Journal of World Architecture, 2025, Volume 9, Issue 4
https://ojs.bbwpublisher.com/index.php/JWA
Online ISSN: 2208-3499
Print ISSN: 2208-3480

Intelligent Evaluation System of Industrial Heritage Museum Building Based on Completion and Use

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Abstract: This study investigates the application of smart building technology in museum architecture and proposes a corresponding evaluation system. It focuses on three main aspects: first, the integration of smart building technologies in museum facilities, including power supply and distribution, security, and intelligent monitoring systems, which capable to enhance operational efficiency and user experience; second, the role of architectural design in exhibition layout, HVAC systems, and energy-saving measures to optimize energy use and environmental adaptability; and third, the use of information technologies like data management and virtual displays to improve museum management and service quality. The study aims to develop a scientific evaluation framework to assist decision-makers and architects in effectively assessing and selecting smart technologies for museum buildings. By optimizing design and operations, this approach seeks to enhance exhibition quality, resource utilization, and visitor satisfaction, thereby promoting the advancement of the museum industry.

Keywords: Smart building; Smart museum; Research on evaluation system; Industrial heritage

Online publication: 4th September 2025

1. Introduction

The industrial revolution began in the UK in the 1860s. It not only brought epoch-making technological innovations in production, but also led to industrial buildings, a new type of building that can adapt to large-scale production activities. After the founding of the People's Republic of China. China urgently needs to synchronize the development of the world's industry, and quickly complete the transformation from a backward agricultural country to an advanced industrial country. Driven by clear industrialization goals such as the "First Five-Year Plan", China began to carry out large-scale standardized plant, large-scale workshop and industrial facilities [1].

In the 1990s, the transformation of economic structure began to develop the adjustment and upgrading of industrial structure oriented by service industry and the implementation of the policy of retreating two into three, "that is, the second industry launched the urban area and the third industry entered, resulting in a large number of traditional urban factories to close, stopping, merging and transferring" and leaving behind a large-scale industrial complex with special location. As these industrial relics have the free exhibition line formed by large-span factories, the architectural style containing industrial aesthetics and the historical memory and cultural value of the city, they are precious reusable urban heritage in the context of the current urban renewal pursuit of land use and functional upgrading and the rise of the concept of spatial activation and reuse. Among them, the transformation of industrial buildings with outstanding historical, cultural and artistic values into museums and art galleries has become a widely recognized and effective activation path. This transformation not only effectively protects the authenticity and integrity of the heritage space, but also gives it a new public cultural function, organically integrates into the modern urban texture, and coordinates with contemporary urban life and sustainable development.

2. Post-use wisdom evaluation of smart buildings and museums

2.1. Research status at home and abroad

2.1.1. Research status of intelligent building at home and abroad

The impact of the development of information technology has given birth to people's new requirements for architecture. For the first time, the United States has integrated the concept of "intelligence" into buildings, which has led to the rise of intelligent buildings. However, the current development of global smart buildings is still in the initial stage of exploration based on the integration of intelligent building technology principles and information technology development [2].

As a key symbol in the development of intelligent buildings in the United States, Bloomington Shopping Center integrates Bluetooth technology, internet of things monitoring system, identification and positioning system and other intelligent technologies, effectively solves the problem of supply logistics, reduces operating costs, and improves work efficiency. Relevant statistics show that 70% of new projects in the United States in 2016 have applied intelligent building technology, and many government projects under construction and large-scale investment projects generally put forward the requirements of intelligent design. In addition, the attention of green environmental protection, energy conservation and sustainability were also increasing. Canada's Toronto United Alphabet Google opened its first smart city complex in 2023 [3]. The German government promotes the development of market technology and helps the deep expansion of the smart building market by actively holding an international professional exhibition, Intersec Building.

Although the intelligent building started late in China, the development process of the market has ranked among the world's leading ranks. Ali's "White Paper on Smart Architecture" released in 2017 provides an important reference for existing problems and transitional research. In 2018, it reached about 550 billion yuan, of which new construction accounted for about 60% and transformation accounted for about 40%. Most of the new projects are supported by foreign enterprises. For example, Johnson Controls Asia Pacific Headquarters Building, its energy consumption is about 40% lower than the domestic standard. Lize SOHO, a new landmark in Beijing, effectively avoids unnecessary energy consumption with the help of an efficient building integration platform. This energy-saving solution is a comprehensive solution for weak electricity provided by Honeywell. In 2019, China took the lead in formulating international standards for smart buildings, and international recognition increased. In 2020, the “Smart Building Evaluation Standard” was released, with seven indicators to promote the industry to conduct a comprehensive assessment, standardized and refined development.

2.1.2. Research status of smart museum architecture at home and abroad

As a branch of the field, the wisdom museum building has low social attention. Although there are commonalities with smart cities in the underlying technologies such as internet of things architecture and data integration, the unique functional attributes of museums, such as cultural preservation and educational communication, make their technical application paths significantly different. At present, a mature and systematic paradigm for the construction of smart museums has not yet been formed internationally. However, institutions represented by Europe and the United States have achieved initial results through technical pilots, such as the digital twin of the Louvre, the AI security of the British Museum, and the adaptive lighting of the metropolis, and have carried out cutting-edge explorations in the dimensions of environmental monitoring and audience service. In terms of academic research, the empirical literature currently available focuses on a small number of head museum cases. In addition to the afore mentioned institutions, there are only sporadic reports on the energy management optimization practice of the Vienna Museum of Art History and the immersive navigation system of the Chicago Museum of Art. The scarcity of cases reflects that the field is still in the stage of fragmented practice, and it is urgent to establish a universal construction framework. The wisdom characteristics of foreign countries are directly reflected in the visitor “experience”, such as the analysis of user data habits of Australian Museum of Art; interactive Map of the Spencer Museum of Art; the interactive wall of the Cleveland Museum of Art and so on [4]. The “Smart Museum Case (Series 1)” introduces the cases of intelligent practice of 10 museums in Europe and the United States, and provides a reference for domestic development.

China’s research on the construction of smart museum began in 2012. From 2012 to 2022, a total of 232 articles were retrieved with the keyword “smart museum”. The earliest one is “Smart Museum, My Museum-Museum Audience Experience System Based on Mobile Application” written by Zhang Yu and Wang Chao in 2012 [5]. The number of studies increased rapidly after the National Cultural Heritage Bureau identified seven pilot units in 2014, and peaked at 37 in 2018. Through practice, these pilot museums have initially achieved the results of intelligent system construction: the application has been well received by the audience, and the experience has been recognized by the industry. The “Smart Museum Case (First Series)” published in 2017 summarizes nearly 20 cases at home and abroad and the first batch of pilot results. In recent years, research has shown an interdisciplinary trend. Scholars have discussed its theoretical and practical value from multiple perspectives to promote the construction of the National Smart Museum.

2.2. Intelligent evaluation

The smart building evaluation system is a key tool to measure the degree of building intelligence, performance and sustainable development. It provides a scientific evaluation framework and decision-making basis for the planning, construction, operation and optimization of smart museums. Nowadays, the market’s evaluation of smart buildings is mainly focused on the extension of green energy saving and intelligent management. Smart buildings can be regarded as the result of intelligent green buildings. The smart building evaluation system is a tool to measure the degree of intelligence, performance and sustainable development of buildings. The evaluation framework and decision-making basis are applied to the construction and operation of smart buildings. At present, the core of the intelligent evaluation system is to use big data, artificial intelligence and Internet of things technology to realize data collection, analysis and feedback, so as to improve the scientific and efficiency of decision-making [6]. For example, in the construction of smart museums, both the European Union's Horizon 2020 plan and the United States "Saving America's Wealth plan" have realized the intellectualization of cultural relics protection and display through information technology [7]. However, due to the particularity of industrial heritage museum buildings, such as the complexity of building structure, the need for functional transformation and the multidimensional nature of visitors' experience, a targeted intelligent evaluation system has not yet been formed. This research gap provides an entry point for the discussion of this article.

2.3. Post occupancy evaluation

Post-Occupancy Evaluation (POE) was first proposed in the field of environmental psychology in the 1960s. The main significance of POE is to improve the design quality of buildings, cities and environments as an effective and direct feedback mechanism. The basic method of post-occupancy evaluation in the world comes from the book "Post-Occupancy Evaluation" published by Pletcher in 1988. According to the definition under Pritzker, post-occupancy evaluation is a systematic and formal evaluation process. People can choose to invest different degrees of time, energy and resources in a building, and finally get a satisfactory evaluation result in one or two days, one or two months or longer [8]. POE can be divided into three types: declarative POE, investigative POE and diagnostic POE. The declarative POE is relatively short in that the evaluation team members have a deep understanding of the building type and have rich experience in post-use evaluation. Investigative POE carries out detailed and accurate analysis of specific problems, and requires horizontal and vertical evaluation of technical aspects; diagnostic POE integrates a variety of methods to conduct horizontal comparative evaluation of similar buildings, which is time-consuming and costly. Regardless of the scale type evaluation method of the object, the basic framework of the evaluation is shown in Figure 1.

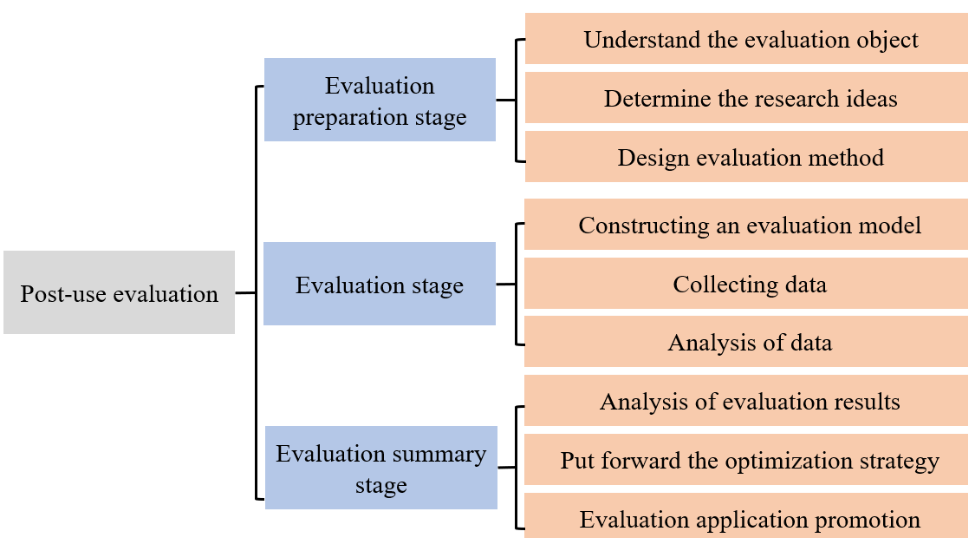

Figure 1. Post use evaluation flow chart.

Post-occupancy evaluation of museum is a systematic evaluation method, which aims to provide a basis for subsequent improvement through quantitative and qualitative analysis of the use effect of the built environment.

The process usually involved three stages: data collection, analysis and feedback, involving many aspects such as visitor behavior pattern, space use efficiency and display effect. In the industrial heritage museum building, the application of POE is special, because it not only needs to pay attention to the functionality of the building itself, but also needs to consider the cultural value and display needs of the industrial heritage. For example, the study of Qingdao Zhonglian U Valley 2.5 Industrial Park shows that visitors have a high degree of satisfaction with the cognition and external space environment after building renovation, but there are deficiencies in supporting facilities and greening environment [9]. This result highlights the importance of POE in the evaluation of industrial heritage museum buildings, and also provides a practical reference for the construction of intelligent evaluation system.

3. Construction of wisdom evaluation system

The post-use evaluation of the museum is a process of evaluating the performance of the museum and its intelligent system through scientific methods after it is put into use and whether the intelligent system meets the design goals and user's operational needs. Its particularity lies in three objects: collection environment, audience experience and operation management. It is enough for the ordinary building POE to pay attention to the human experience, but the museum also needs to monitor the preservation status of cultural relics.

3.1. Determination of indicators

The protection and utilization of industrial heritage museums is the core of the intelligent evaluation system. The key is to balance the authenticity, integrity and modern functional requirements of the heritage. The protection should follow the principle of circular regeneration, and the evaluation index should include the comparative analysis of the architectural elements and the original state, the integrity maintenance of the single building and the spatial layout [10]. The use level focuses on spatial plasticity and the rationality of functional transformation design, providing a basis for the continuation of historical value and future development. At the same time, reuse needs to be combined with regional characteristics, and the evaluation system must be included in the economic dimension. Sustainable development can be achieved by integrating historical and cultural values and economic values, such as the revised case of Suzhou industrial heritage.

The evaluation criteria of the exhibition effect cover three aspects, first, the scientific and artistic nature of the exhibition display, through the combination of static and dynamic layout to enhance the attraction and audience understanding; the second is the spatial planning and narrative logic of exhibition design to ensure the coherence of content; the third is the advanced nature of display technology, such as the internet of things technology to achieve environmental monitoring and exhibit protection, and big data analysis to optimize the display form. The combination of intelligent security and exhibition system can comprehensively improve the display efficiency [11].

Visitor experience evaluation focuses on process optimization, comfort improvement and interaction enhancement. It is necessary to evaluate the rationality and convenience of the visit streamline design to avoid congestion caused by a single route; monitoring environmental comfort parameters, such as temperature and humidity, air quality, lighting and supporting facilities; the introduction of interactive experience technology to enhance the sense of participation and memory depth [12].

The evaluation of operation and management efficiency emphasizes the application of intelligent means: daily operation realizes data-driven decision-making through energy consumption monitoring of the Internet of Things, improves efficiency and promotes energy conservation; resource management needs to evaluate the rationality of exhibit maintenance, facility maintenance and human resource allocation; security relies on intelligent security system for real-time risk early warning. Efficient management is the basis for reducing costs and optimizing services.

To sum up, the intelligent evaluation system integrates the multi-level indicators of the four dimensions of protection and utilization, display effect, visit experience and operation management. The specific evaluation indicators are shown in Figure 2. It systematically evaluates the comprehensive performance of industrial heritage museums in heritage protection, functional adaptation, audience service and long-term operation and maintenance, so as to ensure a balance between historical inheritance and modern development.

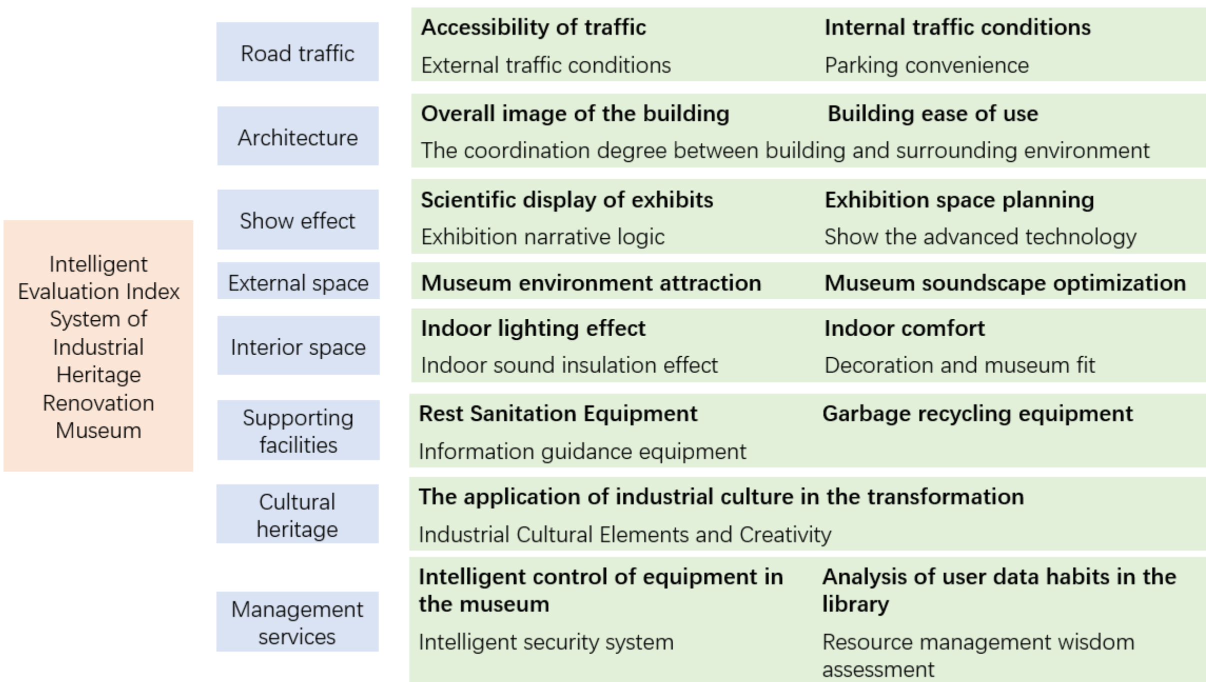

Figure 2. Intelligent evaluation index system of industrial heritage renovation museum.

4. Summary

The research focuses on the construction of industrial heritage museum buildings, aiming to construct a set of intelligent evaluation system to promote the scientific development of buildings in this field. The feasibility and effectiveness of the constructed evaluation system are verified by two typical cases: the former site of Zhujiang Brewery in Guangzhou and the Shanghai Museum of Contemporary Art in Shanghai, China. The industrial heritage museum is not only "old bottled new wine", but also through spatial narrative, technical restoration and format reconstruction, so that abandoned factories become urban cultural chips. The core of success lies in: awe of historical traces, embrace innovative functions, and balance public welfare and profitability.

Funding

Jiangxi Province Intelligent Building Engineering Research Center Open Fund Project (Project No.: EZ202311417).

Disclosure statement

The authors declare no conflict of interest.

References

[1] Zeng G, Wang C, 2005, Political Economics, Chongqing University Press.

[2] Wang Y, 2020, Research on the Evaluation Index System of Building Equipment in Smart Museum. China Equipment Engineering, 2020(17): 32–33.

[3] Liu T, 2021, Smart Building Evaluation Method and Its Application Research, thesis, Jianzhu University.

[4] Zuo W, 2021, Study on the Construction of Smart Museum Ecosystem, thesis, Henan University.

[5] Zhong G, Zhang J, 2020, A Review of the Research on Smart Museums in China. Science Education and Museums, 6(5): 347–354.

[6] Li H, Li Y, Wang R, 2021, Preliminary Study on the Construction Standards and Evaluation Methods of Smart Museums. China Museum, 2021(1): 87–93.

[7] Shi X, Li H, Wang R, 2023, Research on the Construction of Smart Museum and Evaluation Criteria. Information Technology and Standardization, 2023(11): 59–63.

[8] Hanmer, 2019, Subjective Feeling Evaluation of Architectural Space Based on Spatial Fabric Theory, thesis, Tsinghua University.

[9] Guo Y, Zhao M, Wang R, et al., 2022, Post-evaluation of the Built Environment of Industrial Heritage Renovation Creative Industrial Parks: Taking Qingdao Zhonglian U Valley 2.5 Industrial Park as an Example. Urban Architecture, 19(22): 26–28 + 49.

[10] Jing S, 2022, Thoughts on the Protection and Reuse of Museum Chemical Industrial Heritage. Construction Technology, 2022(23): 83–85 + 91.

[11] Luo C, Wang D, 2023, Construction of Industrial Heritage Evaluation System Based on Urban Multi-dimensional Value: Taking the Revision and Application of Suzhou Industrial Heritage Evaluation System as an Example. China Famous City, 37(4): 29–36.

[12] Nie H, Li C, Su H, 2023, How to Build a Smart Museum. Intelligent Building Electrical Technology, 17(2): 26–30.

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