

Heritage Values Mathematical Model Design of Middle Eastern Railway Architectural Complex

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Abstract

Combining the practical situation, this article analyzes the heritage value of Middle Eastern Railway buildings in Hengdao Hezi from various perspectives. Research framework is established, including overview, architectural scale and pattern, building components, structure and space, and this paper designs heritage values mathematical model of Chinese Eastern railway architectural complex. By using Analytic Hierarchy Process (AHP), research on the quantization and cascade protection was also carried out.

Keywords: hengdao hezi, Chinese eastern railway architectural complex, quantification of value, analytic hierarchy process

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1. Introduction

Hengdao Hezi is an ancient town underwent hundreds of years of wear and tear. Its overall floorage is 32215m². With 97 Russian-style buildings built in the early 20th century, Hengdao Hezi has a significant imprint of Russian cultural and historical charm. Among those Russian-style architectural complexes, Chinese Eastern Railway buildings are well-preserved with more buildings and building types; the architectural complex is of high conservation value and exploitation value. Based on typical characteristics of railway buildings, value factors affecting protection and utilization of building, from group value to individual value of buildings, are extracted comprehensively and systematically, and marks are made accordingly. Thus, most valuable materials and data could be further provided for protection and utilization of buildings.

Chinese Eastern Railway architectural complex is an industrial heritage with outstanding characteristics and important value. Combining the current situation, characteristics and value of Hengdao Hezi Chinese Eastern Railway buildings could be summarized as: historical value, social value, features and value of urban planning, architectural aesthetics and artistic value.

Generally speaking, the construction of Chinese Eastern railway could be divided into two periods, the first is when Chinese Eastern railway was occupied by Russia (1900 - 1935). Most buildings were for the construction and maintenance of Chinese Eastern railway. Construction work for Chinese Eastern railway broke the silence and brought about prosperity to the town day by day. Hengdao Hezi became transportation junction and key town. The second period is when the town was occupied by Japanese (1935-1945). During this period, most of the buildings were to the benefit of colonial rule; and the buildings are mostly Russian-style. Chinese Eastern Railway is a solid evidence for the aggression and enthrallment that Russian imperialism and Japanese imperialism have exerted to China. Therefore, the architectural remains have great historical values.

Meanwhile, Chinese Eastern Railway architectural complex also has great social value. Buildings of Chinese Eastern Railway made the originally backward town prosperous. Russians brought about the church, business and trade. According to historical records, "In eastern regions of Heilongjiang Province, the church once has been activity center for Orthodox believers; and the number of believers could even be more than 5,000." [1]. Therefore, it would be rather easy to imagine the prosperous scene of "Town of Garden" at that time. Chinese

Eastern Railway architectural complex witnessed the colonial aggression during the construction of the railway and the working life of a large number of railway workers. It can be said that Hengdao railway is the one of the best example for modern social development based on railway construction and maintenance. Meanwhile, because of the spirit of the times, railway culture and national complex of fighting against aggression carried by Chinese Eastern Railway becomes important symbol of those days. Besides, the railway also has great emotional value for the Russian technicians worked here and to Russian and Chinese families and their descendants. Protection and reuse could also bring about stability to residents in Hengdao Hezi Town. Apart from economic development, Russian culture was also brought here. At that time, some Chinese people also go to church. Their eating and living habits were also influenced. Especially the marriages between Russians and Chinese led to biculturalism. Children of such families continued the same habits. For example, town people like beer, wine and spirits liquor; they also like eating ham, bread. Women are accustomed to wearing skirts even in winter. All those customs reflects Russian features.

Hengdao Hezi has four distinct seasons. With its fertile soil and pleasant scenery, Hengdao Hezi is a natural place for housing, amusement and recreation. Its physiognomy is full of variety and played an decisive role in planning and construction of cityscape.

Urban land-use structure has ribbon shape and segmentation features. And the town extends along the international transportation routes of the railway. During the few decades of Russian occupation, topography of the town on the axis started to take shape as a belt. The middle part of the town was for residential and commercial activities. West part of the town had most historical building of the town; most of the residents are Chinese. North part of the town is multifunction: for storage, army and government (guard point), habitation, etc. The layout of the town was dependent on international means of transportation (railway) and working life of Russian railroader.

Based on the location of the railway, the town was established in flat area and divided into rational function partitions. Train station was built in the central part of the town; the town center was close to the railway station settings, including railway maintenance offices, staff housing, and railway warehouse, etc. Judging from functional location and land size, core area of town is between train station and Orthodox Church of Our Lady, of which the activities, trades and business were all less than in the area of train station.

Overall planning features can be summarized as: planning is strictly based on functions with typical shape and pattern of a mountain town. Architectural form and structure has distinctive Russian-style characteristics: dendrite-shaped block plane pattern, multi-dimensional composite streets, integrated planning and design of physical environment, historic sites and folk life.

Apart from its outstanding historical value, Chinese Eastern Railway also has great artistic value. First of all, the artistic value lies in the originality, advance and rationality of building materials, building structures and construction technology and is also shown in the qualification for development of architectural science. Secondly, the correlation of architectural type and architectural style between Chinese Eastern Railway architectural complex and a certain architectural trend also reflects the architectural value of Chinese Eastern Railway. Bellow is detailed information:

(a) Russian architecture is the main architecture type of Chinese Eastern Railway architectural complex. The construction technology and construction techniques were at a more advanced level.

(b) Building shape and form of the Chinese Eastern Railway architectural complex are typical Russian architectural style, which is most typical material results of Russia invasion and meets the historical and modern artistic features of Russian architecture.

(c) Hengdao Hezi is now a huge Russian historical architectural complex.

(d) The mingling of local culture and foreign culture for hundreds of year brings about great scientific value and reference value for buildings represented by Chinese Eastern Railway architectural complex.

2. Research of Architectural Complex's Heritage Value

As the transformation of China's economic system and the adjustment of the town industrial structure and land use structure, Hengdao Hezi is facing the problem of the reuse of a

large number of historic buildings. Due to immature management system and lack of understanding on protection of buildings, sometimes valuable historical buildings could be tore down overnight. As a result of the disregard for the protection and renovation of railway historical buildings, protective reuse is still one of the most important tasks that require urgent protection and intensive study.

The evaluation of the value of Chinese Eastern Railway and whether or not it should be preserved or transformed are questions of great importance in practice. Based on the successful references from abroad, systemic and mature rules and regulations are strong guarantee for protection. If a set of methodical research program, which may determine the relevant factors and quantitative indicators related to Chinese Eastern Railway architecture, could be put into use, it would be of great importance for the reconstruction of buildings along Chinese rail line and even for reconstruction of industrial buildings. Such program could offer authoritative answers to the question of how to protect the buildings, and it also could be condition-prerequisite for protection and reuse of Chinese Eastern Railway historical buildings.

Under the influence of Russian architecture in special modern environment, Chinese Eastern Railway buildings belong to European or Russian architecture of "function reflects the form". Such architecture made it possible to research historical buildings based on western research methods. Western architectural heritage protection expert, J.Kirkhwin, systematically introduced western research in his book, *Conservation Philosophy and Practice for Western Ancient Buildings*. List for construction materials and components, including materials, structure, window cover, dormer windows, corner, glass tile, doors and door pocket, is also in the book. Taking the research of J.Kirkhwin as reference, this article reaches the following research sub-items by means of using Analytic Hierarchy Process (target, element indicator and factor indicator), choosing different value sub-items and make scores based on practical situation.

Determination of research scope

Scope of this research is along the belt region of Chinese Eastern railway in the town of Hengdao Hezi, mainly located in the blocks surrounded by east and north parts of Hengdao River and Bergamot Mountain (Figure 1).

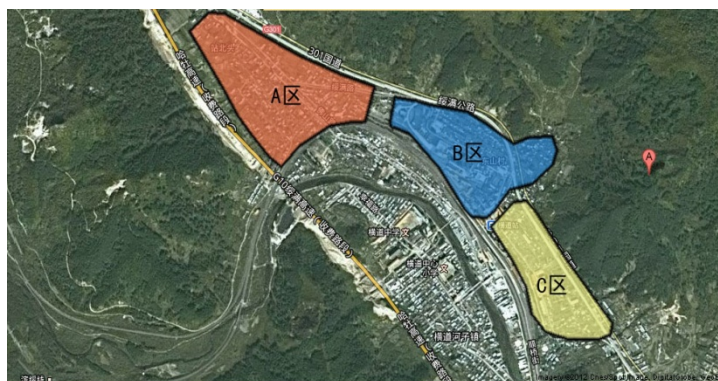


Figure 1. Scattergram of Major Blocks in Hengdao Town (illustrated by the author)

Selection of research objects

For convenience of the investigation, the whole town is divided into three areas in accordance with the functional structure: Area A-west part of Hengdaohe Town where the distribution of historical buildings is concentrated, including the Big White Building of Chinese Eastern Railway, and most of the buildings are small-size housing stocks; Area B-blocks between the Russian Street and Machinery Garage of Chinese Eastern Railway, including the military camps of Japanese garrison, and there are small-size housing stocks on both sides; Area C-blocks between Orthodox Church of Our Lady and the train station, and there are small-size housing stocks and public buildings. Research objects were selected to cover all the three areas as much as possible.

Five buildings were selected as representative buildings for further comprehensive research. Generally speaking, the five selected buildings are able to represent all styles and structures of Middle Eastern Railway historical buildings.

The five buildings are as follows:

Orthodox Church of Our Lady: Russian wooden building, built in 1903, national cultural protection building

Far East Machinery Garage: Russian-style architecture, built in 1903, a national cultural protection building

Russian Chalet (House of Tian Muming): Wooden Russian rural residential style, built in around 1903-1907, municipal cultural protection building

Water dungeon: eclectic style of classical imitation, listed building

House of timber merchant: Russian national style, built in around 1905, listed building

3. Quantitative Analysis for the Heritage Value of the Architectural Complex

3.1. Determination of the Factors

An index factor is sub-indicators established under main factor system and has obvious influence over the value of historical Industrial buildings.

In value segmentation research, 13 items are divided into 46 sub-items, which are derived from consideration for the particularity of railway buildings and are closely related with the value of railway buildings. Scores are given to those factors: 1 point for each of the 46 sub-items. There are six levels: 0, 0.2, 0.4, 0.6, 0.8, 1, which respectively mean: very poor, poor, poor, normal, good and excellent.

The quantification advisory group consists of eight people, and most of them are experts, professors and postgraduates from schools of architecture in HIT and NFU in urban planning, architectural history and protection of historic streets; there are also personnel from Heilongjiang provincial Bureau of Cultural Relics. Each member is required to complete an inquiry sheet of Chinese Eastern Railway's architectural value. Thus quantitative scores are collected and average scores for all sub-items could be achieved. Even though the grading is designed to be as objective as possible, there is still inevitable subjectivity.

3.2. Quantification Procedures

(a) Delivery of the inquiry sheet: Inquiry sheets are delivery in the following way: for the reason that some of the consultants are not located in the same region, it would not be high-efficient to use questionnaires. In that case, soft copies of the inquiry sheets are sent to the consultants by e-mail, as well as the reply from those consultants. Materials that need to be prepared are: value questionnaire, including criterion level score sheet and weight score sheet; basic information for object buildings, including photos, background information, should be delivered to consultants by e-mail. The consultants should conduct quantification according to background information and fill in the above-mentioned sheets in detail.

(b) Information feedback: Results of the first time will be sent to the consultants again. Consultants would be asked to give scores once again, and the scores will be collected again. Then there will be further comments about major differences lies in the two information feedbacks. In the end, a relatively reasonable value could be achieved.

(c) Final results of the statistics and survey: the relevant data of each building is analyzed and calculated in the formula of Analytic Hierarchy Process (AHP) so as to achieve the scores of every building.

3.3. Weight of Factor Indicators

The above determined the main factors and quantitative factors affecting the value of Chinese Eastern Railway historic buildings. However, owing to the specialty of those buildings, same functional factors would have different influence on the values of different buildings (including historical buildings in different locations, of different properties and structures). Therefore, analysis for the values has to be objective and rational. On one hand, analysis for the main factors and principal divisors should be conducted; on the other hand, influence degree of each factor and divisor, i.e. the weight of indicator, need to be analyzed.

Weight of the factor could be determined in various methods. After comprehensive analysis, the conclusion that weighting could be achieved by experts' appraisal and

questionnaire survey is reached. In the designing phase, the initial weight survey and performance score are designed at the same time. Through one survey, relatively comprehensive data could be achieved; Specialty of railway historical buildings and correlation with protection value should be taken into consideration in order to determine the weight. For the convenience of statistics, initial expert consultation weight value are set from 0-100; then weight sum would be made to 1 point by means of weighted approach. As for performance score, 46 factors would be 46 points; then the score for 46 factors would be adjusted to 100 points by means of data weighting. Processing and calculation results are normalized on the basis of the questionnaire:

$$(Performance\ score)F_x' = F_a * 100 / 46 \quad F_{wx} = (Weight) / 100$$



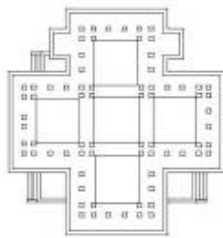
(calculation of the score):

$$V = F_a' * x_{fwa} + F_b' * x_{fwb} + F_c' * x_{fwc} + \dots + F_k' * x_{fwk} + F_l' * x_{fwl}$$

4. Comprehensive Quantitative Analysis-- Orthodox Church of Our Lady as Example

Orthodox Church of Our Lady, also known as Church of Yuejinsike, is an wooden Russian building with an area of 614 square meters. It is located in the north part of 301 State Road at the end of Russian road. The church could admit around 500 believers to conduct religious activities, and once became the center of Orthodox Church from Yabuli to Harbin, and to Hailin and Tieling River. Main part of the building is Mongolia structure with Greek cross shape in geometric plane surface. The shape, structure and craftwork are genuine Russian-style. Reinforced concrete frame was used in the hall for maintenance in recent years. Religious activities stopped after the withdrawal of the Soviets in 1955. The building had been used as workshop for Hengdao fruit winery workshop, and from the year of 1993, it has been used by organizations for preservation of cultural relics in Linhai. Research steps are: preliminary prospecting for current situation, preparation of investigation sheet, collection and grading for relevant documents, materials, drawings and diagrams. Due to limit space, general situation and structure are illustrated within the table below (Table 1).

Table 1. Survey and Assessment of the Profile and Scale of the St. Maria Chapel

Orthodox Church of Our Lady Of the building groups along the Chinese Eastern Railway						
Comprehensive category	Profile			Sales and layout		
	Year	1905				
Content	Category	Orthodox, a branch of Christianity – Cathedral buildings		Overall scale	Covering a construction area of 614 sq meters, it could contain 500 congregations for worships, whose scale was only next to that of the "St. Nicola's Cathedral".The protection area of the cathedral covers 10623 sq meters; It is one of the symbolic buildings.	
	Grade	It was appraised as a national class cultural building		Graphic layout	Graphically it is a concentrated layout of Greek Cross . In the South of the building, it has two entrances which are located on each side and there is a side entrance at the northwest.	
	Current condition and usages	It serves as Far East Museums				
	Appraisal of the current condition				Style	It is a wooden Orthodox Cathedral known over the country with a pure early Russian style
Photos						
	The cathedral photographed in 1023 ¹		The cathedral photographed in 2011 (by the author)			
Scores	Subitems	1. Characteristic	1	Subitems	6. Overall scale	1

	2. Historical age	1		7. Completion degree of the graphic layout	0.8
	3. Cultural relic class	1			
	4. Current condition and usage	0.8		8. Feature of the landmark	1
	5. Appraisal of the current condition	0.8			
Total		4.6	Total		2.8

Through weight advice and data integration treatment by the specialists, following conclusion is reached:

Table 2. Value Consultation and Comprehensive Scores Evaluated

A Target layer	B Quantitative criterion layer	C Factor quantification layer	Scores	Scores embodied	Weight normalization(Scores of the importance)	
The quantitative value mode of the St. Maria Chapel Of Hengdao Hezi of the Chinese Eastern Railway	Profile(A)	1、 Characteristic	1	Fa=4.6 Fa'=10.9	100 Fwa=1	
		2. Historical age	1			
		3. Cultural relic class	1			
		4. Current condition and usage	0.8			
		5. Appraisal of the current condition	0.8			
	Scale and layout(B)	6. Overall scale	1	Fb=2.8 Fb'=6.67	100 Fwb=1	
		7. Completion degree of the graphic layout	0.8			
		8. Feature of the landmark	1			
	Architectural components(C)	Entrance and porch(C1)	9. Condition of the doors	0.4	Fc=9.8 Fc'=23.3	80 Fwc=0.8
			10. Porch	0.8		
		Window (C2)	11. Condition of the windows	1		
			12. Type of the housings	1		
		Roofs(C3)	13. Condition of the roofs	0.8		
			14. Type of the walls	1		
		Wall(C4)	15. Condition of the walls	1		
			16. Foundation type	1		
		Foundation(C5)	17. Condition of the foundation	1		
			Other feature components	18. Importance of the components		
		19. Condition of the components		0.8		
	Structure(D)	20. Structure type	1	Fd=3 Fd'=7.14	90 Fwd=0.9	
		21. Load-bearing type	1			
		22. Structure technique	1			
	Materials(E)	23. Originity of the materials	0.8	Fe=2.6 Fe'=6.19	90 Fwe=0.9	
		24. Technique feature of the materials	1			
		25. Readiness of the materials	0.8			
	Spacing(F)	26. Constructional spacing	1	Fi=2 Fi'=4.76	100 Fwi=1	
		27. Environmental spacing	1			
	History(G)	28. Historical persons and events	1	Fg=3 Fg'=7.14	100 Fwg=1	
		29. History of the architecture	1			
		30. History of the geological section	1			
	Human emotion (H)	31. Influence degree of the emotion	1	Fh=2 Fh'=4.76	95 Fwh=0.95	
		32. Landmark and social publicity	1			
	Location(I)	33. Traffic location and convenience feature	0.8	Fi=2.8 Fi'=6.67	90 Fwi=0.9	
		34. Prosperous degree	1			
		35. Location of the town	1			
	Re-construction(J)	36. Expansion of the external appearance	0.8	Fj=2.6 Fj'=6.19	80 Fwj=0.8	
		37. Alteration of the internal function	0.8			
		38. Quality of re-construction	1			
	Environmental	39. Environmental pattern	0.8	Fk=1.6	85	

landscape(K)	40、Landscape features	0.8	Fk'=3.8	Fwk=0.85
Planning and layout(L)	41、Street environment	0.8	Fl=1.6 Fl'=3.8	90 Fwl=0.9
	42、Characteristics of the planning and layout	0.8		
Completeness of the scene(M)	43、Scale of the streets in history	1	Fm=3.6 Fm'=7.82	90 Fwm=0.9
	44、Continuity of the street landscape	0.8		
	45、Continuity of the street life	1		
Authenticity of the original scene preserved(N)	46、Function and structure of the street in history	0.8	Fm=3.0 Fm'=7.14	80 Fwn=0.8
	47、Conservation status of the historical features	0.8		
	48、Conservation status of the architecture features	0.8		
	49、Conservation status of the spacing pattern	0.8		
	50、Transition of the location and site	0.6		

Thus, the scores of St. Maria Chapel amount to:

$$V=Fa' \times fwa + Fb' \times fwb + Fc' \times fwc + \dots + Fk' \times fwk + Fl' \times fwl \\ = 10.9 \times 1 + 6.67 \times 1 + \dots + 3.8 \times 0.85 + 3.8 \times 0.9 = 82.234$$

Table 3. Scores of the Historical Architecture to be Researched by Using the Same Methods

Name of the architecture	Comprehensive scores	Name of the architecture	Comprehensive scores
St. Maria Chapel	82.234	The original stable of the Chinese Eastern Railway	58.347
Locomotive shed	83.316	Hengdao Hezi Railway Station	73.866
Russian style wooden house(Dwelling house of Tian Muming)	78.623	Train operation depot site	71.114
Water dungeon	67.689	Russian style residence Big round door	70.036
Dwelling houses of timber merchants	68.951	Russian row dwelling houses on No 6, Xinxin Rd.	63.527
Railway police station site	71.329	Russian style bricks houses, 66-9, Suiman Rd.	49.648
Big white building of the railway	76.134	Russian style buildings, 95, Suiman Rd.	56.138

5. Applying the Quantification Results

Analyze the Middle East railway historic architectural values situated in Hengdao Hezi County so that they can be rated according to the analysis results, which will effectively enhance the standard management over the historical railway architectures by adopting specific strategy and measures base on rated protection and utilization levels. Judgment and analysis to all values during the rating process would recognize the value compositions and orientations of these historical architectures further, of which differences could play the best of its value when the historical building to be re-utilized.

The rating methods to the Middle East railway historic architectural values in Hengdao Hezi County can be inferred from the aforementioned research results. According to the value distribution, the Middle East railway historic architectural values could be rated into 5 levels. 1st level (80-100 points), the quantification refers to excellent railway historical buildings; 2nd level, (80-60 points) the quantification refers to good railway historical buildings; 3rd level (60-40 points) the quantification refers to ordinary railway historical buildings; 4th level (40- 20 points) the quantification refers to bad railway historical buildings; 5th level (below 20 points) the quantification refers to very bad railway historical buildings. Comprehensive points would be obtained of all other buildings base on the quantification methods. The processed final statistics is shown as below:

Table 4. Quantification Research Statistics of the Middle East Railway Architectures

Building Name	Scores	Rating	Note
St. Maria Chapel	82.234	Grade I	Key protection
Locomotive shed	83.316	Grade I	Key protection
Russian style wooden house(Dwelling house of Tian Muming)	78.623	Grade II	
Water dungeon	67.689	Grade II	
Dwelling houses of timber merchants	68.951	Grade II	
Railway police station site	71.329	Grade II	
Big white building of the railway	76.134	Grade II	
The original stable of the Chinese Eastern Railway	58.347	Grade III	Protected
Hengdao Hezi Railway Station	73.866	Grade II	
Former train operation depot	71.114	Grade II	
Russian Residences, big round gate	70.036	Grade II	
Russian row dwelling houses on No 6, Xinxin Rd.	63.527	Grade II	
Russian style bricks houses, 66-9, Suiman Rd.	49.648	Grade III	Under protection
Russian style buildings, 95, Suiman Rd.	56.138	Grade III	Under protection

Regarding the protected Middle East railway historical buildings, detailed and specific protection guidelines shall be made according to the rated value levels. No matter the protected or non-protected buildings, corresponding protection standard shall be drawn in light of both the protection guidelines and the land administration regulations for land planning. According to the above mentioned rating outcome for the historical buildings, it suggests 5 types of protection and utilization, including strict, general, guiding, reserved and re-defined protection, among which the strict, general and guiding are standard protection efforts shall be given to the key protection buildings mentioned in this paper. And reserved and re-defined are standard protections for the other historical buildings.

This paper divides the Middle East railway historical buildings in Hengdao Hezi into 6 levels, from I to VI, and the protection efforts are summarized in the following table in according to respective levels:

Table 5. Protection Efforts for Middle East Railway Historical Buildings

Strictly controlled (I)	Generally controlled (II)	Controlled under guidance(III,IV)	Reserved(V)	Re-defined(VI)
St. Maria Chapel	Russian style wooden house(Dwelling house of Tian Muming)	The original stable of the Chinese Eastern Railway		
Locomotive shed	Water dungeon	Russian style bricks houses, 66-9, Suiman Rd.		
	Dwelling houses of timber merchants	Russian style buildings, 95, Suiman Rd.		
	Railway police station site			
	Big white building of the railway			
	Hengdao Hezi Railway Station			
	Train operation depot site			
	Russian Residences, big round gate			
	Russian row dwelling houses, No 6, Xinxin Rd.			

6. Conclusion

As one of the nine industrial heritages in China, the Middle East railway historical architectures possess multi-values, and also as Hengdao Hezi County the hub in the Middle East railway, thus its historical buildings would have greater history research value. To make the integrate research and quantification analysis to the Middle East railway in Hengdao Hezi and give ratings base on the analysis would provide important reference for the building protection and utilization in the next step with setting the relevant protection standards.

Acknowledgements

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