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RESEARCH ARTICLE

Study on ecological adaptability construction characteristics of residential buildings in Kangba area, Tibet, China

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Abstract

Located in the southwest of the Qinghai-Tibet Plateau, Tibet is characterized by high cold, high radiation, and large differences in temperature between day and night. Tibetan residential buildings are famous for adapting to the harsh ecological environment and maintaining durability. Based on the residential buildings in Tibet, this paper extracts the technical process and color decoration culture in the construction process in order to adapt to the harsh natural environment. This paper first analyzed the four ecological construction modes of Tibetan residential buildings, analyzed the interior layout characteristics and cultural customs connotation, and introduced the architectural decoration characteristics and decorative color painting. The results show that the ramming type of adobe mainly includes the selection of building foundation, wall laying, floor and roof construction and so on, and its insulation effect is better. The rubble masonry type mainly adopts irregular gneiss, supplemented by clay, which has strong compressive capacity. Logs dry type using log masonry, heat preservation. and shock resistance is better. Concrete-infilled wall frame is composed of horizontal and vertical load-bearing system, which has stronger seismic performance. Tibetan residential buildings generally have two or three floors. The first floor is the enclosure and sundry room, the second floor is the rest place, and the third floor is the Sutra hall and sun terrace. The overall outdoor color of Kangba Tibetan buildings is mainly red and black, while the indoor color is mainly blue and red, with wood carvings and furniture. The layout of Tibetan villages can be divided into centripetal layout and scattered layout. Tibetan residential buildings provide a new sustainable development direction for the current global urbanization process at the expense of the ecological environment. It can alleviate the crisis of global resource shortage, climate warming, and biodiversity degradation.

Keywords Tibetan residential buildings · Ecological adaptability · Construction methods and materials · Architectural space layout · Color and decoration

Introduction

After the 1760s, Europe took the lead in entering the era of industrial revolution. In just over 200 years, the global urbanization rate continued to rise from 8.36% in 1760 to 55.37% by the end of 2020 (Wang et al. 2012; Wang and Yang 2019; Zhang et al. 2020). According to the "Global Energy Consumption Report" released by the United Nations in 2020, the current energy consumption of building operation accounts for more than 45% of the global total energy consumption and shows a continuous rising trend (Cabeza et al. 2018; Liu et al. 2021). The global population continues to concentrate in cities, and a large number of high-energy buildings have caused a series of problems, such as inefficient use of energy, damage to the ecological environment, soil erosion, escalation of the conflict between human and land, aggravation of environmental pollution, and ecological degradation (Gao et al. 2019; Jiang et al. 2020). In the face of problems such as resource shortages, energy consumption and ecological deterioration brought about global rapid urbanization. The research on low energy consumption and ecological adaptability of buildings has important theoretical significance and application value for the sustainable development of global economy and resource recycling.

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Located on the Qinghai-Tibet Plateau of China, Tibet is the highest and largest plateau in the world. It has a typical low-pressure hypoxia, low average temperature and relative humidity, high wind speed and solar radiation, less rainfall, and other natural environment (Chen et al. 2021; Liu et al. 2019a; Zha et al. 2019). The Tibetan residential buildings adapt to the unique environment of the plateau. The architectural structure, interior and exterior decoration, and the surface color of the buildings all have typical local styles (Bai et al. 2018; Liu et al. 2018; Yang et al. 2012). This style is based on the geographical environment in the long-term historical development and gradually stable solidification. In order to explore the characteristics of Tibetan residential buildings, global scholars have made multi-level research. Some scholars use DeST-h to simulate the indoor thermal environment of Tibetan residential buildings, in order to reduce the energy consumption of Tibetan residential buildings and improve the indoor thermal comfort (Sun and Leng 2015). Some scholars have studied the heating system combining solar air collector and hollow ventilated inner wall of residential buildings in Qinghai-Tibet Plateau (Yu et al. 2019). Some scholars have studied the abundant practical ways of building solar energy utilization on the Qinghai-Tibet Plateau and analyzed the solar energy potential of each region (Wang et al. 2018). Some scholars have tested the heating effects of passive and active solar heating in residential buildings in Tibet. The results show that solar heating can effectively reduce the traditional energy consumption and improve the indoor thermal environment.

The adaptability of residential buildings is to explore the relationship and law of the interaction between buildings and environment, so as to study the evolution mechanism of buildings in the natural environment and human social environment in a specific region (Adamczyk and Dylewski 2017; Houghton and Castillo-Salgado 2020; Melchert 2007). The ecological adaptability concept of Tibetan residential buildings mainly responds to the geographical specific natural geographical conditions such as landform, climate, and hydrology, as well as social and cultural conditions such as religious belief and ethnic habits. It adopts local building materials and construction technology, which makes it show regional differences with other regional buildings in the long-term process of adaptation and reconstruction (Liu et al. 2019b; Qin and Yang 2017). Some scholars have evaluated 92 housing projects in Spain and determined their ecological footprint (González-Vallejo et al. 2015). Some scholars use life cycle assessment (LCA) method to construct an energy demand model to evaluate the energy demand in rural areas of China. The results show that the energy demand of traditional adobe residential buildings is lower than that of concrete structures. Some scholars have discussed the effects of sunshine ratio and solar space depth on space heating of passive solar houses in the Qinghai-Tibet region (Liu et al. 2019b).

Although some scholars have studied the Tibetan residential buildings, the literature mainly focuses on the Tibetan culture and the exterior decoration of buildings. At present, it is still facing the following problems: What types of Tibetan residential buildings include? What are their specific construction processes and how to choose construction materials? How do they adapt to complex and harsh natural environment and reduce energy consumption? In order to fill these gaps, this study went deep into the Kangba Tibetan area to investigate and map important information of Tibetan residential buildings, such as building types, construction techniques, building materials, internal layout, and exterior decoration. These research results will provide detailed information for the global scholars who pay attention to the Tibetan living environment and also provide important reference for the research of new low-energy buildings and ecological adaptability.

Study area and data source

Study area

Located in the hinterland of the Qinghai-Tibet Plateau and the northwest of the Sichuan-Tibet Plateau, the Kangba Tibetan region roughly coincides with the Hengduan Mountains in geographical scope and is the place with the most complex topographic changes in the world. The administrative areas include Qamdo Prefecture of Tibet, Garze Tibetan Autonomous Prefecture of Sichuan, Yushu Tibetan Autonomous Prefecture of Qinghai, and Diqing Tibetan Autonomous Prefecture of Yunnan (Fig. 1). Weizang area, Kangba area, and Amdo area are known as the three major Tibetan inhabited areas in China. Because of the unique geographical terrain of Tibet, Kangba region has gradually formed its own unique regional culture, customs, architectural structure, decoration, and color painting in the integration of Central Plains culture and Tibetan culture. Adhering to the concept of harmonious coexistence of ecological environment, reducing environmental pollution caused by buildings, and reducing energy consumption of building insulation, Kangba people build houses under harsh natural conditions such as high cold, lack of oxygen, lack of materials, backward technology, and inconvenient transportation. According to the conditions of the surrounding environment, they created a rich and colorful architectural structure and decorative culture. Therefore, it is of great significance to study the residential buildings in Kangba Tibetan area for understanding their ecological adaptability and energy-saving concept of construction.

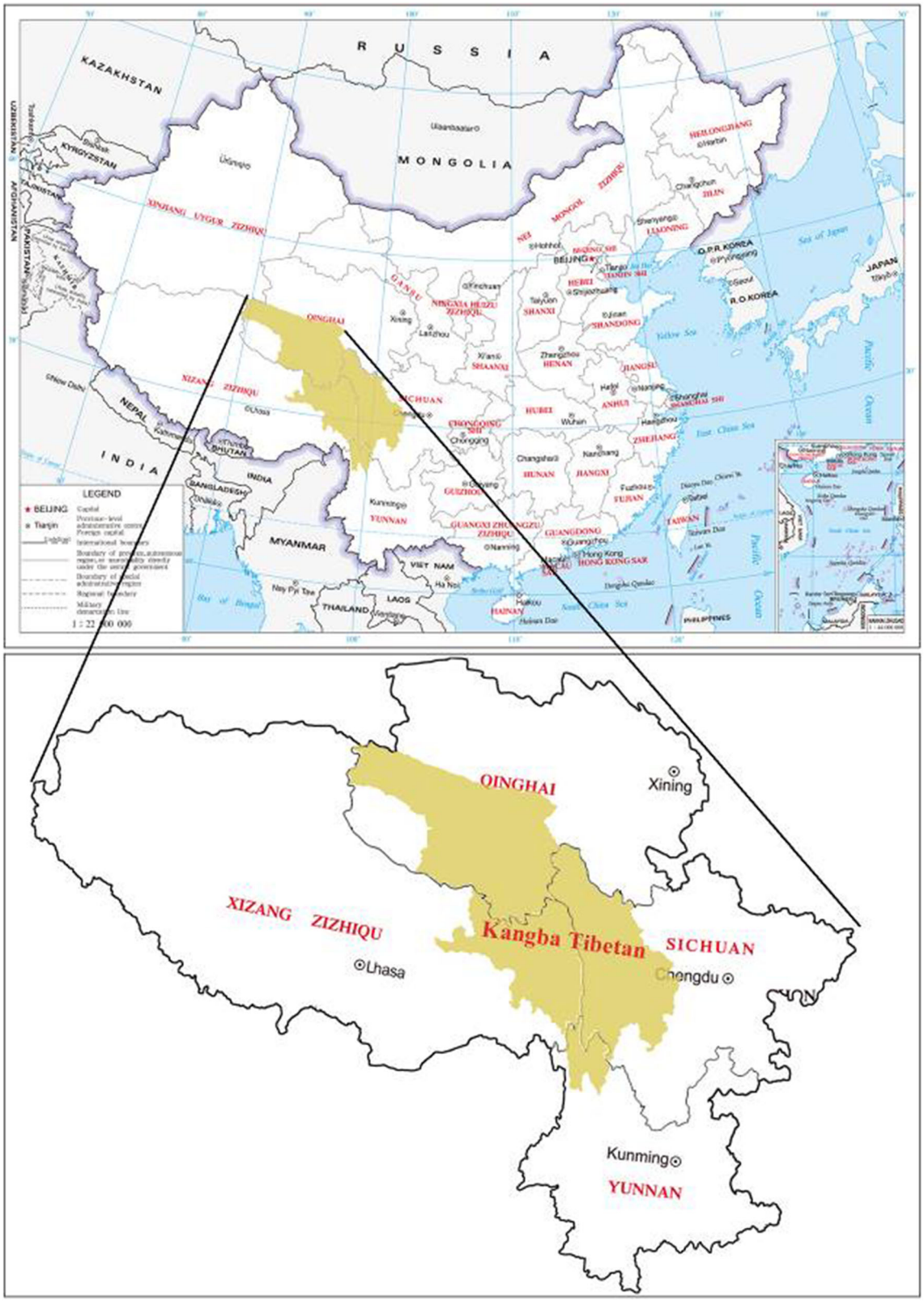


Fig. 1 Location map of Kangba Tibetan area

Data sources

The research methods adopted in this study mainly include field investigation, geographic mapping, and field interview, and the materials come from field investigation and data access.

Method

Because the whole area of Kangba Tibetan is located in the Jinsha River and Yalong River high gap river corridor area of Hengduan mountains area with average elevation of 3700 meters, it belongs to the alpine zone of the three Tibetan area. According to Residential Characteristics Research Report in Kangba area, 48.7% Tibetan houses are close to the valley, of which 65.6% are made of tiles, 24.7% choose the masonry, and 9.2% choose the logs. After the implementation of the 12th Five-Year Plan, new Tibetan dwellings started to use concrete-filled wall frame.

Adobe structures

In valley areas, rivers endlessly flow throughout the year, bringing fertile soil. Tibetan residents along the valley therefore used local materials, especially loess as the best material for the construction of houses. The construction of an adobe house concludes several main steps, including the choice and excavation of housing base, the selection of ramming material, the masonry of rammed wall, and the construction of floors and roofing (Barontini and Lourenço 2018) (Fig. 2).

According to Danzhu er, there is a statement about the choice of Tibetan residential site, "If a piece of land has a similar shape with a turtle's back, it will lead to death or poverty the owner of the land will be in the danger of annihilation. As a result, people should definitely avoid choosing such a place." If the foundation wall of the building is located on rocky soil, it often only needs to dig to about 15~25cm depth below the surface; if the foundation wall of the building is located on the sand, it often only needs to dig to 25~40cm depth below the surface; some even directly excavated from the ground; the specific depth of the foundation is based on the hardness of ground, the lay of the land, and the drainage conditions.

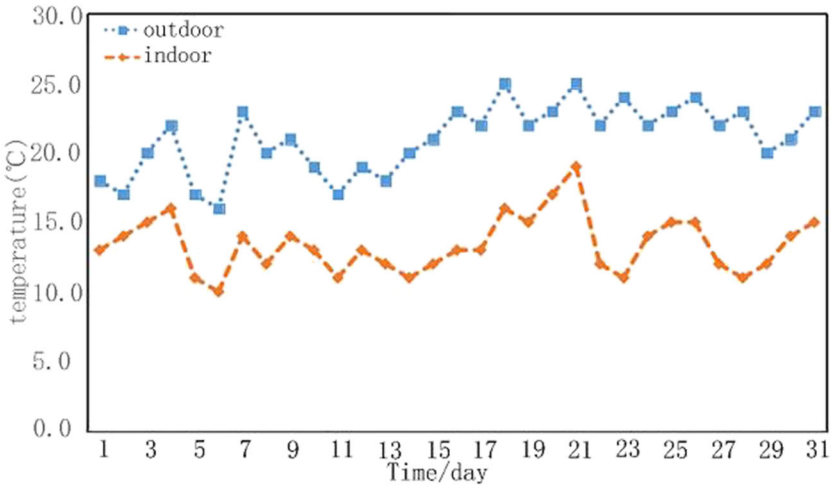
Fig. 2 Adobe ramming

The selection process of adobe materials for Tibetan houses is often very strict. Generally a Tibetan settlement or even a village will adopt a common land acquisition point. There are strict requirements for soil texture and sediment concentration and even for colors. Four stakes will first be installed inside and outside the foundation wall, and two sides of each stake will be tied with 25~35cm wide wood. After fixed, it will be filled with soil layer by layer. Inward wall will not only reduce the center of gravity of adobe wall and also be in line with the Tibetan aesthetic. The pouring of the roof is often more complex but very important. The roof cannot be stamped until the wall naturally air dried. The roof is generally first covered by a layer of wood with 2~4cm thick and 20~40cm wide and then covered by a grass mud surface mixed by highland barley bar and husk. Then it should be continually beat with a hammer to tamp down the earth, and 4~8cm is a better variable. Though the construction technology and materials of the adobe structures in Tibetan areas are very primitive, after the author's continuous room temperature test in winter and summer, it proves that this structure keeps the room warm in winter and keeps it cool in summer (Fig. 3).

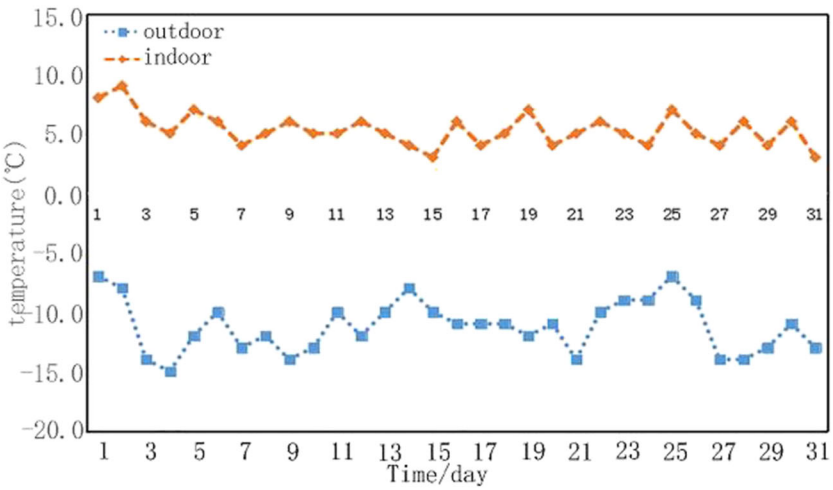
Masonry style

People are familiar with this traditional way of construction since ancient times. In after the Han Dynasty, South Mannan Southwest Biography, it stated that those people are inhibited on the mountains, living in stone houses. The early steps of the building of masonry houses are similar with that of adobe ones. As a result, some distinctive characteristics of masonry houses will be detailed. The masonry houses are rare in Kangba Tibetan areas, mainly concentrated in the areas with stone production and some mountainous areas (Acito et al. 2020; Belliazzi et al. 2021). Tibetan people, who have no other better choices or do not want to occupy the valuable land resources of the mountains and be willing to dig the mountain gneiss, will adopt this kind of building method (Fig. 4).

Due to the materials' characteristics and the relatively primitive mining methods, self-excavated gneiss often appears irregular in size and shape. Masonry way is also comparatively primitive and simple, using lager pieces to constitute a plinth from the foundation to the wall with about 800cm thick and then using stones with natural shape supplemented by mud and clay (blended with cattle and sheep hair and blood, etc.) as natural bonding materials to assemble the houses. The size and gap of stones lack obvious composition rules, showing a chaotic visual sense. There is one thing more



a)Summer indoor temperature



b)Indoor temperature in winter

Fig. 3 Indoor temperature measurements of the soil. **a** Summer indoor temperature. **b** Indoor temperature in winter

obvious: The bottom of the wall and the corner often use bigger stone, and it tends to use smaller stones future up the wall. Those houses made with irregular stones and original binder can stand still in the long years (Fig. 5).

Fig. 4 Masonry building complex

Logs dry

Most of the houses adopt logs styles, and the load-bearing frame is generally square column net. Whose vertical and horizontal space is usually same as 2.5~3.5m. The main beam is generally lengthwise arranged along the flat surface, and a few of them use horizontal layout. The end side will be assembled into the gable, even if flat surface appears a rectangle shape (Viholainen et al. 2020). Tibetan expert Mr. Chen Yaodong called it as "vertical frame." This is opposite with the main beam arrangement of modern frame structure. The connection beams are generally not arranged between two horizontal beams, but woods will be directly used to assemble the houses. Wooden strips are usually used as a transition, perpendicular to the beams. Above the wooden strips, two beams are intertwined and each of them extend from some

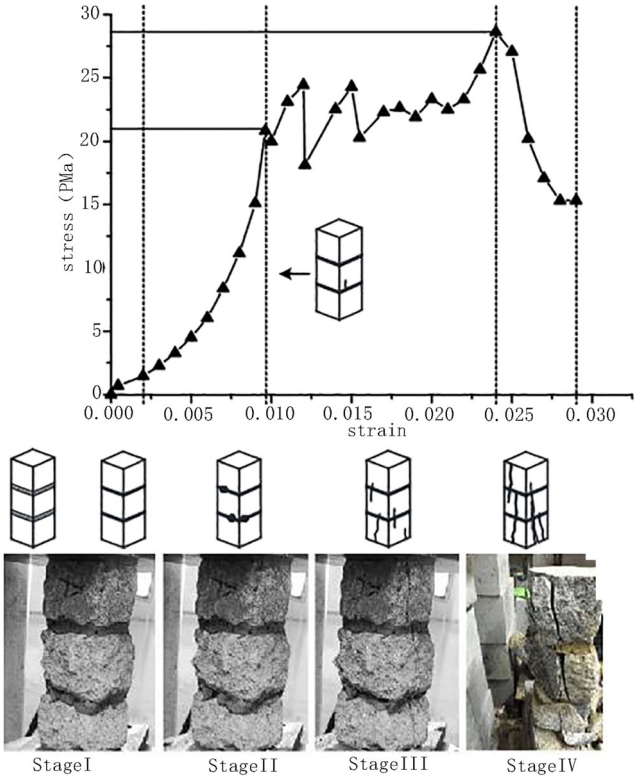


Fig. 5 Rubble wall compression test

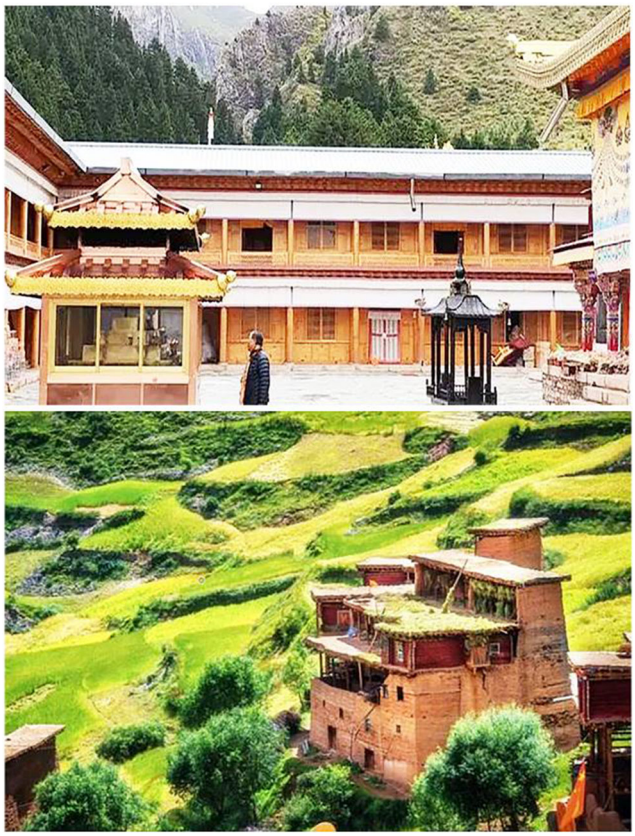


Fig. 6 Schematic diagram of flat roof and pitched roof

distance, which is quite different from the ancient riveting or nail handicraft in inland China.

The building styles of several hundred years houses in Kangba Tibetan are quite different with several buildings built in recent years. The old houses generally have relatively lower layers, and the new high houses are close to those in the inland areas, with floor height about 2.6~3.2m, while the connection methods of beams and columns have also changed a lot, similar to the form of riveting. The specific steps are the following: dig the top of the column into a concave surface, on which a beam is located. Under the beam, a purlin will be set up. The general diameter of a column is about 250~300mm and that in the living room is about 300~320mm. The wooden main beam is divided into two parts: upper one and lower one, generally made from pine and a few made from fir or other trees.

Tibetan houses are generally not measured with m^2 as a parameter. The size of a room is generally calculated by using the number of columns, such as a room with "two pillars and four beams" representing for eight column network units. There are two different types of roofs: flat roof and slope roof. Adopting which type of proof is mainly based on the local rainfall and preference of the owner. Owner generally has different requirements for water proof and drainage system. Flat roof is generally covered with thicker mud, with a linoleum in the middle and grass mud in the surface, which is conducive to drainage (Fig. 6).

Concrete-filled wall frame

Concrete-filled walls are also rare in Tibetan villages, mainly focused on the two sides of a walking or commercial street with government planning. There are three changes compared with abovementioned traditional construction methods, including structural systems, functional spaces, and external decorations.

The most obvious change in the structural system is that it is more complete than logs style. All the beams and columns are changed from traditional wood or civil structures to concrete beams, forming a set of vertical load-bearing systems. Adobe wall adopts a kind of horizontal load-bearing system, under which a "concrete-filled wall frame" is structured. The main changes in the new load-bearing system are that the bearing capacity is greater than ever before and the interior space is more concise. The bearing ratio of this kind of load-bearing system is the smallest one. However, through anti-seismic performance tests, compared with previous three methods, this method appears strongest seismic performance (Fig. 7).

At the same time, there is a new pattern of functional space and volume relationship, which has evolved from the traditional "livestock - living - church" vertical space into a modern "garage/shop - residence - church." In order to adapt to the

Fig. 7 Concrete-filled wall

new functional space requirements, the biggest change takes place in the bottom space. With new concrete frame system, it attains a larger bay and a larger door. Bottom space canceled traditional livestock partitions, and its shape turns into a pure square or rectangular.

Changes in the external decoration are also very obvious. The wall will no longer bear weight since the adoption of a new structural system. Taking the already built commercial residential as an example, the changes in filling wall lie in that the distance of gaps between larger stones is more and more regular. The window and the cornice are also made of brick or concrete masonry, and the form is different from that of the rafters, but the decorative pattern of the wood beams is preserved. The four corners of the white stone feet now generally use concrete or cement. Some new buildings even omit this kind of Tibetan traditional decoration.

According to the field investigation and the collection of test data, the Tibetan residential buildings made of four materials in Kangba Tibetan territory have their own characteristics. Adobe ramming has the best thermal insulation performance, rubble masonry has the strongest load-bearing capacity, log well drying has the best adaptability, and concrete-filled wall frame has excellent capacity in all aspects (Table 1).

Results

Architectural space layout characteristics

Kangba hiding indoor space is generally two or three layers, a layer of space is generally used for captive livestock and debris storage, two-story space is a family member of the resting place, three-tier space is mainly by the church and the balcony, and there are family elders living in three.

The first floor of Tibetan residential buildings is usually used for livestock breeding and storage. In order to keep warm, the columns are dense, and there is no window, only a small hole. Its lighting is relatively dark, its height is low, according to the field measurement, about 2.2m-2.6m.

The second floor is generally a living space, which is not separated by partitions, but divided into different sizes of bedrooms, kitchen, living room, storage room with wood. The most obvious entry into the room is a red wooden pillar called Sanhuzhuang, a symbol of the family's ancestors and gods. A brazier is usually placed on the floor in the center of the house, which is used to cook tea in summer and warm the room in winter.Along the door opposite the two wood partition, around the column is placed in two rows of high and low, Row for the back of the table for the chair.

The most important space on the third floor is the scripture hall, which is deep and spacious.The main function of the sutra hall is to place Buddha statues and ritual vessels needed for chanting sutras. Its pillars are decorated with colored paintings in the main colors of red, blue and blue. The red, blue, white, and yellow are the basic hue of the church, the ceiling and the walls are painted, the pattern is mostly Tibetan Buddhism Buddha story, in order to create a mysterious religious atmosphere, and the window has become a pure decoration. All in all, the layout of these internal spaces is to take full advantage of the vertical and horizontal building space partition and open to the internal furnishings, decoration and light color, and many other elements of contrast, creating a simple and warm family atmosphere and deep confusion religious worship (Fig 8).

Table 1 Comparison of Tibetan architectural structure system

Structural style	Heat preservation	Compressive strength (Kpa)	Shear performance (Kgf)	Combustion performance	Sound insulation (dB)	Corrosion resistance	Construction cost (yuan/m^2)
Adobe structures	Very good	≥130	60–80	Non-combustible	30–70	Good	1200
Masonry style	General	≥160	40–60	Non-combustible	20–50	General	950
Logs dry	Good	≥75	20–40	Combustible	20–40	Poor	650
Concrete	General	≥190	50–90	Non-combustible	20–70	Very good	1700

Architectural color and decoration

The features of exterior architectural decoration. The overall architectural color in Kangba Tibetan areas is red and black auxiliary by white, yellow, and cyan, reflecting Tibetan people's simple and unadorned character. The most important things for Tibetan houses' exterior decoration are the door and the window, especially the decoration of the window. Windows usually have various beautiful styles. A single window is generally decorated with two or three decorative treatments. The above two are often decorated with the stack of letters convex concave and white wood processing, and the upper and lower grid carvings are often displaced with each other. Its opening side is generally equipped with "Basu." Around the window, a circle of black or dark gray "Baka" will be decorated with various styles. Black and red ones are greatly distinct with each other (Fig. 9). Cornices are built with a 3–5cm white ribbon as coping and then assembled with light decorative walls.

The features of interior architectural decoration. Mangkang's houses have a "simple outside decoration and has a gorgeous inside decoration." The biggest indoor feature is its painting, wooden handicraft, and furniture. From the indoor pillars, Queti, wooden partition to the ceiling, colored drawing can be seen everywhere. Interior colored painting is mainly composed by blue and red colors supplemented by green and yellow. The color saturation is also softer than that of the outside. There are three main types of architectural composition and design: concentric composition, central composition, and sub-format composition. The main theme of colored painting is Eight Swiss Phase, Qibao Phase, Tibetan plants, etc. In addition, some individuals prefer Six Longevity, Five magic, and so on. Engraving is also important in Tibetan architecture, especially used in the wooden partitions between houses with classic "words," "rhombus," and other elements (Fig. 10).

Discussions

Village centripetal layout

The distribution of the Tibetan villages in the city of Kangba Tibetan can be divided into centripetal layouts around the sacramental tribute temple and scattered layouts based on the surrounding surroundings. These two very different dwelling arrangements can be grouped into natural geography factors and spiritual life factors.

Natural geography factors. When building houses, Tibetans first consider whether there is sufficient water source in the surrounding small environment. The direction of the opening, this type of habitat generally along the contours of horizontal layout, the shape of the combination of terrain, free stretch, in the undulating terrain on the mountain to choose a relatively flat platform to build housing.

In the early years, due to the fear of all unknown things, tibetans developed a primitive worship of mountains, trees and stones. After the introduction of Buddhism, Tibetans'

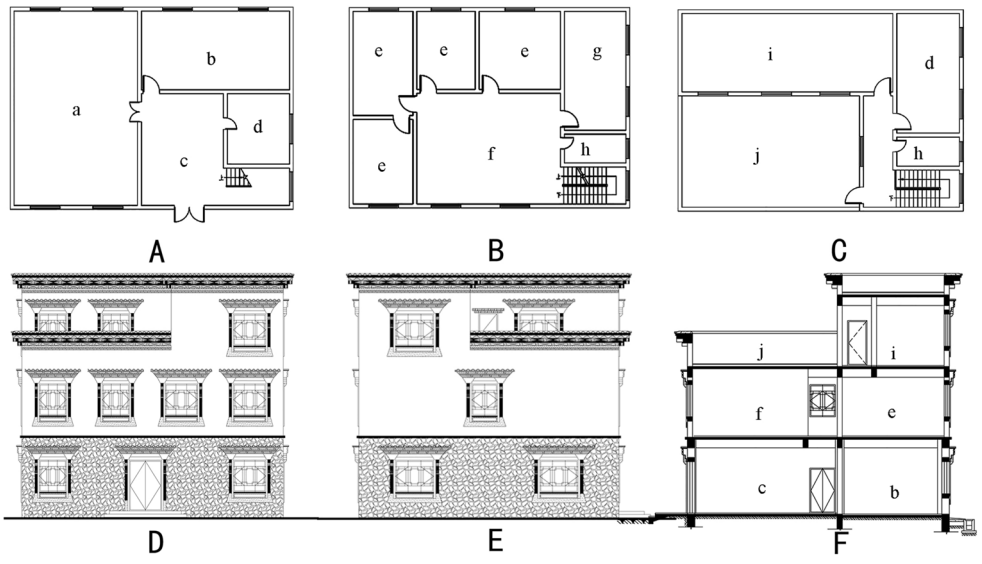


Fig. 8 Schematic diagram of the spatial layout of the shelter. **a** Bull ring, **b** sheepfold, **c** the hall, **d** locker room, **e** bedroom, **f** reception room, **g** the kitchen, **h** toilet, **i** Buddhist temple, **j** roof terrace

Fig. 9 Exterior decoration

worship of religion was not only reflected in ritual customs such as chanting sutras in the morning and evening, but also reflected in the layout of buildings. Among them, there are 103 households in Xiushui Village, Quzika Township, Tibetan Area of Kangba, among which 62 households are located around Tibetan Buddhist Lagong Temple.

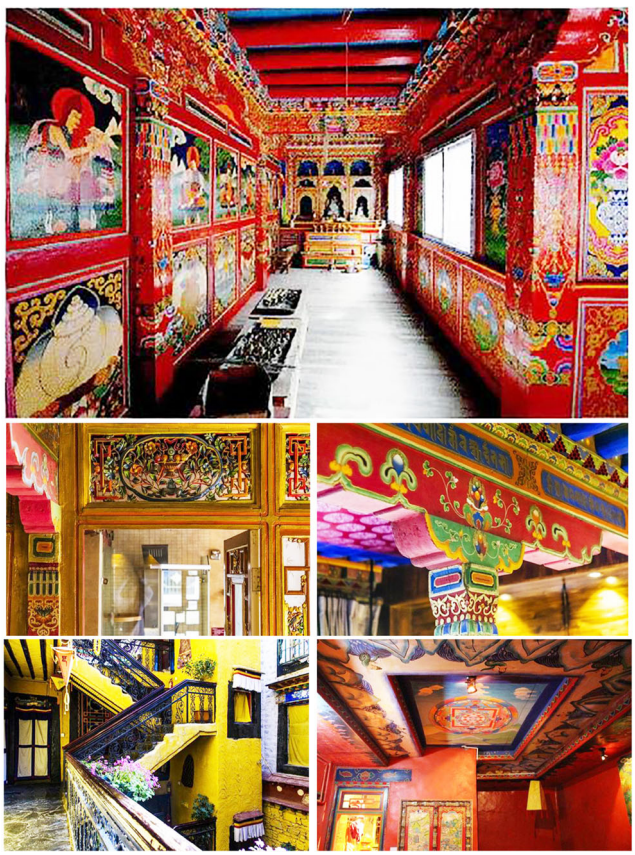


Fig. 10 Interior decoration

Villages are naturally distributed in layout

The natural layout of Tibetan residential buildings is generally distributed between the slopes and ravines. Willow trees are planted around the houses and many fields are cultivated. According to the survey, one of the Tibetan buildings consists of front yard, residence and backyard, covering an area of 2130km^2 with a construction area of 682km^2.The residence has been built for more than 10 years, with more than 20 people living in it. At present, the permanent resident population is 13 (Fig. 11).

There are trees all around the yard, timber in the front yard, and farmland around the back yard. The whole yard around the grower plateau red willow, standing in the front yard to see the building front, light shape, elegant color. The main house for the typical adobe Ramming, the roof for the wear-style wooden structure flat roof, three residential, about 11.5m high. A layer of captive livestock, the second floor for the living, three for the Church and the balcony.

A layer of space was L-shaped, which is divided into three parts with a wooden grille, the largest is the bull ring, followed by sheep and firewood, the upper space of the pillars all fall to a layer, about 22, 2.2m, or so, surrounded by no windows, only a few small holes, taking into account the ratio of area and height, a layer of space appears dark and narrow.

The second floor is the kitchen and living space and the bedroom and the living room through the secret door directly connected; there is no transition space, and the wooden partition can be directly disassembled; it is because the family members of the changes, and flexible settings. When the family members can be more time to split the big bedroom into many small bedrooms, and vice versa. Indoor painting pattern is particularly rich, the color is also very full, but the bedroom bed is extremely simple, only a board with a bedding. The

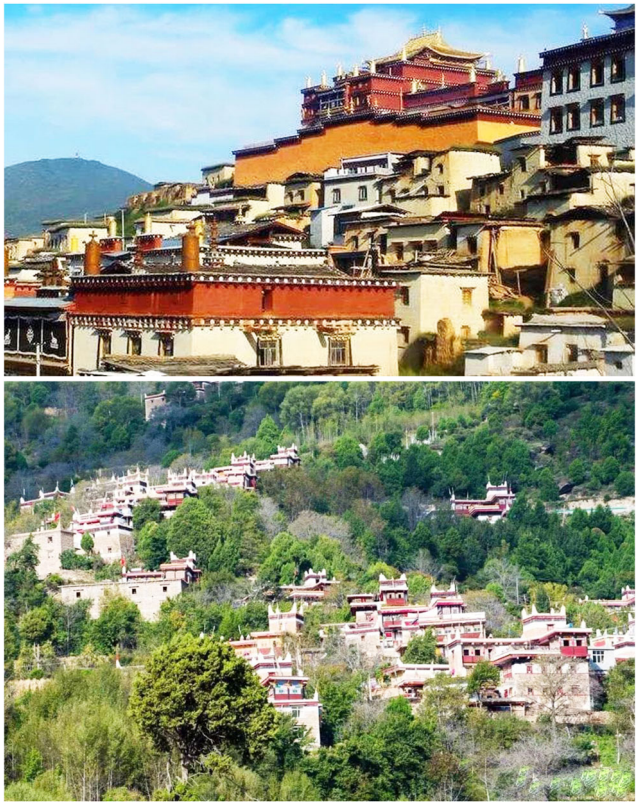


Fig. 11 Tibetan folk ecological layout

third floor has a large church, with an area of 56 m^2, and occupies a quarter of the roof; in the hall, three statues of Buddha and a large number of Buddhist scriptures and related religious instruments are placed.

Conclusions

Tibet is located in the southwest of the Qinghai-Tibet Plateau in China, with vast territory and rich resources. It has a harsh natural environment, such as high cold and high radiation and large temperature difference between day and night. In order to adapt to the natural environment of Tibet, Tibetans have accumulated the experience of using ecological materials to build residential buildings in thousands of years of exploration. The purpose of this paper is to extract the technical process and color decoration culture in the construction process of Tibetan residential buildings in order to adapt to the harsh natural environment. This paper first introduces the geographical location and national culture of Kangba Tibetan area and analyzes the four ecological structures of its residential buildings. It analyzed the interior layout characteristics and cultural custom connotation of residential buildings and further introduced the architectural decoration characteristics and decorative color painting. Finally, it analyzed the village layout forms of two different cultures.

The results show that the adobe ramming type mainly includes the selection of building foundation, excavation, rammed material, rammed wall masonry, and floor and roof construction. It is built with soil, rocks, and logs from the natural environment, but it has a better insulation effect. Rubble masonry type is mainly distributed in mountainous areas and stone producing areas, which is mainly made of irregular gneiss, supplemented by clay, and formed by repeated processing. Its compressive resistance is strong, but its shear and torsional resistance are weak. Log well dry uses log masonry, generally for square column network load-bearing, roof has flat top and slope two kinds, and its thermal insulation and seismic performance are better. The concrete-infilled wall frame is composed of horizontal and vertical load-bearing system, and the wall is filled with masonry, so its internal space is larger and cleaner, and its seismic performance is stronger. Tibetan residential buildings generally have two or three floors. The first floor is the enclosure and sundry room, the second floor is the rest place, and the third floor is the Sutra hall and sun terrace. The first layer is mainly for keeping cattle and sheep warm at night, and the window hole is small, leaving only an air vent. In order to adapt to the changes of family members, the second floor generally does not have a fixed wall, but is only separated by a screen to form a dynamic space. The third floor is mainly decorated with oratory, for family members to pray in the morning and evening, and a sundeck for drying grain and meat products. The overall outdoor color of Kangba Tibetan building is mainly red and black, supplemented by white, yellow, and green, showing the plain Tibetan characteristics. The interior is full of painted patterns, mainly including concentric composition, central composition, and sub-format composition. The interior is mainly blue and red, supplemented by green and yellow, with wood carving and furniture. The overall layout of Tibetan villages can be divided into the centripetal layout with the temple as the center and the scattered layout adapted to the mountain environment.

The ecological adaptive construction characteristics of Tibetan residential buildings provide a new sustainable development direction for the current global urbanization process at the cost of the ecological environment. The idea that it is derived from nature and fully adapted to the mountainous landscape and coexists harmoniously with the surrounding ecological environment is worth thinking about the root causes of the current global resource shortage, climate warming, and biodiversity degradation.

Author contribution Yufeng Wang: Conceptualization, methodology, software, investigation, writing original draft, validation, formal analysis, and visualization

Hongjun Cao: Resources, writing - review and editing, supervision, and data curation

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Data availability All data generated or analyzed during this study are included in this published article.

Declarations

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Consent to participate Not applicable

Consent to publish Not applicable

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