The Study on the Construction of Cultural Gene Information Chain and Inheritance Pathways for the Ruins of Longshan Lock on the Grand Canal

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Abstract. The Grand Canal has profoundly influenced the planning and development of cities along its route, impacting them in terms of history, transportation, culture, and ecology, thereby fostering the evolution of urban forms and sustainable development. The Ruins of Longshan Lock, as a living cultural heritage site, carry excellent historical and cultural memories and are an integral part of the water conservancy facilities in the Hangzhou section of the Grand Canal. The research conducted in-depth analyses on the historical development, construction techniques, and public education displays of the Ruins of Longshan Lock through methods such as on-site surveys and literature review. Based on this, the cultural gene retrotranscription extraction method was adopted to refine the information on cultural gene elements, after which a cultural gene identification index and a cultural gene information pedigree chart were established. Subsequently, a cultural gene information chain was constructed using typological principles, and its characteristics were analyzed. From the environmental, architectural, and cultural dimensions, the study revealed the multidimensional value of the Ruins of Longshan Lock and their role in inheritance, and proposed strategies for protection and inheritance. This research provides insights and references for the protection and development of the historical and cultural values of the water conservancy facilities of the Grand Canal, thereby promoting the planning and construction of the Grand Canal National Cultural Park.

Keywords: The Grand Canal Planning, Ruins of Longshan Lock, cultural gene information chain, characteristic analysis, inheritance pathway

1 INTRODUCTION

The interplay between the Grand Canal of China and urban planning has been instrumental in shaping the development of cities along its route, marrying functionality with cultural and historical significance. In 2014, the Grand Canal was officially inscribed on the World Heritage List, an international recognition and affirmation of this vast linear water conservancy heritage, its basin culture, and the grand living cultural landscape. The "Construction Scheme for the Great Wall, Grand Canal, and Long March National Cultural Parks" in 2019 emphasized that the establishment of national cultural

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parks is crucial for reinforcing cultural confidence and showcasing the enduring influence of China's exceptional traditional culture. After thousands of years of water conservancy practices, the Grand Canal has left behind an extensive legacy of water conservancy engineering heritage. The Hangzhou section of the Grand Canal, as part of the national cultural park, traverses the southern canal and the eastern Zhejiang canal and continues to play a vital role in water management and navigation to this day[1]. Sluice facilities, as one of the typical forms of water conservancy infrastructure, possess multiple water management functions and hold immense material and spiritual value.

Currently, research related to the Grand Canal is primarily focused on the protection and utilization of its heritage, the integration of culture and tourism, and the study of its heritage value, but these studies are still in the exploratory phase[2-5]. Most research is at the macro level of the Grand Canal, with less focus on the micro-environmental characteristics and facilities. Research on the Grand Canal's hydraulic engineering facilities mainly includes aspects such as the composition of hydraulic heritage, historical development, protection and utilization, tourism development, and value assessment[6-8]. However, research on sluices primarily focuses on technical aspects and aquatic environments, still lacking comprehensive theoretical guidance and studies on planning and implementation. The theory of cultural genes offers a new perspective for understanding and maintaining the cultural inheritance of the Grand Canal as a living heritage, emphasizing the dynamic protection and renewal of cultural heritage through the identification, deconstruction, and extraction of cultural genes[9]. The Ruins of Longshan Lock are not only an integral part of the water conservancy system in Hangzhou and the broader Jiangnan region but also serve as a crucial portal to the understanding of ancient Chinese hydraulic engineering techniques and the history of canals. This paper takes the Ruins of Longshan Lock in the Hangzhou section of the Grand Canal as a case study. Hangzhou, with its long history as a hydraulic engineering heritage area, contributes significantly to the construction of cultural gene maps. Such an approach not only aids in the systematic analysis and protection of the cultural heritage of the Grand Canal but also provides theoretical support for the formulation of urban planning strategies and the creation of characteristic landscape spaces.

2 OVERVIEW OF THE STUDY AREA

The Ruins of Longshan Lock is located at the confluence of the Zhong River and the Qiantang River and is one of the significant hydraulic engineering projects of the Grand Canal in Hangzhou (Fig 1). As an ancient water lock, it played a crucial role in regulating the water level of the canal, controlling floods, ensuring navigation, and facilitating irrigation. Longshan Lock is not only an integral part of the water conservancy system of Hangzhou and the Jiangnan region but also a vital window into the ancient Chinese hydraulic engineering techniques and the history of the canal. The Longshan River was connected to the early Grand Canal, serving as a conduit between the Qiantang River and the inner rivers of Hangzhou, and was the true starting point of the Grand Canal at that time. It remained navigable for bamboo and wooden rafts until the 1960s. In 1997, the lock was dismantled due to the dike construction project. It was

announced as the sixth batch of provincial-level cultural relics protection units in Zhejiang Province in 2011. Moreover, the White Pagoda was built to guide the safe navigation of ships, serving as a landmark and dubbed "the first pagoda of the ancient canal. "

The research data was primarily collected through on-site investigations, literature reviews, and interviews. An initial survey was conducted at the Longshan Lock site in Hangzhou, examining the lock's structure, decorative patterns, and surrounding historical facilities. This was followed by organizing the application status, landscape environment, historical development, construction techniques, and decorative textures of the Longshan Lock site through photography, drawing, map annotation, and surveying. Current site photographs were also taken and selected in the sample area, with the shooting period spanning from September 2023 to February 2024.

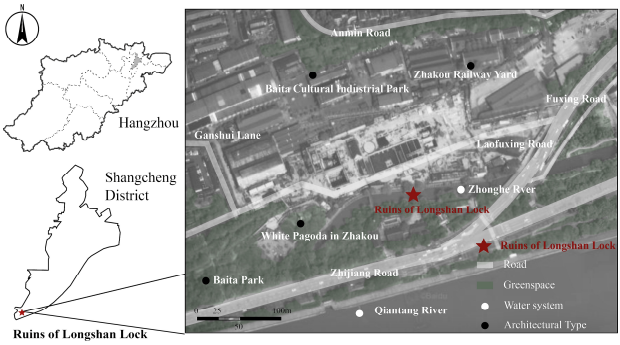

Fig. 1. Overview of the Ruins of Longshan Lock.

3 RESEARCH METHODS

3.1 Cultural Gene Identification and Extraction Method

Currently, there are three methods for extracting cultural genes that can be found: reverse transcription, shape grammar, and SPSS statistical methods. This study mainly employs the most popular and effective method, reverse transcription. The extraction of cultural genes is similar to the extraction of biological genes, where RNA serves as a template for reverse transcription, catalyzed by reverse transcriptase to synthesize DNA. Essentially, the reverse transcription process involves collecting as many instances of cultural elements as possible, including function, form, color, pattern, structure, craftsmanship, and materials, through field research, interviews with relevant personnel, and literature review. These cultural instances are akin to the proteins in bioengineering. Cultural instances are classified based on the connotation and function of culture to establish groups, and core cultural elements are identified through abstract analysis, completing the reverse translation from instances to elements. Core cultural elements carry unique cultural characteristics, functioning and featuring like RNA in biological genes. By condensing and refining cultural elements, cultural genes with hereditary, inheritable, and stable characteristics are obtained, completing the reverse

transcription process from elements to genes (Fig. 2). This process leads to a comprehensive understanding of the Ruins of Longshan Lock facilities and proposes strategies for their protection and inheritance.

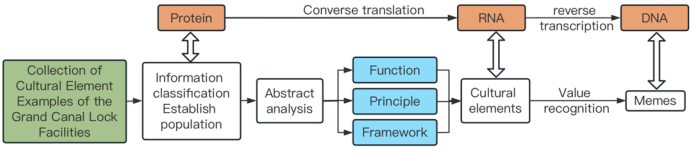

Fig. 2. The Principle of Cultural Gene Extraction for the Grand Canal Watergate Facilities.

3.2 Cultural Gene Information Chain Construction Method

The encoding of cultural gene information chains can clearly display the types and forms of cultural genes, enhancing memory points to refine the cognitive system of cultural genes for the Grand Canal's sluice facilities[9]. To obtain the cultural genes of the Grand Canal's sluice facilities, it is necessary to sort and encode the identified cultural genes, to arrange them in a logical order to construct a cultural gene map information chain. This article, based on typological principles[10] and referencing the encoding methods of the "Chinese Library Classification" and "Classification and Codes for Basic Geographic Information Elements, " applies the N-level encoding theory to encode the cultural information of the Ruins of Longshan Lock.

In this study, the encoding structure of cultural genes is divided into area code + category code + feature code: the area code sets the Hangzhou section of the Grand Canal as Zhe A, where Zhe represents the Zhejiang region, and A represents Hangzhou; the category code refers to the subject classification of the Chinese Library Classification, using M, proposed by Dawkins for "Meme, " to denote cultural genes, with the three major types of genes, environmental gene, architectural gene, and cultural gene, represented as M1, M2, and M3 respectively11; the feature code, in reference to "Classification and Codes for Basic Geographic Information Elements, " divides the cultural gene's hierarchical relationship of the Ruins of Longshan Lock into "primary elements, secondary elements, and cultural gene elements" three levels, using Arabic numerals for encoding (Fig. 3).

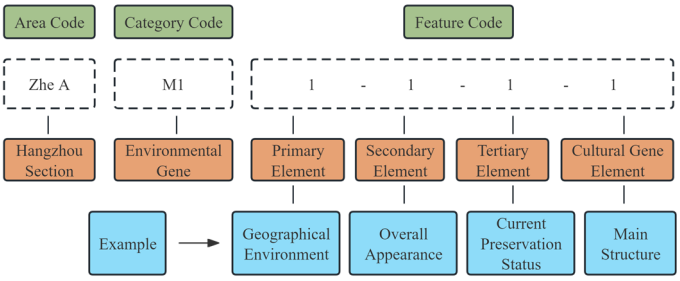

Fig. 3. Cultural Gene Coding Structure.

4 CONSTRUCTION AND CHARACTERISTIC ANALYSIS OF THE CULTURAL GENE INFORMATION CHAIN FOR THE RUINS OF LONGSHAN LOCK

4.1 Identification and Extraction of Cultural Genes

Based on the results of field research, cultural element information collected was classified and analyzed using the reverse transcription method[12], leading to the identification of cultural genetic markers for the Ruins of Longshan Lock on the Grand Canal (Fig. 4). This includes three major categories: environmental genes, architectural genes, and cultural genes, with seven identification indicators[13]. Environmental genes describe the basic situation of the site, namely, the geographical and spatial environment. Architectural genes reflect the ingenuity and skill under the conditions of limited productivity, scientific technology, and material craftsmanship of the time, as manifested in the building's texture and construction techniques. Cultural genes encompass historical culture, folk culture, and regional culture. Historical culture indicates the development and evolution of the Ruins of Longshan Lock, representing not only a part of the history of China's hydraulic engineering facilities but also a segment of the Grand Canal's historical progress in Hangzhou. Folk culture includes folklore and literary arts, while regional culture is composed of economy and trade, as well as popular beliefs. Subsequently, this was further refined to form a cultural genealogy chart related to these factors (Fig. 5). Among them, historical and cultural information is the most abundant, accounting for 23.08% of the total; architectural texture is reflected through the materials used in construction and the overall color scheme, making up 19.23%; geographical environment and spatial environment account for 15.38%, while regional culture and folk culture each constitute 11.54% of the total; architectural technology only represents 3.85% (Fig. 6).

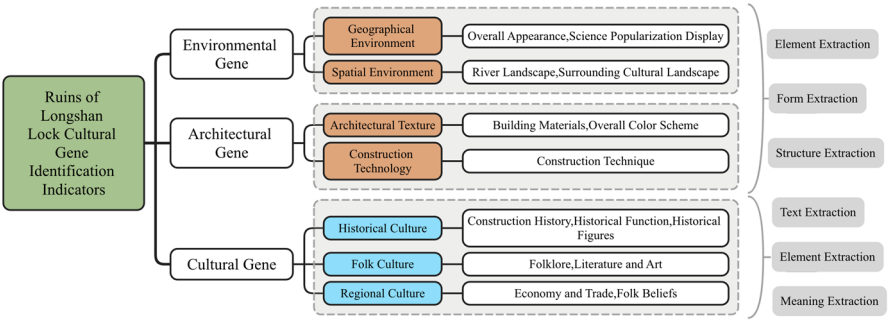

Fig. 4. Cultural Gene Identification Indicators for the Ruins of Longshan Lock on the Grand Canal.

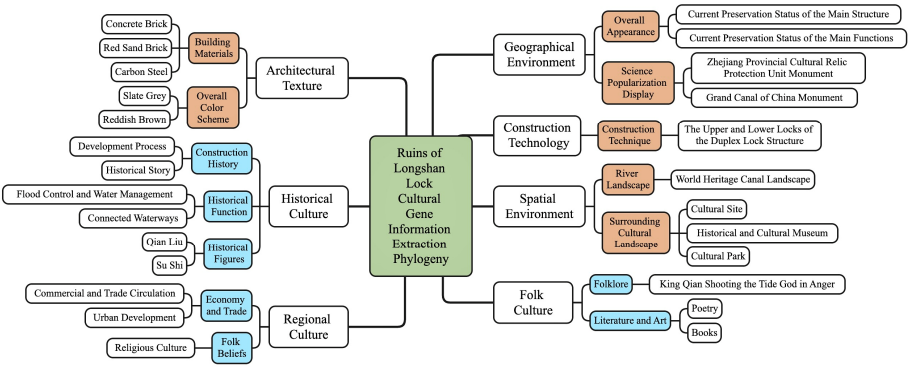

Fig. 5. Genealogical Chart of Cultural Gene Extraction Information for the Ruins of Longshan Lock on the Grand Canal.

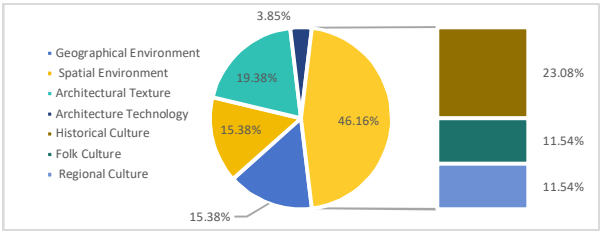

Fig. 6. The proportion of cultural gene information in the Ruins of Longshan Lock of the Grand Canal.

4.2 Construction of the Cultural Gene Information Chain

This chapter focuses on the classification of cultural gene elements of the Grand Canal's Longshan Lock ruins, primarily based on the cultural gene information chain construction method described in section 2.2, and following the identification and extraction of cultural genes in section 3.1. It constructs the cultural gene information chain of the Longshan Lock ruins (Table 1) and clarifies the primary genes, attached genes, mixed genes, and variant genes based on the cultural gene classification method (Table 2) (Fig. 7). Among these, primary genes are the core elements in the cultural gene map, playing a crucial role alongside attached genes, both encompassing characteristics of environmental, architectural, and cultural genes, accounting for 28.57% and 42.85% respectively. Mixed genes, composed of two or more types of genes, include cultural gene characteristics, making up 14.29% of the total. Variant genes, which form innovative regional cultural characteristics by absorbing external elements, contain features of environmental and cultural genes, also accounting for 14.29%. Through encoding and classification, it is possible not only to identify the encoded cultural genes of the Grand Canal's water lock facilities but also to accurately determine the classification and relationships among the numerous cultural genes.

Table 1. Construction of the Cultural Gene Information Chain for the Ruins of Longshan Lock on the Grand Canal.

Area Code	Gene category	Primary Element	Secondary Element	Cultural Gene Element
Zhe A	M1 Environmental Gene	1 Geographical Environment	1 Overall Appearance	Zhe A-M1111 Current Preservation Status of the Main Structure; ZheA-M1112 Current Preservation Status of the Main Functions
			2 Science Popularization Display	ZheA-M1121 Zhejiang Provincial Cultural Relic Protection Unit Monument; ZheA-M1122 Grand Canal of China Monument
		2 Spatial Environment	1 River Landscape	ZheA-M1211 World Heritage Canal Landscape
			2 Surrounding Cultural Landscape	ZheA-M1221 Cultural Site; ZheA-M1222 Historical and Cultural Museum; ZheA-M1223 Cultural Park
	M2 Architectural Gene	1Architectural Texture	1 Building Materials	ZheA-M2111 Concrete Brick; ZheA-M2112 Red Sand Brick; ZheA-M2113 Carbon Steel
			2 Overall Color Scheme	ZheA-M2121 Slate Grey; ZheA-M2122 Reddish Brown
		2 Architecture Technology	1 Construction Technique	ZheA-M2211 The Upper and Lower Locks of the Duplex Lock Structure
	M3 Cultural Gene	1 Historical Culture	1 Construction History	ZheA-M3111 Development Process; ZheA-M3112 Historical Story
			2 Historical Function	ZheA-M3121 Flood Control and Water Management; ZheA-M3122 Connected Waterways
			3 Historical Figures	ZheA-M3131 Qian Liu; ZheA-M3132 Su Shi
		2 Folk Culture	1 Folklore	ZheA-M3211 King Qian Shooting the Tide God in Anger
			2 Literature and Art	ZheA-M3221 Poetry; ZheA-M3222 Books
		3 Regional Culture	1 Economy and Trade	ZheA-M3311 Commercial and Trade Circulation; ZheA-M3312 Urban Development
			2 Folk Beliefs	ZheA-M3321 Religious Culture

Table 2. Classification of cultural genes.

Category of cultural genes	Principles for the classification of cultural genes	Key Features
Primary gene	Whether it has a prominent status and prominent status and regional cultural dominance	Dominant cultural attributes, identification of regional cultures, maintenance of cultural diversity
Attached gene	Whether it is culturally identifiable and unique to a city along a canal	Identifying regional cultures and maintaining cultural diversity
Maxed gene	Whether it is culturally related, shared by two or more canal cities	Maintaining cultural diversity
Variant gene	Whether it has the characteristics of variation and integrates new elements in the evolution of history	Maintaining cultural diversity

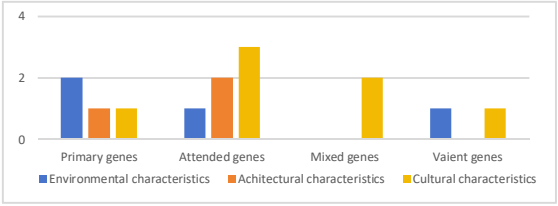

Fig. 7. Comparative Chart of Cultural Gene Information Chain Characteristics of the Grand Canal Longshan Lock Ruins.

4.3 Analysis of the Characteristics of the Cultural Gene Information Chain

Environmental Gene Feature Analysis.

(1) Geographical Environmental Aspect Feature Analysis

From a geographical environmental perspective, the Ruins of Longshan Lock, historically an important hydrological structure connecting the Zhong River and the Qiantang River, has lost its direct connection to the Qiantang River. However, through modern renovations, it still plays a role in water resource management and environmental protection. In terms of educational displays, despite certain challenges, effective information dissemination and education allow Longshan Lock to remain a significant portal to the history and culture of China's hydraulic engineering, enhancing the public's understanding and appreciation of the cultural value of waterworks.

In terms of the overall appearance, the Ruins of Longshan Lock are poorly preserved and no longer serve any hydrological function, with its original architectural form being untraceable. Today, the Longshan River starts at the southern lock gate and extends north to Fengshan Gate, connecting to the Zhong River but no longer to the Qiantang River, with its water sourced from the cooling water of a power plant at the lock. Additionally, during the construction of the standard seawall in 2000, a new Longshan Lock with two gates was built, containing a bidirectional diversion and water pumping station for the Zhong River and West Lake. As for the educational displays, the main

features are the Zhejiang Provincial Level Cultural Relics Protection Unit Marker and the Grand Canal of China Marker. The former marker states "Qiantang River and Canal Port Shipping Facilities – Ruins of Longshan Lock, " while the latter features a map of the Grand Canal of China on the front and, on the back, a text and pictorial description of "Longshan River and Lock" of the Grand Canal of China. Currently, the text descriptions have faded and are indistinguishable, presenting an issue for interpretation. (Table 3)

(2) Analysis of Spatial Environmental Characteristics

The spatial environmental characteristics are primarily shaped by both the river landscape and the surrounding cultural landscapes. The river, with its crystal-clear water surface and verdant banks, forms a picturesque scenery within the urban fabric. Meanwhile, cultural landmarks like the sluice gate's White Pagoda and White Pagoda Park profoundly reflect the cultural depth and historical accumulation of the area. Despite this, the full value and historical significance of the Ruins of Longshan Lock as a vital hydro-engineering heritage have yet to be fully showcased and utilized, necessitating further efforts in protection and heritage transmission.

In terms of the river landscape, Hangzhou boasts a multitude of water bodies, offering a rich variety. Hydro-engineering facilities are predominantly situated along key waterways, contributing to a diverse range of aquatic landscapes. Notable among these is the section of the Grand Canal that is a World Heritage site, including the protective planning of the river landscapes of the Grand Canal (Zhejiang section). The Ruins of Longshan Lock are located along the heritage-listed stretch of the Grand Canal – Longshan River – which links the inner waterways of Hangzhou to the Qiantang River and is designated as a drinking water reserve protection area. Green pathways are laid out along the banks of Longshan River, with the eastern starting point marked by an engraved panel commemorating King Qian of the Wuyue Kingdom for excavating Longshan River and constructing the lock. As the navigation channel was closed, Longshan River has been transformed into a scenic waterway that attracts passersby to linger and enjoy the view. Regarding the adjacent cultural landscapes, the area around the Ruins of Longshan Lock includes cultural landmarks such as the White Pagoda at the sluice gate, the historical and cultural exhibit hall of White Pagoda, and Hangzhou White Pagoda Park (Table 3). The White Pagoda at the sluice gate, a Buddhist structure from the Five Dynasties Wuyue Kingdom, was listed as a national key cultural relics protection unit in 1988. Hangzhou White Pagoda Park, centered around the White Pagoda, serves as concrete evidence of the West Lake cultural heritage and is also the site of the city's first railway station.

Table 3. Genetic Characterization of the Environmental Features of the Ruins of Longshan Lock.

Category		**Photo sampling**		
Environmental Gene	Overall Appearance			
	River Landscape			

	Science Popularization Display			
	Surrounding Cultural Landscape			

Architectural Genetic Feature Analysis.

(1) Analysis of Architectural Texture at the Structural Leve

The construction materials used for the Longshan Lock water conservancy facilities of the Grand Canal are primarily brick and stone, including concrete bricks, red sand bricks, and carbon steel. In terms of material properties, concrete bricks have high strength, are flame-retardant, and durable. Red sand bricks are hard and coarse-grained, offering good air permeability and water permeability. Carbon steel is characterized by its high strength, hardness, and good wear resistance. Regarding the color scheme, the overall saturation is relatively low, with concrete bricks having a cooler grey tone; red sand bricks and carbon steel generally present a warmer grey tone. (Table 4)

Table 4. Analysis of Architectural Genetic Characteristics of the Ruins of Longshan Lock.

Material	Color Extraction	Material Characteristics	Color Characteristics	Example Image
Concrete Brick	#656064 #8e888d #b9adb2 #d7d5d8	High strength, fire-resistant, durable, but relatively heavy and not easily insulated	Low lightness, overall cold grey	
Red Sand Brick	#8f7e6c #bfa29b #bdaba6 #dabbb8	Hard texture, larger grain size, good air permeability and water permeability	Primarily featuring shades of brownish-gray and reddish-gray	
Carbon Steel	#736a6d #a4949b #bdaba6 #cbb7a3	High hardness and good wear resistance, but it is prone to rust and has strong corrosiveness	Tone leans towards warm grey, with low saturation	

(2) Analysis of Architectural Technical Features

Qian Liu proposed a solution to the problem of the large sediment content in the Qiantang River. He suggested constructing dual locks similar to those of the complex ship locks at the mouth of the canal. When the tide in the Qiantang River surges, the upper lock is opened and the lower lock is closed to allow the tidal waters to flow into the Longshan River. After the tide recedes, the lower lock is closed to allow sediment deposition. Once the sediment has settled, the lower lock is opened to release water into

the next section of the canal, known as the Zhong River, thus delaying the canal's siltation and ensuring navigability. Undoubtedly, Qian Liu's adoption of the dual lock system to alleviate the siltation caused by sediment in the Qiantang River is a significant innovation. The Longshan Lock site corresponds to the Ruins of Longshan Lock.

Cultural genetic trait analysis.

(1) Cultural genetic trait analysis

The characteristics of historical and cultural aspects are primarily manifested in innovative engineering design, water level regulation functions, and profound impacts on urban life and economic activities. The creative solutions by Qian Liu and the technical insights from Su Shi not only demonstrate the wisdom and innovative spirit of ancient Chinese hydraulic engineering but also reflect a profound understanding of water resource management and protection. Longshan Lock not only promoted the economic development of Hangzhou and its surrounding areas but also provided valuable resources for the study and research of hydraulic engineering for future generations, becoming an important milestone in the history of Chinese hydraulic engineering.

From a historical construction perspective, the development of the Longshan Lock facility mainly includes the construction period in the early Southern Song Dynasty, multiple constructions and abandonments during the Southern Song Dynasty, restoration of functionality in 1316, reconstruction as a dam at the end of the Ming Dynasty, reconstruction as a lock and dam in 1724, the period of embankment renovation in the 1950s, and the period of abandonment in 1958 (Table 5). From a historical functional perspective, the Longshan Lock could regulate water levels. When the water level of the inner city moat in Hangzhou was higher than that of the Qiantang River, boats could flow downstream into the Qiantang River by removing the sluice gates. During high tides or floods, when the water level was equal or higher, opening the sluice gates allowed boats to enter the inner city moat. It could prevent blockages by using a compound lock structure. After the tide subsided and sediments settled, the gates could be opened to discharge water, effectively slowing down the silting of the canal. It promoted transportation and water supply, facilitated travel for business and tourism, provided water sources for the city's water system, and also prevented tidal surges from flowing backward into the river. In terms of historical figures, including Qian Liu and Su Shi, Qian Liu was the builder of Longshan Lock, who creatively adopted the compound lock form to effectively address the silting problems caused by sedimentation in the Qiantang River. Su Shi, on the Hangzhou Canal, borrowed Qian Liu's techniques to build the Hunshui and Qingshui locks, further advancing hydraulic engineering technology. The Longshan Lock site is the Ruins of Longshan Lock.

Table 5. Analysis of the Historical Characteristics of the Construction of Longshan Lock on the Grand Canal.

Number	Era	Remarks
1	Early Southern Song Dynasty (First built)	Constructed by Qian Liu at the canal's entrance to the river mouth, using a double lock gate system to alleviate the siltation of the Qiantang

		River on the canal, ensuring the canal's navigability
2	Southern Song Dynasty Period (Construction and Abandonment)	Longshan River was rebuilt multiple times due to tidal surges. Due to its proximity to the imperial palace, the Longshan River and Longshan Lock were abandoned and no longer navigable
3	Year 1316 (Restoration)	The Jiangsu-Zhejiang provincial governor dredged the Longshan River and restored the Longshan Lock, reinstating its function
4	Late Ming Dynasty (Reconstruction)	When river water levels were lower than the canal, the Longshan Lock was converted into a dam, requiring boats to cross over the dam for passage
5	Year 1724 (Reconstruction)	The Longshan Dam was rebuilt into a lock, and subsequently converted into a weir dam
6	1950s (Dam Crossing)	A dam remains, requiring boats, bamboo rafts, etc. , to cross over into the Longshan River, entering the city through the Fengshan Water Gate and into the central river
7	Year1958 (Abandonment)	Ruins of Longshan Lock was ultimately abandoned

(2) Analysis of Folk Cultural Characteristics

At the level of folk culture, characteristics are reflected in the rich folklore and profound literary and artistic deposits. The Qian Wang legend in folk tales not only reveals the local people's reverence and commemoration of historical figures but also reflects praise for the achievements of hydraulic engineering. Literary and artistic works, ranging from poetry to historical records, not only depict the Longshan Lock and its surrounding natural and cultural landscapes but also record related hydraulic engineering and historical changes, demonstrating the concept of harmonious coexistence between humans and nature. These characteristics together construct a rich cultural memory and inheritance of the Longshan Lock and its surrounding areas, reflecting its unique folk cultural genes.

From the perspective of folk legends, it is a literary style that has been passed down through generations among the people, just like traditional operas, folk songs and dances, and traditional handicrafts, it is also a form of intangible cultural heritage. The legends and stories around the Hangzhou Canal have always been rich and colorful, reflecting the canal's charm that often captivates people. For instance, the Qian Wang legend was included in the national list of representative projects of intangible cultural heritage in 2011. It is based on the life story of Qian Wang, the king of Wuyue, telling the story of how Qian Wang angrily shot the Tide God, thereby enabling the people to successfully build the Qiantang River embankment and avoid the threat of flooding. From the perspective of literary and artistic works, there are poems and books that provide relevant records, mainly depicting the scenery of the canal, the history of hydraulic engineering facilities, canal navigation, etc. , such as the ten scenic spots of the canal "Dragon Mountain Pagoda Shadow", the seven-character quatrain "Shahe" by Li E, a poet from Hangzhou in the Qing Dynasty, Tian Rucheng's "Travel Notes of West Lake" in the Ming Dynasty, "Dreams of Liang" in the Southern Song Dynasty, Volume 18 of

the "History of the Yuan Dynasty", Volume 21 of the "Travel Notes of West Lake" in the Ming Dynasty, etc.

(3) Regional Cultural Characteristics Analysis

At the regional cultural level, the characteristics are reflected in its developed economy and trade, strong ethnic beliefs, and unique construction techniques. Economically, the Longshan Lock and its surrounding Hangzhou area became the political, economic, and cultural center of the Wuyue Kingdom and even the entire southeastern region, demonstrating its important historical position. In terms of ethnic beliefs, the Longshan Lock area is famous for its special geographical location and the prevalence of Buddhist culture, reflecting the region's profound cultural heritage. In terms of construction techniques, through innovative hydraulic engineering design and construction, it effectively solved the challenges brought by geography and environment, demonstrating advanced technological strength and wisdom. These characteristics together shape the unique regional cultural identity of the Longshan Lock and reflect the region's important value in history, culture, and technological innovation.

From an economic and trade perspective, the construction of the lock and tower was an important measure taken by the Wuyue Kingdom to resist river tides and actively promote overseas trade and cultural exchanges. In addition, decades of efforts by Qian Liu and his son further expanded the urban scale of Hangzhou, improved urban facilities, and basically formed the West Lake scenic area. The social economy prospered, making it "rich in the southeast, " surpassing Suzhou in the west of Zhejiang and Yuezhou in the east of Zhejiang in social status. It was not only the capital of the Wuyue Kingdom but also the political, economic, and cultural center of Zhejiang and Fujian. From a folk belief perspective, Buddhism culture once prevailed in the Longshan River at the end of the Beijing-Hangzhou Grand Canal. There are records in ancient books such as the Ming Dynasty's "Record of Touring West Lake Volume Six" and Qing Dynasty's "Collection of Green Mountains on the Lake" and "Study of Ancient Chinese History". The special geographical location of the Longshan River, close to the Southern Song Imperial Garden and transportation hub, winding under the Longshan Mountain, has created a region known for its many temples and hermitages along the riverbank.

5 RESEARCH ON INHERITANCE PATHS

5.1 Environmental Genetic Inheritance Path

From the perspectives of geographical environment and hydrological functions, the disconnection between Longshan River and the Qiantang River, coupled with the reliance on the cooling water from the sluice gate power plant, has not only impacted the hydrological environment of the Longshan Lock ruins but also exerted profound effects on the surrounding ecosystem. The inheritance pathway should prioritize the continuous management of water resources and innovation in environmental protection measures. On the public education and outreach front, science popularization displays are crucial for enhancing public understanding of the hydraulic engineering projects

and their cultural values. The inheritance pathway should include bolstering the construction of science popularization facilities, leveraging modern technology to enhance the efficiency of information dissemination, and organizing educational activities to deepen public comprehension. Regarding the spatial environment and landscape, the geographical location and river landscape of the Longshan Lock ruins constitute a space of historical and cultural value. However, issues such as natural erosion and structural aging have exacerbated the damage to the facilities, risking the loss of the sluice's original functions and historical value. The inheritance pathway should focus on protecting and restoring the river channels and surrounding cultural landscapes, thus enhancing their aesthetic and ecological values in the urban context.

5.2 Architectural Genetic Inheritance Path

In terms of materials and colors, the original texture of the Longshan Lock ruins has disappeared after several reconstructions. The path of heritage should focus on protecting and restoring the use of traditional building materials while enhancing their durability and functionality with modern technology. This includes researching and inheriting the original design concepts, maintaining color harmony, and considering innovative designs in modern renovations. On the craftsmanship level, as a historical and cultural heritage, the restoration and protection of Longshan Lock face complex technical challenges. It's essential not only to restore its physical structure but also to preserve its historical appearance. The heritage path should involve the sensible integration of modern engineering technology in the preservation of historical sites. Through interdisciplinary cooperation, it's possible to develop restoration solutions that protect the historical value of the site while meeting modern functional requirements.

5.3 Cultural Genetic Inheritance Path

From the perspective of historical culture, the Longshan Lock has had a profound impact on urban life and economic activities throughout history. The path of inheritance should focus on its historical functions and roles, demonstrating its historical capabilities in water level regulation and the promotion of navigation through the establishment of related museums or science and education centers. In terms of folklore culture and literary arts, the area surrounding the Longshan Lock is rich in cultural heritage and artistic literary accumulation, reflecting cultural memories related to hydraulic engineering. The inheritance path should include the protection and promotion of these intangible cultural heritages, for example, through exhibitions of literature and art, organization and dissemination of folk tales, to enhance public understanding of the cultural depth of this region. On the regional cultural level, the area of Hangzhou where the Longshan Lock is located possesses a unique regional cultural identity, including advanced economic trade, ethnic belief backgrounds, and construction skills. The path of inheritance should emphasize showcasing the role of the Longshan Lock in the regional economy and culture, as well as its value in technological innovation and cultural heritage.

In summary, the heritage pathway of the Longshan Lock ruins of the Grand Canal

focuses on protecting and showcasing its environmental, architectural, and cultural values through the conservation and restoration of the landscape environment, the repair and innovation of building materials, and the display and development of regional culture. The aim is to protect and inherit the site's history and culture, while simultaneously enhancing its ecological, educational, and cultural functions within contemporary urban planning and design.

6 CONCLUSION AND DISCUSSION

In the context of advancing the protection and inheritance of the Grand Canal culture, it's necessary to explore the planning of cultural heritage related to the canal's water conservancy facilities. This paper takes the Longshan Lock ruins as a case study, constructing and thoroughly analyzing its cultural gene information chain to propose corresponding inheritance pathways, leading to the following conclusions:

(1)The construction of the cultural gene indicators and information chain for the Grand Canal's Longshan Lock ruins through the reverse transcription extraction method is a comprehensive investigation that blends technology, art, history, and culture. It effectively addresses the challenges of excavating the unique cultural values of water conservancy facilities, identifying indicators, and classifying cultural characteristics.

(2)An in-depth analysis of the spatial form and structure of the Longshan Lock ruins was conducted from environmental, architectural, and cultural perspectives, taking into account both the overall and detailed characteristics of the site. By exploring its geographical location, spatial environment, architectural texture, building techniques, historical culture, folk culture, and regional culture, the multi-faceted value of the Longshan Lock ruins as a cultural heritage in its maintenance and inheritance process was revealed.

(3)The relationship between the characteristics of the cultural gene information chain of the Longshan Lock ruins and the inheritance pathways was discussed. It was found that the inheritance strategy for the Grand Canal's Longshan Lock ruins mainly involves protecting and restoring the landscape environment, updating and creatively applying building materials, and showcasing and enhancing regional culture. The goal is to ensure the effective protection and transmission of the site's history and culture, thereby further enhancing its ecological value, educational significance, and cultural role in modern urban planning and design.

Based on the different types and attributes of cultural genes at the Longshan Lock site, this study explores corresponding paths for heritage conservation, aiming to provide insights and references for the protection and inheritance of cultural heritage of hydraulic engineering facilities, thereby promoting urban planning and the construction of the Grand Canal National Cultural Park. In future research, it is suggested to further explore how to utilize modern technological means, such as digitization and virtual reality technology, to restore and showcase the historical appearance and engineering principles of hydraulic engineering facilities, thereby enhancing public awareness and interest in these heritage sites. Meanwhile, for the inheritance of cultural genes, more consideration should be given to the participation

of local communities and the public. By organizing cultural festivals, workshops, and other forms of activities, it is aimed to stimulate the interest and involvement of local communities in conservation efforts, thus forming a social consensus and driving force for cultural heritage protection.

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REFERENCES

1. C. Wang, YW. Zhang, L. Li, et al. Structural equation model of the spatial distribution of water engineering facilities along the Beijing-Hangzhou grand canal and its relationship with natural factors. Herit Sci. **11**, 245(2023).
2. S. Yu, GB. Yu, Y. Liu, et al. Urbanization impairs surface water quality: eutrophication and metal stress in the Grand Canal of China. River Research and Applications. **28**, 1135-148(2012).
3. N. Tsung, R. Corotis, P. Chinowsky, et al. A retrospective approach to assessing the sustainability of the Grand Canal of China. Structure & Infrastructure Engineering. **9**, 297-316(2013).
4. TQ. Zou, Q. Han, J. Qin. Pedigree Identification and Spatial Differentiation of the Millennium Canal Brand genes. Geographical Research. **41**, 713-730 (2022).
5. X. Jiang, Q. Lin. Research on the Features of Traditional Landscape System in the Area along the Huaiyang Canal under the Influence of the Canal Water Conservancy. Chinese Landscape Architecture. **38**, 34-39(2022).
6. F. Mao, YX. Wu, BF. Yang, et al. Water Environment Evolution along the China Grand Canal. IOP Conference Series Earth and Environmental Science. **17**, 012170(2014).
7. H. L. Schafer, R. Macciotta, N. A. Beier. Tailings dam closure scenarios, risk communication, monitoring, and surveillance in Alberta. CIM Journal. **11**, 80-90(2020).
8. W. L. H. Pinto, L. M. C. F. Fais. The Small Dams Safety Index (SDSI): a tool for small dams safety assessment. international journal of river basin management. **21**,551-558(2023).
9. G. Taylor. Environment, Village and City: A Genetic Approach to Urban Geography; with Some Reference to Possibilism. Annals of the Association of American Geographers. **32**, 1-67(2009).
10. XZ. Wang, SC. Li, L. Li, et al. Regional cultural gene repetitions and the conception of humanism transgenosis space control. Human Geography. **29**, 1-9(2014).
11. R. L. Dawkins. *The Selfish Gene*. Quarterly Review of Biology. **32**(1976).
12. C. Zou, J. Xuan, JN. Yang, et al. Construction and Feature Analysis of Landscape Gene Information Chain in Xiamei Ancient Village at the Starting Point of the Tea Road. Chinese Landscape Architecture. **39**, 96-102(2023).
13. XJ. Yang, CS. Fang, YY. Wang. Construction of Gene Information Chain and Automatic Identification Model of Traditional Village Landscape: Taking Shaanxi Province as an Example. Geographical Research. **38**, 1378-1388(2019).