Research on Adaptive Facade Renovation Design of Industrial Architectural Heritage: A Case Study of Nanjing Hutchison Factory

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Abstract. The post-industrial era witnesses the gradual decline or transformation of China's traditional industrial industry. Meanwhile, the original facade design of most of the existing industrial architectural heritage can no longer keep up with the pace of the times, which left a lot of issues that need to be considered and studied urgently in the renovation of industrial architectural heritage. In this article, the adaptive facade renovation design of industrial architectural heritage was studied and effective design strategies were summarized. Firstly, the research background of adaptive renovation of industrial architectural heritage and the research objects in this article were outlined and discussed, and then the relevant concepts and materials of facade renovation of industrial architectural heritage were summarized. Secondly, the renovation of Nanjing Hutchison Factory was cited here as an example for specific analysis. Finally, based on the analysis and summary of the case, corresponding design strategies and methods for the adaptive facade renovation were summarized, and the future research direction was put forward. This article is not only of great guidance and promotion to the renovation of Hutchison, but also of certain reference value to similar facade renovation projects of architectural heritages in China and even in the world.

1. Introduction

Entering the 21st century, the Chinese government strongly advocates sustainable development under the joint force driven by energy crisis, environmental protection, resource recycling and urban cultural construction, etc... Construction has seen large-scale demolition, reconstruction and renovation. The original facade design of most of the existing industrial architectural heritage can no longer keep up with the pace of the times, not to mention shaping a good image of the city and creating a unique artistic conception of the city. Therefore, the adaptive renovation of the facade of the industrial architectural heritage has become a key content in the current construction and renovation work. With the development of new building materials, new technologies and diversified building theories, the facade renovation of industrial architectural heritage is no longer limited to simple traditional methods, but is performed by using similar materials to perform facade reconstruction while keeping the historical context.

The research scope of this article is limited to the adaptive facade renovation of Nanjing Hutchison Factory along the Yangtze River in Nanjing, aiming at summarizing the corresponding design strategies for facade renovation based on the case study of Nanjing Hutchison Factory, an industrial heritage
complex. Nanjing Hutchison Factory is the largest existing industrial heritage complex in modern China. Located at 168 Baotaqiao West Street, Xiaguan District, Nanjing City, Jiangsu Province, it was founded in 1912 as the first foreign-funded food processing factory in Nanjing. Nanjing Hutchison Factory was designed by Norwegian architect E. J. Muller and constructed by Yao Xin Construction Factory. In September 2015, the original site of Nanjing Hutchison Factory was basically demolished, but there were still more than 10 historical buildings built in 1920-1930, including office building, laboratory building, factory building, slaughter room and cold storage, with a total construction area of about 70,000 square meters. As one of the modern factories built in China by its investors William Vestey and Edmund Vestey, Nanjing Hutchison Factory is a model of the combination of western modern technology and production technology with local technology and craftsmanship, and is also a sample of the integration of architectural style and technology (refer with: Figure. 1). Therefore, it is of great significance to select such an industrial architectural heritage as the research object in this article. The author had the honor to participate in the renovation design of Nanjing Hutchison Factory as one of the assistants of the project manager in the autumn of 2017. Here, the concept, method and corresponding strategy of the adaptive renovation of the facade of industrial architectural heritage will be discussed based on the author’s experience in the whole project design.

![Figure 1. Aerial View of Nanjing Hutchison Factory](image)

The focus is put on the facade renovation design of industrial architectural heritage. In Chapter Two, the concept and related materials of adaptive facade renovation are summarized, and the general principles and commonly used facade materials of adaptive facade renovation are explored and analyzed. In Chapter Three, the principles followed in the renovation design, the facade materials used and the corresponding effect feedback of Nanjing Hutchison Factory are illustrated. In Chapter Four, three design strategies for the adaptive facade renovation of industrial architectural heritage are proposed. Finally, the significance of the adaptive facade renovation of industrial architectural heritage is concluded.

2. **Concept and related Materials of Adaptive Facade Renovation of Industrial Architectural Heritage**

It is necessary to pay attention to the general principles affecting the design in the adaptive facade renovation design of industrial building heritage, so that the completed building can meet the basic requirements of all aspects. It should be said that any building facade design has principles to follow, but different building design projects attach varied importance to the principles and show different emphases or understandings.

Four general principles, namely, the principle of coordination between function and individuality, the principle of visual aesthetics, the principle of durability and easy maintenance, and the principle of environmental protection and sustainability, were put forward for adaptive facade renovation design. Specifically speaking, first of all, the renovation of the facade should conform to the principle of
coordination between function and individuality, which means that the renovated works shall be able to meet the requirements on function and use. It can neither be done simply nor pursued deliberately. We should respect the industrial architectural heritage, ensure that the individuality of materials is consistent with the functions of buildings, and use rigorous analysis methods to inspire our own creative inspiration and design architectural works that meet the actual functional needs.[1] If the renovation is carried out roughly without considering the coordination between the architectural function and the material individuality, it will cause confusion to people, which is thus an irresponsible behavior. Secondly, the renovation of the facade should conform to the principle of visual aesthetics, including people's basic feeling of visual elements such as shape, light, color and space of the architectural appearance. Material performance shall conform to the architectural aesthetic standards under the influence of current society, consumer culture and popular culture, and facade renovation design shall be carried out according to appropriate proportion, color and texture. Only by incorporating new design techniques or giving it a brand-new appearance on the original noumenon framework, and removing the gross from its essence, can the lingering charm of industrial architectural heritage be preserved while maintaining the overall aesthetic feeling of the industrial architectural heritage. Thirdly, the renovation of the facade should conform to the principle of durability and easy maintenance. We should reduce unnecessary costs and waste, make old buildings look brand-new on the premise of satisfying practical functions, reduce unnecessary economic expenditures, and save resources and create economic value. With the passage of time, the materials of the exterior walls of the industrial architectural heritage will be rotten and dilapidated, and we should follow the principle of practicality, beauty and economy to renovate the historical buildings. Finally, the renovation of the facade should conform to the principle of environmental protection and sustainability. Nowadays, in order to meet the design requirements, designers have gradually abandoned natural materials and adopted a large number of industrial materials that are not environmentally friendly or have short service life, thus causing more and more environmental problems. We are beginning to realize that instead of relying on natural materials, we have ironically lost the foundation on which we maintain our current lifestyle.[2] As early as 1998, Mr. Wu Liangyong put forward in “Prospect of Architecture in 21st Century " that "in an era of coexistence of multiple technologies, high and new technologies, appropriate technologies and traditional technologies should be developed jointly according to local conditions. We need to see this direction and clearly recognize that appropriate technologies themselves have simple sustainable development guidelines as times change."[3] Therefore, in the process of facade renovation, we must follow the principles of environmental protection and sustainability and reasonably select materials. From this, we can see that the four general principles mentioned above contain rich project design experience and philosophical thoughts, which should also be of great reference value and guidance to the renovation design of Nanjing Hutchison Factory.

However, since the exterior wall of the buildings is constructed from various materials, no matter how perfect the principle is, the facade renovation design cannot be completed without in-depth study of the materials. The purpose of material performance is to make use of the characteristics of different materials in shape, color and texture, and through careful organization and arrangement by designers, to produce beautiful architectural forms. So, different building materials can bring a completely different form of buildings, and this beautiful architectural form can be perfectly preserved in the renovation of old buildings.[4] Therefore, analyzing the materials, understanding the properties of materials and exploring the performance characteristics of materials (such as shape, color, texture and texture, regional characteristic, etc.) can play a favorable guiding role in the design and implementation of specific building projects.

Exterior wall materials used in the renovation of China's industrial architectural heritage mainly include lacquer, cement mortar, washed granolithic plaster and stone granular facing mortar, etc. (refer with: Figure. 2). Lacquer is a kind of paint imitating marble and granite. It is mainly applied to imitate the stone effect of exterior walls. It has the characteristics of fire prevention, waterproof, acid and alkali resistance, pollution resistance, non-toxic, tasteless, strong adhesion and never fading. Replacing dry hanging of stone with lacquer not only reduces the cost, but also reduces potential safety hazards.
Moreover, the layout can be designed and planned at will, which is convenient and fast. It accelerates the construction progress and improves the overall aesthetic appearance of the building. Cement mortar is made of mortar, cement, gravel and sand according to a certain mix proportion and prepared manually according to the original process. Washed granolithic plaster represents a traditional construction technology, which can make the texture of the wall surface natural, the color solemn and beautiful, and the decorative surface firm and durable. It does not fade, and has better resistance to pollution. Stone granular facing mortar is an overcoating material composed of natural stone particles with different particle sizes. It can be used for colorful decoration, with soft color and good durability. As common building materials for restoring modern architectural heritage in China, these materials have been enduring in the development process of China’s architecture and are favored by the majority of architects. Of course, with the progress of technology, there are other materials that have also played an important role in the facade renovation of the architectural heritage. Due to the limited space of this article, they will not be discussed here for the time being.

![Figure 2. Four major exterior wall materials used in the renovation of china's industrial architectural heritage](image)

As Nanjing Hutchison Factory is located along the Nanjing Yangtze River Bridge, it has advantageous geographical location and profound historical and cultural background. Hence, the renovation design of it has naturally become the top priority of Nanjing and even the whole country. As the gateway to Nanjing, the image of its complex is particularly important. Therefore, the selection of appropriate design principles and materials for facade renovation has become the top priority in the design of this project.

3. Principles and Materials for Facade Renovation Design of Nanjing Hutchison Factory

Nanjing Hutchison Factory used to be a food processing factory invested by foreign capital in history. Because of the renewal of the city, its actual function has declined. In addition, due to the long history, the external wall of the original buildings is seriously damaged, and the architectural style cannot fit the existing city style, but its architectural space still has use value. Therefore, the Nanjing Municipal People’s Government decided to redesign such an industrial heritage complex to maximize the vitality of the area. As a designer, our team made full use of and developed the general principles discussed above in renovation design of Nanjing Hutchison Factory, as detailed below:

3.1. Principle of Coordination between Function and Individuality.

Under normal circumstances, window opening is not required in renovation of the general facade of commercial buildings, and the application of materials is more flexible. Metal wrapping and glass curtain wall are mostly used for material reconstruction. If the renovated industrial building heritage is used for office or residence, lighting and other factors need to be considered. At this time, the application of materials should be based on the environment in which the building is located, and should not be
exaggerated. The principle of coordination between function and individuality should be followed in such circumstances. In the facade renovation design of Nanjing Hutchison Factory, the design team analyzed the features and values of the facades of various historical buildings in advance and then carried out appropriate renovation design on the basis of fully retaining the historical marks so as to ensure that the renovated building facade can meet the needs of internal functions. For example, cinemas and auditoriums have lower requirements for daylighting, so they were mainly arranged in closed exterior walls. Commerce and repast have higher requirements for daylighting, so they were mainly arranged in exterior walls with large windows (refer with: Figure. 3).

![Rendering of Facade Renovation](image1)

**Figure 3.** Coordination between Function and Individuality in Facade Renovation of Nanjing Hutchison Factory

3.2. **Principle of Visual Aesthetics.**

Generally speaking, the facade design of historical buildings will follow a set of classical rules of order and the rigorous geometric order will derive its inherent beauty of order. Therefore, Nanjing Hutchison Factory attaches great importance to the regeneration of old buildings in the process of design, takes its essence and discards its dross, preserves the sense of order, and maintains the geometrically classical beauty of order through the integration of new design techniques (refer with: Figure. 4).

![Functions Corresponding to Facade](image2)

**Figure 4.** The Facade Restructuring of Nanjing Hutchison Factory and Its Application to New Buildings

*(photo source: by the author)*
3.3. Principle of Durability and Easy Maintenance.
With the passage of time, the materials of the exterior walls of Nanjing Hutchison Factory were rotten and dilapidated, and we followed the principle of practicality, beauty and economy to renovate the historical buildings. In the selection and application of materials, we considered the durability and easy maintenance of the materials to reduce unnecessary cost and waste and make the old buildings look brand-new.

The exterior wall facing design of Nanjing Hutchison Factory fully reflects the texture of the original materials. When we designed, we adopted cement mortar facing just as that used in traditional buildings. Through mixing different materials and modulating colors, the exterior wall materials of historical buildings are re-imitated to make the historical buildings glow with vitality.

4. Facade Renovation Design Strategy of Nanjing Hutchison Factory
Although the facade renovation of the complex of Nanjing Hutchison Factory followed the appropriate principle and used the appropriate materials in the process of facade renovation design, our design team still faced many details that ran counter to the expected results in the process of project construction. For example, if the facade painting method was not guided by the correct design strategy, it is likely to produce different facade effects (refer with: Figure. 5). Therefore, it is particularly important to further summarize the relevant design strategies for adaptive facade renovation. According to the performance characteristics of the facade materials of industrial architectural heritage, the article attempts to divide the facade renovation strategy into four main aspects: Harmony of color strategy, material shape and scale reconstruction strategy, material texture analogy strategy, and material fragment retention strategy, which are further explained and discussed below.

![Image](Figure. 5 Comparison of Test Samples Using Stone Granular Facing Mortar for Exterior Wall Repair)

4.1. Harmony of Color Strategy- Harmony of Color Technique.
The color of materials can become a "binder" for connecting various elements on the building facade, and also a "repellent" for separating various elements.[5] When the color of the facade materials of industrial buildings tends to be consistent in the proportion and brightness, the whole will present a coordinated and integrated effect. Therefore, architects can create mutually harmonized colors on the original facade materials to achieve an overall harmonious effect, and this is called the Harmony of Color Technique.

In the process of reconstructing the facade materials of industrial architectural heritage, it is inevitable to encounter the problem of conflict between the old and new materials, that is, the problem of inconsistent material language. At this time, the Harmony of Color Technique is an effective solution. This technique can not only present the charm of the exterior wall material of industrial architectural heritage in a brand new manner, but also fully solve the problem of the fusion of new material color and the original color. In this case, it acts as a “binder”. In the process of restructuring the exterior wall materials of historical
buildings of Nanjing Hutchison Factory, we imitated the interface colors of the industrial architectural heritage according to its characteristics and the surrounding environment, highlighting the sense of the times and organically integrating the old and new styles (refer with: Figure. 6). The Harmony of Color Technique makes the facade renovation of Nanjing Hutchison Factory well blended with the surrounding environment. And the fusion of slight difference in tone and brightness between materials can effectively make buildings well integrated into the surrounding environment. It helps form a new coordination relationship without abruptness.

Figure. 6 Adaptive Renovation Design of the Color of the Exterior Walls of Nanjing Hutchison Factory

4.2. Material Shape and Scale Reconstruction Strategy.

4.2.1. Grading of Material Shape and Scale

Architecture has the classification of shape and scale. Similarly, materials also have the classification of shape and scale. In the adaptive renovation design of facade material shape of industrial architectural heritage, the design focus is to integrate shape and scale for materials of different scales in different periods and coordinate the proportion between old and new elements.

T. Hamlin, an American modern architect, thinks that "In architecture, scale makes the building present a certain proper size as expected, which is a unique characteristic that seems to be inherent in architecture."[6] According to this, this kind of proportion relation should meet people's psychological and visual requirements. Different proportions of materials give people different feelings. Designers express various understandings of buildings through the treatment of different shapes and scales of materials.

As for the material of cement, its shape and scale can be cut in different dimensions to form prefabricated modules by technical means as required. In the renovation of facade materials of Nanjing Hutchison Factory, we classified the old and new materials according to their length, area, volume, specific structural details and decorative details to eliminate the obvious difference between the old and new materials. The transition of scale is formed between materials, which gives people a sense of coordination and makes the scale expression clear and distinguishable. At the same time, the reserved long glass window forms a strong contrast to the small brick material, thus presenting a sense of rhythm (refer with: Figure. 7). This method is widely used in the renovation of industrial architectural heritage.
4.2.2. Reorganization of Material Shape and Scale- Modulus Analogy Technique

In the facade renovation of industrial architectural heritage, there is a kind of logical relationship between the new material and the old material in terms of shape and scale, which makes the new material and old material match quite well after renovation. And this is called modulus analogy technique. In applying this technique, we should pay attention to the following points. On one hand, the shape of the original materials should be strictly distinguished to prevent confusion; on the other hand, the shape and scale of the new materials should be correlated with the old ones so as to achieve the effect of synergy.

In facade renovation of Nanjing Hutchison Factory, the glass curtain wall materials of the new building adopted modulus analogy technique, i.e. the glass curtain wall was divided into many groups on the X axis, and the width of each group corresponds to the width of the opening of the facade of the historical architecture, thus echoing the historical structural characteristics of the old building and completing the adaptive renovation design for shape and scale (refer with: Figure. 8). The facade surface pieced together by different combinations can also arouse people's remembrance of the old factory building.

4.3. Material Texture Analogy Strategy.

Texture of materials plays an important role in material performance. In renovation of existing buildings, the introduction of new materials is bound to produce differences in texture. Therefore, how to make the old and new materials well blended in texture requires advanced technology and philosophy.
In decomposition of the texture of the existing buildings facade, it is necessary to preserve, extract and summarize the historical symbols, interpret the historical information of the materials, and awaken and heighten such historical symbols and information in renovation. In doing so, the historical sense of the buildings can be preserved and a new image will be presented, thus bringing a collision between history and modernity. In adaptive renovation design of the historical buildings of Nanjing Hutchison Factory, stone granular facing mortar was used to restore the charm of the historic buildings. In this process, in order to make the restored facade of the historical buildings perfectly integrate into the well-preserved facade of the existing historical buildings, the texture of the exterior wall materials for the new buildings should be as close as possible to the facade texture of the historical buildings preserved on site. Therefore, how to allocate the proportion of sand, stones and other basic materials is particularly important (refer with: Figure. 9).

**Figure 9.** Test Samples of Historical Exterior Wall Materials Mixed in the Renovation Site of Nanjing Hutchison Factory

4.4. Material Fragment Retention Strategy.

"The feeling of detail is an indispensable part in aesthetics. It is fundamental to the basic aesthetic choice and the complex reflection of comments. It is 'rooted' in feelings."[7] For those buildings with high retained value and rich historical information, the color, shape and texture of the original facade materials of industrial architectural heritage will not be re-designed for adaptive renovation, but the material fragments will be selectively reserved or some detail components will be added, so as to enrich the form of industrial architectural heritage and strengthen the existence and identifiability of buildings. The relationship between material details and architecture is complementary. The choice of detail decoration depends on the volume of architecture. Generally speaking, the adaptive renovation design of material details should be relatively simple and distinguished, while buildings of small volumes should choose delicate and exquisite details.

Figure. 10 shows a reconstruction of the “northern factory building” of Nanjing Hutchison Factory. The exterior wall of this building has been dilapidated before. In order to maintain the characteristics of historical buildings and to maintain the visual continuity of the building facade, the designers used new steel to reinforce the original wall structure, replaced the incomplete windows of historical buildings with new steel windows, and retained the original water tower on the roof. The preserved water tower looks more exquisite and touching on the restored building ontology. Elements that seem to have failed to adapt to the development of the times can still be stimulated to achieve rational modeling effect as long as they are treated prudently and put in a correct position. The water tower placed in the roof garden seems to have a direct dialogue with the tourists. It records the passage of time, arouses people's emotion and collective memory of the place, and continues the breath of the old factory.
Figure 10. Adaptive Renovation Design Strategy of Fragmental Retention of Nanjing Hutchison Factory

5. Summary
Four design strategies for facade renovation of industrial architectural heritage were proposed based on the exploration of the general principles and materials applied in adaptive facade renovation of industrial architectural heritage with Nanjing Hutchison Factory as the study case. The research is not only of great significance to guide and promote the renovation of Nanjing Hutchison Factory and preserve its historical essence, but also of certain reference value to similar facade renovation projects of architectural heritages in China and even in the world.

China has left over a large number of abandoned buildings in its rapid development, which reflects the complexity of the problem. Limited by culture, regional materials and research objects, the design strategies summarized in this article cannot solve all the problems of facade renovation of existing buildings in the world. Therefore, the author plans to make in-depth investigation of existing architectural renovation cases in more regions, so as to go further in the research on facade renovation of architectural heritage.

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