Analysis on the Protection and Reuse of Urban Industrial Architecture Heritage

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Abstract: Since the reform and opening up, China's urbanization has developed rapidly. Due to the reorganization of the functional structure of the urban center due to the upgrading and adjustment of the urban industrial structure, many old industrial areas in the city have entered the stage of transformation, integration, and even dismantling. Where should the industrial heritage go is an important topic of current social concern. As a materialized industrial culture, old industrial buildings in cities should not be blindly abandoned or blindly overturned. They should be classified and protected or transformed and reused according to their value attributes, during the renovation process, AHP can be used to evaluate the green renovation of industrial buildings, to seek the rebirth of the industrial architectural heritage in the new era.

1. Introduction
In the middle of the 20th century, a large number of industrial buildings survived in large-scale industrial construction in China. In the 1990s, due to the decline in the proportion of heavy industry, industrial buildings in some cities that were relatively prosperous in the old industrial period appeared to be idle in large quantities. Preliminary exploration of transformation and reuse. With the passage of time and the study of mature foreign theories and practical experience, a number of excellent practical cases for the renovation and reuse of old industrial buildings have gradually emerged. At present, Chinese construction industry has entered a stage of rapid development, and the urban spatial structure will also undergo major changes. The industrial focus will shift to emerging industrial areas and suburbs, the old industrial building base in the city center will gradually decline and become abandoned. Therefore, how to transform the old building space Making it rationally used has become a crucial research topic.

2. Perception of urban industrial architectural heritage
Industrial archaeology, industrial heritage, and industrial architectural heritage are three basic concepts that are closely related. The concept of industrial heritage in China was put forward relatively late, it did not go through the stage of "industrial archaeology", so directly entered the stage of protection of "industrial heritage". Because the researcher-led field pays more attention to the "industrial architectural heritage" in the "industrial heritage", in order to emphasize the "architectural" attribute of the research object, the "industrial architectural heritage" is extracted from the industrial heritage[1].

1 Liu Boying. Overview of the protection of industrial architectural heritage [J]. Architecture Journal, 2012(01).
2.1 Cognition of the protection process of urban industrial architectural heritage
In the history of human development, the research on industrial architectural heritage began with the investigation and research of the industrial relics and remains after the Industrial Revolution by British private research groups in the 1950s based on "industrial archaeology". In 1973, the British Industrial Archaeology Society was established and held the first International Conference on the Protection of Industrial Monuments. In 1978, at the Third International Conference on the Protection of Industrial Monuments in Sweden, the first world-wide industrial heritage organization-the International Industrial Heritage Protection Committee (TICCIH) was established. In 1986, the British Iron Bridge Gorge was officially included in the "World Cultural Heritage List" by UNESCO and became the world's first world cultural heritage known for its industry. By the end of 2005, there were more than 30 sites in 22 countries around the world. Industrial heritage is included in the "World Heritage List." The theme of "International Day of Historic Sites and Sites" on April 18, 2006 was industrial heritage. The first China Industrial Heritage Protection Forum was held in Wuxi, and the constitutional document "Wuxi Proposal" on the protection of industrial heritage was passed. On November 5-7, 2010, the Industrial Architectural Heritage Academic Committee of the Architectural Society of China was established at Tsinghua University. This is the first academic organization in the field of industrial architectural heritage protection in China[2].

2.2 Value perception of urban industrial architectural heritage
Since the Industrial Revolution in the 18th century, a large number of industrial buildings have emerged, creating a rich industrial culture. Industry has become the leading industry in urban development, while other industries have gradually developed along with the emergence of industry. The rapid development of industry has changed people's lives while also greatly changing the appearance of the city. The buildings, industrial plants, equipment and streets left over from the industrial period have become part of the urban industrial landscape after years of baptism. The industrial buildings that carry the culture and memory of the industrial period are the "living fossils" for future generations to understand and learn industrial history, and have far-reaching significance in the development history and social level of a city.

"Culture is the precipitation of history, which remains in the building and merges into life."-Wu Liangyong

"Only a city where the old and the new coexist is a city in the true sense. Only by blending the past with the modern can we see a wonderful future."-Tadao Ando

2.2.1. Witness the historical value of time change
Industrial architectural heritage is the result of civilization created by mankind and needs long-term preservation and extensive exchange. Its existence preserves precious historical memories for the city, while adding cultural texture and value to the city, it also provides an important value reference for the start and development of contemporary industrial activities in the city.

2.2.2. Witness the technological value of technological progress
Preserving the industrial architectural heritage with outstanding value under different historical development stages is conducive to future generations to find a relatively complete development track of science and technology in the industrial field in contemporary production and development, and it is even more important to protect a special production process or a pioneering model.

2.2.3. Witness the social value of civilization and progress
Industrial architectural heritage records the unforgettable life of ordinary working people in each era, it is the foundation of social identity and belonging. It not only conveys relatively complete and true historical information of industrialization,

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2 Li Bingying. Discussion on the Mode of Protective Reuse of Urban Industrial Architecture Heritage [J]. Industrial Architecture, 2009 (S1): 4-6.
but also helps future generations to better understand people’s production and lifestyles during this period. It is a commemoration of the historical contributions of traditional industries and workers and the inheritance of the noble spirit.

2.2.4. The economic value of avoiding waste of resources
The formation and development process of industry often requires the injection of a large amount of manpower, material and financial resources. The protection of industrial architectural heritage can avoid the waste of resources and prevent the multiple valuable industrial architectural heritage from turning into "construction waste" during the major demolition and construction of the city. At the same time, the sustainable development of buildings can be pursued through green renovation.

3. Location and spatial characteristics of urban industrial architectural heritage

3.1. Location characteristics of urban industrial architectural heritage
With economic integration and industrial restructuring, as well as changes in traditional production technologies and transportation methods, industrial areas are constantly approaching the city center and urban areas from the edge of the city. The increase in location value also leads to differential rents of industrial land due to land price differences. Retreating from two to three, vigorously developing the tertiary industry and service and creative industries have become the main content of industrial restructuring in industrial cities[3].

3.2. Spatial characteristics of urban industrial architectural heritage
From the perspective of the spatial characteristics of the industrial architectural heritage determined by the characteristics of the production process after the Industrial Revolution, the main manifestations are:

1) “Large-span” industrial architectural heritage is generally divided into “single-story large-span type” and “multi-story multi-span type”. Buildings with large single-story spans are generally common in large warehouses, heavy industrial plants, etc., and its structure is mainly giant trusses, steel frames, arches, etc., forming a tall space with open interior without columns. "Mid-span" industrial buildings with multiple floors and large floors are often used in multi-storey factories and warehouses in light industry.

2) "Conventional" industrial building heritage, whose structural form and building form are mostly similar to ordinary civil buildings, because of the low requirements for span, it usually adopt reinforced concrete frame structures. It can be used for a wide range of purposes, and different plant spaces can be constructed according to different needs.

3) "Special type" industrial architectural heritage, buildings or structures with special shapes built due to industrial production needs, have strong landmarks, at the same time, there are certain restrictions on the transformation.

4. Analysis of the status quo of protection and reuse of industrial architectural heritage at home and abroad
As the society attaches more importance to sustainable development in the process of urban development and construction planning, the awareness of the protection of urban industrial buildings is becoming clearer, at the same time, the renovation of industrial buildings is also in full swing.

4.1. Analysis of the status quo and classic case studies of the reconstruction and reuse of old industrial buildings abroad
Beginning in the 1950s, Western developed countries began to pay attention to the protection and reuse of old industrial buildings, especially industrial heritage, and chose a compromise and more feasible

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3 Xu Qingfeng, Zhu Chunming, Zhu Lei. Sustainable Reconstruction and Utilization of Existing Industrial Buildings[J]. Industrial Construction, 2007 (12).
way between closed protection and demolition and reconstruction—reconstruction and redevelopment. Utilization, the Shanghai Institute of Building Research once organized a delegation to investigate and study the renovation and reuse of old industrial buildings in France, Britain and Germany. Now the key inspection objects are summarized as follows:

(1) Reconstruction of Docklands on the River Thames, UK

London Docklands was once one of the busiest and largest docks in the world. In the 1980s, a large number of industrial buildings on the dock were left unused. From 1981 to 1998, through the guidance of the government and the implementation of preferential policies, a large number of industrial buildings in the area were transformed into high-end restaurants, bars, shopping malls, museums, exhibition halls, etc., which increased employment opportunities and promoted the harmony of the community Development, achieving the revival and re-prosperity of the region.

(2) TATE Museum of Modern Art, UK

The predecessor of the British TATE Museum of Modern Art was the Bankard Power Plant on the Thames. According to the characteristics of the power plant, the designer arranged a two-story atrium along the longitudinal direction of the plant, forming a huge beam and a chimney in the center. A visually balanced relationship is formed, and the turbine engine hall is transformed into an exhibition hall. The transformation of this project not only meets the needs of the exhibition and collection of the art museum, but also regenerates the old industrial building and the surrounding environment[4].

In short, in the protection and reuse of industrial architectural heritage, Western developed countries start from the perspective of respecting history and inheriting culture, focusing on the long-term coordinated development of the overall urban planning, paying attention to the sustainable development of buildings. In the process of reconstruction, it pays attention to the use and protection of the surrounding environment and the combination of social science and architectural art.

Figure 1 Turbine engine hall, chimneys that contrast with the roof beams, and the original pipes retained in the restaurant

4.2. Analysis of the status quo of protection and reconstruction of domestic industrial architectural heritage

From a narrow perspective, industrial heritage is the modern industrial heritage after the Industrial Revolution. The country has only the first oil field in Daqing, the site of the first nuclear weapons research base in Qinghai, the Qiantang River Bridge, the early buildings of the Tsingtao Brewery, and Nantong. Compared with other countries, the number of 13 sites including Dasheng Yarn Factory and Hanyeping Coal and Iron Factory and mine site is very limited. This reflects that China has less protection of modern and industrial heritage and has not paid much attention to it.

4.2.1. The change of domestic attitude towards old industrial buildings

For a long time, China has often adopted a negative state of idle and abandoned industrial buildings that have withdrawn from production. If unfortunately encounter a new round of planning and construction, there is a great chance that it will be razed to the ground mercilessly. However, in recent years, Inspired by Western developed countries’

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4 Zhang Zhe, Zhou Yi. Reconstruction and reuse of historical industrial buildings[J]. Shanxi Architecture, 2009(30): 39-40.
reutilization of abandoned factory buildings and industrial buildings, relevant domestic industry professionals and government departments have also carried out research on the protection and reutilization of old industrial buildings. Old industrial buildings have gradually changed their tragic fate.

4.2.2. Main achievements of domestic old industrial building protection Shanghai has been developing creative industries since 2005, through the transformation and reuse of industrial buildings, within the construction land area of the 2010 World Expo planning area, about 70 houses and old industrial buildings of about 500,000 square meters will be preserved and transformed. No. 210, Taikang Road, Shanghai, was originally a machine parts factory built by the Japanese in the 1930s[5].

Beginning in 2006, under the joint appeal of experts, scholars, the public, and social media, Beijing began to investigate and research the heritage resources of industrial buildings such as 798, Shougang, and Beijing Coking Chemical Plant, combining the research topics of the Planning Commission and the Industrial Promotion Bureau. A census of Beijing’s key industrial heritage resources was conducted, the "Beijing Industrial Heritage Evaluation Criteria" was determined, and the "Beijing Guidelines for the Protection of Industrial Heritage" were issued.

Tianjin has become the focus of the third national cultural relics census due to its rich modern industrial heritage. More than 30 industrial heritage sites have been registered, including Tianjin Machinery Bureau, Beiyang Bank and Yuan Bureau, Mint General Factory, Dagu Dock, Power Airport, A group of modern industrial architectural heritages such as the Fujuxing Machine Factory and the French Electric Light House.

Liaoning Province, Hubei Province, Shanxi Province, Lanzhou City, Wuxi City, Ningbo City and other regions have also made outstanding achievements in the protection of industrial architectural heritage.

5. Classification and protection and utilization mode of urban industrial architectural heritage

5.1. Historic industrial buildings

5.1.1. Examples of historic industrial buildings Historic industrial buildings focus on the word history, that is, the preserved buildings and locations are either associated with historical figures or historical events on the historical stage, or used as a historical mirror image, reflecting the social outlook and superb craftsmanship in a specific historical period.

For example, the Lushun Shipyard, which was built in 1890, was the largest military factory in northern China at that time. Its large dock was known as the largest dock in East Asia at that time. The water pipeline was the earliest water supply facility at that time. At the end of 1902, the Dalian Shipyard was completed and put into production and its supporting central power plant was the only power plant in Dalian at that time.

Another example is the Beijing Jingxi Coal Mine, which is currently the most complete mining area in the country where the original ecological environment of ancient mining is preserved. While coal mining, different folk customs are also derived. These are precious industrial cultures[6].

5.1.2. Characteristics of historic industrial buildings From the above two examples, it can be found that historic industrial buildings and their locations have the following characteristics:

1) It has important historical and cultural value

A historic industrial building is like a history book. It not only witnesses the historical trend and development process, but also records the continuous improvement of industrial engineering technology in the process of industrial development. On the other hand, due to the inheritance of folk customs and

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5 Liu Jinwei, Zhou Baowei. New progress in the renovation and reuse of old industrial buildings[J]. Industrial Construction, 2008(08): 31-34.

6 Tang Liping. Discussion on Rebuilding and Reusing Old Industrial Buildings[J]. Urban Construction Theoretical Research (Electronic Edition), 2011(21).
traditional culture, they also have emotional functions such as identification, belonging, and commemoration.

2) The historical value is higher than the value of the building itself
As the non-renewable carrier of human industrial culture, the historical value of historic industrial buildings has far exceeded the value of their buildings themselves, and more is the embodiment and inheritance of industrial civilization.

5.1.3. Transformation methods of historic industrial buildings For historic industrial buildings, both domestic and foreign countries adopt the method of preservation and protection of cultural relics and historic sites for reuse, during the transformation process, the original form is retained to the greatest extent. The main methods are as follows:

1) Keep the original appearance and update the function
The main structure and appearance characteristics of the original building are retained, and the internal space is rationally transformed according to the functional requirements of the use. The historical identity of the industrial building itself is the key point. At the same time, the surrounding environment of the building is appropriately transformed to form an urban industrial landscape.

2) Restore the original appearance and rebuild the old site
The damaged historical industrial buildings can be restored in key parts, and the old site can be reconstructed according to the original appearance, so as to restore the buildings and culture that have left a deep mark in people's hearts and deepen the industrial cultural connotation of the area.

5.1.4. Transformation direction of historic industrial buildings The historicality itself is a kind of exhibition, and its transformation direction will also be restricted to a certain extent. The transformation directions of historic industrial buildings at home and abroad are mainly as follows:

1) Direction of theme museums and exhibition halls
This type of transformation is mainly in the form of collections and exhibitions to show the public the production machines, production lines and production techniques of the time, focusing on the inheritance and development of industrial civilization at that time. For example, a foreign laundry with a long history has been transformed into an exhibition hall showing the development of clothes washing methods. Another example is the Manchester Museum of Science and Industry in England, and the National Railway Museum in York.

2) Industrial Expo and Business Tourism Direction
Build an industrial expo or industrial museum, hold a large-scale industrial exposition, and at the same time integrate with business activities and tourism industries. For example, the Jiangnan Shipyard will be transformed into the "Corporate Pavilion" in Shanghai World Expo Park, which can be transformed into a large-scale industrial exhibition after the Expo Pavilion and supporting related entertainment facilities.

3) The direction of theme parks and creative cultural industry parks
Historic industrial buildings can also retain the main industrial buildings in the center during the renovation, and the surrounding environment will be reconstructed and developed with the building as the center, forming a theme park that echoes the industrial plants, such as the Ruhr Industrial Zone in Germany after the implementation of the revitalization plan in 1989. It not only retains the old sites of cinder hills and steel mills, but also leaves a large area of open green space and lakes. The supporting cafes, bars, food courts, and various amusement facilities and entertainment centers greatly increase its tourism and public service.

5.2. Non-historical industrial buildings

5.2.1. Examples of non-historical industrial buildings The "non-historical nature" of non-historical industrial buildings does not mean that there is no history, and there is history when it exists. It's just that the history is short, and its historical value is small compared with its architectural value. For
example, a large number of renovated industrial buildings in the Shanghai World Expo Park are such old industrial buildings.

5.2.2. Characteristics of non-historical industrial buildings
1) Strong architectural properties
   Generally, industrial buildings are high-quality buildings with strong structures and huge volumes, and abandoned industrial buildings are a large number of high-quality construction resources.
2) Unique spatial structure
   Industrial buildings such as warehouses, workshops, and production workshops are large in volume, with open internal spaces and high storeys. The general industrial workshops have a bent frame structure with a column spacing of 6-9m, which is sturdy in structure and can be separated into two spaces.
3) Strong plasticity and easy to transform
   Because the non-historical industrial buildings are not very historic, they can be rebuilt and expanded on a large scale to make them have architectural functions in the new era, reducing the waste of construction resources and giving the old industrial buildings a new lease of life.

5.2.3. Transformation methods of non-historical industrial buildings
   For non-historical industrial buildings, it is not feasible to adopt the “formalin” protection of cultural relics and historical sites, the unique characteristics of the building should be used for tailor-made transformation. The main means of transformation are:
   1) Partially demolished and re-layout
      Some buildings or structures with no use value can be demolished to update the functions of old industrial buildings and create more favorable use spaces. At the same time, the surrounding areas of the building can be re-distributed and developed to meet the functions of the new areas and maintain long-term vitality.
   2) Retain the structure and comprehensively transform
      For old industrial buildings with strong structures and good performance in all aspects of the building, the original structure can be retained. With the help of structural engineers, they can be added and re-planned indoor space, which not only avoids the waste of resources of major demolition and construction, but also Industrial buildings can be used as the theme to create relevant event venues with industrial cultural feelings.

5.2.4. Transformation direction of non-historical industrial buildings
   The volume of non-historical industrial buildings is huge, and there are more directions and possibilities for renovation, designers should be open-minded, and make bold attempts in the renovation and reuse of industrial buildings while paying attention to the protection of industrial heritage. For example, in Neunkirchen, Germany, the cinema renovated by the water tower, the Water Culture Museum of Mühlheim, can also transform the industrial site into a park, such as the North Duisburg Landscape Park in Germany and the Maximilian Children’s Park.

Figure 2 The MOIS Museum in Manchester and the cinema renovated by the water tower in Neunkirchen, Germany
1) Direction of Cultural and Creative Industry Park

The cultural and creative industry park is at the embryonic stage in China, and there are few classifications of them, the transformation of non-historical industrial buildings is classified as "old factory buildings and warehouses as location dependencies" in the division of location dependencies. The Dashanzi Art District, which appeared earlier in China, relies on the old factory building of the 798 Factory, Jiuxianqiao Road, Chaoyang District, Beijing. These creative parks are a good demonstration of the combination of cultural industry, industrial historical building protection, cultural tourism, and the combination of architectural value, artistic value, historical value and economic value.

| Construction area | project name | Initial function | Modification method | Function after transformation |
|-------------------|--------------|------------------|---------------------|------------------------------|
| 20000 m²          | Sixing creative depot | Shanghai Sixing Warehouse built in 1927 | Keep the warehouse and steel-concrete structure, and separate the internal space | Urban planning, architectural design, advertising shooting |
| 12700 m²          | Media Cultural Park | Shanghai Aviation Equipment Factory built in the 1980s | Keep the architectural framework, re-separate the interior space and decorate | Animation art, television production, photography studio |
| 40000 m²          | Creative Industry Park | Old textile factory built in 1932 | Keep the architectural framework, re-separate the interior space and decorate | Modern art trade exhibition halls, artist studios |
| 20000 m²          | Tianzi Fang | Lane factory in the 1930s | Keep the architectural framework, re-separate the interior space and decorate | Design industry (architecture, clothing, interior, pattern) |

2) Direction of tourist shopping center

It refers to the establishment of a shopping center in the center of a scenic spot developed by an industrial building or the use of the reconstructed building itself, equipped with cafes, bars, gyms and other entertainment venues, to create a comprehensive development direction integrating shopping, tourism, leisure and entertainment. For example, the Vienna Gas Plant transformed four huge gas storage tanks into a presidential suite, a 5A-level commercial building, a store and an entertainment center, and became a local tourist attraction.

3) Makerspace direction

In the context of the new era of "mass entrepreneurship and innovation", the executive meeting of the State Council has deployed strategies for the development of makerspaces and the construction of dual-innovation bases, encouraging the use of abandoned factories and warehouses to transform into makerspaces[7].

4) Display space direction

The exhibition spaces are mainly industrial exhibitions, expositions or museums transformed into other themes, similar to the transformation of historic industrial buildings, so I won’t repeat them here.

5) Business direction

The World Expo Design Building project renovated by Shanghai No. 3 Printing and Dyeing Factory is hailed as the "First Building of the World Expo" in the industry. After the transformation, it will be mainly used as the command center for the Shanghai World Expo 2010, with functions such as display, office, and meeting.

6. Conclusion

The protection and reuse of urban industrial heritage is of great significance. With the rapid development of urbanization in China today, relevant laws and regulations should be formulated as soon as possible.

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7 Dong Lili, Wang Wei, Peng Yunni. Reconstruction of old industrial buildings into a suitability strategy for heavy space damage[J]. Industrial Architecture, 2019(02): 31-37+79.
to protect it, and professional scholars and designers should be encouraged to transform and reuse the industrial heritage in a realistic manner. To avoid the unfortunate disappearance of precious industrial civilization under the drastic measures of urban construction and development. We must actively learn from the advanced experience of developed countries in the renovation and reuse of industrial buildings, combine the characteristics of China’s development, and start from respecting history, protecting culture and building a sustainable society, and explore an urban industry that is compatible with China’s economic, cultural and environmental development. The road to protection and reuse of architectural heritage!

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