POST-INDUSTRY REDEVELOPMENT DESIGN IN SHANGHAI, PEOPLE'S REPUBLIC OF CHINA

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ABSTRACT

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With the development of the world's industrial technology to a new era -- the post-industrial era, many manufacturing plants were abandoned and gave way to green space or service industry, among other possibilities. Site reconstruction has become an increasingly popular thing in urban planning and design around the world. In Shanghai, many famous industrial heritage sites have been transformed into public facilities, but there are still many normal industry sites visible in the community. Many of them still have retained a lot of values. There is no accurate set of variables to define what determines the effect of industrial land renovation. This study selects a post- industrial site in Shanghai, conceives three different designs through different concepts, collects and calculates data to analyze different variables in the three different types of designs, and explores new methods to protect these post-industrial sites. The Friedman analysis of comparative methods has been applied to reach a value of 9.51. On the other hand, the value of X, with 2 degrees of freedom, is 5.991. It is smaller than our data of 9.51, which then means the value is effective. Finally, a multiple comparison procedure proves that industrial elements is a more effective way of transformation. This research will help landscape architects, urban planners, and others interested in this topic understand the appropriate steps required for industrial site reconstruction.

Key words：Landscape Architecture, Post-industry Redevelopment, Urban Design.

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Chapter 1. Introduction

1.1 Brownfield and transformation

A large number of cities are now entering the post-industrial era, with manufacturing factories being replaced by service industries, and abandoned sites turned into brownfields. Brownfields, which refers to fields contaminated by industry, are evident in more than 450,000 plots in the U.S. alone (“Overview”, 2017). As many industrial age buildings and sites will be demolished, the question is: how can one preserve these cultural heritages and rejuvenate them? The cultural renaissance emerged in the 1980s as a result of the transformation of the economic structure of Western Europe in the 1970s, which led to social and economic transformation, especially from the industrial economy to the post-industrial economy (Bell 1973; Bianchini, 1993). People find that cultural strategies can promote cultural consumption and integrate cultural infrastructure such as theaters and museums to achieve economic recovery and urban boosting (Sharp, et al., 2005). This study focuses on the cultural heritage of redeveloping industrial sites. The transformation of the industrial economy into the post-industrial economy has resulted in many industrial sites losing their original value. However, for landscape architecture, these renovations have become popular topics. How to maximize the preservation of these former industrial sites and make old cultures intersect with the new culture, and how can the post-industrial landscape be better preserved as a new type of landscape? (Wu, 2011).

Wu (2011) showed that it is inevitable for people and planners of many cities to reclaim old brownfields, because there is no better alternative plan, such as a plan to ingeniously transform those brownfields. To find a solution, Wu's approach to design depends on the most complete integration of cultural and economic values. However, to expand cities, governments need more economic returns, which is why most industrial sites have been demolished. Wu

(2011) recommended to explore more sustainable development plans for the protection of heritage and residents' interests. Wu (2011) also recommended preserving cultural identity, protecting the original urban landscape, providing connections to local villages and the city center, creating new jobs for locals and new immigrants, and creating new green, multi-purpose public spaces.

Many factories have become obsolete through the elapse of time, and various problems have emerged, such as site pollution and the restrictions those factories impose on urban development. In the face of outdated industrial land, cities often answer by abandoning them, but such abandonment will bring negative economic, social and environmental effects to urban areas. Demolition and landfilling are the main methods to remove these leftovers (Tatiya, et al., 2018), but those treatment methods will cause many detrimental consequences, such as heavy metal pollution and other chemical pollution (Ren, et al., 2014). In addition, as most of the debris is landfilled, it results in large amounts of carbon dioxide emissions and land pollution (Dantata, et al., 2005).

The post-industrial transformation aims to renovate and improve some abandoned factories and buildings from the old industrial period. The conversion of industrial heritage is a novel development concept for all cities in the world. Those industrial heritage are records of history, economic recovery and social development. Today, many manufacturing plants that have been abandoned are turned into green spaces and buildings for service industries. Reconstruction has become a trend in cities around the world (He, et al., 2005).

A considerable part of the data shows that there is a huge potential for transforming construction material in the structures and infrastructure of industrial land, and some materials can be completely reused or recycled (Stumpf, et al., 2011). In addition, some building parts, which have been designed from the beginning to be easy to install and disassemble, will achieve better sustainable development in the future re-modification or improvement (Guy, et al., 2008).

Therefore, by properly redesigning old industrial land, we can improve the old industrial land heritage redevelopment method. It can not only protect the environment and achieve sustainable development, but also provide better welfare to the community and offer residents aesthetic enjoyment and convenience in their daily life.

1.2 Post-industrial era and the importance of transformation

There is a prevalent belief that the industrial society has entered a period of rapid change since the 1960s. For instance, among one of those changes is the transformation of the focus of production – from product production to service production (Bell, 1973). Since 1960, human beings have been in the post-industrial era for a long time, as generally recognized by the public. Post-industrial redevelopment has increasingly become an important factor in land-use planning and urban design, because it directly helps to minimize natural resources consumption, especially non-renewable resources, and also helps to gradually develop renewable resources. At the same time, redevelopment will also coordinate economic development and environmental elements with the people (De Sousa, 2003). The original post-industrial landscape is functionally and materially obsolete and, in many cases, decaying. Although historically significant, these sites are often not widely regarded as valuable contributors to our heritage. However, these landscapes still exist, and we cannot deny that they are indeed culturally significant (Arnold, 2017).

1.3 Meaning and purpose of protecting post-industrial sites

Protecting the industrial sites as a cultural heritage is very important. In the Middle Ages, nature did not exist as a theme. With the beginning of the Age of Enlightenment, people began to create and become independent thinkers. The German philosopher J. Johann Gotfried Herder saw the continuity of human progress as a goal of history. In his opinion, every chapter of history can be regarded as a cultural unit (Höfer, 1998). The land of the old industry is a symbol of the industrial age, and the construction land itself has a very strong historical and cultural presence. Thus, with the regeneration of abandoned industrial land and the development of industrial heritage tourism, the post-industrial landscape enhances people's memory of industrial civilization, improves the relationship between site use and local people, and is conducive to the reform of declining industries (Zhang, 2007). In spite of the pollution brought about by industrialization, the advent of industrialization was a milestone in human history. It has brought about a series of lifestyles that people are familiar with now, such as urbanization (Loures, 2015). If a cultural heritage is linked to the surrounding culture and environment through transformation, then it can be preserved. Thus, this proposed study will benefit not only the urban planner but also the whole urban society.

In fact, industrial heritage can also be considered as cultural heritage. With the development of technology, most architectural forms with industrial characteristics will no longer exist.

Preserving some industrial elements during land transformation is a commemoration of human history. It will remind people how human beings gradually change the world through machines, and encourage people to make future development. Thus, the results of this study may have a long-term impact on the life of people living in urban areas.

The purpose of this research proposal is as follows: 1) to analyze how to preserve old industrial sites as a cultural heritage, 2) to maximize the preservation of former industrial sites which is a part of history, and 3) to identify the meaning of these culture heritage to the surrounding society by strengthening the relationship between the community and the industrial sites. This study will collect different elements that affect the post-industry redevelopment process, try to re-design a normal abandoned factory in Shanghai, and discuss what kind of design is more effective and beneficial for both the redevelopment and local citizens. Finally, as people tend to easily ignore cultural heritage in the industry sites, we need to determine how to protect and transform the sites in a landscape way and re-express the cultural heritage with a new vitality. This proposed study will also encourage people to appreciate the importance of these culture heritages, in order to better protect post industry sites.

Chapter 2. Literature Review

2.1 Redevelopment issues

In the post-industrial era, retaining original industrial land is not a simple issue. It requires the involvement of local governments and capital operations. Therefore, a large amount of abandoned industrial land during this period was abandoned and abolished (Rea, 1991; Arnold, 2017). Demolition of building structures generates a large amount of material, which in most countries causes a lot of waste. In the United States, demolition waste accounts for 92% of the total construction and demolition (C&D) waste of 136 million tons per year, and about 125 million tons of demolition is sent to the landfill (Kibert, et al., 2000).

The commencement of this redevelopment process causes some issues in society. In some studies, economic reasons have been shown as an important part (Wu, 2011) of the issues regarding the allocation of responsibilities, which is often identified to be one of the main factors that lead to funds moving away from industrial transformation (Wright, 1997). Also in another paper, Gao (2018) showed issues about allocation of responsibilities in the post-industrial site, and this study has proved that there are disputes between the original land users and the landowners over the allocation of reconstruction costs and the distribution of potential profits, and neither is the government willing to bear the consequences of the economic loss incurred by the transformation (Gao. et al., 2018).

Some redevelopment factors, including location, local government support, and the allocation of investment costs, suggest that there is also asymmetry between rural and urban areas. Because of the location of major transportation infrastructure, the previous functions of the brownfields and threats to the environment are factors that the government is considering in rebuilding industrial land. The analysis of the article did not find a significant impact of population density on brownfield redevelopment, but those brownfields are more likely to be located in cities with higher development potential (Osman, et al., 2015), so these factors limit the possibility of redevelopment. Additionally, the inherent high costs in remediation often require large amounts of financial investment to reduce pollution to acceptable levels (Loures, 2015). One solution may be to rebuild the areas and make them more welcomed by the society, but these previous research efforts did not suggest that specifically.

While people who rebuild industrial lands are primarily driven by economic reasons, the value of heritage conservation and community development is also considered as another consideration. In some medium-sized cities like Spokane in Washington, due to the significant reduction in government involvement, individual private investors have undertaken contemporary renewal projects on a small scale, such as building parking lots, new buildings for commercial use, and tourist parks around historical buildings (Mowery, et al., 2016). This makes it possible to retain industrial heritage land as a cultural heritage. In medium-sized cities like Spokane, non-financial needs are particularly strong, and developers must have strong links with the community. The reason is that, if the developer and the community are not well connected, the following will happen: the public square becomes barren and unattractive, and many public housing projects will exacerbate social ills. Therefore, design decisions and residents' attitudes are especially important in this situation.

2.2 Design method and resident attitude

Specific design principles and methods may practically influence and guide redevelopment in reality. In a survey based on a review of 346 case studies worldwide and an in-depth study of six post-industrial case studies, Loures. et al., (2011) it demonstrates the importance of identifying a set of plans and successful use of design principles to rebuild the project that creates the base for post-industrial redeveloping, thus revealing the importance of having a method first. Loures (2011) considered post-industry land as having a high heritage value, recognizing that art, history, and creativity are still key elements of overall design.

More specifically, the redevelopment of the park is closely related with landscape design. Loures et al. (2011) suggested a few methods based on the Millennium Park project in Chicago: For example, by creating a space where people can enjoy their own space and have an intimate relationship with nature and culture, Millennium Park has cultivated a considerable sense of belonging among Chicago citizens. In fact, it's a great example of realizing a unique public-private sense of belonging, not only to capture the attention of private donors, but also to contribute to the construction of parks, especially with the artistic and architectural features. The general public regards the park as one of the reasons for the destination of locals and tourists. Resident preferences are one of the factors that determine how to rebuild the industrial site.
In Navratil's (2018) study, the overall attitude of residents to brownfield was positive, and the transformation of industrial land into green land was recognized by some residents. Even unregulated urban green spaces can be highly valued by residents, who realize that this green infrastructure can benefit to avoid the urban heat island effects by cooling down the city. However, it is not always accepted by the public. Surprisingly, people living in the center of city have less interest in rebuilding public spaces for exercise and relaxation. However, in the suburbs, there is a high level of interest in turning brown areas into recreational places. It may reflect the lack of awareness of the downtown area service and residential functions (Navratil, et al., 2018). As the relationship between investors and the public is not well-connected, the rebuilders will easily fail with their project. When investors are not required under certain policies to invest through the local governments, those investors have no attachment to the local environment, so

rebuilding the environment is purely a way to make money -- but it turned out that they failed to achieve that (Mowery, et al., 2016). This suggests that disseminating more information about the reconstruction among local community and increasing the link between investors and the locals may promote the reconstruction of industrial land in medium-sized cities (Mowery, et al., 2016). However, there are still problems left unsolved by the above studies: What are the appropriate strategies for the industrial landscape redevelopment project, and what kind of landscape creative value and elements should the industrial land use to obtain the residents' support?

2.3 Difference between designer and local

As described in his study, even if the importance of post-industrial land transformation is increasingly recognized, the benefits and obstacles of post-industrial reconstruction are difficult to define (Loures, 2015). An appropriate strategy for industrial landscape redevelopment projects is to identify important obstacles and benefits, as discussed below (Loures, 2015). In this article, Loures (2015) analyzes the different perceptions between public and experts, which is very important. However, he does not have any findings regarding landscape architectural values and local public relations. His article only mentions the notion that the general community and experts have different views on post-industrial land. But does not analyze what values and elements can fit more closely with the public. Planning and landscape redevelopment activities become the design that results in something that designers want, as they emphasize more on the expression of economic and sociocultural power as their primary tasks. Loures (2015) discussed a different understanding of the interests and barriers of post- industrial redevelopment between the public and experts, proposing that designers tend to focus primarily on aesthetics, placing other major goals of society in an unimportant position. Post- industrial redevelopment must be seen as one the of several components in the broader context of urban planning and economic development, which shows the difference between new uses in the post-regeneration industrial landscape. A “cell” in this study represents a situation, like in Norrköping, where the policy implication may be that important cultural heritage values are ignored in order to adapt the landscape to new uses (Small, et al., 2016).

2.4 Deconstruction and recycle materials in landscape architecture

The most important problem arising from the above industrial transformation is the economic issues, and design for deconstruction is an emerging concept, a topic that has become popular recently. It draws ideas based on the design field in the consumer goods industry for disassembly, reuse, remanufacturing and recycling. It is usually defined as the recycling of components and materials from waste land for reuse and remanufacturing. Its overall goal is to improve resource and economic efficiency and reduce the impact of pollution in building alterations and eventual demolition (Guy, et al., 2006). The data show that the role of deconstruction can reduce waste and debris in the house. Demolition can reduce construction site waste by 50-70%, which may save resources and reduce emissions. The material recovered in the deconstruction project reduces the demand for raw material collection and reduces demand for long-distance transportation materials, as older buildings can provide materials for the renovation of historic buildings, or to protect them. In addition, the rate of waste removal from landfills is increased. There has also been a potential reuse of building components, and improvement in local and global environmental protection (Kibert, et al., 2000). The most important benefit of deconstruction is that it is often more profitable than simple demolition (Olson, 2010).

The Natural Gas Plant Park in Seattle, Washington, was one of the earliest post-industrial sites (Way, 2013). It expresses a method very similar to deconstruction in the concept of domicology (Guy, et al., 2006). In the view of landscape architects, the adaptive reuse of abandoned landscapes can not only improve contaminated land, but also transform it into a public service. Although both officials and citizens demanded the removal of the remains of the industrial plant, the designer succeeded in retaining the components of the industrial plant. These parts were not simply demolished but were given a new aesthetic and landscape mission through reuse. The parts of the industrial land that seem to have to be demolished are retained through the landscape. By preserving these structures, not only can history be retained as part of local memory, many economic problems have also been solved, as the demolition is replaced by the retention of a large part of the park 's revenue sources and new job opportunities created (Way, 2013).

2.5 Current metrics

Recently, the comprehensive metrics of environmental variables in landscape architecture are mainly given by the Landscape Architecture Foundation (LAF). In the guide book (Landscape Architecture Foundation, 2018), different metrics including environmental economy and society are listed in detail. As a research on the design of post-modern industrial landscape transformation, this research will focus on indicators related to the industrial environment, as the variables that may be used in the next chapter, and the next chapter will explain more about the variables, such as material recycling and reuse indicators in environmental advantages (Burley et al., 2016). In addition, with a focus on sustainable development, the researchers in a similar research report selected rainwater, adaptation to climate change, adaptability of wild animals and plants, visual quality and maintenance of soil productivity as the final assessment indicators of the landscape (Strauch, 1994).

On the other hand, due to the particularity of industrial land, the impact of construction on the environment should also warrant attention. A study shows that the impact of construction on the environment can be reflected in many indicators, including but not limited to construction and demolition waste, dust, impact of pollution, noise and vibration, other metrics such as the impact on wildlife and natural characteristics, the pollution of surface and groundwater, and so on (Berghorn et al., 2019). At the same time, the research also pointed out that the indicators in the construction will be the destruction of vegetation, visual impact, noise, increase in vehicle flow and parking. The reduction of space and the destruction of public space are also issues that can be analyzed (Berghorn et al., 2019). Therefore, in this research overall, it is necessary to comprehensively consider the construction, structure, environment, society, economy and other indicators to effectively analyze the reliability and prospects of the industrial transformation design.

2.6 Friedman methodology

Friedman methodology is a common way to detect differences in data. It is used to detect differences in treatments of multiple test attempts. Milton Friedman noted in his paper that the use of ranks to increase the accuracy of data, involving statistical data collection and analysis projects, is to study the factors of variable changes (Friedman, 1937; Friedman, 1940). Before that, statistical tools were mainly used for analysis of variance, and the data was often sufficiently extensive. This technical approach is not effective in any other way. Friedman noted that by arranging each group of values of variables in order of magnitude, such as arranging them as 1, 2 and so on, and using these levels to replace the original quantitative values, the difficulties caused by extensive data can be avoided. In the paper, Friedman tried to provide a significance test for data that contains less than six groups of levels and the number of levels in each group is small or medium. The results are effective (Friedman, 1940). Nowadays, the Friedman methodology is a common and effective way to detect the difference of data. First, a wide range of data is effectively arranged and then the difference between several different treatments is detected through this methodology. In the field of design and planning, Friedman methodology solves the difficulty of different variables that are hard to be measured together, and it has been proven to be efficient and successful in the field involved (Burley et al., 2020; Burley et al., 2016). The following sections of will illustrate the use of Friedman methodology in different design areas.

2.6.1 Roof garden impact

A research design analyzes and studies the effective measures of the green roof of the house (Tam, et al., 2020). The location of the research is in the Sylvester Brooms Empowerment Village in Flint, Michigan. A total of five design schemes have been developed for the roof of the house. The site location -- Flint, Michigan, is the seventh most densely populated city in Michigan. It is an open house, now with a history of nearly 100 years. The building has a total of four roofs (Tam et al., 2020). The five designs mainly include Conventional, Self-Design, Extensive, Semi Intensive, and Intensive. There are about 36 variables such as Accessibility, Plant, Function, etc. Through the sorting of more than 30 variables, the final value of each of the five designs is different. The difference generated by Friedman methodology is non-significant. In the end, the author's Friedman two-way analysis of variance supports his article's viewpoints, such as through comparing self-designed roofs, large green roofs, semi-dense green roofs and dense green roofs, people can be sure that dense green roofs are better than self-designed roofs through this statistical method.

2.6.2 Ecosystem

The use of Friedman methodology can distinguish ecosystem solutions. In one study, a granite quarry in West-central Minnesota was analyzed and studied to find a suitable post-mining land use structure (Burley et al., 1988). Because the quarry is adjacent to the Federal Big Rock Wildlife Sanctuary, the main land use after mining is wildlife habitat. The article has studied three main habitat treatment methods (Burley et al., 1988). The first method is its site conditions, the second method is a design plan without wildlife planning, and the third method is to create landscapes for nine wild animal and plants groups after mining. The article analyzes the data of nine wild animal and plants groups, with each plant and animal community having its corresponding comprehensive value of habitat. The ranking of each flora and fauna in the three schemes is given by numerical arrangement. Then the application of Friedman methodology shows that the difference between them is not significant. The final results showed that some design schemes such as adding shrubs to suit animals and plants are effective.

2.6.3 Reduce the impact of the earthquake

The Friedman methodology can also be applied to earthquake mitigation schemes. In the study, researchers assessed environmental safety issues by investigating various landscapes related to the Wenchuan earthquake in China (Feng et al., 2018; Feng et al., 2017). There are three different landscape treatment methods through seven variables, including the height of the building, the space between the buildings, whether the building construction area is related to the flooding area, the choice of escape route, etc. The ranking of these seven variables is used to determine the final result of the three landscape-designs. Through Friedman methodology, to confirm that some treatment methods are significantly better than other design solutions and have more advantages in reducing earthquake impacts.

2.6.4 Railway station design influence

In a study on railway station design, Friedman methodology demonstrated its quick and effective characteristics (Lin et al., 2017). In a study, the researchers chose a station in East

Lansing, Michigan, in order to study people's perception of location in an unknown environment (Lin et al., 2017). The researchers conceived a total of five design schemes, and looked at the train station from the window of the train, each with 12 photos, so a total of 12 data were counted as variables. In addition, a total of 45 interviewees received the questionnaire, which included grouping and ranking of 12 variable pictures, and finally the researchers compared them through Friedman methodology. The final test showed that there are significant differences between all design methods.

2.6.5 Housing design

Similar to the literature review in the previous two paragraphs, Friedman methodology has also been proved to be useful in housing design. A study shows that the housing design is linked to healthy housing (Hallsaxton, et al., 2011). This research was conducted through a list of fourteen variables, including sound, touch, sight, smell, and so on. These fourteen variables are used to evaluate the residential value of the entire indoor environment, and then the results of each design plan are obtained through different calculation methods, and the rankings corresponding to the fourteen variables are given through these results. The advantage of Friedman methodology is to rank various variables first, avoiding the incomparability of a large number of variable data. The final result shows that the sustainable development approach has a better advantage.

Through literature review analysis, it can be found that the biggest advantage of Friedman methodology is that it can rank complex data and more subjective opinions to determine the advantages and disadvantages of treatments. Therefore, it can be widely used in the field of design and planning. Different designs or regions can be used as different treatments to distinguish design ideas and advantages.

2.7 Conclusion and Research plan

Finally, this study may affect people's perceptions of brownfield and industrial elements. This study will discuss in depth how the design will affect the way new industrial landscapes are constructed. One should consider the potential of post-industrial land. Since the post-industrial landscape represents an important cultural asset of the community, reconstruction will create wealth and job opportunities, while improving the vision and aesthetics of the community and addressing the loss of urban expansion and green space. This study will also introduce reconstruction attitudes and practices in contemporary and future generations of social consciousness and preserve industrial heritage to the maximum extent as a cultural heritage.

What is important in this research proposal is to give a certain landscape value basis for industrial land and to find suitable design principles in existing examples, so that industrial land can be retained as a cultural heritage. Two articles by Loures et al. (2011) and Loures (2015) are important for this proposed study as they report on the effective value of industrial landscapes in attracting more individual investors to solve economic problems and also in enhancing the cultural belonging of the local residents through post-industrial land. It also cultivates people's sense of belonging to the place. The aim of this proposed research is also to arrive at the same results.

Therefore, this article will select an old industrial land site for design transformation and create different designs with different emphasis. Finally, data analysis will be used to determine those design advantages and disadvantages and promotes development of the design. The discussion about the design transformation projects and variables will be included in the next Chapter.

Chapter 3. Methodology

The experimental design of this paper has four steps. First, develop three different design scenarios. Then, apply more than 20 related variables to the three scenarios. After that, calculate the variables, compare the three different scenarios across the different variables, and rank the best solution of design plans. Finally, reach the conclusion with the Friedman two-way Analysis of Variance Test.

3.1 Study area description

The methodology of this article is developed based on three design scenarios: the traditional renovation design, green environment design, and industrial heritage design. Part of the design is an independently designed project by me as an undergraduate. The main purpose is to transform an ordinary old food factory into a community resource by applying the methods learned from class. My final decision was to focus this design on industrial inheritance, and the rest of the design plans are created based on this study.

3.1.1 Post industry in Shanghai

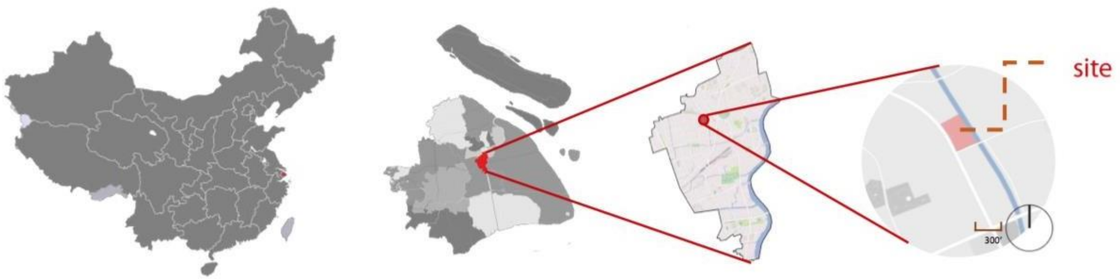
According to statistics, Shanghai has a total of about 40 million square meters of old factories, some of which have been built for nearly a hundred years, and some of which are representatives of the Chinese national industry. In the report, not only the once excellent industrial buildings have changed from idle and abandoned to being protected nowadays, but some of common industrial buildings are also re-emphasizing their value in terms of history, culture, urban landscape and sustainable development through transformation and improvement (Li, 2018).

However, there are still many of the post-industry sites abandoned. What's more, these factories are still polluting the surrounding environment. With the expansion of residential areas, local residents have begun to complain about abandoned factories, hoping to get more urban life experience. These abandoned factories urgently need a transformation plan to benefit the residents. Ever since Shanghai has carried out industrial heritage protection and redevelopment projects, a great number of industrial heritage buildings have been protected. With a lot of good examples, these remodeled factories are being well known and understood. But it also comes with the second question: excellent examples bring blind followers, leading to over-simplification of usage types. For instance, more than half of cases in Shanghai are transforming industrial sites into creative industrial parks (Li, 2018). However, having too many creative industrial parks is also a great waste of resources. These creative parks have specific targeted groups, artists and young entrepreneurs, which cannot form a coordinated relationship with locals.

3.1.2 Location of the study area

The site (See Figure 1) is located by the Puhuitang River in Xuhui District, Shanghai, covering an area of approximately 1.8 acres (7400 square meters). It used to be the food processing plant of Shanghai Wanyouquan Food Company. To the west and south are Qinzhou Road and Huashi Road respectively, to the east is a river, and to the north is a traditional residential area. The entire selected area includes a production building, a flour workshop, a comprehensive building, a pump room and a boiler room.

Figure 1. Location and geographic map of existing sites



3.1.3 Existing context of the study area

The old food factory is located near the center of the city, surrounded by many famous hospitals and city shopping centers (See Figure 2). Undoubtedly, there is very convenient transportation. First, there are more than a dozen bus stops brought by several bus lines around the entire station. Secondly, there are five subway lines. Although the stations are at a certain distance from the study area, they are also within walking distance. The surrounding area is mainly residential. There is a large city shopping mall in the north and south, and it is also close to a stadium. In addition, there are quite a wealth of educational resources in the surrounding area. From primary school to university, there are more than a dozen schools of various sizes, but the green area of the city is relatively less and there are only 4 public parks. In terms of road traffic, it is close to the inner road and Humin elevated Rd. The only two roads that directly contact the study area are Qinzhou Road and Huashi Road.

Figure 2. Surrounding Map (Copyright ©2020 Zhixiang Zhang reserved, use with permission)

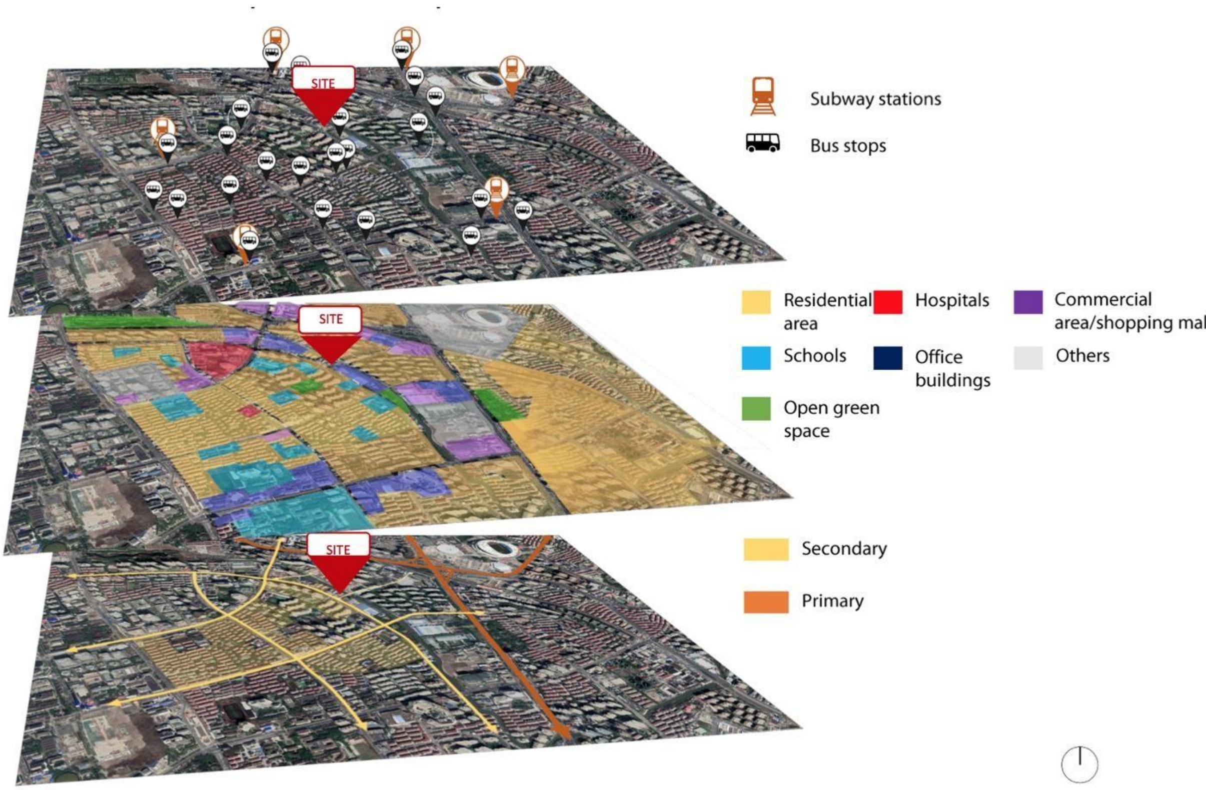
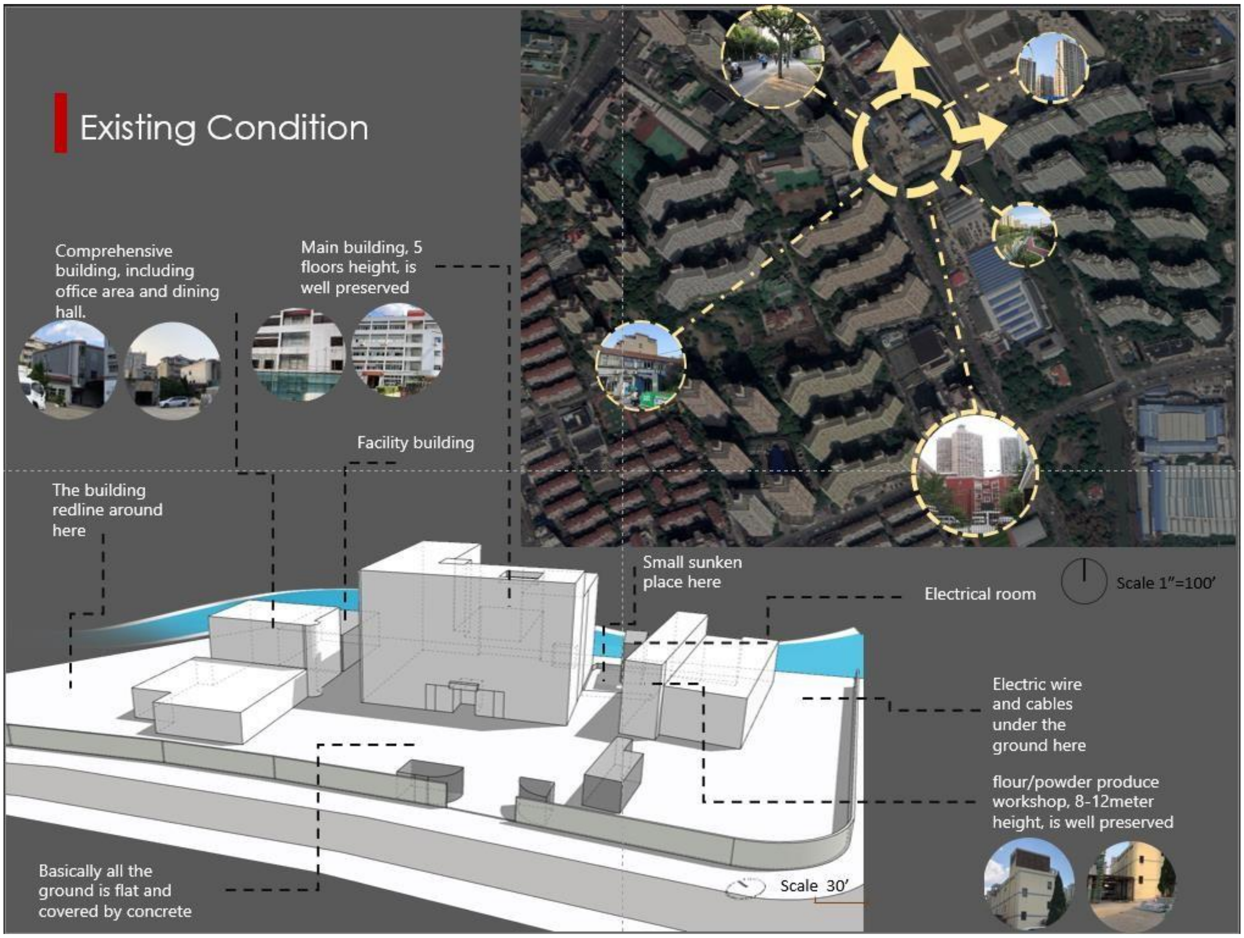


Figure 3. Existing Condition (Copyright ©2020 Zhixiang Zhang reserved, use with permission)



As can be seen from Figure 3, since the site was once used as a food processing plant, a large area of which is made of concrete. The main building (the largest one in the picture) is the production building, with a total of five floors, each with an area of 14,000 square feet (1300 square meters), and the building on the north side is a comprehensive building. The first floor was used for warehouses, the second floor was used for restaurants, and the third floor was used for meeting rooms. The first floor is approximately 8,600 square feet (800 square meters), and the second and third floors are approximately 3,500 square feet (330 square meters). To the south is the flour production workshop, with a total of three floors, but the third floor only has a small area, and the remaining two floors occupy an area of about 8,000 square feet (730 square meters). Except for the main three buildings, there are other small buildings such as power distribution room, garbage room, guard room, and boiler room.

Figure 3 also shows the surrounding environment (See Figure 3). The surrounding roads are typical traditional roads in Shanghai: each road contains two-way single-lane roads equipped with non-motorized lanes, well-planted street plants, the very narrow sidewalks about less than 6 feet, and also a 5 feet green belt. The north and west are mainly old-fashioned traditional small apartment houses, and the east are new high-rise apartment buildings under construction. There is a middle school close to the south, and the government next to the river is building a new green fitness trail and running track.

3.2 Design process

3.2.1 Analysis of the study area

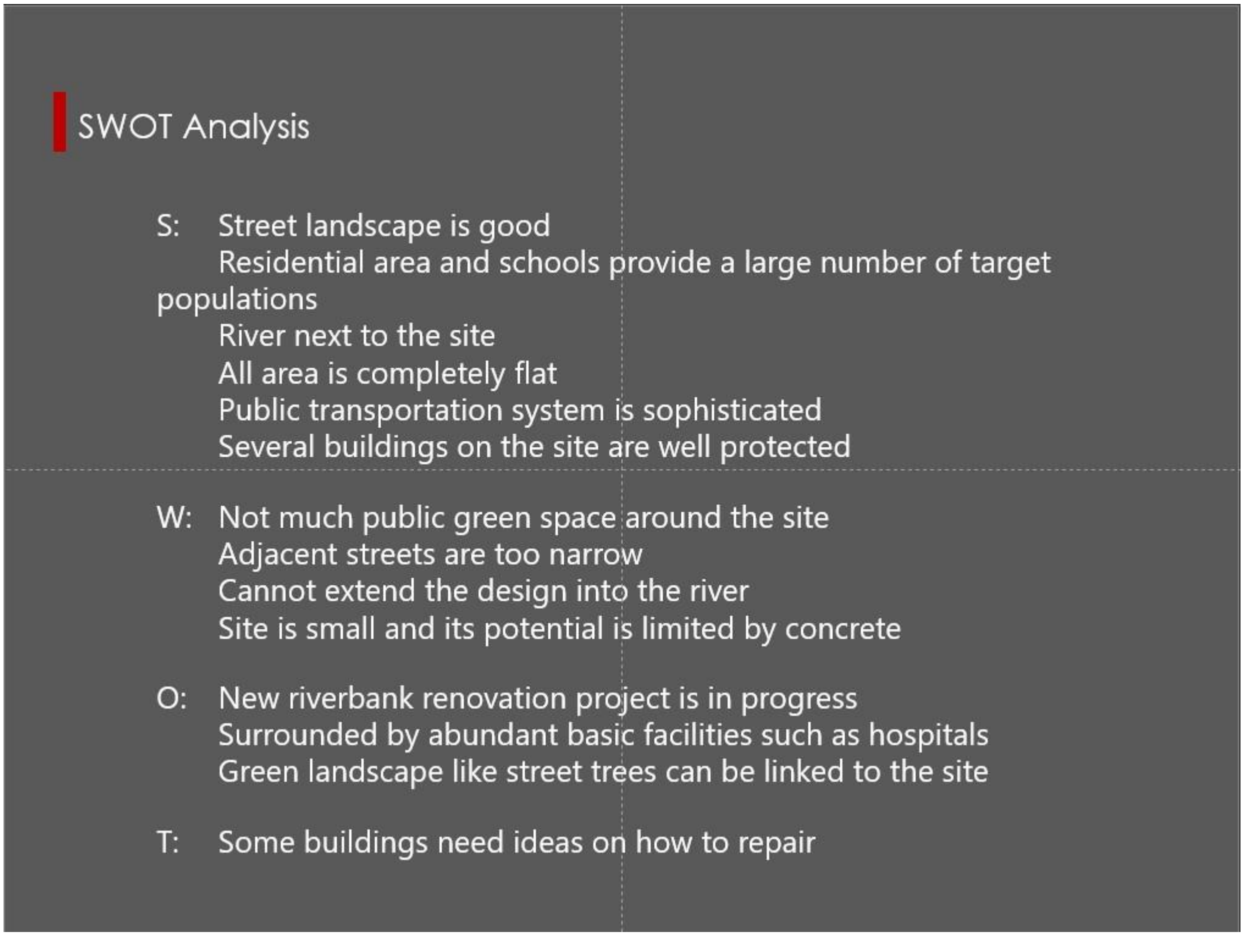
Compared with traditional industrial land, the study area has several special features (See Figure 4). First, because the geographical environment is relatively close to the city center, on the one hand it brings a lot of convenience, but on the other hand, the design needs to consider more aspects. Second, since the predecessor was a food factory, compared with the transformation of metal and chemical industry land, there are fewer concerns about hazardous substances and toxic waste from factories. Finally, due to the surrounding existing environment and some newly built projects, it is a challenge to integrate the study area into the surrounding environment.

In terms of environment, first of all, we need to consider traditional streets. On the good side, it brings a good street landscape. The long-standing plane trees provide a pleasant shade, and the dual-phase single-lane road restricts traffic volume. On the other hand, there are also some drawbacks, such as the sidewalks for pedestrians are too narrow, the green landscape is too simple and so on. Secondly, the surrounding areas are mainly residential areas and a large number of schools, which provides population resources and very complete infrastructure. For example, the transportation system has almost been fully covered, so that there is almost no need to consider how to reach the study area when designing. In addition, hospitals, shopping centers and other facilities necessary for daily life are within walking distance.

Second, we also need to consider the limitations of the site. As mentioned above, because of the uniqueness of the food processing plant, the existence of hazardous substances should almost never be considered. The entire site provides a coveted start to industrial transformation. Because it is almost all covered by a cement surface, it brings an almost flat ground and an environment without soil. With several major cement buildings, the entire space is almost a gray space filled with cement. How to transform and protect this memory is what the design needs more time to consider.

Finally, we need to consider whether the existing street shortcomings can be changed. In addition, the new waterfront runway, etc., combined with the development and transformation of industrial land, also need to be considered in the design.

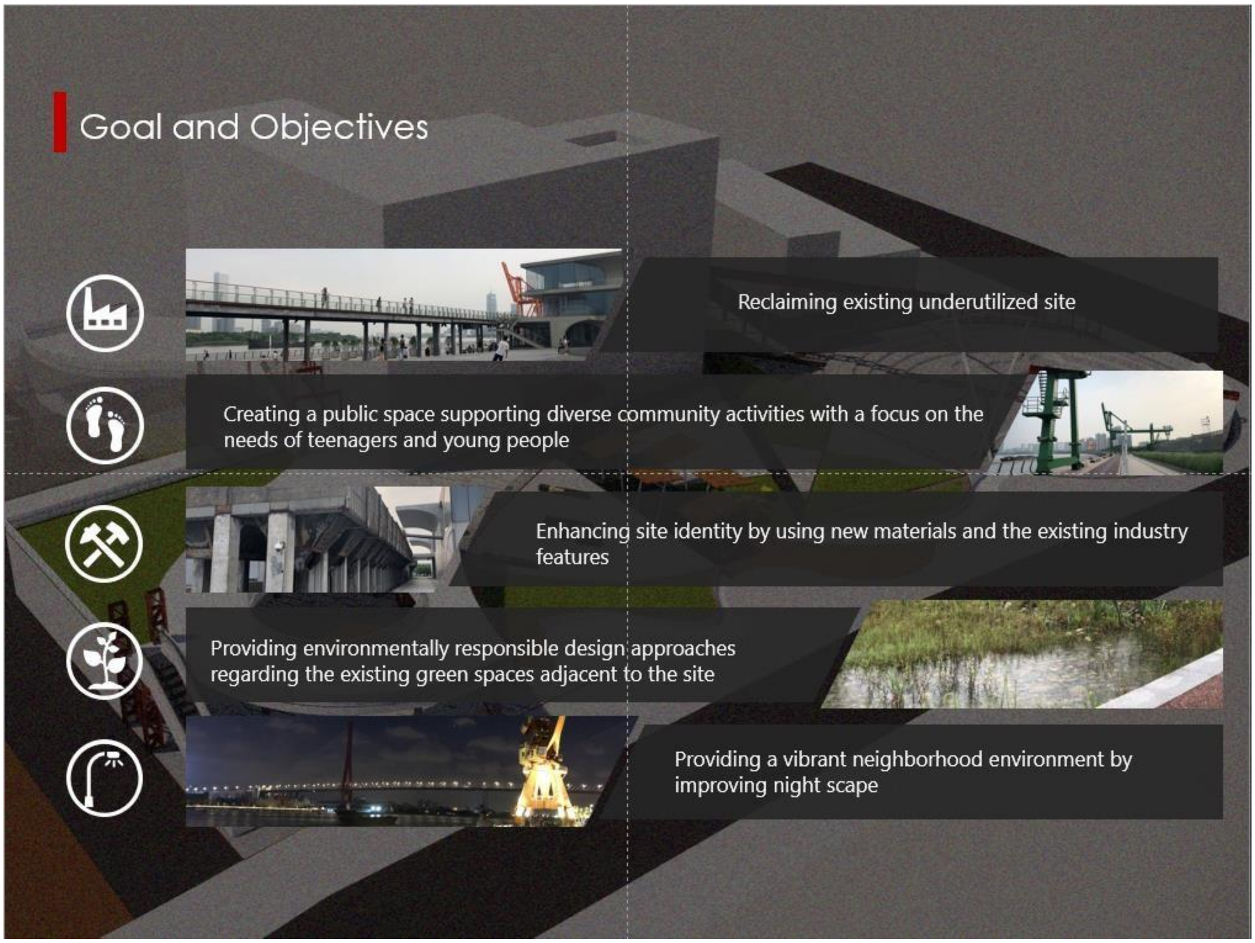
Figure 4. SWOT (Strengths, Weaknesses, Opportunities, and Threats) Analysis



3.2.2 Design goals and Objectives

On the basis of the existing site environment and on-site analysis, as a designer, I determined five main goals and Objectives (See Figure 5):

Figure 5. Design goals and Objectives (Copyright ©2020 Zhixiang Zhang reserved, use with permission)



The first objective is to reclaim existing structures and buildings. The site, especially the three main buildings, will be properly preserved and remodeled. This study mainly studies how to obtain maximum benefits and meet the surrounding needs through design methods in industrial transformation. It is necessary to maintain the main form instead of completely demolishing and then rebuilding. This can effectively reduce the shortage of material and manpower.

The second objective is to make places attractive to multi-generations including children and teenagers. Through analyzing and investigating the surrounding environment, the people that are the most likely to visit the study area are ordinary residents and youth groups represented by students. Therefore, catering to the interests of ordinary residents and students will greatly increase the success rate and satisfaction rate of site transformation.

The third objective is to use recycling materials and keep senses of belonging with the city. As analyzed in the previous literature survey, the biggest difference between industrial heritage transformation and general land use is that industrial heritage has many unique signs, such as production machinery, etc., which gives the site a uniqueness and offers the residents of surrounding cities a record of memory. Using more signs left over from industrial heritage not only adds some special marks to the site, but also gives residents a special sense of belonging.

The fourth objective is to be environmental-friendly. To promote sustainable development, the final design considers environmentally responsible design, and adopts environmentally sensitive design practices, such as rain gardens and permeable paving. It not only improves the site environment but also provides a livable environment for the next generation.

The fifth objective is to create a vibrant night scene by using lighting. Because the environment is close to the city center, when night falls, the venue should not be closed but should provide beautiful night scenes to bring enjoyment and convenience to residents and tourists who need activities at night.

3.3 Three different design

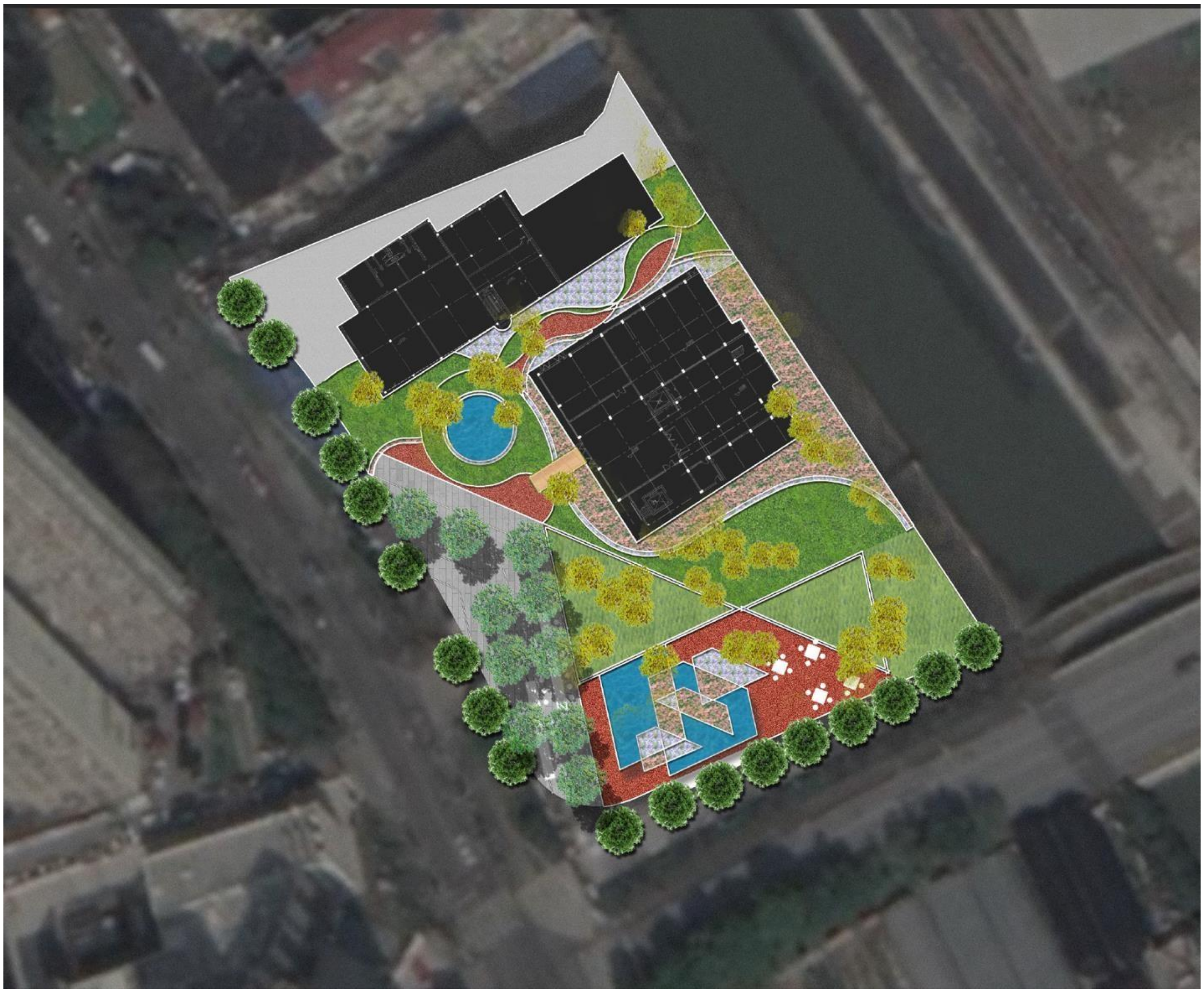
With the support of analysis and design goals, I created three different designs in total.

First, a green environmental design for environmental sustainability. Second, the traditional transformation design for activity areas and buildings. Third, a design focusing on industrial heritage. Note that I finally chose the industrial inheritance design. The other two projects were later expanded and supplemented based on the original design ideas, but please be aware that there may be some neglected issues.

3.3.1 Green environment design

Green environment design, as you can see in Figure 6, mainly focuses on more sustainable development, such as more trees and shrubs, and more walkable areas. The area on the west side close to the street was transformed into a square with the only concrete paved surface. It is mainly responsible for becoming a main entrance and extending the function of the street. The main building retains two seats and hardly changes. It mainly undertakes some indoor activities and catering projects. The design focus is mainly on the south, and the entire south has been transformed into a large children’s garden and walkable grass area. The production building is surrounded by a large flower bed that can be planted with flowers of different seasons, and can also be used as a rain garden when necessary. The height difference between the entrance of the building and the square of the site is connected by a wooden bridge. There is an iconic reflecting pool between the two buildings, surrounded by a walkable green area, which serves as a middle zone connecting several important areas. Except for the concrete plaza and green grass design at the entrance, the rest areas are covered with plastic to protect the youth and prevent accidents such as falls.

Figure 6. Master plan of green environmental design (Copyright ©2020 Zhixiang Zhang reserved, use with permission)



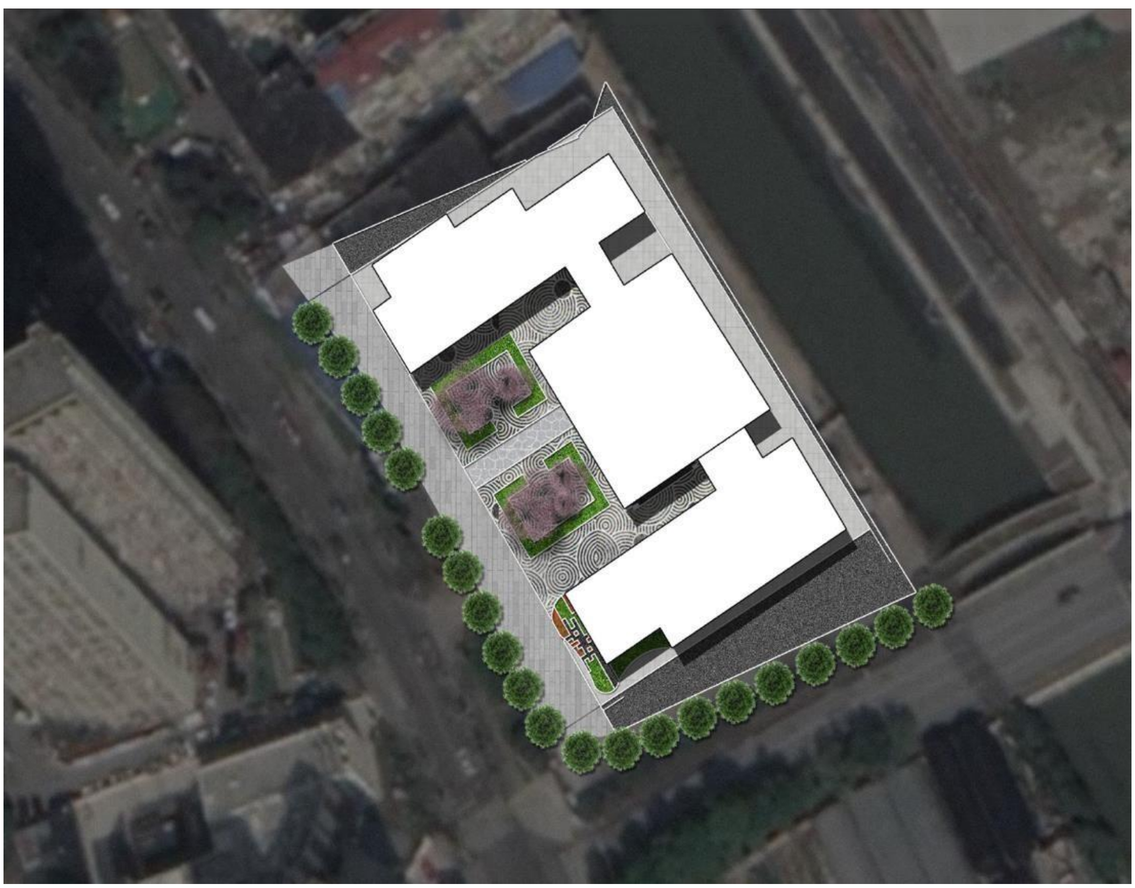
There are several areas that can be changed in the southern children's garden. The water pool can be used as a rain garden or children's play area under special circumstances. All paving can be mixed with steel or concrete pattern strips to enhance the industry identity of the site.

Secondly, the designed reflector can be installed in the paving strip, and some outdoor tables and chairs are provided on the side of the flower bed for residents to use and rest. The northernmost design area is mainly for vehicles, including the underground parking lot entrance and temporary parking sites to facilitate the necessary parking needs of tourists and staff, and is separated by some trees and shrubs.

3.3.2 Traditional renovation design

As you can see in Figure 7, in the traditional renovation design, the main idea is to focus on the design of the interior renovation, expanding and extending the three main buildings and connecting them with sky bridges to make them into a whole. The key point is that the transformation design can have the largest possible activity space, including but not limited to, canteens, classrooms, skating rinks, indoor badminton courts, table tennis courts, basketball courts and other indoor activity facilities. It will provide a leisure and sports place for nearby residents and teenagers.

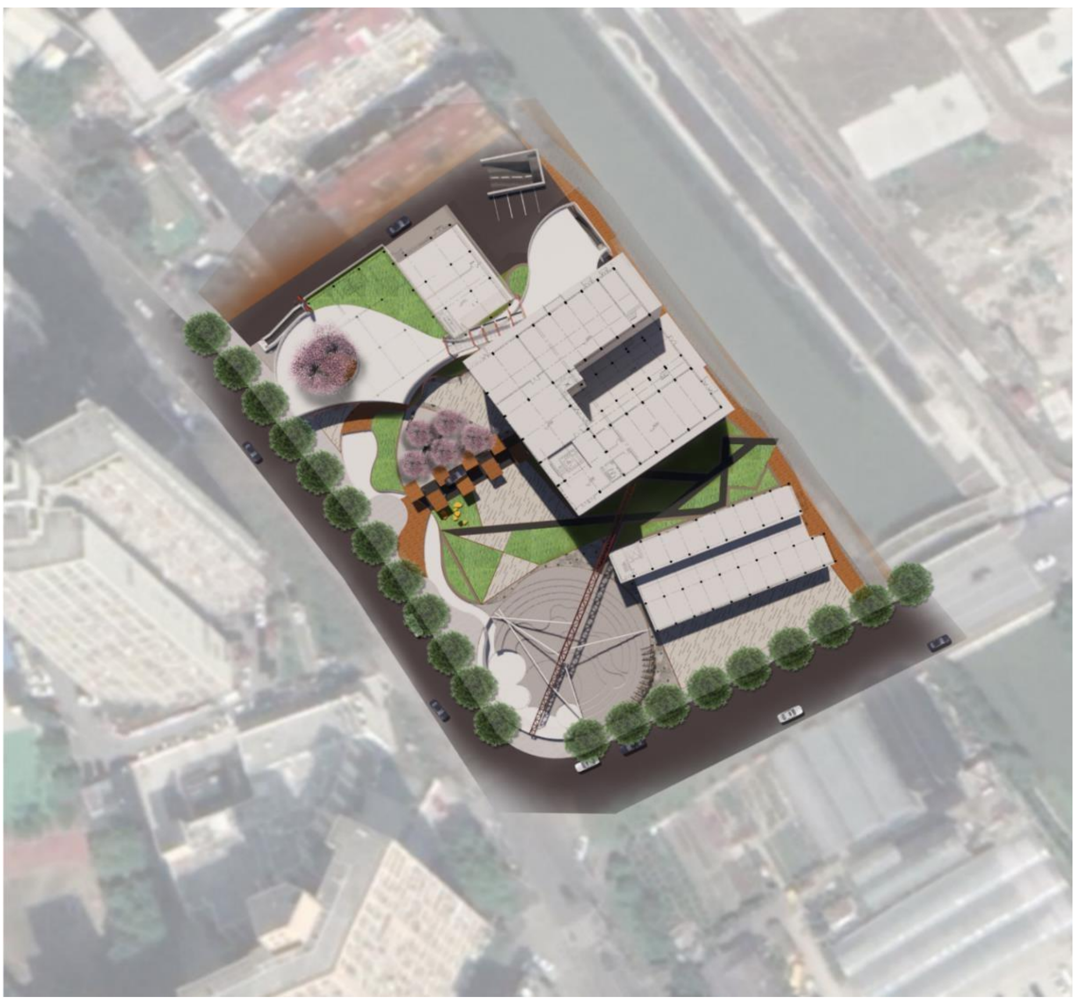
Figure 7. Master plan of Traditional renovation design (Copyright ©2020 Zhixiang Zhang reserved, use with permission)



On the basis of having the largest space, the remaining space can transform the original street environment by emphasizing the trees on the street, widening the width of the street, and making the entire housing area more open to the community. Designing a rest place surrounded by greenery in the priority inner courtyard space can provide some necessary services including charging and drinking, which not only provides space for resident residents, but also provides convenience for tourists. In addition, the north and south sides are changed to asphalt roadsides to facilitate vehicles entering, staying and leaving.

3.3.3 Industrial inheritance design

Figure 8. Master plan of Industrial inheritance design (Copyright ©2020 Zhixiang Zhang reserved, use with permission)



Paying attention to the design of industrial inheritance (See Figure 8), the whole design concept is to retain as many industrial elements as possible. Therefore, the three main buildings have been preserved and remodeled. The production building has minimal changes, mainly reflected in the addition of an open-air platform outside the third floor to connect to the complex. Secondly, the wall of the building is wrapped with a new wooden wall. The main function of the building is to carry out various indoor activities. Half of the complex has been removed and used as the entrance to a small parking lot and an underground parking lot. The roof design was added and transformed into a roof garden, which was connected to the production building by an overhead bridge.

Figure 9. Perspective of Industrial inheritance design-roof garden (Copyright ©2020 Zhixiang Zhang reserved, use with permission)

The central part of the roof was hollowed out into a circle, and large trees were planted on the first floor to form a rich layering. The reconstruction of the comprehensive building is mainly used for the combination of grocery supermarket and canteen to provide daily necessities and food. As the heaviest but difficult-to-reuse structure of the industrial element, the workshop was also retained. The main outer wall was opened up, the concrete post was retained, and it was transformed into a facility for small outdoor sports and entertainment. The open space in the south has been transformed into a sunken square. The transformed square can host some small outdoor performances and light shows. In addition, a fountain installation has been opened up, and combined with the rain garden-like creek connecting the entire site to form a rich water resource landscape.

Figure 10. Perspective of Industrial inheritance design-open plaza (Copyright ©2020 Zhixiang Zhang reserved, use with permission)

The entire site has also been expanded with hills of varying heights to attract young people to enjoy outdoor sports. In terms of landscape, a large number of waste steel and concrete leftover from the site are used as landscape sculptures, including flower beds with aerial steel frame structure, tables and chairs made of concrete and so on.

3.4 Variable: Comparable Elements Calculations

In order to evaluate different design options, with the help of literature review, 24 comparable variables are selected that fit the design goals and special types of industrial transformation from various related indexes. The variables are as follows: material-related: area calculation, material value, material recycling, material reuse, and material maintenance; sustainability-related: air quality, green space area, water resources area, carbon emissions, temperature, and storm water management; surrounding area related: resident feedback, job creation, safety, transportation, and income; and environmental design related: identity, Industrial element retention, landscape, tourism value, health, species diversity, wayfinding system design and lighting design.

3.4.1 Industrial area calculation

Table 1 lists the industrial and material areas for each design, including existing buildings, roads, and concrete paving. The green area and some other elements will be compared in subsequent variables. The total area of the three design schemes is equal, but the shrub belt, flower belt, tree planting, lawn area and water resources area in the entire site will not be counted again.

It can be found that rebar is the most expensive of the common materials. The explanation for the comparison of material value includes the following points. Good score represents a higher proportion of valuable materials, such as steel bars and stones. Midrate score represents that the materials have particularity in terms of beauty or function, such as plastic and plant materials. Poor score represents mostly low-cost materials in the venue.

Table 1. List of different industry material area

	Green environment design	**Traditional renovation design**	**Industrial inheritance design**
Existing buildings	79330 sq. ft.	118951 sq. ft.	104259 sq. ft.
Roads and surface parking	9149 sq. ft.	24326 sq. ft.	14262 sq. ft.
Concrete paving	11442 sq. ft.	31968 sq. ft.	22475 sq. ft.

3.4.2 Material value

The estimated garbage from the demolition of the original factory building is approximately 3,671 cubic meters of concrete, 338 tons of steel bars, 2,000 square meters of steel windows, and 1,23.68 cubic meters of brickwork. The value of Shanghai's conventional building materials is shown in the figure below. The main ones are concrete, steel bars, brick walls, etc. As an explanation for the comparison ranking below, good score represents the most recyclable materials, midrate score represents recyclable materials and tends to be in the middle of the three designs, and poor score represents the least recyclable materials.

Table 2. Main value of industry material

	Rebar	**Concrete:**	**Masonry**
Material value	40~75KG/m2 (lower content in multiple layers, higher content in high layers), 160~300 yuan/m2;	0.3~0.5 cubic meters/m2 (lower content in multiple layers, higher content in high layers) Higher), which is 100~165 yuan/square meter;	60-120 yuan/square meter (higher content of multi-layers, lower content of high-rises)
Work value	600-800 yuan/tons	45-50 yuan/cubic meters	90-150 yuan/cubic meters

3.4.3 Material recycle

Each design is not very similar with one another in terms of material recycling. Material design evaluation has always lacked effective evaluation methods. Through preliminary analysis, the recycling efficiency of materials is mainly judged based on the manufacturing, construction and use stages, demolition, and recycling of materials (Saghafi et al., 2011; Ibrahim et al., 2016). In addition, there are articles pointing out that the waste saving ratio in the recycling of building waste is the lowest among mixed wastes. Therefore, regardless of the special recyclable building materials, we only compare the use of different building materials in the design and the relatively easy-to-recycle materials such as plants, to determine the ranking of those three types of design in material recycling. The first green design favors the use of a large number of plants, and the subsequent recycling of building materials has little value. The second type is traditional renovation projects, which are biased towards the use of concrete, and the subsequent recycling of building materials has a high value. The third type is industrial inheritance design, and the value of subsequent recycling of building materials is small. The main recyclable materials are: concrete, bricks, steel bars, window frame materials (aluminum alloy or steel frame), wires and cables and other non-ferrous metals. As an explanation for the comparison ranking below, good score represents the most recyclable materials, midrate score represents recyclable materials and tends to be in the middle of the three designs, and poor score represents the least recyclable materials.

Table 3. Rank of different recycle material ownership in each design

	Green environment design	**Traditional renovation design**	**Industrial inheritance design**
Concrete	3	1	2
Bricks	3	1	2
Steel bars	3	2	1
Window frame materials	3	1	2
Wires and cable	3	1.5	1.5

Table 3 (cont'd)

Non-ferrous metals	2.5	1	2.5

3.4.4 Material reuse

In terms of material reuse, the main materials that can be used are detachable decorative materials such as a large number of plants, dry hanging stone, and decorative aluminum panels. In the green design, plants can be recycled and reused very efficiently, and secondly, water resources can be reused to a certain extent. There is a lack of reusable components in the traditional renovation design. Concrete has recyclable properties but lacks a way to be directly reused. The entire design also lacks emphasis on reuse. Finally, the industrial heritage design emphasizes the choice of reuse in the design. A large number of ornaments and disassembly materials are added to the plan at the early stage of the design. Additionally, water and plant resources can be removed from the site well. As an explanation of the ranking below, having the most reusable materials means a good score, midrate score means having a medium amount of reusable materials, and poor score represents the least reusable materials.

3.4.5 Material maintenance

Although green plays an important role in landscape ecology, it is obvious that many articles also point out that a certain degree of maintenance is required. Compared with the traditional construction methods of cement, some plants require more manpower and material resources to maintain ecological maintenance (Klingeman et al., 2009).

Among the three designs of this study, the green design has a very high cost of plant maintenance during operation. Secondly, the replacement of a large number of walkable turf, the replacement of seasonal plants in the garden and the conversion of rainwater gardens when necessary also require a lot of maintenance costs. In contrast, traditional renovation projects, have a very low cost of repairing concrete during operation, and the interior design does not require too much maintenance. Finally, the industrial heritage design also has a very high maintenance cost during the operation, which is mainly reflected in the use of landscape rivers, roof gardens, small hills and fountain squares.

As an explanation of the following ranking in material maintenance, good score represents the lowest material maintenance cost in the venue, midrate score represents the medium maintenance cost of the material in the venue, and poor score represents the most expensive material maintenance cost.

3.4.6 Air quality

Obviously, air quality has always been a standard for sustainable design. Emissions of pollutants from power generation, motor vehicles and other forms of combustion will directly affect air quality and affect the life of residents in the surrounding environment. Among the three designs, the green design is the least commercially available in terms of power generation and motor vehicle emissions. The traditional renovation has the most roads and parking spaces, and there have been more indoor activities, with the most power generation and motor vehicles. In addition, a study showed that reducing wind speed and urban impervious surfaces would aggravate the severity of air pollution (Han et al., 2015), and another research pointed out that urban landscape trees would improve air quality to some extent (Eisenman et al., 2019).

Therefore, some elements of the industrial heritage design including wooden textures and plants will bring some advantages. As an explanation of the following ranking in air quality, the good score represents the lowest negative impact on the air quality after the completion of the site, the midrate score represents the medium air quality of the site, and the poor score represents the predictable pollution effect on the air after the site is completed.

3.4.7 Green space area

The common greening effect can help reduce harmful substances in the air and lower the temperature of the city, and the cognitive, emotional and physical benefits of landscape and greening have been established and continuously developed. These benefits include a healthier residential environment, attained through increasing the frequency of residents' physical exercises, helping people recover from stress, enhancing their ability to concentrate, and giving them a more positive attitude (Fuller et al., 2015). Therefore, comparing the greening environment is not only a basic step for comparing the following variables such as carbon emissions, but also a good indicator for the comparison of the surrounding environment. As an explanation of the ranking below, having the most green area means a good score, midrate score means having the second most green area, and the least green area means poor score.

Table 4. List of different green space elements in three design

	Green environment design	**Traditional renovation design**	**Industrial inheritance design**
Trees number	29	25	27
Bush area	7265.64 sq. ft.	2970.84 sq. ft.	4305.56 sq. ft.
Turf area	16576.42 sq. ft.	1076.39 sq. ft.	18944.48 sq. ft.
Garden area	20343.79 sq. ft.	1184.03 sq. ft.	6296.89 sq. ft.

3.4.8 Water resource area

Like the green area, the area of water resources is also a relative variable, but it's easy to quantify. On the one hand, water resources can help the site to manage rainwater, and on the other hand, it can reduce the city temperature and improve the beauty of the site. In some respects, the combination of water resources and trees may not catch attention, but it can reduce the spread of noise and improve the quality of life for the entire surrounding site. As an explanation for the ranking of water resources, good score represents the area with the most water resources, midrate score represents the area with the second most water resources, and the least water area means poor score.

Table 5. List of different water resource elements in three design

	Green environment design	**Traditional renovation design**	**Industrial inheritance design**
Rain garden	7534.74 sq. ft.	0	4144.11 sq. ft.
Reflecting pool	1216.32 sq. ft.	0	1614.59 sq. ft.

3.4.9 Carbon emission

Carbon dioxide is the main greenhouse gas, and it is also a significant contributor to climate change. As for the urban landscape, the main solution to reduce carbon emissions has two aspects. The first is to increase the planting of woody plants (Jo, 2002). The annual average carbon absorption of woody plants is comparable. It plays an obvious role in other landscapes, and it also reduces the carbon consumption and emissions of the entire site. Compared with the other two designs, the environmental greening design has the largest amount of greening, followed by the construction activities that bring the least energy consumption, which is then followed by the industrial heritage design. The traditional renovation project not only has less green area, but also has a lot of traffic and a large amount of indoor space. Thus, the total amount of energy and carbon emissions must be much higher than the other two designs. For the explanation of the ranking of carbon emissions, the good score represents the site has the lowest carbon emissions and energy emissions, the midrate score shows that the site's carbon emissions are in the middle of the three designs, and the poor score represents the most final carbon emissions caused by this design.

3.4.10 Temperature

Because urban areas have less vegetation and higher density of roads and buildings that absorb more solar radiation, the urban heat island effect is quite obvious. Especially in summer, high temperature may bring about the negative effects of increased carbon emissions and air pollutants, and high temperature may also bring heat-related diseases and deaths. Landscape can cool down the areas in the following ways. First, it increases the green area, which can effectively absorb the heat brought by light and reduce the temperature of the city (Zhang et al., 2017). Second, it reduces the roads and buildings that directly reflect solar radiation, and uses different paving and surface walls to reduce heat transmission. Third, it utilizes water resources.

Although green environment design has the most obvious advantage of large green areas, industrial heritage design has a considerable number of measures to prevent the formation of heat island effect, such as the roof garden structure on the north side, and the wooden facade that reduces the directly exposed area of concrete and thus reduces heat transmission. The traditional design has made relatively little effort on reducing the negative effects of heat. In addition, industrial heritage design and green environment design also have rain gardens and creeks that can be transformed to reduce heat pollution. As an explanation for the final ranking of the temperature, the good score indicates that the design has the best positive impact on the site temperature and can reduce the heat island effect, midrate score shows that the temperature of the venue ranks in the middle of the three designs, and poor score represents that the design has a negative effect on the site temperature.

3.4.11 Stormwater management

Good sustainable rainwater management can approach the hydrological function of nature. Sustainable rainwater management measures can reduce floods, prevent soil erosion, improve water quality and reduce thermal pollution. Methods to improve stormwater management mainly include designing bio-safety belts, rainwater gardens, plantations, constructed wetlands, permeable paving and green roofs. Among the three designs, the industrial heritage design has an independent artificial creek that serves as a rainwater garden design. The green roof construction, permeable green hills and road paving give the entire site a good rainwater management system. The green environment design fulfills the purpose of stormwater management by having a large amount of green space, which gives the stormwater a buffer layer to minimize the adverse effects of water pollution caused by rainfall. The traditional industrial design must use groundwater wells to discharge the flood, which has no advantage over the emerging designs such as rainwater gardens. As an explanation of the final ranking of stormwater management, good score represents that the site has the best role in promoting and assisting the urban stormwater management, midrate score indicates that the design assists the urban stormwater management to a certain degree, and poor score represents that the design of the site poses a burden on the urban stormwater management.

3.4.12 Resident feedback

The most direct way to estimate residents' feedback is through surveys. Unfortunately, this study does not have so much space and time to conduct a systematic survey, so it will be estimated based on the literature materials found and the number of facilities that are beneficial to residents' activities and enjoyment, in order to estimate residents' feedback.

According to the survey and research (Gospodini, 2004) about residents' views on the traditional architecture heritage versus buildings that are iconic of modern cities, traditional architecture heritage still seems to be very effective in creating representative urban spaces for residents, especially those who are usually closely related to local traditions (such as low-income residents). On the other hand, innovative design seems to be more effective in creating meaningful and friendly spaces for non-native cultural groups such as tourists, foreign students and foreign professionals. And the main user group of this study area is still local residents, so the statistics of the preserved heritage buildings are compared to that of the innovative design.

Secondly, according to another study (Solitare, 2005), residents tend to be unaware of the urgency of brownfield reconstruction. However, if it is envisaged from the beginning that brownfield reconstruction is a means to improve the quality of community life, then residents may be more willing to participate and support the brownfield reconstruction, as it will affect their life. Therefore, a main standard in the statistics analysis of this paper is residents' attitude towards environmental improvement brought by the three designs, which is determined through changing the number of living facilities provided to the residents.

The green design only preserves two main buildings as heritage, while both the traditional design and the industrial design preserve three main buildings, so green design ranks third among the three designs. The outdoor facilities to improve life are mainly concentrated in the children's park and landscape trails in the south. The traditional renovation design retains the three main buildings and the concrete feel of the site. Compared with green design, it is more inclined to preserve heritage and thus ranks first among the three. The facilities for improving life are concentrated in the rest garden, widened sidewalks and huge indoor space. Finally, in the industrial heritage design, although a considerable part of the main building was retained, almost all of them have undergone innovative renovations, from exterior wall design to new roof gardens. So it can only be ranked second. The improved facilities are mainly reflected in indoor venues, sunken squares and rain garden. As an explanation of the residents' feedback ranking, the good score indicates that the design is most likely to be welcomed by the surrounding residents, the midrate score indicates that the design is in the middle position in the residents' feedback, and the poor score indicates that among the three designs, it may be the least liked by the residents.

Table 6. Number of improved facilities and approximate area

	Green environment design	**Traditional renovation design**	**Industrial inheritance design**
Number of improved facilities	3 (99673sq. Ft.)	4 (118952sq. Ft.)	6 (110,555sq. Ft.)

3.4.13 Job creation

To estimate the career creation of venues, we first need to summarize the types of activities that each venue has. Green design mainly focuses on site maintenance, traditional renovation design focuses on indoor activities, and industrial heritage design has both. As an explanation of the career creation ranking, the good score indicates that the venue can create the most career positions, midrate score shows that the professional positions that can be created by this design rank in the middle of the three designs, and the poor score represents that the professional positions that can be created in the three designs are the fewest.

Table 7. List of different job and demand level

	Green environment design	**Traditional renovation design**	**Industrial inheritance design**
Maintenance worker	lots	low	lots
Indoor activity staff	low	lots	lots
Commercial area sales staff	low	lots	lots

3.4.14 Safety

In terms of site safety, it is mainly reflected in the level of traffic and crime suppression. Properly improving the roadside scene landscape will reduce the pressure related to travel, and may increase the attention of drivers and pedestrians (Mok et al., 2006). In addition, another study researched on how different planning methods affect the design of the park and therefore affect residents' perceptions of safety. It also pointed out that the landscape improves safety (Yang et al., 2013). Therefore, many landscape interventions can improve traffic safety, especially for pedestrians and cyclists. Secondly, a clear wayfinding system, good visibility and line of sight, night lighting, and other design and maintenance measures can prevent crime and thus can improve safety. In terms of traffic, because the vehicles of the traditional renovation project are running on the surrounding site, they can only be isolated from the entrance to the site with isolation piles, which undoubtedly increases the risk of pedestrians and bicycles when they encounter vehicles. There is only one intersection between green design and industrial heritage design, and navigation through the pavement system is useful to avoid the impact of vehicles and other unexpected situations. Night lighting has always been one of the main goals of the design. Through the lighting system of industrial ornaments and the lights installed on the ground, the industrial heritage design and traditional design undoubtedly provide a good view and navigation at night, and because the green design has to take care of the use of green, not every location can have a bright view as the main entrance has. The industrial heritage design is undoubtedly more excellent than the other two. As an explanation for the final ranking of safety, the good score indicates that the design has the best safety considerations, the midrate score shows that the safety factor of the venue ranks in the middle of the three designs, the poor score represents the most insecure of the three designs.

3.4.15 Transportation

In terms of transportation, as mentioned above, a good transportation design will increase the safety of the site (Mok et al., 2006), good traffic can also impress residents and enhance the aesthetics and surrounding landscape (Ren et al, 2011). Because the surrounding infrastructure is complete, the problem of public transportation is reduced during the design, and each design can enjoy this convenience. The main comparison is about vehicles and bicycles. In terms of vehicles, the traditional renovation project is undoubtedly ahead of the other two designs, because it pays attention to the particularity of the building. The traditional design not only makes roads not conducive to vehicle traffic due to its design concept, but also built many structures such as underground asphalt parking lots, which further increases the complexity of the roads. The green design and industrial heritage design have given up a considerable part of the motor vehicle driving space to match the entire design, due to the design of the walkable area in the site. For instance, because of the existence of the riverside walkway, the designers add the bicycle paths to the industrial heritage design in order to meet people’s needs, as many people would like to bike to this place and then go running or enjoy other activities here. But the green design lacks such conditions. As an explanation of the traffic ranking, the good score represents the best traffic design of the built site, especially catering to the needs of bicycles and cars; the midrate score represents the medium road construction of the site; and the poor score represents the worst traffic construction after the site is completed.

3.4.16 Income

The eye-catching landscape design can attract tourists. These visitors can bring positive externalities including contribution to the economy of the city or region, but those side effects will not be discussed in detail here. Because the design is supposed to serve residents' facilities open to the public, so the main source of income does not include tickets. The sources of income mainly come from parking lots, sports venue rental, bicycle rental, entertainment activities, commercial sales in the restaurants, and venue rentals for special events such as gatherings or performances. A study has also pointed out the social benefits of urban green space, including entertainment opportunities, aesthetic enjoyment, and adjustment of mental health (Zhou et al., 2012). Therefore, some activity facilities in the venue will be important sources of income.

In the design of the green environment, most of the areas are public green spaces, and the main income is concentrated in the activity facilities inside the building. Compared with green environment design and industrial heritage design, traditional renovation design has the largest internal space to develop activity facilities, and these spaces undoubtedly bring a strong source of income to the site. Secondly, the traditional design also has the most convenient and largest parking space to generate income. As for industrial heritage design, although there are not as many indoor spaces as in traditional renovation projects, there is still a lot of space to develop commercial value. For example, a series of outdoor and indoor facilities and sports projects can offer the surrounding schools a place to exercise. In addition, the open-air plaza can be rented for special events such as performances. As an explanation of the income comparison, good score represents the largest source of income that the design will bring to the site, midrate score represents that the revenue brought by the venue will be ranked in the middle of the three design, poor score means that income brought by the venue is less than the other two designs.

3.4.17 Identity

One aspect of the value of the site was explained at the beginning of the design objective -- it needs to have some uniqueness to deepen the memory of residents and visitors. Among the three different designs, traditional renovation projects are undoubtedly the most lacking in uniqueness. When investigating the background information of Shanghai, it is shown that the large amount of land being transformed into creative parks makes these reserved industrial parks with huge spaces not so unique but common (Li, 2018). In green environment design, although the surrounding green space is relatively small, there are ordinary urban parks and green area in residential squares, so overall the design does not deviate from the standard. This gives it the most unique environment among the three designs. For example, it has both the landscape of industrial transformation and the sense of design in the combination of plants and urban concrete. As an explanation of the ranking below, the element with the greatest degree of uniqueness means a good score. For example, the design may not be common in the surrounding area, as its design considers the site's own attributes instead of simply copying other successful cases. The midrate score represents a moderate degree of uniqueness, and the most common design or lack of uniqueness means poor score.

3.4.18 Industrial retention

Industrial retention is also a variable that is somehow easy to distinguish. I have compared the retention of industrial elements in the former industrial land among three different designs. The green environment design only retained the two main buildings, and the remaining large- area factories and industrial elements were appropriately removed to fit the concept of large greening area. Although the traditional design of the house has been preserved, large-scale changes have also been made, such as reconstructing the structure of the house to obtain a larger internal space. The industrial heritage design mainly retains workshops, and the main industrial structures such as discarded steel make it rank first in industrial retention. As an explanation of the final ranking of industrial retention, good score means that the retention of industrial elements in the site is the most and successful, midrate score indicates that the design has preserved a certain degree of industrial elements, and poor score means that it is difficult to see the industrial elements in the site.

3.4.19 Landscape

The most direct way to estimate the ranking of landscape value is to analyze the green area of the landscape in each design, the number of sculptures, and the unity of the overall style. The green area is undoubtedly the number one green environment design. The possible number of sculptures is listed in the table below. As an explanation of the landscape ranking, the good score represents that the site is most likely to have the best landscape design, including green environment, sculptural elements, unique industrial elements, and other landscape elements. The midrate score indicates that the landscape design of the site ranks in the middle, and the poor score represents the least landscape design among the three designs.

Table 8. List of sculptures numbers

	Green environment design	**Traditional renovation design**	**Industrial inheritance design**
Sculptures numbers	10	4	14

3.4.20 Tourist value

Tourism value here refers to the ability to attract visitors, not including the permanent residents nearby. The attractiveness to tourists is determined by comparing the number of unique designs in each design, as well as the potential to attract tourists through parks and contracted activities. First, traditional design is made to provide most convenience to nearby residents, so if it does not have a unique place for activities, then it has the lowest tourism value among the three designs. In addition, due to the small size of the site, the places where people are most likely to entertain are parks and gardens nearby, and the industrial elements included in the industrial heritage design may contain the highest tourism value. As an explanation of the tourist value ranking, the good score indicates that the tourist value is the highest and can attract the most tourists, the Midrate score indicates that the tourism value of this design ranks in the middle of the three designs, and the poor score represents the lowest tourism value.

3.4.21 Health

Designing environmental landscapes can contribute to a healthy residential environment to a certain extent. For example, as mentioned in the previous article, a good green environment can make people recover from stress faster, concentrate their minds, and get a more positive mentality (Fuller et al., 2015). In addition, sports venues can provide more exercise opportunities, and exercise can keep people in a good state of mind. Therefore, from the perspective of health, the industrial heritage design with green area and sports venues is better than the other two designs. As an explanation of the ranking of health, the good score represents the site's improvement of the community's health environment, including mental and physical health, the midrate score indicates that the site's improvement in the health of the surrounding community ranks in the middle, and the poor score indicates that the design has the least health improvement effect for surrounding communities.

3.4.22 Species diversity

Biodiversity plays a considerable role in maintaining the balance of the ecosystem. It also helps to protect regional species pool. The main goal of conservation planning is to protect local species, so that the ecosystem will remain stable and the ecological balance of the nature will be maintained (Werner, 2011). Additionally, the diversity of species in the landscape can play a role in resistance to drought, pests, pollution and other factors. The most direct way to estimate species diversity is to quantify the ratio of some species that may exist on the site. However, due to the lack of relevant information, it is only possible to analyze and compare the different landscapes that may appear in each design. Among the traditional renovation projects, there are only street landscape trees, shrubs and woody plants in the garden, so it ranks the last. Industrial heritage design and green environment design have some aquatic plants because of the rainwater gardens and streams. Although the roof garden in the industrial heritage design and the flower bed in the green environment design have similar environment, they are not comparable due to their different locations. Additionally, the children's garden in the green design can bring some special cultivation environment. Compared with the green design, industrial heritage design is more of small hills for children and adolescents to play, so it is weaker than green environment design in terms of species planting.

Urban greening directly affects the possible diversity of species, so good score represents the most green environment and plant species in the site. The midrate score indicates that the green environment design and species types in the site rank middle among the three designs, and the poor score represents the least green environment design.

3.4.23 Wayfinding system design

The wayfinding system is a feature that is easy to overlook in the design, but a good road design can help new visitors accurately find the location, save time, and make the entire site appear tight and organized. A study shows that a good wayfinding system can make the environment easier to understand and navigate, leading to a better and more enjoyable experience for the visitors (Lu, 2016). By looking at the road system design in each design separately, we can see that the green environment design has only one main entrance beside the pedestrian walkway in the west, and the main building is straight ahead. The paving pattern is delineated by metal bands, and the south is the garden and the north is a circular pool. Although it brings visual beauty, more efforts must be made in road design, such as the design of wayfinding signs. However, the road system of the traditional design is much simpler, where on both sides there is an avenue in the middle of the motor vehicle lanes that passes through the gardens on both sides. Although the industrial renovation project looks messy, there are still traces to follow. The main road is paved with asphalt to connect the main entrance and the building. The direction from the square to the building is also mainly guided by the pavement, which can be indicated by the use of lights. As an explanation of the ranking of the way-finding system, good score means the site has the clearest way-finding system, including clear signage and reasonable road design. Midrate score means having some way-finding system and signage, while poor score indicates a chaotic road design.

3.4.24 Lighting Design

Having a good lighting system can assist the wayfinding system at the venue. It can also increase the visibility and thus safety at night, and lighting is also one of the important design goals. As a big city, there are a lot of activities at night in Shanghai. Many commercial centers will provide lights to a certain proportion of public spaces for the citizens to gather at night and enjoy activities such as walking dogs, which will undoubtedly increase the interactions among people. I will mainly analyze the types of lights and approximate light areas included in each design to compare three different lighting systems.

As an explanation of lighting design, good score means the most illuminated area with the most brilliant lighting effects, midrate score indicates lighting design that ranks in the middle of the three designs, and poor score represents the least lights at night.

Table 9. List of different outdoor lighting and its approximate irradiation area

	Green environment design	**Traditional renovation design**	**Industrial inheritance design**
Street lights	4305 sq. ft.	10225 sq. ft.	9687 sq. ft.
Foot lights	7534 sq. ft.	3229 sq. ft.	8072 sq. ft.
Trail and garden lights	4305 sq. ft.	215 sq. ft.	1291 sq. ft.
Projection lamps	3534 sq. ft.	1076 sq. ft.	4305 sq. ft.

Table 9 (cont'd)

Total Light area	19678 sq. ft.	14745 sq. ft.	23355 sq. ft.

3.5 Conclusion of variables

The study is designed into three design options: green environment design, traditional renovation design, and industrial heritage design. For each design, 24 variables have been selected for analysis based on material correlation, sustainable development, surrounding residential environment impact and design impact.

Friedman test is a non-parametric surrogate test used to adjust and evaluate treatment based on its ranking results. Friedman's analysis of variance by rank and multiple comparison procedures will be used to determine whether these three design options are statistically significant and their respective pros and cons. The final result is based on comparing the sum of the variables' ranks among the three designs. Then, used use the adjustment number method to adjust the previous result data. Last, a multiple comparison procedure is used to check the results (Daniel,1978).

Chapter 4. Result

4.1 Rank of each variable

The calculation of these variables can be ranked among the three design options as follows. Table 10, Table 11, Table 12, Table 13, and Table 14 correspond to the different rankings of the three designs in the material-related variables. Table 15, Table 16, Table 17, Table 18, Table 19, Table 20 correspond to the ranking of variables related to sustainable development. Table 21, Table 22, Table 23, Table 24, and Table 25 correspond to variables related to the impact of the surrounding living environment. Table 26, Table 27, Table 28, Table 29, Table 30, Table 31, Table 32, Table 33, and Table 34 correspond to variables related to design influence.

The final statistics include building area, concrete paving area, and total parking area on roads and sidewalks. The industrial area of green environment design is 99,921 square feet, the traditional design is 175,246 square feet, and the industrial heritage design is 140,996 square feet. Therefore, according to the previous explanation, the traditional design with the largest industrial design area ranks 1, the second most industrial area industrial heritage design is 2, and the least industrial area is green environment design 3.

Table 10. Rank of different industry material area

	Green environment design	**Traditional renovation design**	**Industrial inheritance design**

Table 10 (cont'd)

Industry material area	3	1	2

By analyzing the value of the materials required for each design, we can conclude that the main cost of green environmental design is the cost of dismantling the entire construction site concrete, laying soil and planting various plants, so there are fewer materials to consider. The cost of traditional design is mainly reflected in various materials, so relative to the value of materials, industrial heritage design requires the lowest cost, especially by reusing scrap steel. Among the three designs, the industrial heritage design has the highest proportion of valuable materials, which has a large amount of use of steel bars, so it ranks 1. Secondly, the green environment design is ranked 2 because the materials are special in aesthetics or functions, such as plastic and plant materials. However, most of the traditional design sites are low-priced materials, so its lowest value leads to its ranking as 3.

Table 11. Ranks of material value

	Green environment design	**Traditional renovation design**	**Industrial inheritance design**
Material Value	2	3	1

According to the previous analysis and explanation of material recycling, traditional design focuses on the use of concrete, and thus there are the most recycled materials in the subsequent construction, ranking 1. Industrial heritage design entails some window frame materials (aluminum alloy or steel frame), wire and cable and other non-ferrous metals, with recyclable materials in the middle of the three designs, ranking 2. Ranking 3 is the green environment design, as most of the materials are difficult to recycle.

Table 12. Rank of material recycle

	Green environment design	**Traditional renovation design**	**Industrial inheritance design**
Material recycle	3	1	2

Through the above explanation of the reuse of materials, green environmental protection projects and heritage reconstruction projects have the biggest advantage, mainly in planting. Most of the area in green environmental design is occupied by plants, and the high reuse value of plants means that it has the highest performance, ranking it 1. The midrate score represents a moderate amount of reused materials, in the industrial heritage design, where the number of reused materials such as plants, dry-hanging stone, and decorative aluminum panels is more than that of traditional designs, so it ranks 2. The traditional design ranks 3 because of its minimal reuse of materials.

Table 13. Rank of material reuse

	Green environment design	**Traditional renovation design**	**Industrial inheritance design**

Table 13 (cont'd)

Material reuse	1.5	3	1.5

In terms of material maintenance, due to the high maintenance cost of plants, the maintenance cost of green design and industrial heritage design is higher than that of traditional design. Thus, the material maintenance cost of the traditional design is the lowest, so the ranking is 1, as shown in the following table.

Table 14. Rank of material maintenance

	Green environment design	**Traditional renovation design**	**Industrial inheritance design**
Material maintenance	2.5	1	2.5

Among the three designs, because green design has the lowest degree of commercialization in terms of power generation and motor vehicle emissions, green design has the least emissions and thus ranks 1. The industrial heritage design has some improvement facilities, such as the wood-grain exterior wall and the plant garden, which will improve the air quality to a certain extent, so it ranks 2. The traditional design has the most roads and parking spaces, more indoor activities, and the most power generation and motor vehicles, having the most impact on the air, so it ranks 3.

Table 15. Rank of air quality

	Green environment design	**Traditional renovation design**	**Industrial inheritance design**
Air quality	1	3	2

As calculated in the previous chapter, the total green area in the green design is 44185 square feet, the green area in the traditional design is 5231 square feet, and the total green area in the industrial heritage design is 29547 square feet. Therefore, the green area of green design ranks 1, industrial heritage design ranks 2, and traditional design ranks 3.

Table 16. Rank of green space area

	Green environment design	**Traditional renovation design**	**Industrial inheritance design**
Green space area	1	3	2

The statistics of the total water area is provided in the last chapter. The total water area in the green design is 8751 square feet. The traditional design has no water resources design, and the total area of the industrial heritage design is 5758 square feet. Therefore, the total water area of green design ranks 1. Industrial heritage design ranks 2, and the traditional design ranks 3.

Table 17. Rank of water resource area

	Green environment design	**Traditional renovation design**	**Industrial inheritance design**
Water resource area	1	3	2

The ranking of carbon emission can be procured by comparing the absorption of carbon emissions by woody plants and the main carbon emission areas (such as indoor space). The green environment design has the least indoor space, and as woody plants have the most carbon emission absorption function, the site's carbon emissions and energy emissions are the least, ranking 1. The traditional design has the largest indoor space, and thus the largest carbon emissions and energy emissions, so it ranks 3, as shown in the table below.

Table 18. Rank of carbon emission

	Green environment design	**Traditional renovation design**	**Industrial inheritance design**
Carbon emission	1	3	2

The table below provides the final ranking for temperature, which is obtained through a series of analyses on the water environment, green areas and concrete reduction area in the previous chapter. There are the most green areas in the green environment design, but some material improvements in the industrial heritage design can successfully reduce the area of exposed concrete. Therefore, these two designs have a strong positive effect on the site temperature, which can reduce the heat island effect, and finally gives a tie result of 1.5.

Table 19. Rank of temperature

	Green environment design	**Traditional renovation design**	**Industrial inheritance design**
Temperature	1.5	3	1.5

The traditional design has the lowest requirements for stormwater management, so it has no advantage over the other two designs. Therefore, it is the worst in the stormwater management rankings, as can be seen the table below.

Table 20. Rank of stormwater management

	Green environment design	**Traditional renovation design**	**Industrial inheritance design**
Stormwater management	1.5	3	1.5

In the previous chapter, through the analysis of the residents' attitudes, compared with the other two designs, the traditional industrial design provides the most interaction with residents and possibilities of resident activities. Secondly, the traditional industrial design has an advantage from an emotional aspect, as it has preserved the most original elements of the site, making the traditional industrial design more likely to be welcomed by surrounding residents than the other two, ranking 1. The industrial heritage design also has many movable projects, and the preservation of industrial elements makes it the second most likely design to be welcomed by the surrounding residents. So the ranking is shown in the table below.

Table 21. Rank of Resident feedback

	Green environment design	**Traditional renovation design**	**Industrial inheritance design**
Resident feedback	3	1	2

Through comparison and analysis of the job opportunities that can be created, industrial heritage design can create the most job opportunities, especially in positions dealing with maintenance, business and activities management, so it ranks 1, as shown in the table below.

Table 22. Rank of job creation

	Green environment design	**Traditional renovation design**	**Industrial inheritance design**
Job creation	3	2	1

According to the detailed analysis in the previous chapter, the industrial heritage design has a good traffic environment design and night lighting design, so it has the best safety considerations and thus ranks first. However, traditional design and green design can only reduce the safety level to 2.5 because of the dangers that traffic may bring and the uncertainty at night. So the ranking is as follows.

Table 23. Rank of Safety

	Green environment design	**Traditional renovation design**	**Industrial inheritance design**
Safety	2.5	2.5	1

In terms of transportation, industrial heritage design has been greatly improved in that aspect, and traditional design has the same ranking as industrial heritage design due to its basic concept that entails the excellent transportation of the site after their completion. The green design has the worst traffic construction. The ranking is shown in the table below.

Table 24. Rank of Transportation

	Green environment design	**Traditional renovation design**	**Industrial inheritance design**
Transportation	3	1.5	1.5

According to the analysis in the previous chapter, because the green design provides an open green space environment, it is relatively weak in the income sources it can bring, compared with the other two more profitable designs. In contrast, the other two designs can bring more sources of income to the entire site. The ranking is shown as below.

Table 25. Rank of income

	Green environment design	**Traditional renovation design**	**Industrial inheritance design**
Income	3	1.5	1.5

As mentioned in the previous chapter, the industrial heritage design has a uniqueness in that it focuses on industrial transformation, preserving the most industrial elements. In addition, this design is not common in the surrounding areas, so it is more unique than the other two designs, ranking it 1. The traditional design itself is a common traditional renovation method, with many design methods copied from other projects, so its uniqueness is the worst, ranking 3. The ranking is shown in the table below.

Table 26. Rank of identity

	Green environment design	**Traditional renovation design**	**Industrial inheritance design**
Identity	2	3	1

Through a simple analysis of the industrial heritage preservation in the previous chapter, the industrial transformation design has the greatest advantage in that it preserves the most industrial elements, so it ranks 1. The traditional design also retains a certain degree of industrial elements, such as the concrete house structure, so it ranks 2. The green design removes the preservation of industrial heritage, so it ranks 3.

Table 27. Rank of industrial retention

	Green environment design	**Traditional renovation design**	**Industrial inheritance design**
Industrial element retention	3	2	1

The three designs of the overall style have their own clear design concepts, but a landscape with relatively more concrete is common in the city. Therefore, the ranking of landscape value is generated by comparing the unique effects that different styles of plants and possible structures can bring. The industrial heritage design and green design are equally likely to have excellent landscape design, so they are tied for 1.5, and thus the possible rankings are as follows.

Table 28. Rank of landscape

	Green environment design	**Traditional renovation design**	**Industrial inheritance design**
Landscape	1.5	3	1.5

Through the analysis and comparison of some other variables, the tourism value can be seen to a certain extent. Compared with the common traditional design and green environment design, the industrial renovation design with the most favorable activity environment and unique scenery is better than the other designs, as it has the highest tourism value and can attract the most tourists. So the ranking is 1.

Table 29. Rank of tourist value

	Green environment design	**Traditional renovation design**	**Industrial inheritance design**
Tourist value	2.5	2.5	1

From the perspective of green environment and sports activities, both indicators of industrial heritage design have a good ranking. Therefore, overall the industrial heritage design can bring the most improvement in the psychological and physical health of the city, so it ranks 1. The other two designs have equally outstanding contributions in landscape and activities respectively, so they are tied for 2.5. The ranking is shown in the table below.

Table 30. Rank of health

	Green environment design	**Traditional renovation design**	**Industrial inheritance design**
Health	2.5	2.5	1

In the urban environment, the maximum level of species diversity depends on the size of the green area. Because of its particularity, the species to be considered are the most, including insects, birds and plant species. Therefore, among the three designs, the green environment design has the most green environment and plant species, ranking it 1st. The industrial heritage design, which is the second most green, ranks 2. The traditional design is the worst, ranking 3.

Table 31. Rank of species diversity

	Green environment design	**Traditional renovation design**	**Industrial inheritance design**
Species diversity	1	3	2

As mentioned in the previous chapter, industrial heritage design uses various methods to improve the role of road signs, while green environmental design does not have a strong purpose. Therefore, the industrial heritage design ranks 1 as it has the clearest pathfinding system, clear signage, and reasonable road design. The traditional design is relatively balanced, ranking 2. The green environment design is rather chaotic in pathfinding, ranking 3. The ranking is shown in the table below.

Table 32. Rank of wayfinding system design

	Green environment design	**Traditional renovation design**	**Industrial inheritance design**
Wayfinding system design	3	2	1

Through the detailed analysis of the different lighting areas and sizes of the lighting area among the three designs in the previous chapter, we can see that the industrial heritage design has the most brilliant lighting effects and the most illuminated areas, so it ranks 1. The size of lighting area of the traditional design is the second, and the lighting area also covers the road and the main landscape, so it ranks 2. The lighting designed for the green environment mainly serves the night scene outline, and the illuminated area and light size are the smallest, so it ranks 3. The final ranking is shown in the table below.

Table 33. Rank of lighting design

	Green environment design	**Traditional renovation design**	**Industrial inheritance design**
Lighting design	3	2	1

4.2 Friedman's statistical test

The first step of Friedman's statistical test is to list the ranks of all designs under each block (Daniel, 1978). Block indicates that the selected variable is considered as a design influence element. Based on the previous Chapter, the overall ranking results are shown in the following table (Table 34). These rankings are rated from 1 to 3. 1 indicates that the design is the best, and 3 indicates that it has disadvantages compared to the other two designs. Similar results will be produced in the form of 1.5 and 2.5.

Table 34. Ranks of variable values for treatments

	Green environment design	**Traditional renovation design**	**Industrial inheritance design**
Industrial material area	3	1	2
Material Value	2	3	1
Material recycling	3	1	2
Material reuse	1.5	3	1.5

Table 34 (cont'd)

Material maintenance	2.5	1	2.5
Air quality	1	3	2
Green area,	1	3	2
Water resources area	1	3	2
Carbon emissions,	1	3	2
Temperature	1.5	3	1.5
Stormwater management	1.5	3	1.5
Resident feedback	3	1	2
Job creation	3	2	1
Safety	2.5	2.5	1
Transportation	3	1.5	1.5
Income	3	1.5	1.5
Identity	2	3	1
Industrial preservation	3	2	1
Landscape	1.5	3	1.5
Tourism value	2.5	2.5	1
Health	2.5	2.5	1
Species diversity	1	3	2
Wayfinding system design	3	2	1
Lighting design	3	2	1

The second step is to propose and study the hypothesis. In this case, Ho also calls the null hypothesis that all design schemes are similar in comparison and have similar research effects, while research hypotheses, called H1, mean that at least one design has greater value than another different design (Daniel, 1978).

The next step is to set the risk level to alpha (α), which is related to the null hypothesis. It is also called probability of exceeding the critical value. In this article, since many variables are subjective evaluations and there are only three designs, the error may be relatively large, so we will choose α equal to 0.05, which is the 95% accuracy standard.

The final result is based on comparing the sum of the variables' ranks among the three designs. The formula used is mentioned in the text (Daniel,1978):

$$x_r^2 = \left(\frac{12}{bk(k+1)} \sum_{j=1}^{k} R_j^2 \right) - 3b(k+1)$$

Where

b is the number of block

k is the number of treatment

R is the sum for ranks of each treatment

In this study, according to Table 33, b (block number) is the number of variables corresponding to 24, treatment is a total of three designs (k=3). The sum of the respective rankings of all designs is 52, 55.5, and 36.5. Therefore:

$$x_r^2 = \left(\frac{12}{24 \times 3 \times (3+1)} \times (52^2 + 55.5^2 + 36.5^2) \right) - 3 \times 24 \times (3+1) = 8.52$$

Because some of the data are difficult to distinguish between the two in many variables, they are ranked together, which are collectively called ties. We need to use the adjustment number method to adjust the previous result data, and use x to divide the adjustment number, so the adjustment number formula is as follows,

$$1 - \sum_{i=1}^{b} T_i / bk\,(k^2 - 1)$$

Where

$$T_i = \sum t_i^3 - \sum t_i$$

t_i : is the number of ranks tied by a specific number in the block

In the case of this article, there are a total of ten variables with ties, so we will bring 10 blocks with two ties into the adjusted test

$$8.52 / \left(1 - \frac{(2^3 - 2) \times 10}{24 \times 3 \times 8}\right) = 9.51$$

Finally, we need to find out whether our value corresponds to our hypothesis by using the table of critical values of chi-square distribution with degrees of freedom (Daniel, 1978, p.452). Now we have got the final value of 9.51, and by looking for our k-1 degree of freedom through the table, we can find the degree of freedom as 2. With our error a being 0.05, we can find in the table that the value if X with 2 degrees of freedom is 5.991. As 5.991 is smaller than our data of 9.51, our hypothesis is valid, which means that at least one design is better than the other.

In order to determine whether the industrial heritage renovation design is better than the other options, a multiple comparison procedure used with the Friedman test is required. The equation is as follows

$$\left| R_j - R_{j,} \right| \geq z\sqrt{\frac{bk(k+1)}{6}}$$

among them

R_j and $R_{j,}$ is the sum of two different treatments.

z is a table value provided by a specific table of Daniel (Daniel, 1978, p.452), corresponding to α/k(k-1) (Daniel, 1978).

In this equation, if the absolute value of the difference between the sum of two different treatments is greater than or equal to the other side, we can say that this hypothesis is definitely better than the other hypothesis statistically. In this study, α is equal to 0.05 and k is 3. z is equal to 2.41 in the table in Daniel (1978, p. 452). The differences between different design methods are as follows.

$$z\sqrt{\frac{bk(k+1)}{6}} = 2.41\sqrt{\frac{24\times3(4+1)}{6}} = 16.7$$

Finally, we conclude that the difference is 16.7

$\left|R_j - R_{j,}\right|$ is the difference between two sums of treatments as the following table shows

Table 35. Difference of two sums of variable values for treatments

Design Scenarios Combinations	Difference
Green environment design & Traditional renovation design	3.5
Green environment design & Industrial inheritance design	15.5
Traditional renovation design & Industrial inheritance design	19

In conclusion, we have a total of three designs -- green environment design, traditional renovation design and industrial heritage design. The overall ranking score of industrial heritage design is higher than the other two designs. Through the multiple-comparison procedure, we find that at least the advantages of industrial heritage design can be recognized. Therefore, it can be determined that the industrial heritage design is relatively superior to the traditional renovation design. Among the three types of designs, although the industrial heritage design has not opened the gap with the green design, it has better data in many variables.

Chapter 5. Discussion and conclusion

5.1 Discussion of variables and results

The results of Friedman's test support that the design of one site has at least an advantage over another site. Through the final analysis of the overall ranking results, my final design focusing on industrial heritage protection has overall advantages over traditional designs, which basically meets my expectations. In this study, a total of three design schemes were constructed, including 24 variables, and a Friedman statistical test was performed. When doing variable statistics, I found some interesting observations that can be shared in detail in the discussion section.

The first observation is about the materials. Green environmental design can be said to be full of plants. The main advantage in terms of materials is that it has a high possibility of reuse, as plants can be easily reused by removal. Compared with the direct destruction of certain materials, it is more environmentally-friendly and sustainable, but the daily maintenance costs of those plants are much higher than traditional renovation design. Secondly, the materials left over from the industry can be reused to save costs and increase the value of the site, which makes the value of industrial heritage design the highest. The traditional design has obvious advantages in terms of materials, mainly from an economic aspect. First, it is convenient to recycle and thus can reduce expenditure, and second, it requires less maintenance. However, the traditional design does not provide much support for the environment and sustainability.

Therefore, it is obvious that in terms of environmental protection and sustainable development, traditional renovation design is at a disadvantage in all aspects, while industrial heritage design and green design have played a significant role in improving the surrounding environment. Through a series of comparisons in air and rainwater management, we can find that plants have a huge improvement effect on the site. Unexpectedly, in the residents' feedback according to the documents found, the traditional renovation project that maintains the original style of the site and has the largest movable space are more popular among local residents. The reason is that, the design not only preserves many original features, but also provides the local residents with a lot of improvements to their life.

In the research process, although I once thought that the protection of industrial heritage is much better than the other two designs, in fact, after applying the statistical test, I finally found that the design of industrial heritage cannot be separated from the green design. The heritage design ranks higher in the overall ranking, but it has not reached the value that can be judged to be better than the green design. The traditional design has proved to have no advantages over the industrial heritage design. Based on these two points, compared with the green design and industrial heritage design, the biggest difference in the traditional design apparently lies in the degree of greening. Traditional design is mainly designed to renovate the land for beautification and other objectives, because the site is well preserved. Particularly, I only added the condition of preserving the original building as much as possible, while the greening and other ecological improvement measures are only kept at the minimum standard. As mentioned above, although traditional design may have the most practical space for activities compared with green environment design and industrial heritage design, it still brings many problems, such as water resources management. The greening can enrich the environment and provide a stronger function of stormwater management. Because of its backwardness, the traditional design does not take into account new concepts such as sustainable development and rainwater management, which leads to a gap with the industrial heritage design.

Through a more in-depth analysis, the industrial heritage design gets the best place in the overall ranking, which can bring more inspiration to the design of an industrial land transformation design. This original land is a very typical old factory renovation, and it does not have the universality of the other famous large-scale transformation projects that are now popular in Shanghai. Although it is just a very ordinary old food factory, its location is relatively closer to the urban area compared to other large-scale projects. In the design process, I want to keep the industrial elements in the extraction site more than the overall style, because from the aesthetic point of view, the original site is outdated. Fortunately, this concept is consistent with the material analysis in the later section about variables. Some elements of the original design, especially the building structures, can be preserved for renovation to avoid the loss caused by renovation and reconstruction. Scattered materials and tools can be retained as landscapes in the site to increase the overall industrial elements. In addition, because of the location of the city, the site must serve the surrounding residents, so the reserved site must have a certain degree of functionality, such as having a sports space or an activity area. Although the green environment design has an advantage on maintaining a sustainable ecology as it is outstanding from the perspective of sustainable development, aesthetics, and the environment, the final value still has a narrow gap with the industrial heritage design, because it lacks a certain degree of functionality. For instance, the green space analyzed before is only used as an ecosystem or simply an aesthetic decoration, but it does not provide pedestrian and activity space, especially in densely populated cities. In addition, economic services should also be considered. The industrial heritage design is better at providing welfare and convenience for local residents while taking into account the ecological environment. Through the discussion about the entire design, it is obvious that the industrial heritage design considers many factors. So no matter if we are looking at economical or aesthetic factors, it never ranks as the worst design compared with the other two designs. As a whole, it performs better at the overall design level, which is the reason why the industrial heritage design can obtain more advantages than the other two designs. In my opinion, although traditional renovation design and green environmental design are undoubtedly excellent in some aspects, they cannot take into account certain factors, and they do not highlight the special environment of industrial land. In comparison, industrial heritage design not only transforms those seemingly unfavorable factors into unique features, but also can contain more elements.

In addition, the merits of industrial heritage design can better inspire subsequent industrial heritage renovation design projects from the following perspectives. First, designers can consider establishing an ecological environment system, controlling the green space, and using rain gardens, green roofs, and indoor open planting methods to effectively utilize the space. Second, by taking into account the function of the venue, the designers can think about how to develop the venue to bring more convenience to residents' activities, such as converting the transformed space into skateboard parks, basketball courts, indoor spaces, and so on. Third, the designers should also consider preserving the memory of the site and extracting the original industrial elements of the site for analysis and transformation. For example, maybe the scattered steel frame structure can be turned into a landscape sculpture, and the original factory building can retain its iron doors and windows to display as a supermarket or restaurant with a unique style. From these perspectives, the development and design of the original industrial land will be more suitable for the future development of the city.

5.2 Limitation

This research has limitations in many aspects. The first is about the choice of sites. Because the article wants to study the way to transform a common industrial land, I chose an old food factory, but compared to many other industrial lands, it lacks many common features.

Because the food factory does not have toxic leftovers on the site as other typical industrial land does, all designs here are based on the same assumption that no toxic elements remain on the site, which is a rare condition for many industrial land. Secondly, it is quite close to the city center, but industrial lands in the city center are usually the first to be demolished, so more industrial lands are concentrated in the suburbs, which means that the supporting facilities are not as comprehensive as the sites in this study.

The second limitation is about the variable research. Although this article provides a total of 24 variables, there are more variables that are difficult to compare, such as noise isolation, taxation, etc., because of the difficulty in data collection and the scarcity of relevant studies.

Additionally, the biggest limitation is that there is a certain degree of errors and subjectivity in many variables. Because many data do not have a clear method for quantitative comparison, the pros and cons of comparisons can only be judged through measures such as data query. For technical reasons, some variables that need to be compared through questionnaires do not have corresponding data. Therefore, the data in some variables depend on the researcher's subjectivity.

Finally, all design changes will affect the final results of the test, which means that if we change any part of the design, the results may be different. The most critical part of the Friedman test is the number of variables and design options, so the ranking changes caused by some numerical arrangements or one of the design changes will greatly affect the final research results of this article.

5.3 Conclusion

In recent years, the transformation of urban industrial land has become a typical problem in the process of urban development. After a certain amount of large-scale and well-known industrial land has been transformed, ordinary traditional factories and industrial land with influence only in the local area catch the designer's attention. Many lands have been rudely demolished, rebuilt and turned into new landscapes. In a sense, these original special architectural and industrial elements are also a type of usable value. These special values are studied and discussed in this article, with a contemplation on how to give them new vitality and how to better protect them.

After comparing three typical representative designs with 24 variables, the final conclusion is that the design that focuses on the transformation of industrial heritage projects not only has a small gap with the traditional designs in the aspects where traditional designs usually have obvious advantages, but also has great contributions to sustainability and the surrounding environment. The design has injected new vitality into the entire site and created unique values, giving troublesome abandoned industrial element a better solution. The design plan comprehensively provides the community with more gathering spaces and community gardens, which brings many visible short-term benefits and long-term environmental improvement to surrounding residents, and also provides residents with more opportunities to interact with community members. In the end, the conclusions reached prove that these industrial elements not only cause no pollution and additional costs, but also can be integrated into the design to create a better industrial transformation design. Although there are many limitations and subjectivity in the article, the variable design and design ideas of this research can also provide inspirations for future industrial transformation.

In general, the design guidelines of this study will enable industrial elements to find their place in industrial transformation land, and obtain safe and beautiful benefits in the future. In addition, future studies may consider more variable comparisons and the value brought by industrial elements in the design. These studies will contribute to the future development and progress of cities.

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