São Paulo —the state capital (MuseusBr, 2023). For this research, three emblematic museums in the city of São Paulo that received AR projects were selected: 1) the Paulista Museum, 2) Pinacoteca, and 3) the São Paulo Museum of Art (SPMA) (Table 2).

Table 2
Relevant data about the buildings that comprise the multiple cases study

	Paulista Museum		**Pinacoteca**		**SPMA**	
	Ipiranga Museum	**Expansion Building**	**Pina Luz**	**Pina Contemporânea**	**Lina Bo Bardi Building**	**Pietro Maria Bardi Building**
Original Design	Tommaso Gaudenzio Bezzi	H+F Arquitetos	Ramos de Azevedo	Hélio Duarte	Lina Bo Bardi	Plínio Adams
Original Use	Monument-building	Museum	Scholl of Art and Crafts	State school	Museum	Residential building
Architectural Language	Eclectic	Contemporary	Eclectic	Modern	Modern	(result of the real estate)
Construction	1885-1890	2019-2022	1897-1900	The 1950s	1957-1968	1954-1956
Museum Conversion	Hermann Von Ihering/ Affonso d'Escragnolle Taunay		Paulo Mendes da Rocha, Eduardo Colonelli, and Weliton Ricoy Torres	Arquitetos Associados + Silvio Oksman		Metro Arquitetura
Adaptation period	1893-1923/ 2019-2022	2019-2022	1994-1995	2022-2023	1997-2001	2021-2024
Area (m^2)	9 ,415	6,845	10,815	6,858	10,485	6,945
Inauguration as a museum	1895	2022	1905	2023	1968	2024

Source. Own elaboration based on information obtained from Museu Paulista, 2023, https://museudoipiranga.org.br/; Pinacoteca de São Paulo, 2023. https://pinacoteca.org.br; Masp, 2023. https://masp.org.br/

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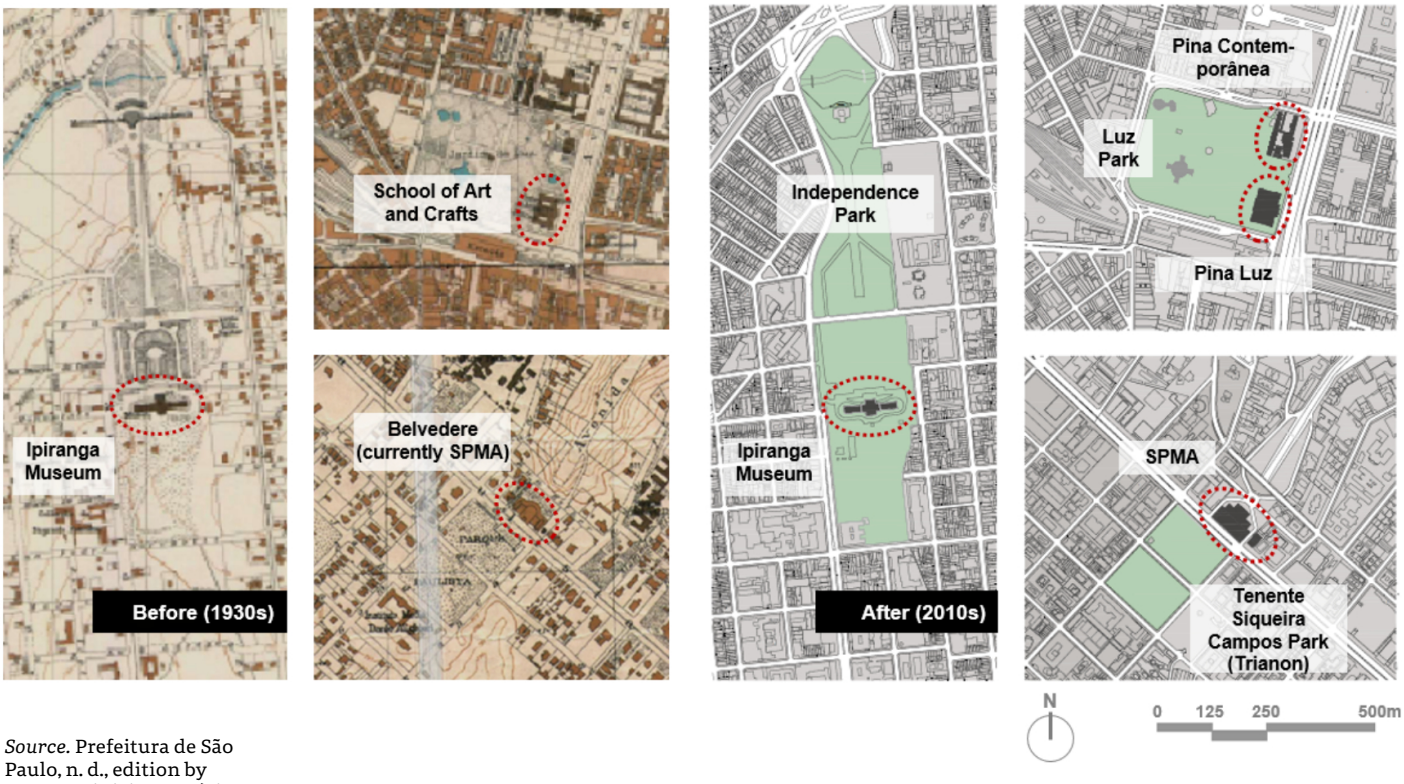
Among the pre-existing buildings presented in the framework above, there are two eclectic buildings, two modern buildings, and one residential real estate building without a completely clear architectural language. The average original area of the main buildings is 10,238 m², while the average area of the expansions is 6,883 m², thus representing about 40 % of the overall area after the AR process.

From the buildings involved in the analysis, only two (Lina Bo Bardi Building and Expansion Building of the Ipiranga Museum) were fully designed, built, and occupied as a museum from the beginning. The diversity of original uses triggered adaptations to meet specific requirements for museums. Historic buildings received smaller-scale and reversible interventions (in some cases), while merely old buildings underwent more invasive modifications to their image and materiality.

Transversal Axial

The changing characteristics of time and space can be observed in the maps (Figure 2) and the mosaic of images (Figure 3). In general, the site underwent successive and overlapping adaptations to meet the growing demands of museums installed in old buildings.

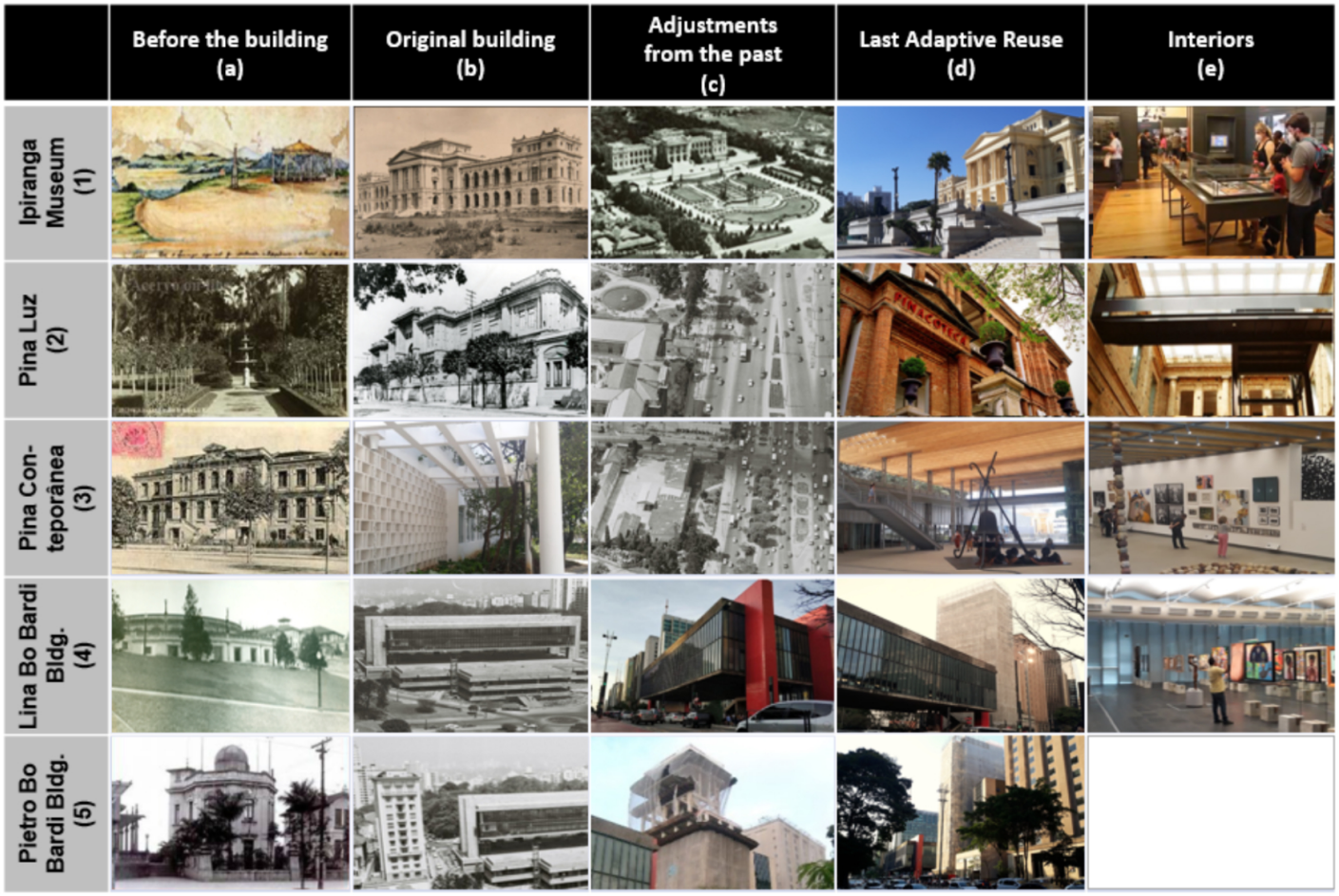
Figura 2
Maps: 1930 and 2012



Source. Prefeitura de São Paulo, n. d., edition by Marcus Vinicius Rosário da Silva.

The current urban density differs from the past reality (e.g. 1930s), except in the case of the School of Arts and Crafts, the current Pinacoteca, whose surroundings were already quite busy. In the past, the surroundings of the Ipiranga Museum and the Belvedere (current SPMA) predominantly consisted of residential and institutional facilities, as is the case with the observatory that eventually gave way to the Dumont-Adams Building, future Pietro Maria Bardi Building.

Figura 3
Image mosaic



Source. Own elaboration based on images obtained from the Paulista Museum collection (1a, 1b, 2a, 3a); FUNSAI Collection (1c); Pinacoteca Collection (2b); Municipal Historical Archive (2c, 3c, 4a, 4b, 5b); IAG/USP (5a) and authors (1d, 1e, 2d, 2e, 3b, 3d, 3e, 4c, 4e, 4c).

Adjustments were made over time in all the selected cases, either to adapt to the suitability of the surroundings (e.g. Ipiranga Museum and Pina Luz), to the architecture (e.g. Pina Contemporânea and Pietro Maria Bardi Building), or to the demands of exhibiting and storing the collections (e.g. in all the cases).

The Ipiranga Museum was built over a previously unoccupied area, while the other examples emerged from the demolition of buildings already consolidated in the urban landscape. The main buildings of the Ipiranga Museum and Pinacoteca follow the classical language of architecture, while the main building of the São Paulo Museum of

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Art stands out in the landscape due to its open space, independent structure, glass curtain wall, terrace with garden and fluid space —precepts of modern architecture—. The school building and the residential building have a more modest scale and shape compared to the others.

The new expographic environments of the Ipiranga Museum comprise peripheral panels (on walls and frames of the historic building) and steel furniture, while Pina Luz maintains the exposed brick surfaces — original to the unfinished building—, maintaining the appearance of a white cube in a few rooms. This look was also sought in the exhibition environments in the recent expansions of the Pina Contemporânea and Pietro Maria Bardi Buildings. The long-term exhibition hall of the Lina Bo Bardi Building features the design´s original 'crystal easels', which allow for greater visual permeability throughout the entire exhibit floor. Spaces of great height are also present in the expansion of the Ipiranga Museum and in Pina Contemporânea, it should be mentioned that the latter is a covered space only.

The similarity of the large spaces in the new expansions is related to the reception of larger objects, such as artistic installations, or to ensure greater compartmentalization flexibility for different future exhibitions.

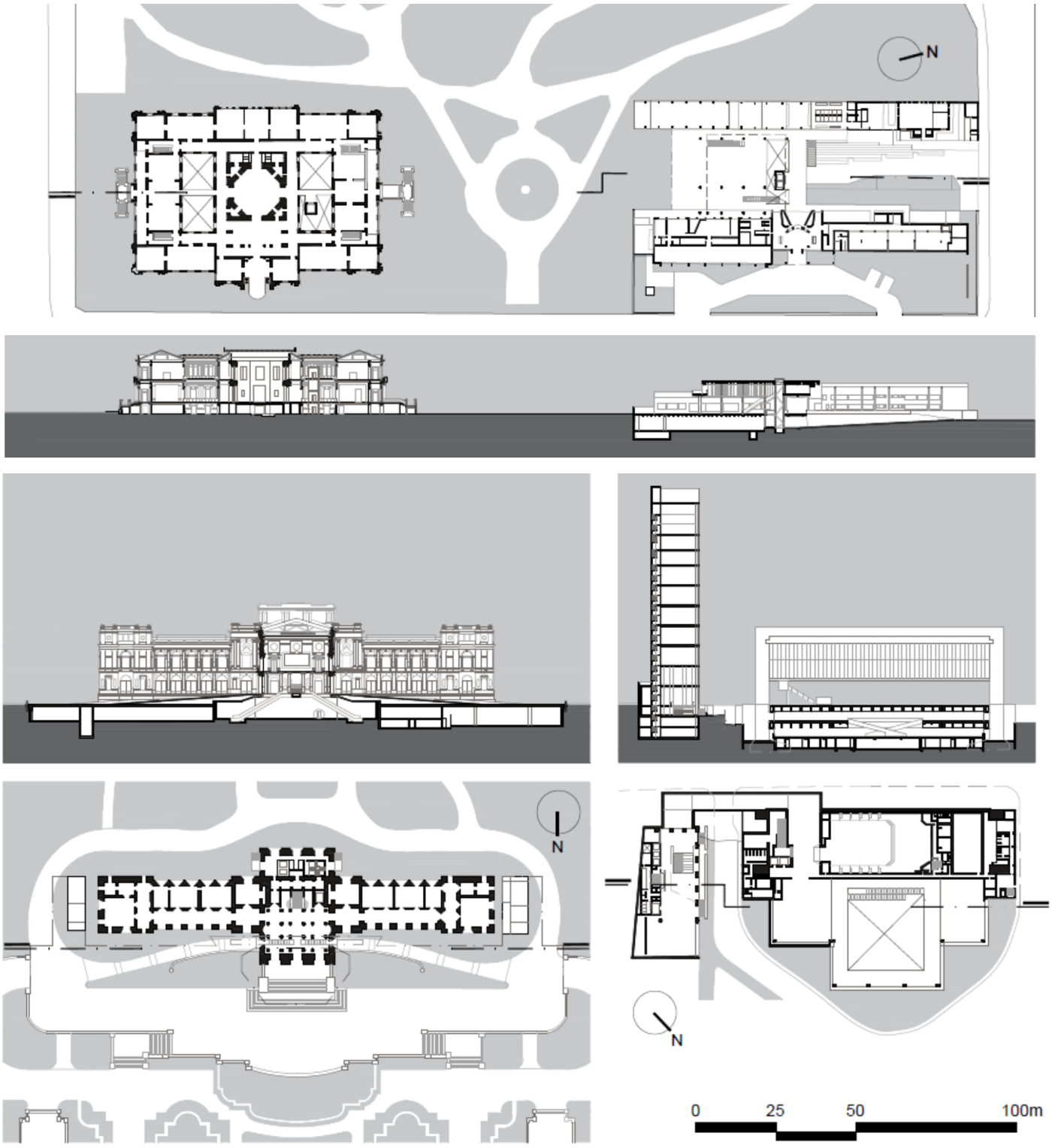
Vertical Axial: Macro Scale

The AR process of the analyzed museums reveals the coexistence between the two types of modules and can be identified in Figure 4. The historic building of Ipiranga Museum and Pinacoteca present a rigorous geometric relationship between the parts and symmetry in their general composition. Moreover, Pina Contemporânea and the São Paulo Museum of Art complex present clear sectors and a hierarchy of spaces.

The three main museum buildings stand out in the local landscape. Outside, the expansions have a direct relationship with squares and parks, allowing for a seamless experience and guiding the visitor to a (semi) underground level which provides access to the new exhibition spaces. Inside the 19th-century buildings, AR used additional metal elements to mark the interventions carried out to implement a museum route between rooms. In all three cases, a museum route is not imposed, but optional routes are suggested to enjoy the museums' multiple exhibits.

The drawings presented in the previous figure reveal the use of the basement for direct circulation between the headquarters buildings and the expansions –except for Pinacoteca, which did not include the interconnection but considered implementing the strategy in the design

Figura 4
Drawings: Floor plan and section of buildings converted to museums



Source. Pinacoteca de São Paulo, 2021, drawings adapted by Marcus Vinicius Rosário da Silva.

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phase. This integration between the annex and the main building caused: the 1) rupture of the original cyclopean concrete foundation of the Ipiranga Museum (under the approval of the structural engineer), and 2) the future disappearance of a small auditorium at SPMA.

Vertical Axial: Meso Scale

Table 3 presents a comparative analysis between the three museums based on the Physical factors.

Table 3
Analysis of the physical factors

Group	Factor	Ipiranga Museum	Pina Luz	Pina Contemporânea	Lina Bo Bardi Bldg.	Pietro Maria Bardi Bldg.
Architectural	Minimum intervention	No	No	No	No	No
	Potential of reversibility	No	No	Yes	No	No
	Explicitness of alterations	Yes	Yes	Yes	Partial	No
	Architectural harmony and Visual compatibility	Yes	Yes	Yes	Yes	No
	Structural layout	Yes	Yes	Yes	Yes	Yes
	Catalyst for urban upgrading	Yes	Yes	No	Yes	No
	Creativity*	Yes	Yes	Yes	Yes	No
	Age value of materials	Partial	Partial	Partial	Yes	No
	Building usability	Yes	Yes	Yes	Yes	Yes
	Material durability	Yes	Partial	Yes	Yes	Yes
Structural	Extension in building's life	Yes	Yes	Yes	No apply	Yes
	New technical system x artworks	Partial	Partial	Partial	Partial	Yes
	Load-bearing structure	Yes	Yes	Yes	Yes	Yes
	Choice of materials	Yes	Yes	Yes	Not apply	Yes
	Technological innovations	Yes	Yes	Yes	Yes	Yes
	Orientation and solar access	Yes	Yes	Yes	Yes	Yes
	Flexibility of components	Yes	Yes	Yes	No	Partial

Note. The definition of Creativity used in the reference is associated with the creativity of adapting the needs and concept/design of the existing building.

Source. Collected by the authors, based on Vafaie et al. (2023).

The minimum intervention was not fully applied to any of the buildings, resulting in a loss of material and image in interior spaces. The potential reversibility is also not applied in most cases, due to specific demolitions inside buildings. Regarding the explanation of the changes, most cases show contemporary interventions carried out inside the buildings using construction materials and color contrast. Architectural harmony is maintained in all cases, except in the Pietro Maria Bardi expansion building, whose solution opted for the de-characterization of the existing building.

Concerning the underground floor, the buildings underwent structural interventions to technically make underground expansion viable. Similar to 19th-century buildings, they also received structural reinforcement to ensure the safety of the building and people. The current expansions carried out in originally independent buildings have not catalyzed urban regeneration in the immediate surroundings. However, old buildings adapted for museums had the potential to influence local development. The 'age value of materials' factor is heterogeneous between cases as the patinas of time have been removed and in an effort, in some cases to complete the decorative ornaments on the facades.

The materials that make up the (internal and external) seals are generally durable. Pina Luz's choice to maintain the visible solid masonry construction system ends up allowing the more accelerated natural degradation of the porous element exposed to the elements. In all cases, the life of the buildings was extended through their use as a museum.

Only SPMA features air conditioning in all its exhibit areas —both in the modern building and in the building rehabilitated as an expansion—. Both the Ipiranga Museum and Pinacoteca have exhibit spaces with natural ventilation and other areas equipped with air conditioning. Moreover, non-air-conditioned indoor environments tend to have greater fluctuations in temperature and humidity than environments controlled with air conditioning systems.

In all cases, the AR included technical improvements to the buildings' supporting system to ensure structural safety and the new intended loads. The finishes, in turn, were appropriately specified and (re)used from the buildings themselves, seeking to mitigate environmental impact. The technological innovations used refer mainly to the automation system dedicated to other systems, such as air conditioning, lighting, fire safety systems, etc.

The solar orientation of the annexes follows the alignments of the museums' headquarters buildings, considering that the 19th-century buildings have small vertical openings and skylights in central spaces. On the other hand, the modern building has curtain-

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wall facades on the northeast and southwest sides. The buildings reused for expansion received solar barrier elements, such as the asymmetrical weave roof at Pina Contemporânea and the aluminum membrane covering the facades of the Pietro Maria Bardi building. It is worth noting that, specifically for museums, it is necessary to filter ultraviolet radiation to avoid damages to works of art.

The proposed new exhibition spaces are designed with flexible components to meet the different demands of museography and curation.

Table 4 presents a comparative analysis between the three museums based on the Flexibility and Adaptation strategy. While Table 5 displays the universal design criteria associated with accessibility and inclusion.

Table 4
Accessibility and Inclusion strategies criteria

	Paulista Museum		**Pinacoteca**		**SPMA**	
	Ipiranga Museum	Expansion Building	Pina Luz	Pina Contemporânea	Lina Bo Bardi Building	Pietro Maria Bardi Building
Equitable Use	Yes	Yes	Yes	No	Yes	Yes
Flexibility in Use	Partial[1]	Yes	Yes	Yes	Yes	Yes
Simple and Intuitive Use	No	No	Yes	No	Yes	Yes
Tolerance for Error	Yes	Partial[2]	Partial[3]	Yes	Partial[4]	Yes
Low Physical Effort	Yes	Yes	Yes	Partial[5]	Yes	Yes
Size and Space for Approach and Use	Yes	Yes	Yes	Yes	Yes	Yes

Note. (1) There are museum spaces, such as the lobby and the main lobby in the historic building; (2) Emergency staircase in yellow demands contrast; (3) The interface between the stairs and the bleachers may cause falls; (4) Hollow cade; and (5) Regarding the main access staircase.

Source. The authors, based on Filová et al. (2022).

Table 5
Flexibility and Adaptability strategies criteria

	Paulista Museum		**Pinacoteca**		**SPMA**	
	Ipiranga Museum	Expansion Building	Pina Luz	Pina Contemporânea	Lina Bo Bardi Building	Pietro Maria Bardi Building
Configuration flexibility	Yes	Yes	Yes	Yes	Yes	Yes
Product dismantlability	No	No	Yes	No	Yes	No
Asset multi-usability	Yes	Partial[1]	Yes	Yes	Yes	Yes
Design regularity	Yes	Partial[2]	No	Partial[2]	Yes	Partial[2]
Functional convertibility	Yes	Yes	Yes	Yes	Yes	Partial[5]
Material reversibility	Partial[3]	Yes	Yes	No	Yes	Partial[3]
Building maintainability	Partial[3]	Partial[3]	Partial[3]	Partial[3]	Partial[3]	Partial[3]
Resource recovery	Partial[4]	Yes	Yes	Yes	No apply	Yes
Volume scalability	Partial[5]	Yes	Yes	Yes	Yes	Partial[5]
Asset refit-ability	Yes	Yes	Yes	Partial[6]	Yes	Partial[6]

Note. (1) Mainly in the atrium, *loggias* and expansion areas with metal structure (top); (2) Despite the proposed modulation, the openings created present dimensional variation; (3) Limited by the envelope; (4) Limited to reused wooden flooring from the dismantled rooms of the historic building; (5) Large air-conditioned exhibition spaces have limitations regarding floor-ceiling partition; and (6) Limited to small interventions during the operation and maintenance stage.

Source. The authors, based on Hamida et al. (2022).

The criteria fulfilled as 'partial' are predominantly related to the limits imposed by the constructive and aesthetic elements of historic buildings.

Vertical Axial: Micro Scale

This section takes up the environmental and heritage dimensions of the cases studied (Fresneda-Fuentes et al., 2022). The three museums present best practices regarding the environmental dimension (sustainability) during the expansion process. The Ipiranga Museum reused copper roofing to cover the two new exhibition galleries. The wooden flooring removed from dismantled rooms to make space for elevators, toilets, and emergency stairways was used for the expansion building. While the collection and storage of rainwater is dedicated to the external area.

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The decision-makers at Pina Contemporânea and Pietro Maria Bardi building opted for the LEED New Construction version 4.0 environmental certification process. Pina Contemporânea received Silver certification based on the verification of 53 points, on September 28, 2023, highlighting: 1) 16 % reduction in energy consumption compared to the baseline; 2) at least 50 % reduction in water consumption indoors and 100 % outdoors, also compared to the baseline. There was also a reduction in the impact on the life cycle of buildings through the reuse of historic buildings and the renovation of degraded buildings. The certification of the Pietro Maria Bardi Building is still in progress.

As for the built heritage, the Ipiranga Museum underwent extensive restoration, as did part of the complex that makes up Pina Contemporânea. As a result, access to the built heritage in the three cases was open to the public in 2023, providing visits to 651,133 people at the Ipiranga Museum, 530,235 people at SPMA and approximately 800,000 people in all the buildings that make up the Pinacoteca. Lina Bo Bardi building has a structure conservation plan (Oksman et al., 2018) —public access—, with emphasis on the need for contracting to minimize the impacts of vibration of the slab next to the main avenue, treatment of construction pathologies on the stairs, and rainwater drainage from the roof.

DISCUSSION

Architectural objects, especially those that house museums, foster the coexistence between the old and the new in their built facilities, addressing a possible path for the built environment that considers UN (2015). The existing parks in the immediate surroundings of museums: 1) Independence Park – Ipiranga Museum; 2) Luz Park - Pinacoteca; and 3) Tenente Siqueira Campos Park - SPMA (Figure 2), have the potential to promote a more suitable microclimate, both for the comfort of visitors and for the conservation of collections and buildings.

The decision-making to expand the three relevant museums studied can be explained by the confluence of several factors, such as: 1) extending the useful life of buildings (Pieczka & Wowrzeczka, 2021); 2) complying with current rules and regulations (Alhojaly et al., 2022); 3) reducing hygrothermal variations in exhibition and storage spaces (Taylor, & Boersma, 2018); 4) reducing demand for future corrective maintenance (Pieczka, & Wowrzeczka, 2021); 5) making the visitor experience more pleasant (Misirlisoy, & Gunce, 2016); 6) serve a larger audience due to fast population growth (Bortoluci, 2020); 7) and, finally, remaining in the dispute and in the discussion agenda about the aesthetic, material and political aspects (Bortoluci, 2020).

The museum institutions studied come from different sectors, such as private, state government and public universities. It is interesting that the three expansions were approximately 7,000sqm, distributed in different programs —with emphasis on air-conditioned exhibition spaces, with much larger dimensions and high ceilings, which allows receiving, within the required parameters, artworks from other institutions/entities—.

Accessibility and inclusion were also addressed in the three cases, in order to generate solutions to reduce physical barriers (Marín-Nicolás et al., 2023), such as door widths, installation of elevators and/or lifting platforms, adequate restrooms and ramps where there are floor differences for use by people with disabilities (Lynch, & Proverbs, 2019) and reduced mobility (Ravi et al., 2021). Among the universal design criteria (Filová et al., 2022), attention must be paid to the 'error tolerance' with the correction of architectural elements that ensure safe use, especially regarding the lack of contrast between unevenness.

When dealing with the flexibility and adaptability criteria (Hamida et al., 2022), attention must be paid to the precision of the execution of the regularity foreseen in the project and the maintainability of the buildings during the design phase. This will ensure adequate access and reuse of materials to carry out periodic maintenance on the facilities, including contributing to the sustainability of the building.

In this regard, the environmental and heritage dimensions were also aspects considered in the three expansions. It should be noted that two expansions received systemic treatment regarding the environmental dimension, opting for LEED New Construction certification. Among the criteria adopted, one can highlight the search for reduction in energy and water consumption —a liability for the long phase of use, operation and maintenance—. In addition to the concern for the future of the building, there were also proactive attitudes towards the preservation of the built heritage. Restorations and adaptive reuse processes were carried out. The three museums received visits between 500,000 and 800,000 people, namely, 4.5 % to 7.2 % of the population of the city of São Paulo.

Compliance with the criteria presented by international authors reveals that the similarities between the three cases are greater than the differences in the final aesthetic result. They reveal a tendency to align with cutting-edge institutions around the world. Serving as a local reference for implementing criteria that meet the current needs of the public and solutions to the challenges of large museum institutions.

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As far as limitations of the study are concerned, access to certain technical areas was restricted, and the economic, authenticity and historical, legal factors were little considered. Moreover, the limitation presented by the multiple-case method itself is that it does not allow for generalization through sampling but does permit replication in other contexts.

As a future development, a critical analysis could be carried out on museums in other Brazilian regions or even in other countries, and a dedicated museum facility management system for the use, operation, and maintenance phase could be developed, encompassing restrictions regarding historic buildings converted to exhibition spaces. A museum facility management system should address the potential guidance of the implementation of the FM organizational function, conceptualized by ISO 41.011 (ISO, 2017), or guide the appropriate support for old buildings with or without expansion to new properties.

CONCLUSIONS

This study presented similar cases of expanding exhibition spaces. The coexistence of buildings from the 19th, 20th, and 21st centuries is highlighted to meet the specific requirements of museums and the enjoyment of the built environment over time.

These studies' main discovery lies in the efforts to extend the life of buildings based on the necessary adjustments for improved usability and a structure that supports new loads. Other discoveries were: 1) the relationship maintained between the interior and exterior, making the neutral cube completely hermetic, and 2) the lack of attention to two concepts in the heritage field-minimal intervention and the potential for reversibility.

However, the underground spaces deserve to be observed over the next few years to identify the performance of the construction systems adopted concerning watertightness, especially the exhibition rooms located on these levels. On the other hand, the drive to offer international-class exhibition rooms required the three museum institutions to have large continuous spaces with control of environmental conditions and, consequently, the installation of sophisticated air conditioning and automation equipment, which will impact the expertise required for the operation and maintenance of these new spaces.

Similarly, it is important to analyze the future performance of the facilities considering possible new degradation conditions imposed on the artworks installed in the spaces. This includes assessing visitors' perceptions of the changes to the buildings after the AR process and monitoring any construction pathologies following the alterations made to the old buildings.

Based on this study, it is recommended to address user requirements (e.g. structural safety and durability of components, elements, and systems) aligned with compliance with the guidelines of the built heritage discipline such as minimum intervention, potential for reversibility, explicitness of alterations, and creativity in the intervention project.

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CONFLICT OF INTEREST

The authors have no conflicts of interest to declare.

AUTHORSHIP STATEMENT

Marcus Vinicius Rosário da Silva: Conceptualization, Data curation, Investigation, Methodology, Visualization, Writing – original draft, Writing – review & editing.
Sheila Walbe Ornstein: Funding acquisition, Methodology, Supervision, Writing – original draft, Writing – review & editing.

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