Design Study on the Conservation and Reuse of Modern Industrial Building Heritage

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Abstract. As an important part of the world cultural heritage, industrial architectural heritage is an important witness to the achievements of the development process of human industrialized civilization. With the national industrial structure adjustment and urbanization, many typical industrial factories in China are facing the problem of land replacement, among which, the modern industrial architectural heritage is facing the corresponding problem of conservation and reuse. People's demand for material and cultural life is increasing, and they are more concerned about the protection of urban heritage and memory, which actively promotes the protection of industrial architectural heritage and also puts forward higher requirements for the utilization of industrial architectural heritage. The research in the field of industrial heritage in China started late compared to that in Europe and the United States, and usually, architects dominate the design of industrial heritage reuse more than heritage conservators. This paper addresses the problems in the process of conservation and reuse of industrial architectural heritage, and carries out research work from the perspective of heritage conservation and reuse design. It analyzes the current situation of industrial building heritage reuse design in China and conducts research on the problems existing in the process of industrial building reuse design. It also discusses the bottom line and criteria for the conservation and reuse of industrial building heritage, and discusses the design strategies for the conservation and reuse of modern industrial building heritage according to the industrial building research results in categories.

1. Introduction
Since the 21st century, the holistic conservation and adaptive reuse of old industrial buildings in cities has received widespread attention and influence around the world. China is in a period of urban renewal development with parallel industrial restructuring and socio-economic development, and the drawbacks of traditional industrial city construction and layout are becoming more and more prominent, which urgently requires research on industrial architectural heritage conservation and renovation [1]. The disciplinary trend of heritage conservation in the new period has put forward new requirements for the field of industrial architectural heritage conservation and reuse. The scope of protection of industrial heritage extends from industrial building monoliths to urban industrial lots and building clusters, the protection level specifications from heritage buildings to ordinary old industrial buildings, and the protection methods from static pure protection to dynamic adaptive protection and organic combination of reuse. China's modern industrial architectural heritage has rich types and spatial morphological characteristics, and industrial buildings in different regions in different periods have remarkable diversity [2].
In China, the vast majority of industrial architectural heritage does not belong to cultural relics and has great potential for reuse, and in practice, specific reuse designs are carried out through designers. The reuse of industrial architectural heritage is premised on its protection [3]. When designing the reuse of industrial architectural heritage, architects need to understand its value evaluation index, and according to the results of the reuse value evaluation of industrial architectural heritage, they correspond to get the authenticity elements that need to be protected. Thus, in the subsequent design of industrial architectural heritage, the creative value is created while respecting the inherent value of industrial architectural heritage [4].

2. Preservation and reuse of modern industrial building heritage

2.1. Conservation and Utilization of Industrial Building Heritage Abroad

Modern urban architecture and old buildings form a disjointed contradiction, and preserving and transforming old buildings into new vitality for the future requires giving it a new capacity for life. The reuse of industrial building heritage is clarified in ICOMOS as: the introduction of new functions in old buildings and recycling, generally embodied in the overall renovation and repair of industrial buildings. The conservation of industrial building heritage in western developed countries originated in the birthplace of the industrial revolution in central England. By the 1960s, under the impetus of industrial archaeology, the theory of industrial building heritage conservation was initially formed, and the research and social concerns for industrial building heritage have been increasing. The developed countries in Europe and America have preserved a large amount of industrial architectural heritage, therefore, the conservation and reuse of old industrial architectural heritage in these developed countries started far earlier than other backward countries. The change of urban functions and the adjustment of industrial structure have led to a large number of industrial buildings such as factories and warehouses being left unused [5]. Those old industrial buildings in cities that have ceased to be used and have been left idle and abandoned have received attention in western countries due to the development of the urban renewal movement. In the late 1980s, Japan specifically organized a large-scale comprehensive survey on the preservation of production facilities, plants and buildings of industrial building heritage. At the International Architecture Association, we have focused on excellent cases of preservation and reuse of industrial building heritage, and promoted the preservation and use of industrial heritage with the theme of "resource architecture". Considering the overall industrial structure and development strategy of the city, the focus of the study on the conservation and reuse of industrial architectural heritage focuses on the close connection and interaction with cultural and creative industries [6]. The effect of conservation and reuse of Amsterdam City West Gasworks in the Netherlands is shown in Figure 1.

![Figure 1. Effect of conservation and reuse of gas plant in Amsterdam City West, Netherlands](image)

2.2. Conservation and Utilization of Industrial Building Heritage in China

In the late 1990s, all sectors in China gradually realized the historical value of industrial architectural heritage, which is a tangible carrier of the history of national industrial development. In this context,
Chinese academics have drawn attention to the conservation and reuse of industrial architectural heritage and conducted in-depth investigations and studies. In recent years, there have been more and more successful cases of implementing conservation and reuse of industrial architectural heritage, not only in large cities, but also in small and medium-sized cities, where the conservation and transformation of industrial buildings is carried out according to the characteristics of urban development, forming its unique spatial atmosphere in the city [7]. China has certain differences and characteristics in the current industrial heritage protection concept due to different national conditions and different historical development processes; the protection of China's industrial heritage has the tendency of thick in the past but thin in the present. The main differences are that the conservation of Chinese industrial heritage emphasizes architecture rather than equipment; the conservation of Chinese industrial heritage lacks a main body; and the conservation of Chinese industrial heritage has a tendency to be "thick on the past but thin on the present. The Shanghai Urban Sculpture Art Center is also a successful case, which serves as a good experience for the conservation and reuse of domestic industrial heritage [8]. The reuse effect of Shanghai Urban Sculpture Art Center, an industrial building heritage, is shown in Figure 2.

![Figure 2. Reuse effect of Shanghai Urban Sculpture Art Center, an industrial building heritage](image)

2.3. Problems in the conservation and utilization of industrial building heritage

At present, the transformation mode of industrial architectural heritage protection and utilization at home and abroad mainly focuses on industrial heritage landscape parks and creative cultural industries, which are also more successful after development and utilization. However, there are still many old industrial areas that are mainly transformed in a rough way ignoring the comfort and ecological enhancement of the architectural space after protection and reuse. There are many problems in the actual project process of modern industrial architectural heritage [9]. There is insufficient understanding of industrial heritage value in industrial building heritage renovation projects, lack of a systematic and mature comprehensive evaluation system for the protection and reuse of modern industrial heritage, lack of diversity in industrial heritage reuse models, single functional mode of use, no in-depth sorting and summary of reuse design elements and technical routes that reflect the authenticity of industrial heritage, and lack of reuse design that takes the protection of the authenticity of industrial building heritage as the premise. There is a lack of reuse design strategies to protect the authenticity of industrial architectural heritage.

3. Architectural design for reuse of industrial building heritage with authenticity as a criterion

3.1. The necessity of designing authenticity elements for reuse of industrial building heritage

Authenticity is an important principle for testing cultural and natural heritage, and monuments and sites must pass the test of authenticity before being inscribed on the World Heritage List. Authenticity, as an important criterion for value evaluation, is an important way to reflect the value of heritage and to reflect the preservation status of information with heritage value [10]. The conservation and use of industrial architectural heritage are different from the conservation and use of heritage buildings.
Industrial heritage places more emphasis on use, and in order to meet the needs after reuse, demolition, expansion and addition are very common ways of transformation. For industrial heritage with various values, it is necessary to clarify the values that industrial heritage has before carrying out reuse, and not to change and destroy the sources of information that reflect heritage values when transforming. Protecting the value of industrial architectural heritage is the premise of reuse. We need to take the value assessment study of industrial architectural heritage as the basis, sort out the design elements of reuse that reflect the authenticity of industrial architectural heritage, the technical route of reuse, and propose the design strategy of reuse of industrial architectural heritage with authenticity as the standard.

3.2. Designing technical routes for the conservation and reuse of industrial building heritage

Based on the technical lines of conservation and utilization of modern industrial architectural heritage and the selection of reuse design elements, we try to propose the design technical lines of reuse of industrial architectural heritage based on whether the reuse elements reflect the authenticity of industrial architectural heritage [11]. In this paper, we describe the technical route of design, which is the main responsibility of the designer and is related to the authenticity of industrial architectural heritage. The terms used in the reuse design elements are commonly used by architects in their designs and do not require much explanation; on this basis, a distinction needs to be made between the two design elements of structural system and construction. The technical route of industrial building heritage conservation and reuse is described in Figure 3.

![Figure 3. Technical route of industrial building heritage conservation and reuse design](image)

4. Design strategies for reuse of industrial building heritage

4.1. Spatial pattern design of industrial building heritage

The spatial pattern of industrial heritage buildings refers to the general layout and interconnection of each plant and its auxiliary buildings, which constitute the integral part of the overall value of industrial architectural heritage. The spatial pattern itself may reflect the technological value of industrial architectural heritage, including the importance and advancement of planning and design, the relevance to famous technicians and architects, the visual aesthetic quality of industrial buildings and other aesthetic values. We have to design the spatial pattern of industrial architectural heritage in a graded manner. For the outstanding industrial heritage with outstanding heritage value, large scale and complete preservation, the main spatial pattern usually has a certain historical value, and the protection of the authenticity of industrial heritage requires the protection of the main spatial pattern. Take the design of conservation and reuse of industrial building heritage Tianjin Cotton Three Creative Block as an example, the project demolishes industrial buildings with low heritage value and does not reflect the authenticity of heritage, and part of the land is used as urban outdoor public space for new landscape plaza and public service facilities design [12]. In the design of the reuse of this industrial architectural heritage, the other part of the site is used for new buildings, and the new buildings and public spaces are organized to the spatial order of the original factory area, so as to maximize the adaptability of the industrial architectural heritage after reuse without changing the main spatial pattern of the original factory area. Design effect of reuse of the creative district of Tianjin Minsan, an industrial building heritage as shown in figure 4.
4.2. Design of structural system for industrial building heritage
The structural technology of modern industrial building heritage was introduced from western developed countries, and unlike the traditional Chinese wooden buildings, its structure usually has strong durability. Usually, in the design of industrial building heritage protection and reuse, if the whole building is not demolished, the structure of the building needs to be reinforced and repaired without changing the structural system so that the modified structure basically meets the safety requirements. For the excellent industrial architectural heritage with complete preservation, outstanding heritage value and intact main structure, it is necessary to focus on protecting the main structural system of the building that can reflect the heritage value, and to reinforce, repair and maintain the main structural system to ensure that the authenticity of the industrial architectural heritage is not damaged. The effect of building restoration of the old site of Wuxi Zhenxin Yarn Factory, an industrial architectural heritage, is shown in Figure 5.

4.3. Industrial building heritage façade design
The façade of industrial architectural heritage refers to the style, material, organization and construction of the exterior surfaces of each plant and its auxiliary buildings. The façade of industrial architectural heritage is a component of the overall value of industrial heritage, which itself may reflect historical values such as the stated age and architectural style of industrial heritage, technological values such as architectural techniques and aesthetic values such as style schools. In the process of protection and reuse of industrial architectural heritage, the most characteristic parts of the building facades with important heritage value need to be protected; for the facades of heritage or excellent industrial heritage buildings with heritage value, the facades need to be protected in their original state; for the general industrial heritage without heritage value, all of its building facades can be considered for renewal and transformation.
5. Conclusion
Due to the production, property rights and management factors of industrial architectural heritage, field research is difficult, and it is difficult to smoothly start the general plan of the factory, building mapping and photo shooting; at the same time, due to the limitation and limited historical documentary data, many factory records lack the relevant drawings or written records of planning, architecture and other basic construction. China's industrial building heritage research is still in its infancy, and this paper has only completed the combing of the modern industrial development history and the analysis of the basic information of industrial heritage research, and there is still a lot of work that can be done. For example, the summary of a broader protection and reuse model, the support of multi-channel protection and reuse funds, the formation of a more perfect legal system, etc., are expected to provide more results for the protection and reuse of Zhengzhou's industrial architectural heritage.

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