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# Research on Structural Renewal and Renovation Strategies for Industrial Heritage Projects—A Case Study of the Structural Renovation of the "Dahua 1935" Project

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**Abstract:** The wave of post-industrial evolution has led to the emergence of numerous industrial heritage renovation projects in recent years. The renovation and upgrading of the Dahua 1935 project preserve the memories of the previous industrial age while incorporating modern materials and technologies, resulting in a design that blends traditional and contemporary elements. This has made Dahua 1935 a new intellectual property (IP) symbol of Xi'an, earning praise from both residents and tourists from other provinces. Additionally, to achieve a unity of art and technology, Dahua 1935 underwent structural reinforcement and optimization to enhance its aesthetic appeal. This paper aims to further explore methods for structural optimization in the renovation of Xi'an's industrial heritage projects by conducting on-site investigations, data collection, and structural analysis, building upon the structural analysis of Dahua 1935 in Xi'an.

**Keywords:** Industrial heritage; Urban renewal; Structural optimization; "Dahua 1935" project; Carbon fiber reinforcement method

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## 1. Introduction

In the wave of post-industrial evolution, urban renewal—particularly the transformation of industrial heritage—has garnered increasing attention. It not only involves preserving the city's historical memories but also aims to beautify the urban image and enhance the quality of the living environment. A multitude of urban industrial building renovation projects have emerged, like bamboo shoots after a spring rain, providing numerous topics for urban developers and architects to study. Through research and practical investigation, a series of scientific methods have been summarized and applied to collectively advance the renewal and transformation of industrial heritage projects [4,5]. As a representative industrial heritage renovation project in Xi'an, Dahua 1935 has attracted significant attention from researchers in recent years.

For example, Wang's research on the sustainable utilization and transformation of Dahua 1935 and other projects begins with additive and subtractive strategies as well as different functional renovation strategies, proposing a series of renovation plans [1]. Zhao and Yu started the locality study of "Dahua 1935" to create spatial experiences, highlighting its commercial atmosphere within existing industrial buildings to satisfy the spatial experiences of users and consumers [6]. Based on He, using spatial syntax research strategies, evaluated the spatial utilization of Dahua 1935 and provided suggestions on road layout, spatial arrangement, node space settings, exhibition flow lines, safety entrances and exits, and public facilities [7]. Wang analyzed the green technology measures of Dahua 1935, proposing aspects that can be referenced, but do not offer related suggestions or optimization considerations. From the extensive analyses of Dahua 1935 by predecessors, it is evident that the renovation of industrial heritage projects urgently requires scientific and systematic methods to assist.

The main representatives in the research of heritage buildings abroad are as follows. González *et al.* presented detailed examples of structural refurbishment strategies in Madrid, contributing valuable insights into the adaptive reuse of industrial heritage [8]. Huang *et al.* explored the feasibility of using metal-timber hybrid structures for industrial building renewal [9]. With quantitative indicators improving and clearness, Ma *et al.* provided a systematic framework for evaluating district-level industrial heritage renovation strategies [10].

Therefore, under the quantitative analysis and structural technology's background of development, this study will commence with the structural transformation of Dahua 1935, utilizing the original design drawings of Dahua 1935 as well as the Phase I and Phase II structural renovation plans to analyze structural modifications, reinforcement, and form optimization. Moreover, by integrating structural renovation methods (carbon fiber reinforcement method) and application cases of similar types, the study will compare the advantages and disadvantages from various aspects including economic viability, aesthetics, and sturdiness. The goal is to propose structural optimization renovation strategies for industrial heritage projects for collective discussion.

# 2. Results and discussion

## 2.1. Structural analysis of the "Dahua 1935" project

### 2.1.1. Structural selection during the initial construction period

In the early 1930s, against the backdrop of the rapid development of national capitalism and to develop the textile industry in Northwest China, the Xi'an Dahua Yarn Factory was constructed from 1934 to 1936. **Figure 1** shows the initial design by Japanese architects. Most of the factory buildings primarily employed steel structures, supplemented by large-span concrete frame structures and brick-concrete constructions. The office areas and dormitories mainly utilized brick-concrete structures [2].


**Figure 1.** Initial construction floor plan of Xi'an Dahua Yarn Factory (drawn based on materials)

**Table 1.** Architectural structure of Xi'an Dahua Yarn Factory

| Building types structural components | Roof | External walls | Interior walls | Beam frame | Column | Structure |
|---|---|---|---|---|---|---|
| Multistory production plant | steel roof truss, concrete roof truss, rowed single-slope sawtooth roof | Concrete plaster finish, exposed aggregate finish | Green wainscot with whitewashed upper section, painted with propaganda slogans | Concrete Prefabricated Structure beam frame, rectangular long beams joined on both ends to raised basket-shaped end columns, north-south oriented prefabricated | Basket-shaped columns with protruding corbels at both ends, along with steel i-beam columns | Steel structure |
| Single-story production workshop | Rowed single-slope sawtooth roof | Red exposed brick wall | | Continuous span single-story sawtooth steel structure beam frame | Independent prefabricated concrete structure columns, painted green to match the wainscot | Brick-concrete structure, concrete frame |
| Warehouse | Double-slope roof with wooden trusses and steel trusses | Concrete plaster finish, exposed aggregate finish | | | Wooden and stone columns used in coordination with the load-bearing system | |
| Office area | | Gray exposed brick wall, mostly load-bearing walls | | | Wooden and stone columns used in coordination with the brick Load-Bearing System | |
| Auxiliary buildings | Flat concrete roof structure | Red exposed brick wall | | | | |

## 2.2. Analysis of the initial structure

Most of the workshops use concrete and steel frames, which can provide a large span, high heights, and large stiffness, so the internal space can be operated by large machines (**Figure 2**). Furthermore, the concrete steel frame structure has strong operability, and the beam and plate can be dismantled and strengthened. During the process of transformation, we should pay attention to the unity and stability of the structure.

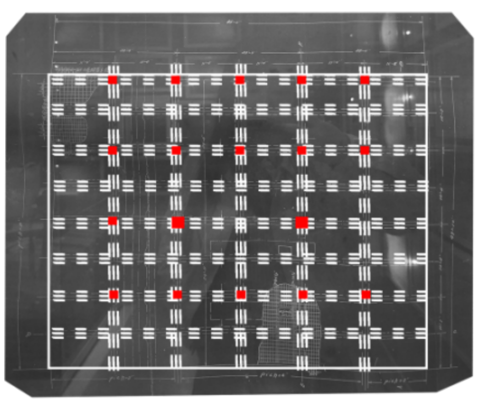

**Figure 2.** Structural plan of initial construction building (drawn according to data)

### 2.3. Structure selection after the transformation

The reconstruction involves the selective demolition of landscape structures. For the workshop, the focus is primarily on retention and reinforcement. Regarding the serrated workshop boundary, part of the roof and exterior walls will be dismantled to create gray spaces and corridors on the second floor.

#### 2.3.1. Phase I production plant renovation

In the first phase of the plant renovation, the original workshop serrated single slope roof is simulated to extend, and the metal brown and yellow texture frame material is used to limit the boundary, breaking the original boundary to extend 5–8 m. The internal skylight adds a metal frame grille to avoid large areas of direct light entering the room and create a comfortable light environment (**Figure 3**). The metal frame grille flows like yarn in the horizontal and vertical planes and the extended three-dimensional direction to the new outdoor structures which is shown in **Figure 3** and **Figure 4** respectively. The old buildings are connected with the new buildings, and the new structures are integrated into the 2.2 m high pipeline equipment layer to achieve the traditional and modern interweaving in the structure [1].

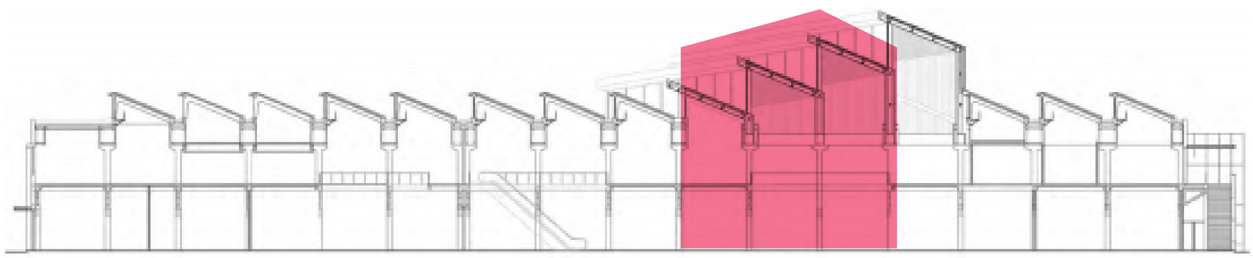

**Figure 3.** Schematic diagram of phase I production workshop section (modified according to data)


**Figure 4.** Perspective diagram of phase I plant renovation (sourced from gooood.cn)

#### 2.3.2. Phase II production plant transformation

The original structure of the second phase workshop is a precast concrete assembly large-span structure. In the transformation process, the steel structure for paste node reinforcement is introduced for a four-way hinge, which provides mechanical support and a unified connection [3]. The atrium part completes the height, removes the second-story floor slab, and introduces the light to solve the problem of insufficient lighting of the serrated skylight in the large space, which is shown in **Figure 5**. The first floor of the original building arranged the concrete box main girder in the north and south direction, the concrete box main girder was arranged in the east and west direction of the second floor, and the broken line secondary beams were erected on the main beams. In the process of transformation, because of the force unity of the structure, the beam and plate were not removed, only the second-floor wall was partially removed, and the two-floor corridor was retained. To unify the space, the stairs of the new steel structure are hung on the second floor and beam, and the stairs plus the structures are unified in the overall structure.

**Figure 5.** Reinforcement of internal atrium and steel structure node in phase II plant renovation (photographs by the author)

### 2.4. Analysis of the structure after the transformation

The first phase of the plant is mainly decorative construction, while the second phase of the plant is mainly rigid hinge reinforcement of rigid nodes and demolition of the two-story floor slab to form a high atrium. The advantages and disadvantages of the comparison and summary are shown in **Table 2**.

**Table 2.** Analysis of the quality of Dahua 1935 plant transformation

| Plant types | Advantage | Disadvantage | Summary |
|---|---|---|---|
| Phase I workshop | Structure and form are unified | Scale imbalance, insufficient lighting | Form, structure, and function are dialectically unified |
| Phase II workshop | Steel structure node reinforcement<br>Atrial lighting | Single space form | Unification of applicability and economy |
| Prospect | Technology and art are unified, and the transformation should not only start from art but also coordinate from the various aspects of applicability (functional vitality, thermal environment comfort, space interest, space accessibility, etc.) | The transformation of the plant will face the situation that the large functions cannot be effectively replaced, so the structure of the large plant to create more space forms will effectively stimulate the commercial vitality | Combined with the technical means of the structure, different forms of structural models are transformed, the integration and flow analysis of spatial syntax are carried out, and the overall planning from the three perspectives of artistry, adaptability, and technology, to promote further scientific development of the renewal of old industrial buildings |

## 3. Conclusion

### 3.1. "Dahua 1935" project structural transformation and optimization

In the early analysis and design of the transformation of the "Dahua 1935" project, the structural design has an imbalance in scale, a single space form, artistic atmosphere construction, and economy that need to be improved. Therefore, the author puts forward the idea from the two aspects of carbon fiber reinforcement and bonded steel reinforcement and establishes the corresponding model optimization.

#### 3.1.1. Application principle of carbon fiber reinforcement method

Carbon fiber reinforcement primarily involves two types of materials: carbon fiber boards and carbon fiber cloth.

These materials are easy to cut, simple to use in construction, and can adhere closely to the contact surface, ensuring effective construction coordination. The low reinforcement weight of carbon fiber will not affect the dead weight of the structure. The used materials are more cost-effective, have low construction efficiency and cost, high operability, low construction difficulty, and can be the first choice in the economy.

### 3.1.2. Design concept of the carbon fiber reinforcement method

The carbon fiber reinforcement method minimizes interference with the original building while occupying minimal space. It is applied primarily to the beams and columns, allowing the design of wall panels to remain diverse and flexible.

For example, the corridor surrounding the atrium in the first phase of the workshop avoids strict linearity, opting instead for varying heights and subtle forward-and-backward shifts to create an engaging spatial experience. The large beams and columns of the workshop are left exposed to foster a sense of openness and familiarity. In some areas, hidden elements or spinning wood grilles are added for visual interest. The independent outdoor corridor incorporates green wall skirts and white walls featuring graffiti, where the graffiti is applied only to the surface, as shown in **Figure 6**.

Inspired by the developmental stages of "Dahua 1935"—from industrial production to the "Great Leap Forward" to the reform and opening-up period—the design integrates different styles and materials. As people move through the space, the walking paths reveal these transitions, gradually unfolding the history and development of the site, evoking resonance among visitors, as shown in **Figure 7**.

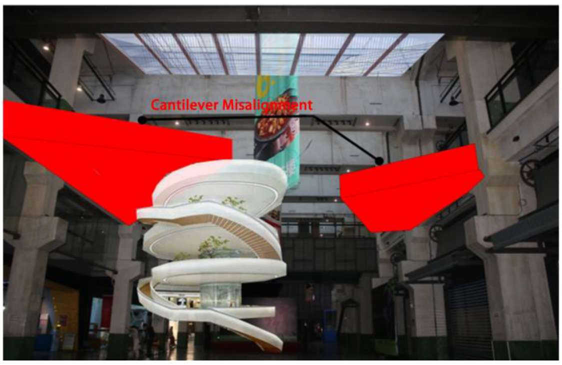

**Figure 6.** Atrium design (drawn by the author)

**Figure 7.** Corridor design (drawn by the author)

Firstly, the author identified the separation between the structural and architectural function design in the "Dahua 1935" project. By reviewing references and related literature, the author analyzed the structural changes of "Dahua 1935," examined relevant transformation cases, and summarized a transformation method consistent with the carbon fiber reinforcement approach used in the project. Additionally, based on the characteristics of the carbon fiber reinforcement method and the inherent contradictions of the "Dahua 1935" project, optimization ideas were further developed, and design strategies were simulated to address the corresponding challenges.

However, due to the influence of multiple factors, the business model of "Dahua 1935" has become stagnant and declining. Of course, the author's proposed transformation plan is just one approach. The revitalization of "Dahua 1935" requires multiple, comprehensive, and scientifically grounded solutions that account for its unique characteristics. We look forward to the collaborative efforts of more outstanding researchers to realize its potential.

## Disclosure statement

The author declares no conflict of interest.

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