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Original scientific paper

Research on Environmental Regeneration Evaluation System and Design of Industrial Heritage from the Perspective of City-Industry Integration

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Abstract: As China gradually enters the post-industrial era, the problem of industrial heritage has become an important issue in recent years. Taking industrial heritage as the research object, city-industry integration as the means, regeneration design as the goal, and Xi'an Liucunbu Petrochemical Plant as the carrier, an evaluation system for the industrial heritage of Xi'an Liucunbu Petrochemical Plant was established by Delphi method and analytic hierarchy process, and the regeneration design of industrial heritage was carried out according to the evaluation system. The results were as follows: (1) the positioning strategy of regeneration evaluation system of Xi'an Liucunbu Petrochemical Plant should be "transformation and utilization" through calculation; (2) the transformation value of tank farm, process plant area and build-up area was determined by weight value, and the corresponding design activities that had certain rationality were carried out, which reduced design positioning errors caused by subjectivity; (3) the construction of a new small-town design strategy system integrating "innovative and entrepreneurial manufacturing factory, modern logistics factory, public facility supporting area and petrochemical plant ruins park" could reasonably solve the problem of industrial heritage in the Xixian New Area of Shaanxi Province, China. Therefore, an evaluation system should be first established for the research of industrial heritage, which will guide the design practice, and the industrial heritage of this plot is further designed based on the national upper-level planning.

Keywords: analytic hierarchy process; city-industry integration; industrial heritage issues; landscape architecture; petrochemical plant

1 INTRODUCTION

Industrial heritage is included in the cultural heritage and witnesses the development of cities. This is an important stage in the progress of human civilization, and industrial culture is also an important part of human cultural heritage. In recent years, studies on industrial heritage have been carried out in many countries and regions. In theoretical research, Sun et al. [1] provided some guidance for the evaluation of regeneration design value of industrial heritage through analytic hierarchy process, and offered some ideas for the resource evaluation stage of industrial heritage regeneration design through quantitative analysis. Liu et al. [2] proposed a method to evaluate the value of industrial heritage by using analytic hierarchy process, fuzzy theory and D-S theory comprehensively, and discussed the protection ways of industrial heritage from multiple perspectives (Note: D-S theory is an inference method about uncertainty, which is of great significance in dealing with subjective judgment and synthesis of uncertain information and providing reliability and validity tests for results [2]). In view of the status quo of Beijing Coking Plant, Luan [3] proposed the strategy of "simultaneous protection and redevelopment", namely, site renewal through the combination of grading protection and zoning protection. Li et al. [4] constructed the research framework of design language based on "landscape syntax", and proposed the analysis and transformation method of Tangshan industrial landscape in Hebei Province, deepening the landscape practice research of industrial wasteland. Fan [5] proposed that industrial heritage should strengthen the relationship between space environment and visitors, and guide the public's traveling experience through the design of five senses. Meantime, in the regeneration design activities of industrial heritage, solutions should be proposed according to the status quo of different sites. For example, Jia et al. [6] sorted out the spatial patterns of six industrial heritage parks, and interpreted the transformation of industrial sites under production unit induction method and the planning method for the purpose of displaying production processes, so as to retain the authenticity of industrial heritage; Zhu et al. [7] reused Shougang industrial heritage in Beijing, China, through the design method of "fragment palimpsest", and proposed that the utilization of industrial heritage in high-intensity development should give consideration to aesthetics and science, rules and freedom; Shougang industrial heritage was also transformed into Winter Olympics Square Park and Industrial Ruins Park.

To sum up, the evaluation of industrial heritage resources and the landscape transformation of industrial heritage have been carried out. However, these researches mostly focus on quantitative analysis or qualitative practice, and lack of corresponding design practice activities according to the data of quantitative analysis. Meanwhile, due to the lack of in-depth research on the transformation objectives of the site and the coping measures of each unit component of the site in the regeneration strategy of industrial heritage, there are similarities in coping methods for different sites, and many regeneration designs of industrial heritage lack systematic positioning of the environment. Therefore, the basic expert evaluation values were first obtained by Delphi method in this study, and after the analytic hierarchy process, the regeneration evaluation system and design practice of Xi'an Liucunbu Petrochemical Plant were established according to the weights.

2 MATERIALS AND METHODS

2.1 Determination of Research Site

Xi'an Liucunbu Petrochemical Plant locates in FengdongNew Town of Xixian New Area, Shaanxi Province, China (Fig. 1). It is near Fengchang Road in the north, Fengye Avenue in the south, and Jianzhang Road in the east. The site has convenient transportation and is located at the junction of Fengye Avenue and Jianzhang Road. Xixian New Area is the seventh state-level new area in China. According to the instruction of The State Council of China, the leading industries in Fengdong Area of

Xixian New Area will be dominated by high-tech and exhibition industry, focusing on high-tech R&D and incubation, sports, exhibition business, cultural tourism, modern agriculture, real estate development, etc. [8]. Therefore, it is of great significance for design activities within its jurisdiction. The petrochemical plant is mainly divided into three zones, namely tank farm, process plant area and built-up area. The current functional units are shown in Fig. 2, and the areas of each zone are rounded as follows (Tab. 1).

Figure 1 Location of the project

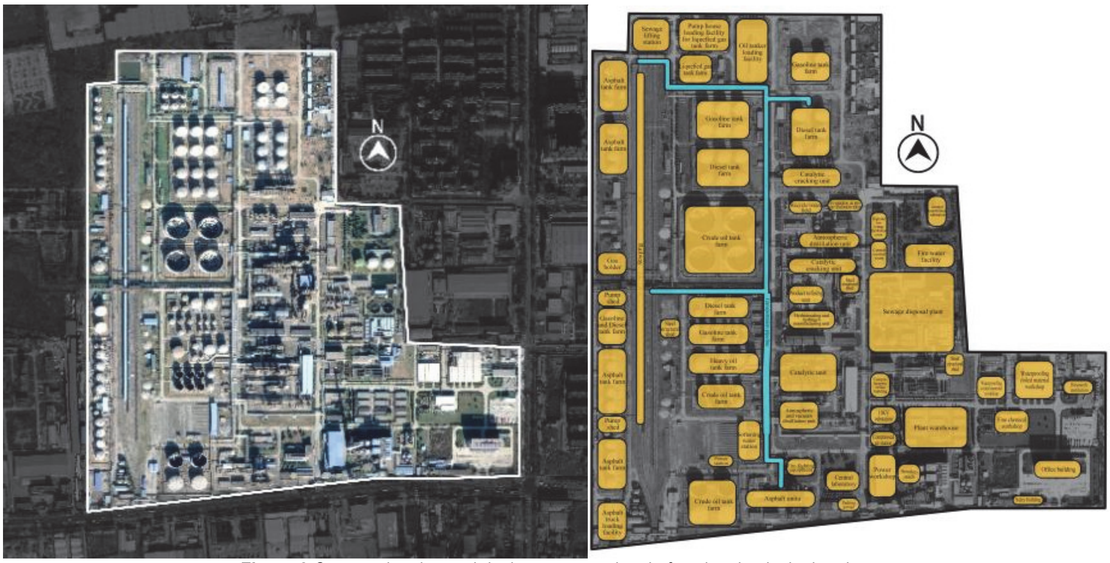

Figure 2 Current planning and design scope and main functional units in the plant

Table 1 Floor space of main zones in the plant

Main zone	Area / ha	Proportion / %
Tank farm	10	16.7
Process plant area	12	20
Built-up area	2	3.3
Other areas	36	60

2.2 Construction of Judgment Matrix

Delphi method is a group decision-making behavior with the characteristics of anonymity, feedback and statistics [9]. Through repeated consultation, modification and summary, the consensus of opinion is finally summarized and analyzed by regression analysis, and used as the data basis of judgment matrix [10]. For the sake of this matter, an expert group needs to be set up to score and obtain data. Analytic hierarchy process is a hierarchical analysis method [11], which has been widely applied in the field of decision science. In the process of research, researchers can have a hierarchical thinking and a mathematical decision-making process [12]. By establishing a hierarchical structure and measuring indexes and comparing them in pairs, weight values can be determined based on the results, so as to clarify the working ideas in decision-making [13]. Flexible use of the two methods can treat industrial heritage issues more objectively and scientifically, and closely combine quantitative analysis with qualitative practice.

(1) Primary selection and determination of index factors.

The index factors in the evaluation system were selected for the first round, and expert opinions were consulted for selection of index factors and subsequent scoring table for constructing judgment matrix. Five options were set for index factors, and the option was scored. The option with a score < 4 was regarded as an excess index factor, that is, the option would not be considered as an index factor of the judgment matrix (Tab. 2).

Table 2 Scoring table for selecting index factors

Very appropriate	Relatively appropriate	General	Relatively inappropriate	Inappropriate
5 points	4 points	3 points	2 points	1 point

(2) Filling in judgment matrix.

Consulting questionnaires were issued to the experts to get data, and the expert group consisted of 15 people (Tab. 3). A total of 15 questionnaires were issued, all of which were recovered. After exchanging opinions and adjusting values for many times, the values of final index factors tended to be consistent and all passed the consistency test. Finally, regression of 15 questionnaires was calculated by arithmetic mean algorithm, and the index factor values of the final judgment matrix were obtained.

Table 3 Composition of expert group

Number of people	Research field	Proportio / %
2	Petrochemical plant operation	14
5	Industrial heritage conservation	33
5	Landscape design	33
3	Urban planning	20

2.2.1 Matrix Model

As the judgment matrix was constructed, the steps were as follows.

(1) The column vectors of judgment matrix were normalized, that is, each factor was divided by the grand total for its column and the values of each column were added up to 1.

$$A_{ij} = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}}, \ (i, j = 1, 2, 3) \quad (1)$$

(2) The judgment matrix after the normalization of column vector should get grand totals for rows, and each factor value after the normalization of column vector was added up by rows.

$$A_i = \sum_{j}^{n} a_{ij}, \ (i = 1, 2, 3) \quad (2)$$

(3) After grand totals for rows and normalized calculation, the feature vector $\boldsymbol{\omega}_i$ of λ_{max} was obtained ($\boldsymbol{\omega}_i$ is the component of $\boldsymbol{\omega}$).

$$\boldsymbol{\omega}_i = \frac{\boldsymbol{\omega}_i}{\sum_{i=1}^{n} \boldsymbol{\omega}_i}, \ (i = 1, 2, 3) \quad (3)$$

$\boldsymbol{\omega}_i = [\omega_1, \omega_2, \omega_3, ..., \omega_n]^{\mathrm{T}}$, T stands for the transpose symbol, namely the transposition of $\boldsymbol{\omega}_i = [\omega_1, \omega_2, \omega_3]^{\mathrm{T}}$.

2.2.2 Consistency Test

(1) $\boldsymbol{A\omega}_i = \lambda_{max} \boldsymbol{\omega}_i$, namely multiplication between feature vector $\boldsymbol{\omega}_i$ and a matrix $\boldsymbol{A}$ was equal to multiplication between λ_{max} and feature vector $\boldsymbol{\omega}_i$.

$$\lambda_{max} = \frac{1}{n} \sum_{i=1}^{n} \frac{\boldsymbol{A\omega}_i}{\boldsymbol{\omega}_i} \quad (4)$$

(2) Calculation of consistency index.

As λ_{max} was calculated, consistency test was performed, and feature vector was converted into weight vector if passed the consistency test. The consistency index was expressed as consistency index (*CI*) (Tab. 4).

Table 4 Consistency index (*CI*)

Consistency index	Character	Inspection
CI=0	Completely consistent	Pass the test
CI<0.1	Consistent	Pass the test
CI>0.1	Inconsistent	Fail the test

$$CI = \frac{\lambda_{max} - n}{n - 1} \quad (5)$$

When the order of the judgment matrix increased, the difficulty of consistency satisfaction would increase, and sometimes there would be matrices that were difficult to satisfy the consistency test. Therefore, it is necessary to introduce random index *RI*, and the *RI* value could be obtained by looking up the table (Tab. 5). From the third order of the matrix, t is necessary to test and judge whether the matrix was reasonable by *CI*: *RI*= *CR* (consistency ratio) (Tab. 6).

$$CR = \frac{CI}{RI} \quad (6)$$

Table 5 Average random index (*RI*)

Order of matrix	1	2	3	4	5	6	7	8	9
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45

Table 6 Consistency ratio (*CR*)

Consistency index	Character	Measure
CR = 0	Completely reasonable	Pass
CR < 0.1	Relatively reasonable	Pass
CR > 0.1	Unreasonable	Adjust judgment matrix

2.3 Research Process

2.3.1 Design Ideas of Industrial Heritage Evaluation System of Xi'an Liucunbu Petrochemical Plant

First, the macro-level policies and countermeasures were established for the industrial heritage of Xi'an Liucunbu Petrochemical Plant, and the regeneration plan of the site was positioned, namely one of the three plans, "status quo reservation", "transformation and utilization", and "demolition and knocking down", was implemented. Second, the follow-up policy and strategy formulation should be carried out according to the final plan selection (Fig. 3).

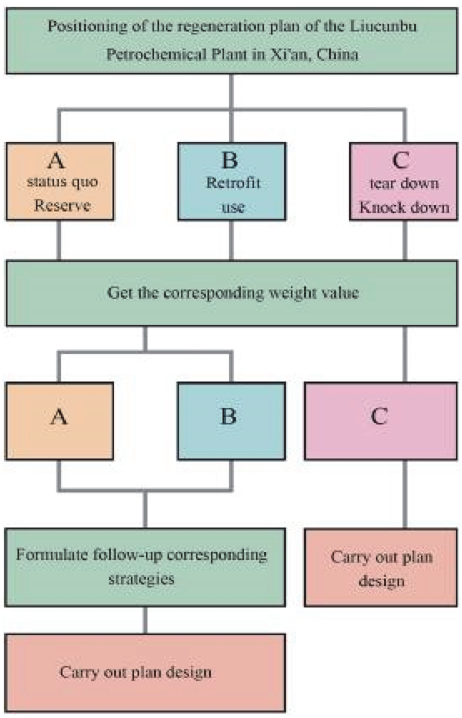

Figure 3 Positioning of regeneration plan of Xi'an Liucunbu Petrochemical Plant

2.3.2 Positioning Strategy of Regeneration Evaluation System of Xi'an Liucunbu Petrochemical Plant

(1) Construction of judgment matrix.

The positioning strategy of the regeneration evaluation system of Xi'an Liucunbu Petrochemical Plant should be determined first when constructing the series evaluation system of the petrochemical plant (Fig. 4). In order to facilitate the calculation, Yaahp software was used for the following calculation.

(2) Interpretation of index factors in judgment matrix (Tab. 7).

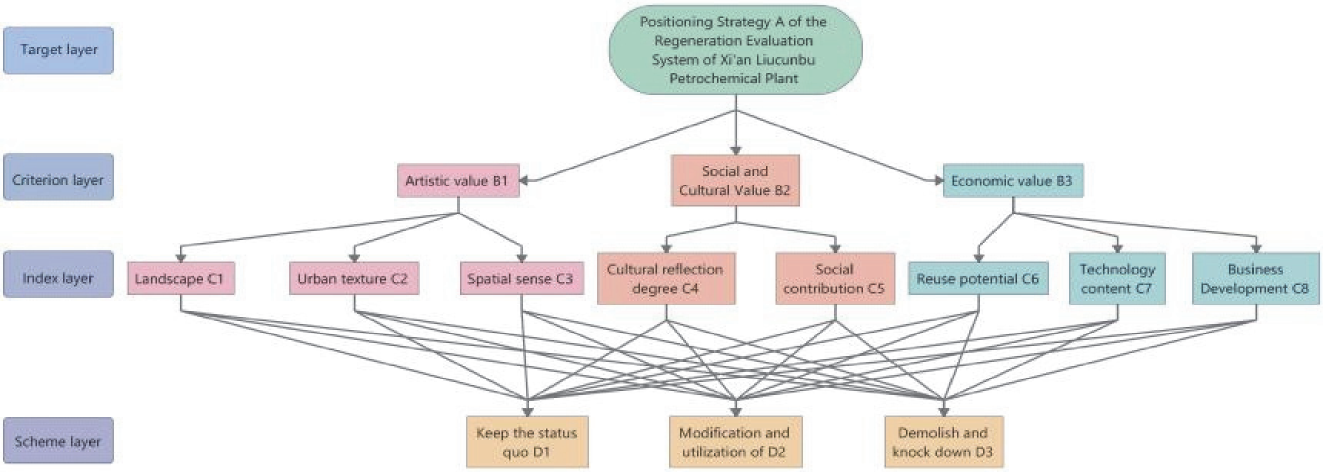

Figure 4 Positioning strategy of regeneration evaluation system of Xi'an Liucunbu Petrochemical Plant

Table 7 Interpretation of index factors in index layer

Index layer	Interpretation of index layer
Landscape	Industrial heritage landscape has unique features and is different from other types of landscape.
Urban texture	It reflects the structural characteristics and functional distribution of the regional planning.
Sense of space	The structural characteristics of industrial heritage make the spatial changes flexible and interesting.
Cultural reflection degree	Industrial heritage represents a period of development history of a country and a period of memory of a city, and the statement of history needs excellent media [14].
Social contribution degree	The "industrial spirit" reflected in industrial heritage, "craftsman spirit, model worker spirit", carry forward the spirit of the times [16].
Reuse potential	For industrial heritage, it should be evaluated whether it has certain reuse value and reuse potential, and some industrial heritage will be transformed from "serving factories" to "serving the public".
Technological content	Technological value is an important limitation that distinguishes industrial heritage from other historical and cultural heritages [17], and some plant facilities even have a milestone significance.
Commercial development	Consumer consumption activities will further drive the economic development of the region, and good commercial development can also reactivate the vitality of the plant area.

2.3.3 Evaluation of Tank Farm of Xi'an Liucunbu Petrochemical Plant

The current main functional units were screened, and the functional units retained after transformation was determined by factors such as location, function, transformation potential and industrial style.

Figure 5 Schematic diagram of functional units of screened tank farm (collated by the author according to the data of petrochemical plant)

After the applicable index factors of the tank farm were screened, the weight values of the functional units in the tank farm were calculated through the index factors of criterion layer in the matrix to determine the importance order of index factors (Fig. 5). Meantime, in order to facilitate the horizontal comparison of tank farm, process plant area and built-up area, a unified evaluation benchmark should be formulated. Therefore, the index factors of the criterion layer should be consistent, and the judgment matrix is shown in Tab. 8.

2.3.4 Evaluation of Process Plant Area in Xi'an Liucunbu Petrochemical Plant

After screening, the functional units of the process plant area are shown in Fig. 6, and the judgment matrix is shown in Tab. 9.

Figure 6 Schematic diagram of function units of screened process plant area (collated by the author according to the data of petrochemical plant)

2.3.5 Evaluation of Built-Up Area in Xi'an Liucunbu Petrochemical Plant

After screening, the functional units of the built-up area are shown in Fig. 7, and the judgment matrix is shown in Tab. 10.

Figure 7 Schematic diagram of function units of screened built-up area (collated by the author according to the data of petrochemical plant)

Table 8 Evaluation of tank farm in Xi'anLiucunbuPetrochemical Plant

<table>
<tr><td colspan="6">Target layer</td></tr>
<tr><td colspan="6">Evaluation of tank farm of Xi'an Liucunbu Petrochemical Plant A</td></tr>
<tr><td colspan="6">Criterion layer</td></tr>
<tr><td>Transformation elasticity B1</td><td>Creative and interesting potential B2</td><td>Space tolerance B3</td><td>Display of industrial cultural memory B4</td><td colspan="2">Economic evaluation of target location B5</td></tr>
<tr><td colspan="6">Interpretation of criterion layer</td></tr>
<tr><td>Variable degree of transformation target; flexibility of target transformation</td><td>Degree of interestingness and creativity of object after transformation activities</td><td>Size of space capacity of transformed target</td><td>Depth of industrial imprint and characteristics of the times reflected by the object</td><td colspan="2">Distance between scheme layer factors and newly added core axis and estimation of its ability to create economic value</td></tr>
<tr><td colspan="6">Scheme layer</td></tr>
<tr><td>Asphalt tank farm C1</td><td>Gasoline tank farm C2</td><td>Diesel tank farm C3</td><td>Liquefied gas tank farmC4</td><td>Crude oil tank farm C5</td><td>Heavy oil tank farm C6</td></tr>
</table>

Table 9 Evaluation of process plant area in Xi'an Liucunbu Petrochemical Plant

<table>
<tr><td colspan="9">Target layer</td></tr>
<tr><td colspan="9">Evaluation of tank farm of Xi'an Liucunbu Petrochemical Plant A</td></tr>
<tr><td colspan="9">Criterion layer</td></tr>
<tr><td colspan="2">Transformation elasticity B1</td><td colspan="2">Creative and interesting potential B2</td><td>Space tolerance B3</td><td colspan="2">Display of industrial cultural memory B4</td><td colspan="2">Economic evaluation of target location B5</td></tr>
<tr><td colspan="9">Scheme layer</td></tr>
<tr><td>Railway C1</td><td>Transportation pipelineC2</td><td>Catalytic cracking unit C3</td><td>Catalytic unit C4</td><td>Asphalt unit C5</td><td>Fire water facility C6</td><td>Sewage disposal plant C7</td><td>Power workshopC8</td><td>Smoke stack C9</td></tr>
</table>

Table 10 Evaluation of built-up area in Xi'an Liucunbu Petrochemical Plant

<table>
<tr><td colspan="7">Target layer</td></tr>
<tr><td colspan="7">Evaluation of tank farm of Xi'an Liucunbu Petrochemical Plant A</td></tr>
<tr><td colspan="7">Criterion layer</td></tr>
<tr><td colspan="2">Transformation elasticity B1</td><td colspan="2">Creative and interesting potential B2</td><td>Space tolerance B3</td><td>Display of industrial cultural memory B4</td><td>Economic evaluation of target location B5</td></tr>
<tr><td colspan="7">Scheme layer</td></tr>
<tr><td>Central laboratory C1</td><td>Comprehensive office building C2</td><td>Plant warehouse C3</td><td>Waterproofing coiled material workshop C4</td><td>Steel structural shedC5</td><td>Research institution C6</td><td>Office buildingC7</td></tr>
</table>

Table 11 Importance weight value of index factors in criterion layer, index layer and scheme layer to target layer

Criterion layer factor	Weight value	Index layer factor	Weight value	Scheme layer factor	Weight value
Artistic value B1	0.1373	Landscape C1	0.0941	Status quo reservation D1	0.2809
		Urban texture C2	0.0128		
		Sense of space C3	0.0304		
Social and cultural values B2	0.2395	Cultural reflection degree C4	0.0479	Transformation and utilization D2	0.6412
		Social contribution degree C5	0.1916		
Economic value B3	0.6232	Reuse potential C6	0.1461	Demolition and knocking down D3	0.0779
		Technological content C7	0.0485		
		Commercial development C8	0.4286		

3 RESULTS

3.1 Positioning Strategy of Regeneration Evaluatio System of Xi'an Liucunbu Petrochemical Plant (Tab. 11)

The positioning of industrial heritage regeneration design is related to the rationality of the transformation and upgrading direction of the plant. Data were calculated by Eq. (1) to Eq. (6). Through calculation by judgment matrix, it can be concluded that the weights of criteria layer factors successively were economic value B3 > social and cultural value B2 > artistic value B1; the weights of index layer factors successively were commercial development C8 > social contribution degree C5 > reuse potential C6 >landscape C1 > technological content C7 > cultural reflection degree C4 > sense of space C3 > urban texture C2; the weights of scheme layer factors successively were transformation and utilization D2 > status quo reservation D1 >demolition and knocking down D3. Therefore, the regeneration of industrial heritage of Xi'an Liucunbu Petrochemical Plant was positioned as "transformation and utilization".

3.2 Weight Value of Tank Farm Evaluation System (Tab. 12)

Data were calculated by Eq. (1) to Eq. (6). Through calculation by judgment matrix, it can be concluded that the weights of criteria layer factors successively were transformation elasticity B1 > economic evaluation of target location B5 > display of industrial cultural memory B4 > space tolerance B3 > creative and interesting potential B2. The weights of scheme layer factors successively were crude oil tank farm C5 > diesel tank farm C3 > gasoline tank farm C2 > heavy oil tank farm C6 > liquefied gas tank farm C4 > asphalt tank farm C1.

3.3 Weight Value of Process Plant Area Evaluation System (Tab. 13)

Data were calculated by Eq. (1) to Eq. (6). Through calculation by judgment matrix, it can be concluded that the weights of criteria layer factors successively were display of industrial cultural memory B4 > economic evaluation of target location B5 > space tolerance B3 > transformation elasticity B1 > creative and interesting potential B2. The weights of scheme layer factors successively were catalytic cracking unit C3 > power workshop C8 > catalytic unit C4 > asphalt unit C5 > railway C1 > smoke stack C9 > sewage disposal plant C7 >transportation pipelineC2 > fire water facility C6.

3.4 Weight Value of Build-Up Area Evaluation System (Tab. 14)

Data were calculated by Eq. (1) to Eq. (6). Through calculation by judgment matrix, it can be concluded that the weights of criteria layer factors successively were space tolerance B3 > economic evaluation of target location B5 > transformation elasticity B1 > display of industrial cultural memory B4 > creative and interesting potential B2. The weights of scheme layer factors successively were plant warehouse C3 > waterproofing coiled material workshop C4 > central laboratory C1 > comprehensive office building C2 > steel structural shed C5 > office building C7 > research institution C6.

Table 12 Importance weight value of index factors in criterion layer and scheme layer to target layer

Criterion layer factor	Weight value	Scheme layer factor	Weight value
Transformation elasticity B1	0.4162	Asphalt tank farm C1	0.0575
		Gasoline tank farm C2	0.1357
Creative and interesting potential B2	0.0624	Diesel tank farm C3	0.2363
Space tolerance B3	0.0986		
Display of industrial cultural memory B4	0.1611	Liquefied gas tank farm C4	0.0836
Economic evaluation of target location B5	0.2618	Crude oil tank farm C5	0.3750
		Heavy oil tank farm C6	0.1118

Table 13 Importance weight value of index factors in criterion layer and scheme layer to target layer

Criterion layer factor	Weight value	Scheme layer factor	Weight value
Transformation elasticity B1	0.0769	Railway C1	0.0800
Creative and interesting potential B2	0.0507	Transportation pipeline C2	0.0505
		Catalytic cracking unit C3	0.2430
Space tolerance B3	0.1534	Catalytic unit C4	0.1640
Display of industrial cultural memory B4	0.4342	Asphalt unit C5	0.0922
		Fire water facility C6	0.0337
Economic evaluation of target location B5	0.2848	Sewage disposal plant C7	0.0630
		Power workshop C8	0.1984
		Smokestack C9	0.0752

Table 14 Importance weight value of index factors in criterion layer and scheme layer to target layer

Criterion layer factor	Weight value	Scheme layer factor	Weight value
Transformation elasticity B1	0.1611	Central laboratory C1	0.1294
Creative and interesting potential B2	0.0624	Comprehensive office building C2	0.1216
		Plant warehouse C3	0.2457
Space tolerance B3	0.4162		
Display of industrial cultural memory B4	0.0986	Waterproofing coiled material workshop C4	0.2273
		Steel structural shed C5	0.1143
Economic evaluation of target location B5	0.2618	Research institution C6	0.0636
		Office building C7	0.0981

4 REGENERATION DESIGN BASED ON WEIGHT RESULTS

First of all, the design objects in tank farm, process plant area and build-up area were adjusted according to the specific design; secondly, the position of more mobile objects could be flexibly adjusted, otherwise they would be transformed on the spot. The design idea was "industrial heritage + urban function", and combined with the weight values of build-up area, tank farm and process plant area, zoning plan was adopted for the site. The build-up area with a higher weight value should be planned as important innovative and entrepreneurial manufacturing factory and modern logistics factory; the tank farm with the second highest weight value should be planned as public facility supporting area; and the process plant area with the lowest weight value should be planned as petrochemical plant ruins park (Fig. 8). The petrochemical plant ruins park would serve as a "grey space" suturing the other three modules.

Figure 8 Planning of site functional structure

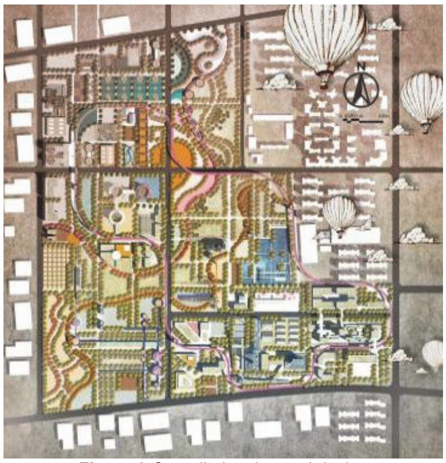

Figure 9 Overall planning and design

Figure 10 Schematic diagram and design sketch of four modules

Therefore, the former northwest tank farm was transformed to public facility supporting area; the former north tank farm, west tank farm and middle process plant area were transformed to petrochemical plant ruins park; the former south tank farm, process plant area and build-up area were transformed to modern logistics factory; and the former southeast build-up area was transformed to innovative and entrepreneurial manufacturing factory (Fig. 9 to Fig. 10).

Table 15 Transformation design strategy of former tank farm

Target weight value	Before transformation	After transformation	New planning area
0.3750	Crude oil tank	Concert hall, comprehensive exhibition hall, museum of tangible and intangible cultural heritage, art creation center	Public facility supporting area
0.2363	Diesel tank	Parent-child interactive experience area, train track, teahouse + small workshop, industrial landscape appreciation	Petrochemical plant ruins park + modern logistics factory
0.1357	Gasoline tank	Book bar, learning corner, light food restaurant + rainwater collection and treatment station, industrial landscape appreciation + small private cinema, garden management, rainwater collection and treatment station, industrial landscape appreciation	Public facility supporting area + modern logistics factory + petrochemical plant ruins park
0.1118	Heavy oil tank	Observation tower, interesting tranquil rest area	Petrochemical plant ruins park
0.0836	Liquefied gas tank	Basketball court, sports equipment room	Public facility supporting area
0.0575	Asphalt tank	Industrial landscape viewing facilities, entertainment center	Petrochemical plant ruins park, public facility supporting area

Table 16 Transformation design strategy of former process plant area

Target weight value	Before transformation	After transformation	New planning area
0.2430	Catalytic cracking unit	Popular science exhibition	Petrochemical plant ruins park
0.1984	Power workshop	High-end manufacturing industry, modern manufacturing industry	Innovative and entrepreneurial manufacturing factory
0.1640	Catalytic unit	Sightseeing platform	Petrochemical plant ruins park
0.0922	Asphalt unit	Outdoor leisure facilities	Modern logistics factory
0.0800	Railway	Industrial landscape appreciation	Petrochemical plant ruins park
0.0752	Smoke stack	Industrial landscape appreciation	Innovative and entrepreneurial manufacturing factory
0.0630	Sewage disposal plant	Ecological transformed waterscape	Innovative and entrepreneurial manufacturing factory
0.0505	Transportation pipeline	Drip irrigation system	Modern logistics factory, petrochemical plant ruins park
0.0337	Fire water facility	Landscape sketch	Petrochemical plant ruins park

Table 17 Transformation design strategy of former build-up area

Target weight value	Before transformation	After transformation	New planning area
0.2457	Plant warehouse	Freight gathering center, de-consolidation center, reserve center	Modern logistics factory
0.2273	Waterproofing coiled material workshop	Delivery center, distribution center	Innovative and entrepreneurial manufacturing factory
0.1294	Central laboratory	Circulation information processing, fine processing center	Modern logistics factory
0.1216	Comprehensive office building	Logistics management center	Innovative and entrepreneurial manufacturing factory
0.1143	Steel structural shed	Industrial landscape appreciation	Public facility supporting area, petrochemical plant ruins park
0.0981	Office building	Logistics office building	Innovative and entrepreneurial manufacturing factory
0.0636	Research institution	Logistics theory research center	Innovative and entrepreneurial manufacturing factory

5 DESCRIPTION OF THREE AREAS OF THE ORIGINAL PLANT BEFORE AND AFTER RENOVATION

The former tank farm (Tab. 15), process plant area (Tab. 16) and build-up area (Tab. 17) were transformed according to the above evaluation system, and the transformation objects in the three zones were designed correspondingly based on weight values. The higher the weight value, the stronger the transformation value, the degree of transformation, the practicability and the functionality.

6 CONCLUSIONS

The importance of the industrial heritage of Xi'an Liucunbu Petrochemical Plant was evaluated by Delphi method and analytic hierarchy process. Based on the evaluation results, the design practice was carried out to quantitatively analyze the transformation value of equipment, devices and buildings in the tank farm, process plant area and build-up area. The conclusions were as follows: (1) the regeneration design of Xi'an Liucunbu Petrochemical Plant should not be direct demolition and rebuilding or reservation without selectivity; (2) the strategies of industrial heritage should give priority to the establishment of value evaluation system; after the weight value was obtained, different design tendencies were given based on weight values, so that different types of industrial heritage could get the maximum value of reuse. To sum up, this study explores the city-industry integration model through the relationship between industrial heritage and urban functions, and guides the design practice through the evaluation system, so as to guide the transformation and upgrading of industrial heritage more systematically and scientifically.

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