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Ecological Construction of Drainage Systems in Traditional Chinese Settlements: A Case Study of Linfeng Village

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ABSTRACT

Rainfall is extremely important as a key link in the natural cycle system. With the rapid development of urbanisation, there are generally a series of water environment problems in residential compounds. The sustainable development theory of modern architecture emphasises the mutual promotion and coordinated development with traditional architecture. Traditional Chinese settlements are worthy of our reference and learning, both in terms of design concepts and construction techniques. This paper focuses on Linfeng Village, a traditional settlement located in Pingdingshan City and uses it as the subject of research. Through research methods such as field research and case studies, the water culture and drainage flood control system of Linfeng Village are analysed. Then the rainwater system composition and drainage system construction technology of typical residential buildings are studied. It is found that Linfeng Village fully embodies the concept of utilising the natural environment and climate resources to create a suitable living environment in its site selection. The drainage system of the residential buildings is designed together with the overall water system of the settlement to form a water circulation system. In terms of construction techniques, different terrain and climatic conditions directly affect the use function of the building and the construction of the rainwater system. The amount of rainfall directly affects the construction methods and techniques of roofs, walls, and courtyards in residential buildings. Through the study, on the one hand, is conducive to the protection of China's ancient architectural heritage in the new situation. On the other hand, it provides new ideas and coping strategies for professionals in the design of building drainage systems

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INTRODUCTION

Due to the uneven rainfall in China, since 2020, major cities have been experiencing different degrees of drainage difficulties, making urban flooding and water pollution serious (Wen, 2022). The drainage system, as an important component of urban infrastructure, has an important position in the construction of urbanisation. It is not only an important carrier for urban development, but also an effective guarantee for urban flood prevention and drainage, rainwater collection and treatment. Improving and optimising the drainage system is of great significance to the improvement of people's living standards and the creation of a good and harmonious society (Guo, 2015). Residential districts account for 40% -50% of the urban construction land area, and with the rapid development of urbanisation, their drainage problems are particularly prominent (Wang et al., 2017). The theory of "sustainable development of architecture" emphasises that modern architecture and traditional architecture should promote each other and develop together (Yang et al., 2020). Therefore, looking back at the traditional settlements in ancient China, it is worthwhile for us to reference and learn, whether it is design concepts, thinking, or construction technology.

Linfeng Village is located in Tangjie Town, Jia County, Pingdingshan City, Henan Province. Originally named Shuitian Village, also known as Zhuwa Village or Hongshi Village. It is the second batch of famous historical and cultural villages in China, as announced by the National Cutural Heritage Administration. It is named because of the red stone, with the gurgling moat, majestic red stone wall, and historical old houses. It is a rare well-preserved ancient village in China and is called ‘number one red stone ancient village in the Central Plains’. Linfeng Village has a long history, and its development and evolution process have the commonality of ancient villages in the Central Plains. Due to the influence of topography, climate and regional environment, Linfeng Village clearly shows individual characteristics and local features in village form, folk customs, and architectural culture. The spatial form of Linfeng Village is complete, the street structure is clear, and the complete and systematic setup of drainage, flood control, fire prevention, bandit prevention and other facilities in the village has high research value. In 1939, 1957 and 1980, there were three (3) major floods in the vicinity of Linfeng Village, and Linfeng Village was unharmed. Exploring the ecological concepts of harmony and unity between humans and nature and the unity of heaven and humanity in traditional Chinese culture, it helps to solve the problems of serious ecological damage and excessive consumption of resources, and to find a new mode of sustainable development of the ecological environment and resources.

In this paper, Linfeng Village, a traditional settlement in Pingdingshan City, taken as an example to summarise the way of water treatment in the planning and construction process of traditional Chinese settlements and individual buildings, in order to study the ecological creation of water environment in traditional Chinese settlements. On the one hand, extracting the design theory and construction technology of ancient residential building rainwater system, through the sorting out of ancient building rainwater system wisdom, is conducive to the protection of China's ancient architectural heritage in the new situation. On the other hand, integrating the historical experience with the contemporary environment, better inherits the ancient architectural rainwater system, and providing new ideas for design departments and professionals in the planning and design of architectural rainwater systems. If modern residential buildings want to achieve a harmonious coexistence with the natural water environment, the first thing to do is to deal with the relationship between the building, the site, and the rainfall. The successive occurrence of water logging, water shortage and runoff pollution in major cities across the country is sufficient proof of this.

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LITERATURE REVIEW

Definition of Terms

Water systems in traditional villages

Ancient civilisations had an in-depth understanding of water, focusing not only on the functions and beauty of rivers, but also on exploring the concepts presented in 'Water and Life'. In Principles of Environmental Science, the water environment is defined as a complex system containing water itself, suspended solids, dissolved substances, sediment, and aquatic organisms, which together constitute the spatial environment for human life and development (Han, 2020). The National Standard of the People's Republic of China (T50095-98), Standard for Basic Hydrological Terms and Symbols, defines a water environment system as a body of water that centres around the space of people and that can directly or indirectly affect human life and development. The village water system in this study refers to all kinds of water elements that are closely linked to the development of the village, such as rivers, drainage streets and ditches, waterproofing facilities of building compounds, and traditional water environment facilities.

Ecological water systems

According to the definition of the discipline of ecology, the elements of the ecological environment include plants and animals, the atmosphere, water, sunlight, and other natural substances, as well as all artificial substances above and below ground. Each element is interrelated, and water is an important part of the environmental elements. In 2017, the United Nations theme of connecting people to nature, China proposed 'lucid waters and lush mountains are invaluable assets', water as an important element of the ecological environment is increasingly valued by human society. According to Chinese scholar Zhao Ke, in ecology, the connection between the whole and the individual is emphasised, which not only protects the whole emphasising the diversity of species, but also, values the dependence of the individual on the environment, and pursues the stability of the ecosystem (Zhao, 2014). The ecological water system of this study, i.e., the organic whole composed of people, villages, and the water environment is in a state of ecological balance. The drainage system, as an important part of the water environment, directly affects the quality of the living environment and is also a reflection of the ecological balance of the traditional village.

Construction

In China's historical literature, the construction of countries, cities, and buildings is often referred to as 'construction', which not only refers to the technical aspects of building construction, but also involves a variety of cultural connotations, such as social, artistic, and humanistic connotations (Li et al., 2023). The construction of material entities mainly refers to the entities that constructed the living space, including the layout of the village site, the construction of buildings, and the facilities of the water environment, etc. While the ideology of consciousness is the cognition and conception of the living space in the minds of the ancestors, including the history, culture, folklore, and craftsmanship that influenced the construction of the village buildings. The construction of this study focuses mainly on the construction of villages associated with water, exploring in depth how ancient village dwellings utilised masonry materials and structural construction, as well as how to effectively respond to water environments.

Review of Relevant Studies

The study of drainage systems in foreign buildings we can trace back to the monster style drip spouts of Gothic architecture. This is a type of gutter that extends over the roof or upper part of the building to prevent rainwater from washing away the walls and foundations of the house (Wang et al, 2006). During the Roman art period, people took religious beliefs as a premise and combined historical development to perfectly combine the practicality of monster-shaped drip spouts with building drainage systems. In Greek architecture, marble lion heads with open mouths were also arranged on gutters. Rainwater flowed through the gutters and out of the lions' mouths, reflecting their majesty in protecting the building and its residents.

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Mays and Angelakis (2007) analyses the construction of local water supply systems, ditches, reservoirs, wells, and other water supply facilities in terms of the environmental conditions of ancient Greece and Rome, indicating the significance for modern water supply. In Roman areas, the ancestors usually also collected roof rainwater and then introduced it into a central storage tank for diversified recycling. Most parts of Ethiopia also use roofs, slopes, roads, etc. to maximise the retention of rainwater for productive and domestic water use (Kamlu & Laxmi, 2017).

The study of traditional Chinese settlements has been carried out relatively early in China, lasting for more than half a century. It is usually believed to have begun in the 1930s with the Ancient Architecture Survey, which was carried out by a group of scholars organised as the China Society of Architecture (Xiong, 2008). After this, for example, in Wang Senqiang's Water Vein Hongcun, the development of Hongcun and the water system is mainly introduced, which also includes the history of the village and the evolution of the water environment. Scholar Wang Mangmang (2016) from the village layout and topography, road square relationship, combined with the drainage system inside and outside the building, explored the perfect integration of the water system of traditional villages and nature. Yan & Tang (2020) analyses and discusses the utilisation of natural water systems and artificially controlled water management methods, which provides a reference for the construction of beautiful villages. He Ying's study divides Huizhou residential water environment into overall village water environment, residential water environment, and water environment within miniature courtyards, and analyses the relationship between residential construction, residential spatial morphology and water environment (Wang, 2023).

In general, domestic and foreign studies are relatively comprehensive, and at this stage, attention has been paid to the role of historical experience as a reference for modern construction. However, most of the existing studies only focus on the excavation and inspiration level of the wisdom of experience, and lack of studies that go deeper into the modern construction to explore the innovative application.

METHODOLOGY

Research Design

This study aims to analyse the composition and construction techniques of the drainage system of traditional villages, and to summarise the ecological wisdom and experience they contain for our contemporary architecture. In order to accomplish the above purposes, the study adopts a combination of quantitative and qualitative research methods: firstly, data collection of the sample case is carried out through on-site research, GIS technology and architectural mapping; secondly, the drainage system of the sample case is analysed through architectural profile analysis, graphical analysis, comparative study and other analytical methods; and finally, the ecological construction characteristics of the sample case drainage system are summarised through the system analysis method and inductive summarisation method, and the ecological concept of the traditional village drainage system is put forward as a revelation of the modern building construction. The specific technology roadmap is as follow (as shown in Fig. 1):

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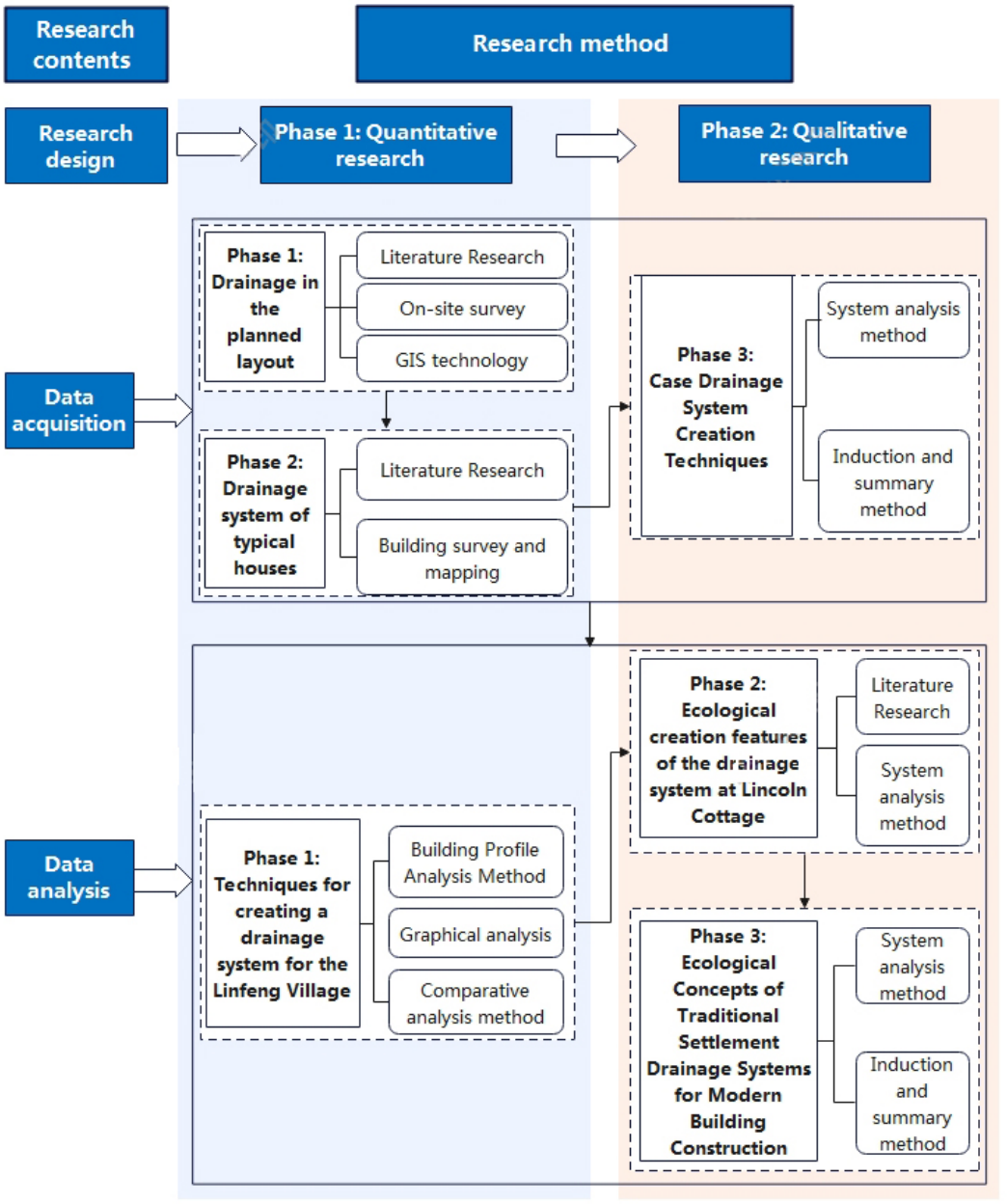

Fig. 1. Research Technology Roadmap

Source: Authors (2024)

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RESEARCH METHOD

Literature Research

Through the obtaining of literature and information related to the selected research objectives, as well as the study of domestic and international literature, we have a better understanding and grasp of the current situation and achievements of the research on traditional settlements. Learning the important theories and ideas, organising the literature according to the facts and needs of the research, and establishing the research concepts.

Field Research

A field study of Linfeng Village in Jiaxian was conducted through on-site research, GIS technology, mapping, and interviews with local residents to increase the direct understanding of the water environment in Linfeng Village as presented in the literature, and to collect image data to inform the content of the thesis. Data were collected, mainly through interviews, to understand the local farmers' basic personal situation, family situation, water use and drainage, as well as their active participation in public affairs of drainage, and their satisfaction with the current drainage situation in the village. It provides a more intuitive and specific knowledge and understanding of the residents and village situation in Linfeng Village, and a further understanding of the ecological creation technology of Linfeng Village's water environment.

Building Mapping and Graphic Analysis

The analysis of Linfeng Village typical residential building drainage system construction. On the basis of architectural mapping data, detailed construction drawings are made for the drainage structures of building roofs, building maintenance structures, courtyards and alleys respectively. Sample drawings of important nodes are drawn to analyse the drainage system construction technology of typical residential buildings in Linfeng Village.

Summarise

On the basis of literature research, field research and excellent case studies, the paper systematically organises and analyses the research results and collected data to explore the protection of regional architectural cultural heritage in the new situation.

ANALYSIS OF THE WATER ENVIRONMENT IN LINFENG VILLAGE

The Water Culture in Settlement Planning and Layout

The concept of choosing a base to live by water is very strong among Chinese ancestors, and water has been given many meanings in traditional Chinese culture. Water is the source of life for all things, and virtue is the cornerstone of human existence. Water flows along the river, and people follow the moral path; water can cleanse everything, and virtue can transform all things; water flows endlessly, and people make unremitting efforts. Water has the characteristic of continuous flow, while the wise are quick to respond and quick to accomplish tasks, and the two (2) have great similarities. In traditional Chinese Fengshui culture, water is regarded as a symbol of ‘the path and source of wealth creation’ (Shou & Xue, 2022).

The Yangliu River, which flows from west to east 100 meters south of Linfeng Village, is the Fengxi River of the past. It is adjacent to the Shihe River (formerly known as Baishui) to the west, and the village is surrounded by artificially excavated village rivers, with water on three (3) sides. Combined with the Lipu Canal to the south, the Linfeng Village has formed a distinct geomorphic feature with a crisscrossing water network. The terrain of Linfeng Village, where the three (3) waters converge, also caters to the psychological needs of the culture of gathering water and wealth and is a rare Fengshui treasure in the plains. In agricultural societies of the past, water was utilised for fishing, oars, drinking, irrigation, microclimate regulation and village landscaping (Fig. 2).

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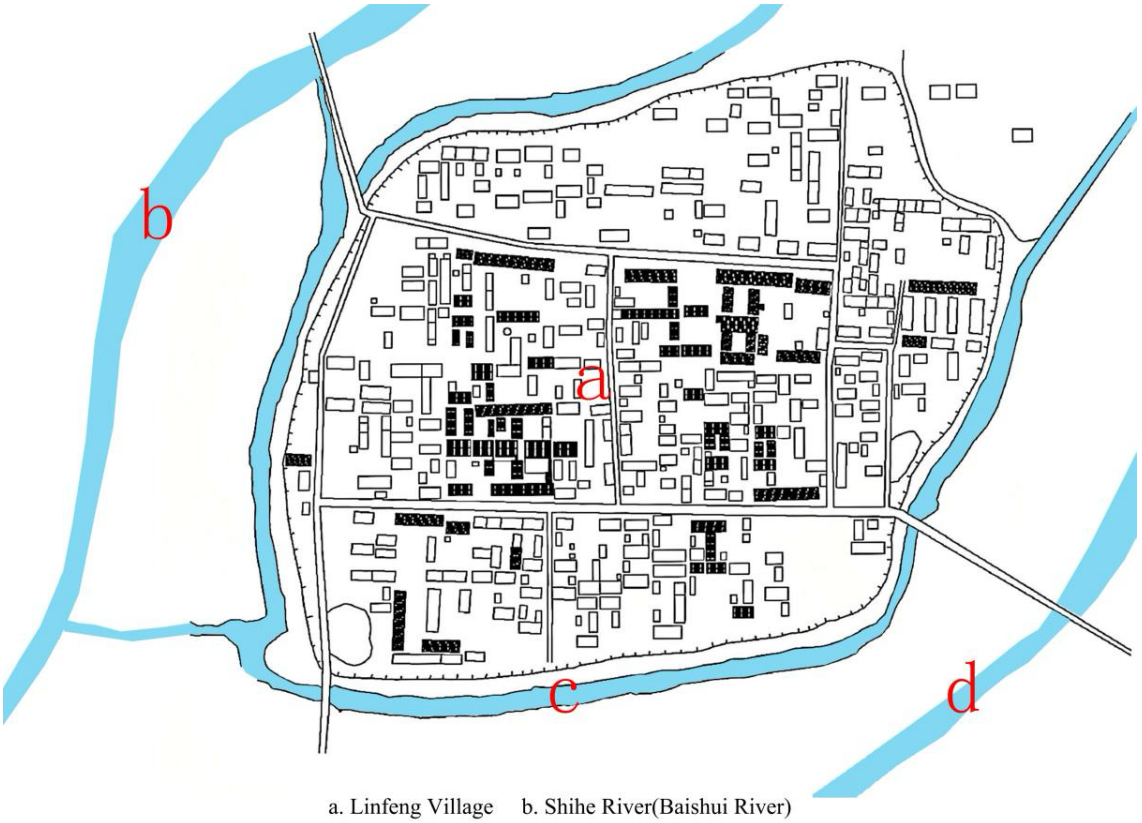

Fig. 2. Water Environment Diagram of Linfeng Village Planning Layout

Source: Author, 2024

Drainage and Flood Control Systems in Settlement Planning and Layout

Linfeng Village is located on a high ridge in a depression, and the ground inside the village is artificially raised. According to the terrain, the village is divided into three (3) drainage areas, with drainage outlets at each gate. Rainwater from the residence drains into the nearby street, which in turn flows into a pond near the village gate (Fig. 3). When there is a large amount of rainfall, the pond plays the role of rainwater precipitation and purification. After preliminary purification by the pond, the rainwater flows to the village River outside the village through the drainage outlet, which can effectively prevent the siltation of the village River. In the season of drought and low rainfall, the rainwater collected in the pond can also be used as water for production and living in the village. Ponds also have an obvious effect on the landscape and microclimate regulation within the village. The village courtyard is a closed and introverted space, while the open pond makes the space in the village have a spatial level contrast between closed and open. The pond is also a place for people's common daily washing, animal drinking and other activities, so such a place often has a strong popularity, and naturally formed a public place for the villagers to meet. Especially in the Central Plains, the common ‘eating place’ is often formed under the big tree by the pond.

The Chinese believe that a residence facing south is the most ideal, and many design concepts are based on this. For example, the height difference between the ground level of the courtyard is high in the northwest and lowest in the southeast, which is called ‘low in the front and high in the back, and the hero in every

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generation'. A south-facing residence has rainwater flowing from the northwest to the southeast. The twists and turns of the drainage outlets and the long route of the water flow are related to the traditional Chinese concept of water as wealth. The design tries to make the source of wealth long, more in and less out.

In order to prevent the backflow of external flood water into the village, there is a water gate on the outside of the three (3) gates of the Linfeng Village. If the flood water outside is raging, the water gate can be closed to make the wall become a strong flood-proof embankment, and the village is protected from flood water.

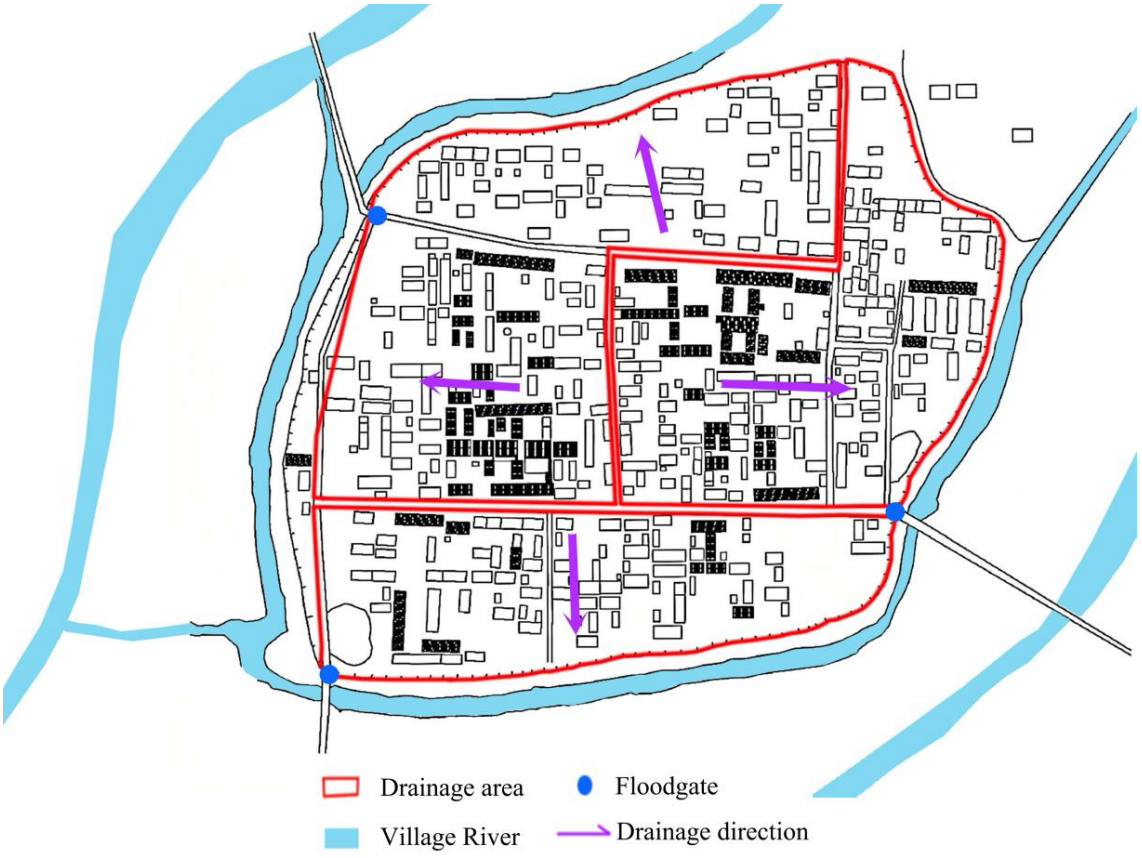

Fig. 3. Schematic Diagram of Drainage and Flood Control System of Linfeng Village

Source: Authors (2024)

ANALYSIS OF TYPICAL TRADITIONAL RESIDENTIAL BUILDINGS DRAINAGE SYSTEMS

Rainwater System Components of Typical Residential Buildings

The residential courtyards in the Central Plains are mostly a combination of three (3) or four (4) courtyards in the form of family gatherings. Still there are also single courtyards in the form of single-family and ancestral halls. Due to the Central Plains rainfall period being relatively shorter, rainfall is not large but more concentrated, easily occurring rainstorms. Hence, the building drainage system is mainly to consider factors such as flood prevention and flood control and drainage. Therefore, the courtyard gradually

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increases in height from one (1) level to the next and connected by three (3) to five (5) steps. This not only conforms to the terrain, but also allows for timely drainage of rainwater to avoid water logging (Fig. 4).

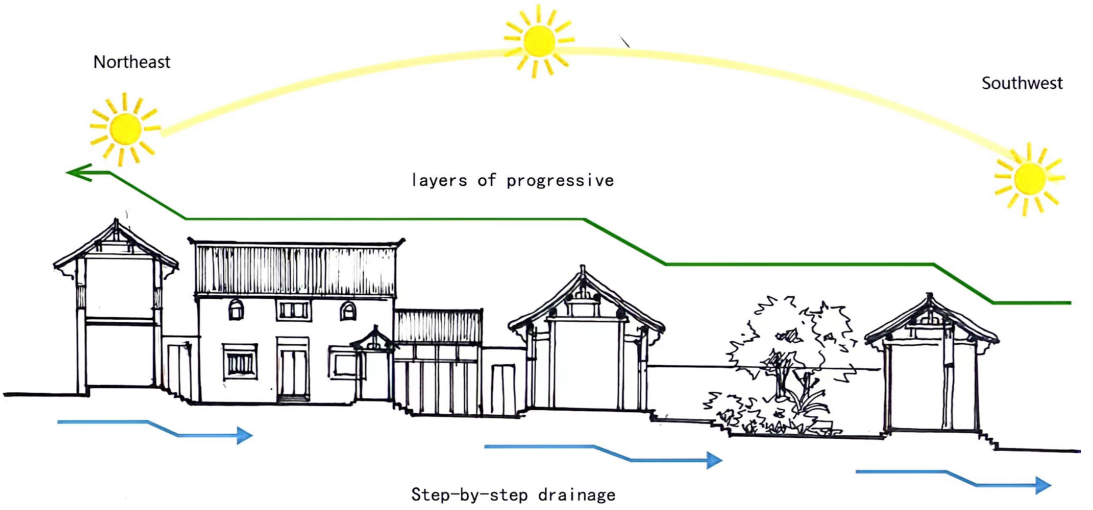

Fig. 4. Schematic Diagram of The Graded Drainage Profile of The Courtyard

Source: Authors (2024)

The drainage system of the Central Plains residential buildings generally consists of three (3) parts (Fig. 5). The first part is a roof catchment system that receives rainwater, which is collected and discharged to the courtyard catchment area. The second part is the courtyard drainage system for discharging rainwater, with the courtyard catchment surface sloping about 2%-4% towards the drainage system. The rainwater collects in the drainage channels and flows to the drainage outlets, where it is discharged out of the courtyard through the outlets. The third part is the rainwater drainage system of open ditches and culverts in the streets.

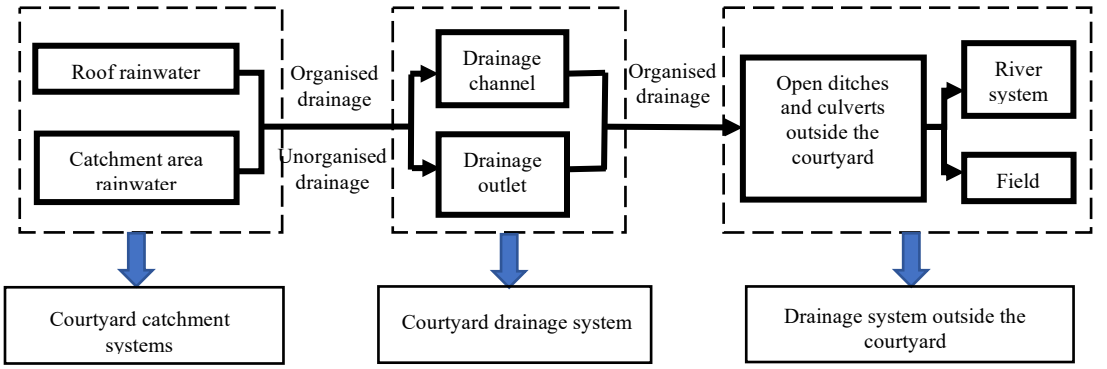

Fig. 5. Schematic Diagram of The Courtyard Drainage System

Source: Author (2024)

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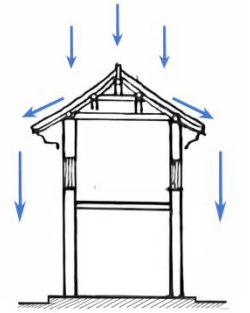
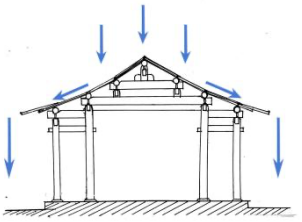
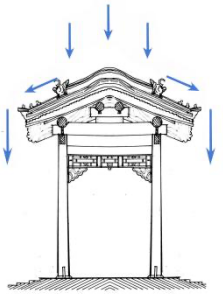
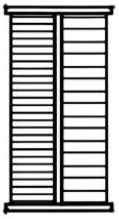
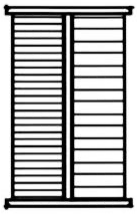
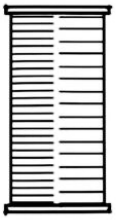
Rainwater Drainage of Building Roofs

The size of rainfall in different areas directly affects the form and slope of the roofs of traditional residential buildings (Zhao & Cheng, 2016). Most of the dwellings in the Linfeng Village use Yingshan roofs with shallow eaves, free roof drainage and moderate slopes, so that rainwater can be directed to the drainage courtyard or outside the courtyard. This design is adapted to the relatively dry climate characteristics of the Central Plains. Residential buildings are usually single or two-story. The type of beam is the post-and-lintel construction commonly used in traditional architecture, generally five (5) beams. Only Zhu Zifeng's living room in the Village has seven (7) beams. The parabolic or hyperbolic character of the roof can also achieve the effect of rapid drainage. Roofs with two-pitch roofs generally do not have gutters, and rainwater flows along the tiles to the eave edge and then falls to the ground (as shown in Table 1).

Table 1. Classification of roof drainage systems

Roof form	Double sloping roof	Double sloping roof	Round ridge roof
Facade			
Plane			
Example			

Source: Authors (2024)

Rainwater Collection and Drainage in The Courtyard

Most of the houses in the village are traditional Chinese closed courtyards. The terrain of the courtyard is high in the northwest and low in the southeast. The rainwater from the roof and surface runoff from the courtyard flows into the planted ground or drainage channels. The drainage channels can be open ditches or culverts, with rainwater draining out of the yard along the channel to the southeast corner (as shown in Table 2). The courtyard is generally higher than the street level to prevent

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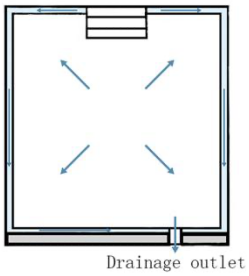
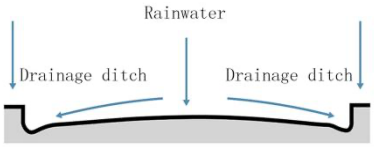
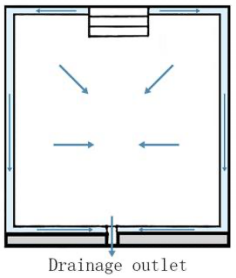
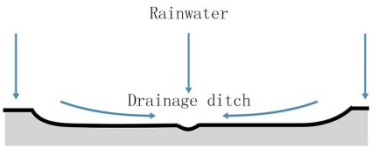
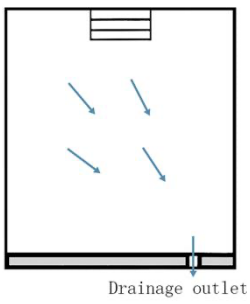
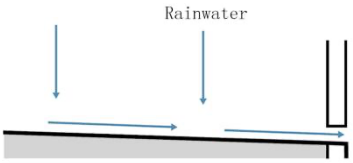
the formation of 'rainwater backflow'. A variety of plants such as deciduous trees can be planted in the courtyard, and besides planting trees, it is also possible to grow flowers and plants in pots and water. A typical scene in a courtyard is to place one or several very large fish tanks in the courtyard, which has the function of collecting rainwater, regulating the air and preventing fire in rainy days. The floor of the house is elevated above the surrounding ground level to facilitate waterproofing and damp-proofing.

Table 2. Drainage type of catchment area

Type of catchment area	Plan sketch	Section diagram	Illustrate
Convex catchment courtyard			The courtyard is low around and high in the middle, and rainwater is drained along the perimeter of the courtyard.
Concave catchment courtyard			The courtyard is low in the middle and high in the surrounding areas, and rainwater collects in the ditch for drainage.
Single side catchment courtyard			Drainage on one side of the courtyard slope.

Source: Wang, 2023

Rainwater Drainage of Roads and Ditches

For a compound with three (3) courtyards, the outdoor level of the third courtyard should be 13-15 centimetres (i.e. the height of one step) higher than the front. Most of the courtyard houses are south-facing, and since rainwater is drained out of the courtyard from the southeast, the level of the courtyard should be at least one (1) or two (2) steps higher than the outside of the courtyard, so as to meet the smooth drainage of rainwater. In this way, we obtain a relationship where the outdoor ground level and the foundation are equidistantly increasing or decreasing in elevation.

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Outside courtyard drainage systems, which are generally converted from open ditch to culvert drainage at the street, discharge to farmland for irrigation purposes or directly to lake and river systems. On the main north-south streets, corresponding ditches have been built as trunk drains (as shown in Fig. 6). Drainage pipes and branch ditches have been constructed on both sides of the main drains and on the roads intersecting them to form a drainage network.

Fig. 6. Schematic Diagram of Roadway Drainage Outside the Courtyard

Source: Authors (2024)

The Construction of Drainage Systems for Typical Residential Buildings

Drainage of building roofs

The roofs of the residential buildings in the Village are mainly in the form of Yingshan roofs, and most of them are double-pitched roofs. The Yingshan roof style building is characterised by a roof ridge that divides the roof into two (2) slopes, front and back, and is covered with grey tiles. The gable walls on both sides are built to the top, and all the wooden frames are sealed in the wall. The wooden frame cannot be seen from the side, which protects the wooden frame from rainwater and facilitates the rainproofing of the enclosure. Roof tiles are laid in layers. When laying roof tiles, with the tiles facing upwards, one on top of the other, in the direction of the ridge. Craftsmen have an easy-to-remember mnemonic 'Press seven (7), show three (3),' which means that when laying roof tiles, the top piece should press down on 70% of the bottom piece in an attempt to reduce the probability of water seepage (as shown in Fig. 7).

In order to prevent roof leakage and seepage, a thick layer of plaster should be laid before the tiles are laid, and this process is called 'Shanbei'. The 'Shanbei' is divided into a number of layers, the focus of which is made up of hemp lime and plaster, in which a large amount of hemp fibres is mixed to strengthen the overall plaster. The type of beam frame is the commonly used lifting beam structure in traditional architecture, usually consisting of five (5) beams. Therefore, in order to effectively resist the wind and rain, the eaves of residential buildings usually adopt special measures, such as strengthening drainage and waterproofing. On the other hand, specially treated eaves also serve as a decorative effect to beautify the roof contour. There are two (2) types of eaves treatments: overhanging eaves and sealing eaves. In order to

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protect the wall from rainwater, eaves overhanging forms are usually used, where the eaves rafters and flying rafters are exposed.

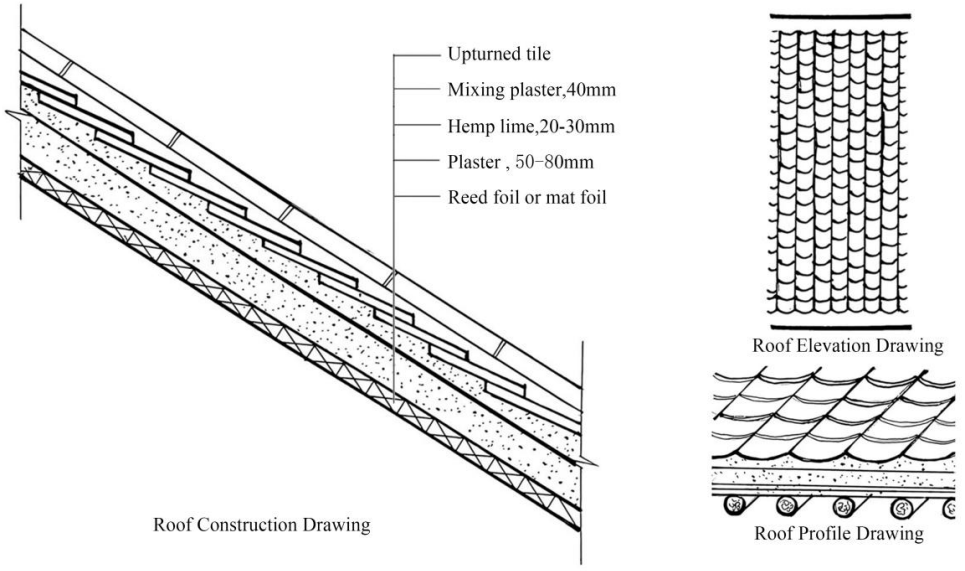

Fig. 7. Schematic Diagram of Roof Construction

Source: Authors (2024)

Waterproofing of Building Wall Structures

Most of the buildings in the Village utilise heavy materials such as soil, brick and stone to form the walls, and the thickness of the materials reaches 520-600 mm, which provides strong protection against rain. The dark gray bricks are larger and wider than the current mechanism red bricks, but slightly thinner. Based on the use of bricks, the enclosure can be divided into the following forms: brickwall, 'lishengwaishu' wall, adobe wall and rammed earth wall (Table 3).

Brick walls, such as the 'lishengwaishu' method, that is, the outer layer of bricks, the inner layer is a thick layer of adobe. The side of the building is also covered with bricks, and the gable is flush gable roof style. Some buildings have two (2) floors, and in order to save costs, the lower layer is made of brick and soil, while the upper layer is made of adobe. Due to the gaps in the masonry, adobe is neither aesthetically pleasing nor durable and is often plastered with white ash. The most economical is the rammed earth wall, which is made of rammed loess and is generally used for secondary rooms. The lower part of the wall must be padded with masonry to protect it from moisture.

The locally abundant red tone is a softer granite that is easier to process than other stones. In order to make the wall strong and durable, a large number of red stone components are used in some key areas, such as foundations, plinths and lintels of doors and windows. Depending on the importance of the building, the lower part of the house is often built with a 40-50 cm foundation of red stone, followed by another 50 cm of red stone to form a stable footing. This not only reduces settlement on soft foundations, but also reduces the impact of rainwater on the building.

The solid wall made of soil, bricks and stones is not only highly rainproof, but also has a good water absorption capacity. The wall removes the liquid rainwater lost and evaporated from the surface, and some of the rest of the rainwater infiltrates and is stored in the envelop enclosure. Because the pressure of water

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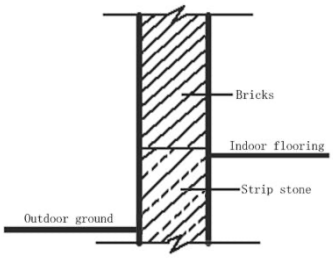
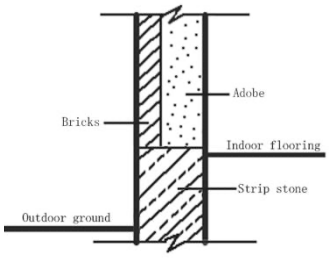
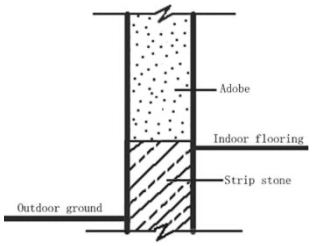
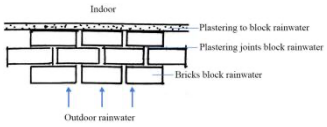
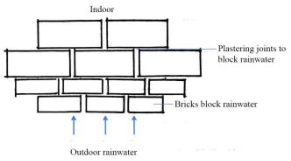
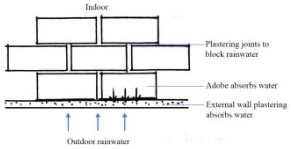
vapor is greater than that of the surrounding indoor and outdoor air, there is also evaporation on the outer surface of the enclosed enclosure after rain. The evaporation phenomenon occurs in such a way that the liquid water previously stored inside the enclosure slowly infiltrates to the outer surface of the enclosure, and in this way, the process of evaporation from the surface of the enclosure continues for some time after the rain. The process of evaporation will be accompanied by heat absorption phenomenon, the temperature of the enclosure and the surrounding air will also be reduced, making the residential building cooling effect is significant.

Table 3. Type of wall structure

Types	Brick wall	'Lishengwaishu' wall	Adobe wall
Structure			
Plane			
Example			
Illustrate	Stack the bricks in alternating rows with the first and second rows to ensure that the wall is wall is structurally sound and effective in keeping rainwater out.	In order to better withstand humid conditions, the wall can also be reinforced by building two (2) to three (3) layers of bricks outside the rammed earth wall.	Adobe walls are highly absorbent, resistant to moisture and water, prone to rot and often used as dwellings in poor domestic environments. Its waterproofing mechanism is comparable to that of brick and stone walls.

Source: Authors (2024)

Drainage of Courtyards and Streets

Courtyard ground, from front to back, each into the sequential rise in the height of a step, in order to facilitate drainage. Generally, the courtyard is paved with plain soil or crushed stones, bricks, and tiles to create a pathway. Rainwater flows through the open or concealed ditches of the pathway to the southeast corner to drain out of the courtyard. In the choice of paving materials, we can use black brick, tamped earth or a mixture of lime, sand and soil of the tabia (as shown in Table 4). When paving the ground, in the choice of bricks, most of the indoor floors use square bricks, while most of the outdoor use long bricks.

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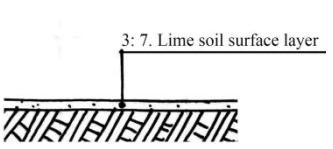
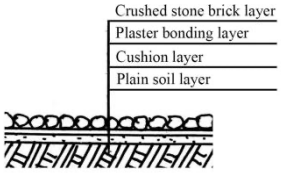
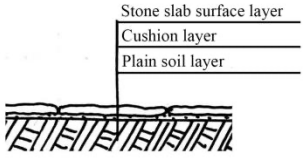
The laying process is divided into two (2) types: fine plastering and coarse plastering. Fine plasterwork is seen in indoor or outdoor formal occasions; coarse plasterwork is mostly used in courtyards, as pathways, aprons, and so on. The coarse plastering ground is relatively rough, usually using unpolished strips of bricks. Due to small errors in the manufacture and firing of the bricks, the dimensions of the bricks are not strictly the same. These strips of bricks with minor differences are laid directly without trimming, which will result in larger gaps between the bricks, which in turn enhances the infiltration effect of rainwater.

Table 4. Type of courtyard paving

Ground type	Rammed earth ground	Gravel and brick ground	Strip stone slab ground
Structure			
Principle	Due to the large-scale production of bricks, they were rarely used after the Ming and Qing dynasties.	The rotor used does not undergo cutting and grinding processing, and the seam is relatively wide, usually used by wealthy households.	Grind the joints of the slate flat to increase flatness and aesthetics. Mostly used for ground paving of residential buildings and shops in mountainous areas.

Source: Authors (2024)

The paving of roads in the village is mostly made of regional materials. Linfeng Village Street main road pavement, from top to bottom, the first layer of the local characteristics of the red stone, neatly planned horizontal pavement on the road. The second layer is laid with a fine sand cushion layer, followed by gravel, and the bottom layer is compacted with plain soil. The main cross-section of the street is designed as follows: symmetrical along the longitudinal axis of the road, high in the middle and low on both sides, with a design slope of 1-2% and a difference in elevation of about 15cm, which is conducive to the drainage of water on both sides of the road.

CONCLUSION

Modern Architectural Construction Based on The Inheritance of Traditional Settlement Drainage Systems

Ecological Construction Characteristics of Linfeng Village's Drainage System

In the construction of villages, the ancestors met the needs of water for production and living as well as flood control and drainage by rationally arranging the relationship between the streets, farmland, courtyards, etc. and the village as a whole, and by functionally creating water environment facilities. For the purpose of water for production and living, villages live near the water and make full use of nature. In order to prevent flooding and drainage, waterproofing and drainage are adequately carried out by utilising the difference in topography and the structure of roofs, walls, and foundations of buildings to prevent traditional buildings from being eroded by rainwater.

The integrated water organisation system of 'collection, storage and drainage' in traditional villages is an effective strategy for the ancestors to cope with the uneven environment of droughts and floods. Residents of ancient villages skilfully utilise the natural terrain height difference of the base and the water environment facilities of the village to complete a series of processes such as 'water collection-storage-drainage' in the village. Firstly, water collection is considered in the courtyard space and building construction, and water collection facilities work together to maximise the introduction of rainwater into the water tank for storage. Secondly, the drainage system is skilfully arranged according to the terrain trend,

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and the drainage flow line fits perfectly with the direction of the village road. The main road of the village takes on the main function of flood discharge, and the runoff from courtyards or rooftops flows into the main road through alleys, draining to the lower terrain. Finally, the ancestors-built ponds in low-lying areas to store rainwater due to the topography of the area. Buildings, streets and alleys were closely coordinated with the terrain, and together they participated in the operation of the collection system.

Multi-functional composite spatial construction characteristics, so that the water from nature, and ultimately also return to nature. The village water environment and its facilities are characterised by multifunctional composite construction (as shown in Table 5). For example, the pond not only meets the multiple roles of drinking for people and animals in drought, water storage and flood control in heavy rain, but also purifies the air, regulates the microclimate of the village, and undertakes a series of public activities such as exchanges and gatherings.

Table 5. Functional complexity of Linfeng Village water environment facilities

Type	Basic functions	Derivative functions
Water tank	Water supply	Water collection, firefighting
Ditch	Drainage	Pollution discharge, water storage, landscape
Streets and lanes	Transportation	Drainage, flood discharge, gathering and socialising
Pond	Daily drinking, laundry, irrigation	Water storage, fire protection, landscape, social gatherings

Source: Authors (2024)

Inspiration for Modern Architectural Construction

Rational Planning and Layout

Traditional settlements and their surroundings focus on the relationship between people and water, people and buildings, respecting nature and adapting to it, so that they become a continuous, organic whole. This includes the microscopic relationship between residential buildings and water, the mesoscopic relationship between village space and water, and the macroscopic relationship of symbiosis with mountains and water. When planning the layout, the ancients fully observed and considered the environmental factors such as sunlight, ventilation and drainage of the residential buildings and adapted them to the local conditions.

Therefore, when planning the layout of modern residential districts, emphasis should be placed on the harmonious development of human and natural water environments. Low-impact development techniques are incorporated in the residential districts to mimic the hydrological characteristics before development. It is an ideal way to build an ecological water cycle in order to realise the transformation of engineering drainage to ecological drainage. Residential districts by maximising the creation of green space within a limited site, such as rain gardens, rainwater ponds, stormwater wetlands and other single or combined techniques. Multi-functional storage is utilised while reducing runoff discharge, thus providing some relief to the drainage of the entire city.

Combining with Terrain and Climate

Traditional settlements are often built near water, and due to the large heat capacity of water, it is conducive to the stability of local temperatures. At the same time, it can effectively supplement groundwater, maintain the natural ecological environment on the surface, and improve microclimate. Traditional residential buildings have different forms due to the slope of the terrain in which they are located. The main drainage method is natural drainage, realised by using the height difference. In special cases, the purpose of storage and drainage can be achieved through manually excavated ditches and natural or artificial water systems for water storage.

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Modern designers are often accustomed to emphasising individuality, thus ignoring the combination of regional culture terrain and climate. Therefore, it is advocated to try to follow the natural state of the land before development without affecting the residential function and living safety of the residential districts. According to the vertical slope of the site, the elevation relationship of buildings, green areas and roads is controlled (Fig. 8).

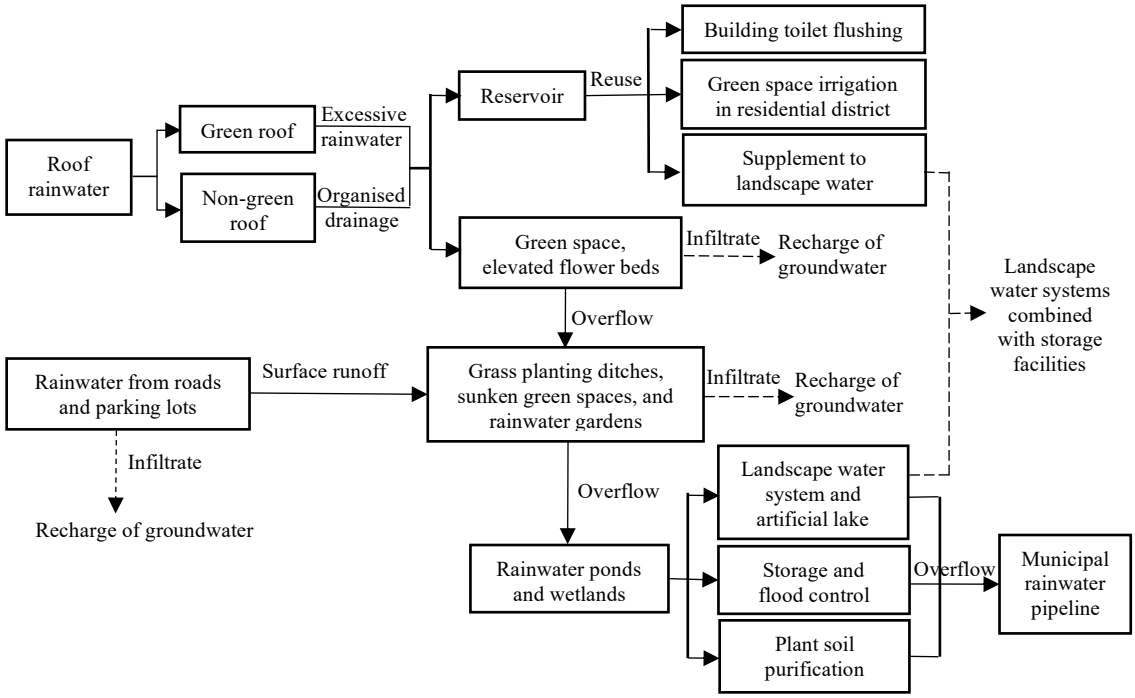

Fig. 8. Schematic Diagram of The Vertical Design of The Residential District

Source: Authors, 2024

Landscape Optimisation Design Combined with Environment

The design of paving, plants and water systems in the residential districts should be considered according to the surrounding environment. The design of sidewalks, some non-motorised roads and parking lots in the residential districts can be paved with permeable bricks. Not only does it have a better purification effect on the rainwater that seeps into the ground, but it can also effectively delay road runoff and increase the moisture content of shallow soil on the site. As a small plant community, residential districts' green spaces should be considered comprehensively based on regional applicability and the surrounding environment of the site. It is best to adopt the compound community structure of plants, choose plants with suitable ecological habits, achieve landscape continuity and hierarchy, and fully leverage their ecological benefits. The development of landscape water systems should be based on the premise of balanced development with natural resources, without excessive external conditions to maintain. It can be designed in combination with infiltration ponds and rainwater wetlands and connected to the surrounding green space to form a natural storage, drainage and purification system.

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CONFLICT OF INTEREST STATEMENT

The authors agree that this research was conducted in the absence of any self-benefits, commercial or financial conflicts and declare the absence of conflicting interests with the supporter.

AUTHORS' CONTRIBUTIONS

All authors involved in carried out the research, Hou Jialin wrote and revised the article, conceptualised the central research idea and provided the theoretical framework, Anis Rosniza Nizam Akbar, Ma Guimin, and Wang Ersong Akbar review and approved the article submission.

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