Study on the Sustainable Development Model of Industrial Heritage

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Abstract. As crucial urban resources, industrial heritage occupies an important geographic location of the city, and it is generally of historical value, social value, technological or scientific value, economic value, and aesthetic value. The paper selected TESTBED2 as the case to study for it is the typical light industrial remains after the industrial revolution in Chongqing. This paper tried to discuss conservation of industrial heritage from multi-sensory marketing and Sustainable development. The paper evaluated the industrial heritage TESTBED2, and provided new methods for the reform of the industrial wasteland, and brought new landscape forms and looked forward to the model and tracks for the protection and reuse for the industrial industry, so as to realize the sustainable development of the industrial heritage.

Keywords: Industrial heritage, sustainable development, green energy, protection and utility.

1. Introduction
As crucial urban resources, industrial heritage occupies an important geographic location of the city, and it generally is of historical value, social value, technological or scientific value, economic value, and aesthetic value. On the other hand, industrial buildings usually have a relatively long service life, with a solid structure and large space, which makes them perfectly suitable for reuse, like providing places or platforms for artistic creation, communication, relaxation, and other activities, a new catalyst for the urban economy.

Research on the protection of industrial heritage can be traced back to Britain in the 1950s. In 1955, Michael Rix of the University of Birmingham in the United Kingdom first used the concept of industrial archaeology in the article "Industrial Revolution in England", pointing out that industrial remains effectively help to understand the scale and the scope of industrialization [1]. In 1973, the Association for Industrial Archaeology was established. In the same year, the First International Conference on the Protection of Industrial Heritage was held in Ironbridge, UK. The International Committee for the Protection of Industrial Heritage (TICCIH) was subsequently established. It was the first world organization dedicated to the research and protection of industrial heritage and the promotion of international cooperation. There are currently 46 countries that joined its membership. Then, similar academic organizations were established in America and many European countries, with various research findings and publications issued. The International Council of Monuments and Sites ICOMOS conducted statistics in 2006 and released the Industrial Heritage Sites on The UNESCO World Heritage
List, showing a total of 43 heritages (https://www.icomos.org/18thapril/2006/whsites.htm). As of June 2020, using industrial heritage as a keyword to search on the World Cultural Heritage website, we could find 88 results (whc.unesco.org). The proportion of industrial heritage in cultural heritage new added has steadily increased, and the value of industrial heritage has gradually been recognized.

Under the brand new concept of consumption, experience becomes more and more important, and the experience economy gradually rises. In Future Shock, Alvin Toffler discussed the possible raise of experience industries [2]. As the most direct and basic part of consumer experience, sensory impressions have become the focus of current tourism, and there is a large research space for research that combines sensory experience with industrial heritage.

Therefore, we selected TESTBED2, also named as Eling No. 2 Printing Factory, as a typical case for research. During the period of the Republic of China, it was a banknote printing plant of the central bank. After the founding of the People’s Republic of China, it was renamed Chongqing Government-owned No. 2 Printing Plant, which witnessed the development of Chongqing industry and had important referential value. Chongqing, as a city that focuses on the development of heavy industry, has a few numbers of light industry factories, many of which were demolished in the rapid urbanization. Therefore, TESTBED2 is very representative of the light industrial remains. What’s more, the factory is located at the peak of Eling, which could shed light on the practice of reconstructing old buildings and improving service for experience in this typical mountain city.

2. Literature Review

2.1. The Definition of Industrial Heritage

In 1986, Iron Bridge Gorge in Britain was included in the World Heritage List as an industrial heritage for the first time. In subsequent released reports and projects on world heritage, industrial heritage was continued to be mentioned. Later in the international guidance document the Nizhny Tagil Charter for the Industrial Heritage signed in 2003 TICCIH International Congress, key concepts and fundamental methods of industrial heritage and industrial archaeology were first clearly defined: “the buildings and structures built for industrial activities, the processes and tools used within them and the towns and landscapes in which they are located, along with all their other tangible and intangible manifestations, are of fundamental importance... Industrial heritage consists of the remains of industrial culture which are of historical, technological, social, architectural, or scientific value. These remains consist of buildings and machinery, workshops, mills and factories, mines and sites for processing and refining, warehouses and stores, places where energy is generated, transmitted and used, transport and all its infrastructure, as well as places used for social activities related to industry such as housing, religious worship or education” [3].

Industrial heritage can be divided into different categories, according to different criteria, such as historical period, industrial nature, related content, and scope. The case we studied is the light industrial remains after the industrial revolution, limited to the protection and reuse of its industrial buildings and auxiliary facilities.

2.2. Research on Protection, Management and Reuse of Industrial Heritage

For the protection of industrial heritage, some scholars try to use sustainable development as a guide for research. The concept of sustainable development was established in the 1980s. The focus of it is to save resources and protect the environment, emphasizing the coordinated development of the three elements-environment, society, and economy. Through the reconstruction and utilization of old industrial buildings, the urban functions of the area could be updated, the social, economic, and cultural aspects of the city will be improved, and the problems of environmental degradation, unemployment, and poverty caused by old industrial areas could be solved, achieving the requirements for sustainable development. In the early 1990s, Wu Liangyong proposed measures to reuse the remaining industrial structures and proposed the concept of urban organic renewal, requiring attention to maintain the overall coordination of the city [4]. After an in-depth study of the city’s history, culture, economic structure,
and development patterns, as well as the basic characteristics of the city, the planning, and design of tourism development should be carried out reasonably. In the process of renewal and reconstruction, the planning and design of this area must consider the specific functions of the surrounding area to achieve the overall harmony of the city [5].

According to the nature of industrial heritage, the development patterns have shown a diversified trend, mainly including patterns as follows [6].

Table 1. The Development Patterns of Industrial Heritage

| Development Types       | Characteristic                                                                 | Typical Cases                                           |
|-------------------------|-------------------------------------------------------------------------------|---------------------------------------------------------|
| Public Space            | Industrial wasteland can be transformed into a public park for residents to entertain and rest, along with the improvement of the ecological environment. | Qijiang Park in Zhongshan, China Landschaftspark Duisburg-Nord |
| Historical Museums      | Preserve the authenticity of the original sites, convert them to museums for relevant displays or exhibitions. | China Shipping Heritage Museum in Fuzhou, China          |
| Creative Industries Centers | Artists reconstruct or innovate industrial structures, promoting the protection and regeneration of industrial buildings. | Soho Manhattan, The 798 Art District in Beijing, China    |
| General Development     | Unified development of the industrial heritage of a region                   | the Industrial Heritage Trail in Ruhr, German            |

2.3. Sensory Experience and Tourist Experience

The research on tourism experience began in the 1960s. As a pioneer in tourist experience research, Boorstin laid the foundation for tourism experience research. Since then, MacCannell, Turner, Cohen, Urry, Smith, etc. have carried out in-depth research on the travel experience, and related academic works have been published one after another. The research content is concentrated on theories of travel experience, travel experience types, travel authenticity experience, and the impact of travel experience factors and other aspects. China’s domestic research on tourism experience started relatively late. In the late 1990s, Xie Yanjun started research on tourism experience. Since then, tourism experience has attracted the attention of domestic tourism researchers [7].

Sensory experience is an important part of measuring tourist experience. Sensation refers to the process of triggering the sensory organs by sensory stimuli (e.g., light, vibration, pressure, and chemical substances), which are converted into electrical signals and transmitted to the brain, placing sensations at the beginning of the individual’s perception of the surroundings. The perceptual process through which sensory inputs are selected, organized, and interpreted results in a “conscious sensory experience”. The aspect is vital in tourism studies because the perception of the experience can change and influence future behavior [8]. According to the analysis of relevant report data, the sensory experiences obtained through sight, hearing, taste, smell, and touch in tourism accounted for 26%, 23%, 19%, 17%, and 15% respectively. Sensory experience, as the most direct and basic link in consumer experience, has become the focus of current tourism planning and has a fairly broad market.

The industrial heritage records the industrial production activities in a specific historical period, and the material remains including its buildings and production facilities reproduce the actual scene, which can bring a real and unique atmosphere to tourists. Industrial heritage tourism has scientific, historical, cultural, and aesthetic values, and thus through tourism programs of education, interaction, and other types, it can bring tourists a rich sensory experience. Until now, China’s domestic research on sensory experience mainly focuses on brand marketing, consumer experience, or product development, while its application in industrial tourism for tourist experience is rarely mentioned. Therefore, our research will study the protection and utilization of industrial heritage from the sensory experience side and expect to develop new ideas for the theory or practice about sensory experience, as well as the service improvement of industrial heritage tourism attraction.
3. Case Study

3.1. Overview
TESTBED2, also named as Eling No. 2 Printing Factory, is located at No. 1, Eling Main Street, Yuzhong District, Chongqing, with a total area of 30,000 square meters. It is funded by Chongqing Tube Cultural and Creative Consulting Co., Ltd. and borrows the concept of "TESTBED" in London from allDesign. Will Alsop's team was invited and took four years to complete the reconstruction of this printing factory, and through the overall transformation of the old building to build a hub for creativity and relaxation, including a cultural and creative market, special catering, artistic exhibition and release center, unique theater, museum, special workplace, boutique hotel, and other business formats. Now, it has become a popular check-in place and city travel destination.

3.2. Background and Development History
The development of TESTBED2 has gone through three stages. The first stage is the start-up of factory (1930-1949). During the Republic of China, it was constructed as the Banknote Printing Factory of the Central Bank, specializing in printing banknotes, stamps, tax stamps, and other securities and government documents. The second stage is the development stage (1949-1999). The factory developed into the largest printing company in Chongqing. It was renamed Chongqing No. 2 Printing Factory in 1953, becoming the color printing center of Chongqing and the color printing giant of the southwest printing industry [9]. The third stage is the transformation stage. In 2012, the factory was moved out for environmental protection, and the original old building was abandoned. With support of the local government, the construction of the new cultural and creative center started in 2014, and the park opened in June 2017, quickly becoming a veritable new landmark in Chongqing. In 2019, the average daily visits in the park exceeded 7,000 and reached 15,000 during the peak period.

3.3. Design Concepts
Through literature searching and field study, we learned that TESTBED2 mainly uses four design concepts. The first is TABULA RASA; the second is the combination of authenticity and innovativeness; the third is to make full use of the internal space and link the overall space; and the fourth is to make the park more interesting with small installation artworks.

Firstly, TABULA RASA. This principle comes from Will Alsop, referring to the blankness whose intimidation is only usurped when marks appear in the form of scribbles, words, or lines. It is described as the conceptual drawing stage, completely free from any thoughts of precedent, codified theories, or predictive ideas, to find the initial, intuitive responses from externalized nature [10]. So, the architecture team started from the elements of this industrial heritage and went to what was required for its regeneration, and finally made the unique and authentic TESTBED2. As TESTBED2 suggests, the reconstruction and renewal of No.2 Printing Factory display the architects’ attitude as an experimenter and innovator.

Secondly, the combination of authenticity and innovativeness, or Rough Luxe. “Rough Luxe” is to maintain the authenticity of the original industrial factory, like its relatively rough spatial structure and texture, and make modifications and renovation on that basis to provide exquisite space that meets the needs of modern life, meanwhile displaying the historical information or collective memory. The Rough Luxe Hotel in London is a typical case of this design concept. And it cannot be simply equated with highlighting the contrast between the old and the new. It should follow the preservation of the old architecture and landscape, determine the elements that are worth keeping, and then add new things to form a response. Embed the characteristics of contemporary art in the design, use bold colors, interpret printing in a more modern way, and consider the relationship between space and human behavior based on that. For example, when renovating the external facade of Building 31, the architects removed the tiles with potential safety hazards, and the resulting random patterns were plastered to form a natural picture. Many colored glasses and colored metal mesh were used in the park to increase its artistic quality and interest.
Thirdly, make full use of the internal space and link the overall space. Based on the geographic location of the TESTBED2 and the special structure of the internal space, the model of "sandwich" is planned. The ground floor is dominated by commercial stored, the floors in the middle are mainly about the office and creative incubation spaces, and the top is used as an observation platform. Commercial circulation opens the building space (Figure 1). By adding 3 flyovers between Building 1 and Building 4, there is a loop formed in mid-air, upgrading the original simple closed factory building into a diverse composite commercial space [11].

Fourth, installation artwork. The architect team invited many artists to cooperate, and a series of small installation works were created under the complete spatial and visual framework of the No.2 Factory, including guide signs, tables and chairs for leisure, retro mailboxes, public area landscaping, which are made from existing items in the old factory for creative transformation, like taking iron bars, metal nets, wooden pallets, old bookcases, waste electrical boxes, and other items apart and creating new objects [12].

3.4. Project Layout
There are more than a dozen single-story or multi-story buildings in the original park. The buildings are mainly divided into five areas, namely TESTMART, TESTART, TESTJOY, TESTDESIGN, TESTSPIRIT.

| Area      | Main Function                                                                 | Typical Shops                                                        |
|-----------|--------------------------------------------------------------------------------|----------------------------------------------------------------------|
| TESTMART  | The experiential cultural market, which dedicated to encouraging the incubation of original brands, and the exchange and creation of artistic creative works, bringing together many unique and creative products, such as original hand-made accessories, wooden crafts, knitwear, etc. | Ziyu Handmade Soap, Summer Flower Shop, Hua Dian Chinese Dim Sum, Collection of Beauty Art Living Space, Fondant Cake Studio |
| TESTART   | The art exhibition area, with many art centers and photography and art studios; many well-known artists have invited for exhibitions | T² International Contemporary Art Center, LikeA museum, FLORAL PHILO   |
| TESTJOY   | Most of them are afternoon tea restaurants, accessories stores, and other shops that enrich the tourist experience of tourists | Jiaofang Chongqing Original Hot Pot                                   |
| TESTDESIGN|                                                                            | Truth living room, 25Hour book bar                                    |
| TESTSPIRIT|                                                                            | Lingshang Number One                                                  |
3.5. Sensory Experience Analysis

Through literature searching and field study, we determined the outline of the survey questions to interview tourists for understanding their sensory impression and satisfaction about visits to the TESTBED2, or TESTBED2. About 2 designers and 25 tourists were interviewed; based on their responses we summarized in table 3.

Table 3. Sensory impression of TESTBED2 Park

| Sensory type | Feature |
|--------------|---------|
| Visual       | 1. Modern creative design based on the preservation of the original conditions of the buildings. For the renovation of old houses, TESTBED2 pioneered the concept of "boarding", that is, making changes to the existing structures while preserving the original appearance of the old factory without destroying one brick or one tile. Set up a series of small installation artworks, dismantle and reorganize the original iron bars, metal nets, lamp tubes, waste electrical boxes, and other items in the factory area, giving a strong industrial atmosphere.  
2. Popular check-in places. Many movies are filmed here, and there are places made for photography that highlight Chongqing's local characteristics, such as the Love Rooftop and LikeA Museum, which are quite attractive to young tourists.  
3. Decoration integrated with the local culture. The setting of shops strengthens the impression of traditional Chongqing, adding elements including dialect characters, typical hot pot, with the new ideas applied by art creators, forming a combination or contrast of the old and the new to enrich the tourist experience.  
4. Enriched way of exhibition. Invite artists from multiple fields to settle in. Introduce the Contemporary Art Center to host various art exhibitions and cultural and creative gift exhibitions.  
5. Diversity of cultural and creative products. In the shops, batik, bamboo carving, and other intangible cultural heritage products are sold, and intangible cultural heritage related places are set up, with Liangping woodblock New Year pictures, movable type printing, and other crafts for viewing. |
| Auditory     | 1. Various types of cultural and music activities. Regularly organize music festivals, immersive street musicals, and other tourism activities to attract tourists to participate.  
2. Create a hustle and bustle atmosphere of the typical Chongqing neighborhood. There are many gourmet food shops and markets on the ground floor of the factory, and the sound of chatters and eating that follow creates a lively and cordial atmosphere.  
3. Clever use of natural sounds. Construct check-in locations such as the Love Rooftop, located high near the Jialing River and the Yangtze River, so that visitors can hear the sound of the wind when enjoying river scenery, especially in the rainy season the combination of the sound of water droplets and the wind, which can leave a deep impression on tourists and relieve tourists' anxiety. |
| Gustatory    | 1. Introduce gourmet food stores to better preserve gourmet culture in Chongqing. For example, Dawang Youcha, Lingju Pickled Chinese Cabbage Chicken Rice Noodles, Chinese Meat Sauce Noodles, etc.  
2. Enrich the way of shop display and spread the local food culture. The restaurant "Jiaofang" is dedicated to promoting Chongqing Trellis hot pot, with illustrations of how to eat and hot pot recipes. |
| Olfactory    | 1. Creative use of green vegetation. Many fronts are decorated with green plants. For example, the Lanyu shop has glass houses and old trees, as well as various plants throughout the year, such as ficus banyan, jasmine, and hydrangea to decorate the courtyard, which could purify the air, reduce the effect of the possible pollution on olfactory function and the surrounding noise, providing a peaceful time for tourists to stay alone.  
2. Smell from local delicacies. The local delicacies offered by gourmet food shops deepen the impression of Chongqing gourmet culture on tourists. |
| Tactile      | 1. Focus on community participation. A wide range of training and gatherings have been prepared for shopkeepers to continuously help them improve. In the limited space of the park, various community organizations, such as the Locomotive Club and the Chaos Planet Business School, play a leading role in the format of business, continuing to and make innovation and breakthroughs.  
2. Experimental cultural market. There are many unique and creative products, such as original hand-made accessories, knitwear, which put emphasis on innovations about local culture related products, like the sale of the movable type printing stamps.  
3. Diversified application of building materials. The installation artworks make full use of materials, like wood and steel, to bring visitors a different feeling of touching and deepen the park’s image as the industrial area.  
4. Organize many interactive activities. For example, carry out lively and interesting programs about banknote printing and related technology, immersive street musicals, LOOPLOOP childlike TESTMART, and set up projects about learning the intangible cultural heritage, such as making Liangping woodblock New Year pictures. |
Through the analysis of results, the visual and touch experience is evaluated higher than the experience of other senses. The visual experience brought by the TESTBED2 Park is featured by its modern creative design, multiple popular check-in places, local cultural stores, diverse exhibitions, and different products, which made it satisfied by more tourists. For the tactile impression, the park’s unique bazaars, multiple interactive activities, and different construction materials impress the visitors. However, about hearing, although the sound produced by entertainment is relatively rich, the sound elements related to the original printing factory are not fully utilized. The taste highlights the local cuisine of Chongqing, but the food in the park has not yet combined any ideas about industrial features, like there is no special food shop related to the workers’ production and life. The green vegetation to improve the impression of smell is quite appropriate, but the elements of industrial and printing have not been included, such as the smell of printing ink and other olfactory characteristics. And there are also few multi-sensory experiencing projects.

3.6. Conclusion and suggestion

3.6.1. Visual. Upgrade the wayfinding system of the park. Now, there are two park overview maps at the entrance of TESTBED2 Park. Each building has wooden standing signs to indicate the distribution of shops inside, and there is still room for improvement. In terms of its user-friendliness[13], guiding content such as the location of and public service facilities, commercial flow lines are not included in the wayfinding system, which cannot help tourists reach their destinations quickly and effectively. Meanwhile, most of the information is written on wooden boards, which is not clear and easy for reading, and some of the handwriting is illegible after abrasion. The park is supposed to update the system and add information to ensure legibility and efficiency. Also, the wayfinding system does not have features about the regional culture and the printing industry. Geometric figures of typical Chongqing landscape elements, such as mountain and river, can be added to the design of standing signs, or wooden guides can be replaced by printing press plates to show the park’s history as a printing factory.

Improve the installation works in the park. The current small installation artworks in the park are mainly made from the original iron bars, metal nets, and lamp tubes in the old factory, which gives an industrial atmosphere but lack the uniqueness of a printing factory. Printing equipment, such as offset printing presses, gravure printing presses, can be placed inside the factory, or elements related to the printing process, such as lithography, type printing, gravure printing, letterpress, engraving, plate making, can be added.

3.6.2. Auditory. Add vegetation to reduce noise. The park could design vegetation for partly isolation to cut off rest areas from rambunctious neighborhoods, reduce man-made noise, and enhance the auditory experience in the quiet environment.

Add scene sound for an immersive experience. The interpretation can be joined to tell the history of the printing factory and the construction purpose of each building, as well as the unique shops inside now. In a specific area, such as the integrally preserved workshop, the recorded or simulated sound of machine operations could be played, allowing visitors to experience the actual production.

3.6.3. Gustatory. Add printing-related elements. Printing products like newspapers, materials like inks, and techniques like gravure can be used as key elements to dishes. More than that, the dishes or eating environment of the past printing factory workers could be presented, bringing tourists an immersive travel experience.

3.6.4. Olfactory. Use vegetation to improve air quality. Plant more green vegetation in the park to degrade pollutant molecules in the soil, or the air, while increasing the humidity, adjusting the surrounding temperature, and maintaining the microclimate of the site.

Add unique industrial odors. Designers can consider collecting odor molecules and then release them in the park to increase olfactory stimulation, such as the smell of burning, rust, petroleum, etc. The
concentration of odors can be adjusted in time with changes in environmental temperature and humidity; the park can also utilize the technology "microcapsules", and the scent could be caught into tiny particles and attached to various unique materials. Then during visits, tourists can be impressed by the industrial features and form special olfactory memory [14].

3.6.5. Tactile. Increase the diversity of touch experience. Increase the number of materials used in the landscape, such as stone, glass, metal, and wood. The combination of different materials appears in the landscape design in various forms, which will produce a rich tactile perception experience for tourists. Designers can pave the ground with different materials and add interactive landscape facilities to make visitors touch these materials. The design of plants and waters can also be added to the park to enrich the sensory experience.

4. Conclusion
Apply modern technology. The application of VR technology could allow visitors to participate in the printing production process and provide corresponding experience about multiple senses including smell and hearing. Meanwhile, a multimedia wayfinding system can be built, interactive modes can be added, and then rich content information can be displayed, which can also provide the interactive audiovisual experience and of four-dimensional space.

Use of vegetation. Appropriately arrange the vegetation to produce natural sounds, like the gentle rustling of leaves. Tourists can also touch the plants and get different feelings about different parts of plants. And the overall environment could be improved or beautified by vegetation management.

Organize different activities. From many aspects arouse tourists’ senses, designing activities such as gourmet festivals, street performance, and design contests.

Use of sensory marketing. The marketing can be shown in many aspects, including logo designing, slogan, and advertisement, to shape tourists’ image of TESTBED2. Through different media, the park could regularly publish articles introducing architectural concepts or various activities online to keep drawing interests and attention from followers. On the site, the park can design customized products for tourists to better satisfy tourist five senses’ experience.

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