

Research on Green Construction Technique of Traditional Settlement in North China Plain Region

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Abstract: The geomorphic features of northern China are complicated with diversified patterns of settlement. Influenced by different geomorphic features, northern settlements take different response techniques. This paper analyzes the landforms of North China Plain, the most representative region in northern China, based on coping strategies of local settlements to adapt to landforms, studies the specific green construction technique of settlements for landforms in this region, and concludes the green construction from winter protection and thermal insulation, ventilation and lighting, sun-shading and heat insulation, drainage and moisture protection, and hazard prevention, to provide reference for constructing new-style village settlements with regional characteristics.

1. Introduction

Chinese dwellings, with long history, have constantly evolved for thousands of years. In long-term practice, combined with factors of geomorphic feature and climate and so on, corresponding construction methods and techniques are formed. There are different construction methods for different landforms, and also different settlement patterns. Settlement, is not only the dwelling for human being, also the crystallization of wisdom and civilization of human being.

The geomorphic features of northern China are complicated with diversified patterns of settlement, forming the pluralistic dwellings in northern region with the integration of local culture. The northern region in this paper refers to the area in the west of Hengduan Mountains and north of Qinling Mountains-Huaihe River line, including northwest region, Qinghai-Tibet region and northern region of four geographical zones in China. The North China Plain is one of typical geomorphic regions in northern China. Through the research on dwelling settlements in this geomorphic region, it can be found that the strategies and specific methods to develop coordinately with natural environment can provide reference for the planning and construction of small-town and village settlement in the new-type urbanization, which is shown in Figure 1.

2. The Development Characteristics of Settlements in North China Plain Region

2.1 The impact of geomorphic features of North China Plain region on the development of settlement

The geomorphic feature of North China Plain is mainly plain with the altitude of less than one hundred meters. The terrain slopes gently. Sequentially, from the mountain foot to the coast, there are proluvial inclined plain, proluvial-alluvial fan plain, alluvial plain, alluvial-lacustrine plain, coast-alluvial plain, and coast plain. A giant alluvial fan is formed downstream of Yellow River in Mengjin, and its margin almost eastward reaches the west on mountains and hills in southwest of Shandong Province. The center shaft of Yellow River alluvial fan is deposited higher, becoming the "water ridge" of North China Plain and separating Huaihe River and Haihe River in the south and north.

According to different regional features of North China Plain, four sub-region plains are formed.

The downstream plain of Liaohe River, with Shanhaiguan as the boundary, is the plain outside Shanhaiguan formed by the alluvial of the Liaohe River, with many marshes and salinization.

Yellow River Flood Plain, between Haihe plain and Huaibei plain, is formed by alluvial of Yellow River, including many flood deposit, saline and alkaline, and desertificated land. Huaibei plain, in the north of Huaihe River and the south of Yellow flood region, is formed by Yellow River flood and alluvial of Huaihe River. Haihe plain, in the south of Yanshan Mountain, the north of Yellow River, and the east of Taihang Mountains, is formed by the alluvial of Haihe River and Yellow River, also called Huanghai plain, which is shown in Table 1.

North China Plain has advantageous natural conditions. As early as seven or eight thousand years ago, there was settlement formed by primitive agriculture and animal husbandry. During the Western Han Dynasty, due to its flat terrain, humid climate and location close to Chang'an, the local population was dense and the agriculture was developed. Therefore, the construction of settlements was generally centralized, that is, the farmland was on one side of settlements or surrounded by settlements. The historical warfare is often the cause of changes in the number of settlements. The war in the last years of the Western Jin Dynasty led to the southward migration of the population, and a large number of settlements were destroyed or abandoned. Due to the vast territory with a sparse population, agriculture was not stressed, and the settlement has become a scattered pattern. However, the formation of settlements is in the landforms with abundant natural resources and superior geographical conditions. Therefore, the geomorphic features have a very important influence on the formation of settlements.

Table 1 Geographical regions of North China Plain

	Range	Categories of sub-region plains	Geographical zoning	Altitude
North China Plain	Stretching from the Taihang Mountains and the western Henan Mountains in the west, to the Yellow Sea, the Bohai Sea and the Shandong Hills in the east, from the Yanshan Mountains in the north, to the Tongbai Mountain and the Dabie Mountain in the southwest, and to the north of Jiangsu and Anhui Province in the southeast, it is connected to the Middle-lower Yangtze plains.	the downstream plain of Liaohe River, Yellow River Flood Plain, Huaibei plain, and Haihe plain.	The northern Beijing, Tianjin, Heibei Province, Shandong Province, Henan Province and Anhui Province, 5 provinces in the north of Jiangsu Province and 2 municipalities.	An average of below 50 meters, and below 10 meters in eastern coastal areas.

2.2 The categories and distribution of settlements in North China Plain

Compared with other provinces, the geomorphic types of Shandong Province are diversified, including plain, low mountains and hills, tableland, and basin, so the settlement types can basically contain that of North China Plain. The survey and materials collected show that the settlement type of this region is mainly defensive fortress. This paper selects the settlements in Shandong region as research object, which are distributed in different small landforms. Based on geomorphic zones in China, these small geographical names are divided into I C and I G, respectively, Ludong low hills and North China and East China low plains; and according to the location of Shandong settlements, I C and I G are subdivided into, I C1: Jiaodong small relief hills, IC2, IC3 and IG4 junction: Jiaolai alluvial plain; Luzhong medium and small relief middle and low mountains; Jiangsu and Zhejiang alluvial delta plain junction, I C3 margin: Luzhong middle and small relief middle and low mountain margin, I G3 and I G4 junction : Huanghuaihai alluvial plain and Jiangsu and Zhejiang alluvial delta plains, shown in Table 2.

Table 2 The categories and distribution of typical cases in Shandong Province

Geomorphic zones		Settlement Name	landforms			Military/non-military settlement	Note
Geomorphic No.	Geomorphic Name		Hilly area	plain	Hillock and hills	Dwelling settlement	
IC1	Jiaodong small relief hills	The Mous' Manor, Du Village, Chengbei Ancient Town, Qixia City, Shandong Province (The third batch of National Historical and Cultural Village Protection)			Highlands in mountain slopes	·fortified fortress	
	Jiaodong small relief hills	Dongchudao Village, Ningjin sub-district office, Rongcheng City, Shandong Province (The third batch of national famous historical and cultural villages)		Coastal slight slopes		Non-fortified	Seaweed house settlement
	Jiaodong small relief hills	Gaojiazhuang, Zi Village, Xinzhuang Town, Zhaoyuan City, Shandong Province			The hillock slopes from hills to plains	Non-fortified blood settlement	
IC1 margin	Jiaodong small relief low mountain hills margin	Xiongyasuo Village, Fengcheng Town, Jimo City, Shandong Province			Coastal and riverside valley	·fortified castle	
IC2,IC3 and IG4 junction	Jiaolai alluvial plain; Luzhong medium and small relief middle and low mountains; Jiangsu and Zhejiang alluvial delta plain junction	Ljiatuan Village, Wangcun Town, Zhoucun District, Zibo City, Shandong Province		Depression region of North China Plain		·fortified fortress	There are dike walls piled by earth and stones surrounding the village.
IC3 margin	Luzhong middle and small relief middle and low mountain margin	Zhujiayu Village, Zhangqiu District, Jinan City, Shandong Province (The second batch of national famous historical and cultural village)			col	Non-fortified settlement	
IG3 and IG4 junction	Huanghuaihai alluvial plain and Jiangsu and Zhejiang alluvial delta plains	Nanyang Town, Weishan County, Shandong Province		riverside		Non-fortified settlement	One of four famous towns of the Canal, it is located around Weishan Lake integrated with the Grand Canal.

2.3 The introduction to typical settlement

Xiongyasuo Village, Fengcheng Town, Jimo City, Shandong Province, is located inside Dingziwan, the coast of Fengcheng Town, close to the sea, river and valley. Its landform effectively avoids natural disasters like typhoon, as the natural barrier. It belongs to fortified fortress, the city is square, the walls are brickwork on both sides, the middle is punned by loess, the circumference is 2 kilometers, and there are four gates with gate towers. The terrain is inclined from south to northwest, but its slope is stepped. Therefore, the settlement combines these terraces for road planning, and the residential houses are naturally located on these platforms, which is a typical representative of the plain settlements combining with the terrain. The south gate and the west gate of Xiongya are facing the main road of the village, in the form of a cross. There are also a number of small roads parallel to it. The road network is similar to a checkerboard layout, crossing and regular. The main road of the settlement is scattered with stones. The small roads are mostly dirt roads with prominent centers and distinct layers. A number of tortuous roads radiate from outside to the four corners of the village, and enliven village roads organization, to form a road system with straight and tortuous roads. The facades of the residential houses that express the road space are diverse, and the materials and forms of the residential walls are different, which together form a rich facade effect, shown in Figure 1.



Figure 1 Xiongyasuo Village, Fengcheng Town, Jimo City (Source: Baidu Image)

Zhujiayu Village, Zhangqiu District, Jinan City, is located in the northwest of Luzhong mountainous hills region. The east of the village is the fault zone of Yuwang Mountain, the south is the fault zone of Mount Tai, one of the Five Mountains, and the west is Dasha River valley of Changqing District. The east, west and south sides are all fault zones, belonging to Luxi fracture region, mainly including low mountains and hills, which also forms the typical settlement features in northern mountainous area with mountains surrounding the east, west and south of the village. The entire ancient village stretches between two mountains from the south to the north, so it develops into a long and narrow stepped settlement, long from south to north and narrow from east to west. The village is defensive settlement. The length from the south gate of ancient village to the foot of Wenfeng Mountain is 2,125 kilometers, and the widest distance between the east and the west mountain foot is about 775 kilometers. Due to the unique geographical location, the settlement is concave along the contour line. The overall layout is compact, conforming to the terrain, and the buildings are well-arranged. The residential buildings are built on the gentle slopes of the mountains, the roads conform to the terrain from top to bottom, and the drainage is organized according to the terrain. The building group extends longitudinally along the roadway and axis to form a linear layout. The road inside the village is combined with the veins of the spring water system, flexible and tortuous, shown in Figure 2.



Figure 2 Zhujiayu Village, Zhangqiu District, Jinan City (Source: Baidu Image)

3. The Analysis on Green Construction Technique Suitable for Settlements in North China Plain

3.1 Winter protection and thermal insulation

The cold-proof insulation measures for settlements in North China mainly are making use of wall, roof and fire sources for thermal insulation.

In North China, heavy walls are generally constructed for settlements. Residential buildings are generally built with local unique stone materials, and a thick layer of loess is applied outside the stone walls to increase the insulation performance of the walls.

The same is true for roofing, which is covered with a layer of earth or just an earth house with flat roof.

The use of fire source for heating is divided into heating by copper stove, heating by Chinese kang, and heating by underground fire stove. In terms of heating by copper stove, the copper stove or the fire pit is placed in the building, and the fire source is used to raise the indoor temperature; the underground fire stove is used to lay the fire tunnel indoors and underground, and a dark chimney is made on walls to achieve the air convection. Through the underground fire, the underground fire channel is heated by the underground fire stove, the heat dissipation is performed by the underground fire channel, and the indoor temperature rises naturally. In this way, the purpose of heating can be achieved, and the indoors can be kept clean.

For example, in Wei's Manor, in order to solve the problem of heating in winter, the kang is set up on the ground and connected through underground passages. The fire tunnel is laid underground and hidden flue is set in the wall. The heat is radiated through the airflow by the underground fire stove to the underground fire path and wall hidden path. The heat dissipation from the ground and wall can raise the indoor temperature. In winter, the fire is made outside the wall, and the interior can be warm by fending off the coldness. This kind of heating method is widely used in the Beijing court and its surrounding Palaces of Prince, but it is rarely found in the middle and lower reaches of the Yellow River in China. At the same time, square vents are opened on the walls of the inner house to make indoor and outdoor air convection, which can effectively compensate for the small windows in the ancient buildings and the poor ventilation of the wooden windows.

3.2 Ventilation and lighting

The landform of North China Plain is mainly plain, so most settlements are constructed in plains, which constrains less the expansion of settlement, so the settlements are in compact pattern. In order to guarantee good ventilation and lighting in buildings, the construction of the main road and the secondary road in the settlement can meet the lighting demand of the residential buildings, while the ventilation is to generate the air flow through the paths between the houses and the open space in the settlement, forming wind pressure to achieve natural ventilation. Since the height of the settlements is basically the same, in order to meet the lighting demand, the principal room is raised to achieve ventilation and cooling in summer and sunlight in winter.

For example, in Mous' Manor, each group of courtyards is separated by paths on both sides, and the buildings in the courtyard are separated by a certain distance. For instance, Gaojiazhuang Zi Village, Xinzhuang Town, Zhaoyuan City, Shandong Province, is located on the flat bottom. There are enough settlements in the streets to meet the lighting of the front and rear rows. There are roadways between adjacent buildings, because the roadway is narrow, so it is just exposed to sunlight for a short period, so that it can be considered as cold alley to adjust the temperature inside the settlement, and the housing is higher than the wing-rooms on two sides, for better lighting in winter and cooling in summer.

3.3 Sun-shading and heat insulation

Due to the influence of geographical conditions, soil is important in the formation of settlements

in the North China Plain. Most of the settlements are made of rammed earth or adobe. This type of raw soil material is an excellent thermal insulation material. Because the landform is flat, there are no natural mountains around the settlement for sun-shading. Therefore, the settlement faces south to avoid the west sun, or densely arranged, intertwined to block the sunlight, and the tall trees are usually planted in the settlements, such as arbor.

For instance, in Wei's Manor, Weiji Town, Huimin County, Binzhou City, most of the wall of the house is 800mm thick. It is constructed by the technical method of sandwiching the adobe with the wooden board and the blue bricks on the inner and outer sides. The wooden board and the blue brick are connected with a shovel saw, so that it can be earthquake-resistant and the indoor space can be warm in winter and cool in summer.

3.4 Drainage and moisture protection

The terrain of the North China Plain is less rolling, and the effect of natural drainage is slow. In order to be waterproof, the rainwater is collected in the courtyard by the roof. The courtyard is mainly made of hard paving, the middle is high and two sides are low, so the rainwater is organized in the drainage ditch with the depth of 15cm and width of 5cm in front of the wall or the courtyard. Besides, the terrain of the courtyard is higher than that of the rainway, the domestic water and rainwater are easily discharged into the rainway after being organized. The rainway is placed with drainage ditch on both sides or on one side. The water discharged from the courtyard will pass through the drainage pipe and flow into the moat or river pond, reservoir and other places. The moisture protection of the settlement is built with plinth, using bricks and stones, which are protruding from the wall to enhance the moisture-proof effect.

For instance, in Mous' Manor, the drainage is completed according to the terrain. The drainage of rainwater of courtyard is achieved by a drainage system. The sloping roof collects the rainwater into the courtyards. The courtyard is mainly hard paving, the middle is high and two sides are low. The rainwater is organized into the drainage ditch of 15cm in width and 5cm in depth in front of courtyard wall or building. Besides, the terrain of the courtyard is higher than that of the rainway, the domestic water and rainwater are easily discharged into the rainway after being organized. The rainway is placed with drainage ditch on both sides or on one side. The whole Manor is high in the north, low in the south, high in the east and low in the west, which is conducive for the drainage. The rainwater is discharged along the terrain into the Wenshui River in the south.

3.5 Hazard prevention

In terms of the layout of settlement, because the settlements are mostly in the plain area and the settlements are dense, each house is separated by the roadways on both sides. There is a certain distance between the buildings. The adjacent courtyards are separated by stone walls to prevent the spread of fire. Due to the shortage of water in northern region, a public pond is often dug in the settlement, or a well in each household; a lead plate is placed on the roof to prevent fire and moisture.

For instance, in Wei's Manor, Weiji Town, Huimin County, Binzhou City, Shandong Province, there is not flood disaster. When building the castle, the soil has been taken from the east of the manor to make a pond and the residential foundation has been raised to prevent the burst of the nearby Yellow River or Daqing River. The underground ditch is excavated in the house and there is a complete underground drainage system, so that heavy rain will not be problem and the accumulated water can be discharged to the eastern pond in time. There is sewer underground in each courtyard. There are drains on the ground. Rainwater drains into the culvert under the ramp of the manor through the drain and sewer, and finally flows into the nearby Daqing River. In addition, because most of the buildings in the manor are wooden structures, in order to prevent fire disaster, a large pond is dug in the east, and deep water wells are dug in the houses. In addition to being used by humans and animals, they can be used for fire fighting at any time. Metal roofs are laid on the roof of each corridor, which can be moisture-proof and prevent fire at the same time.

4. Conclusion

Most settlements are built in the area with flat terrain and slight slopes in North China Plain, so construction methods adopted by settlements can achieve the best effects combining with landforms. Most techniques are adopted for planning and processing of building layout, external building envelope, raising the foundation without changing terrain, so as to prevent the easily occurred destruction brought by disasters. Since the last century to now, the research on settlement and landform has gone through an upward and tortuous development. On the whole, the research on settlement and landform transforms from extensive research to the research focusing on locality, and the research results are more in-depth. The future research will be carried out from these several aspects, including, the comparative study on the difference of settlement between different landforms, and various construction techniques adopted by local habitants for different geomorphic environments. The research object will be transformed to living environment and ecological environment, and the adaption of settlement to terrain, landform and climate. The research contents will be expanded from settlement space and construction layout to green construction technique, so as to conclude and abstract green construction technique adapting to landforms for today.

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