Research on the renovation of Jiarong Tibetan traditional residential building based on the improvement of comfort and safety -- take JiaJu Tibetan village as an example

Sijia Sun¹, Yaqiu Ren², Yuchen Li³ and Yawen Zhou⁴

¹Collage of Architecture and Urban Rural Planning, Sichuan Agricultural University, Sichuan, 611830, China
²Collage of Architecture and Urban Rural Planning, Sichuan Agricultural University, Sichuan, 611830, China
³Collage of Forestry, Henan Agricultural University, Henan, 450003, China
⁴Collage of Architecture and Urban Rural Planning, Sichuan Agricultural University, Sichuan, 611830, China

*Corresponding author’s e-mail: 13550162156@163.com

Abstract. Jiarong Tibetan houses are still not adapted to the Tibetan environment to a large extent, and some of the houses have fallen into disrepair and the living environment of Tibetan people is extremely poor. Most of the previous studies failed to put forward specific and targeted suggestions, so the improvement of Tibetan living environment could not be implemented. Based on the previous literature, this paper attempts to deeply analyse the significant problems of jiarong Tibetan traditional residential buildings, such as severe cold wind penetration, unreasonable functional layout, and poor seismic strength of building components, through the combination of theoretical analysis and experimental simulation, feasibility of high update scheme is put forward, aimed at the next Jiarong Tibetan folk architectural design to provide the reference.

1. Research significance

Since ancient times, jiarong Tibetan village has made use of the characteristics of stone in this region, using yellow mud as a binder to build houses with stone walls. The way that tired lime wall, wearing huge wood as beam is unfalling up to now. However, in the survey, it was found that the villagers’ living environment was poor, and the seismic performance of many ancient traditional dwellings also declined significantly, and there were varying degrees of problems such as poor thermal insulation of the envelope. On the other hand, the local solar energy is abundant and the natural resources are sufficient, but the utilization rate is very low. It is necessary to improve the living environment from the perspective of improving the quality of life of villagers or the construction and development of villages and towns. If foreign modern building technology and modern material is used to achieve this goal, economic and technical threshold does not allow to conform to the current development of local economy. Therefore, based on the Jiarong Tibetan local residential construction technology, in the perspective of architecture, the aim of improving the living conditions of Jiarong Tibetan traditional dwellings can be realized by improving and updating the traditional houses in accordance with the requirements of ecological and environmental protection. The economic and technological feasibility
is high and the ecological and environmental benefits are good. It is beneficial to the sustainable development of ecological environment and economy and society in Jiaju Tibetan area.

2. Case introduction
By referring to the data for comprehensive comparison, this paper selected jiaju Tibetan village located in danba county of ganzi Tibetan autonomous prefecture as the case study. In jiaju Tibetan village with low economic and technological level, the existing local dwellings have poor thermal insulation performance, serious indoor heat loss and high energy consumption, and the indoor walls are dew and moldy in winter, resulting in poor living environment. Weak links are mainly reflected in: external walls, roof, Windows, flue. In addition, there are also poor supporting facilities, poor sanitation and other problems. How to build a comfortable, safe and practical house under the premise of maintaining its style and features is the focus of this paper.

3. Measures of renovation
3.1. External wall insulation
These existing rural houses generally have problems such as poor indoor thermal comfort and large building energy consumption. Through the actual investigation, it is found that there are large cracks in the wall made of stone, brick and wood, which is the fundamental reason.

Based on this, it is suggested that, on the one hand, grass-mud clay is made from local materials with low labor intensity, simple construction and low cost. The cost per square meter is 2-3 times lower than that brick-concrete structure, which is more suitable for local economic conditions. On the other hand, soil wall has strong heat storage capacity and crop fiber has strong heat insulation performance. The grass-mud clay has a strong local flavor, which is ecological and native. In addition, the grass-mud clay material does not contain substance harmful to human health. It does not pollute the environment during construction and use.

Local Tibetan-style residential walls are mostly assembled by stone, brick and wood. The following are the key points of the combination of grass clay and existing walls.

3.1.1. Combination with stone wall
The stone of the house in the process of assembling. It is to use silt agglutinate commonly between stone and stone, occasionally can also be seen to cement with three clay mortar. As a material with both caulking and internal heat preservation function, straw mud can be directly applied on stone walls to improve the thermal performance of stone walls. However, because the stone wall is relatively smooth, directly on the grass mud, not easy to hang. So, must pay attention to certain method. The key points of the combination of grass mud and existing stone walls are as follows:

1) Basic level preparation: before putting the grass mud, should sweep the floating ash on the stone wall, and sprinkle some water on the stone wall, wet the stone;

2) Composition level: generally, the grass mud can be divided into several layers, such as bonding layer, insulation layer, surface layer and decorative layer.

3) Thickness control: the grass mud thickness of the bonding layer should be about 10mm. As a thermal insulation layer, the thickness of grass mud should be 40-50mm in cold areas. Generally, layered construction is required, and the thickness of each layer should be controlled within 20mm. The thickness of the surface layer shall be controlled within 6mm, and also layered construction shall be required. The thickness of each layer shall be controlled within 3mm. The thickness of decorative layer should be controlled at 2-3mm, which is generally completed in one time;

4) Material control: generally speaking, the grass mud used for binding layer, insulation layer and surface layer should be mixed with crop fiber. And the grass mud of adornment layer, need not mix crop fiber, only clay is enough;
5) One thing to be aware of is that in some areas of our country, the stone wall is used in the practice of wooden columns. At this time, the total thickness of the grass mud layer, generally is half of the column diameter, easy to stick the board, to prevent the grass mud off.

3.1.2. Combination with brick wall
The heat preservation ability of hollow brick is better than that of solid clay brick, and the masonry efficiency is also higher than that of solid clay brick. Compared with the traditional stone wall, the appearance of brick wall is relatively dull. From strengthening heat preservation, reducing the gap between beams and columns, doors and Windows and the wall and protecting the overall appearance of the village, it is suggested to add grass and mud surface layer inside and outside the brick wall. The combination of grass mud and brick is similar to the combination of grass mud and stone. The difference is mainly reflected in two aspects: 1) because the brick is rougher than the stone surface, the grass mud is easy to hang on the brick surface; 2) compared with the stone wall, because the size of the brick is regular and equal, the surface of the brick wall is more flat and smooth, so the large grass and mud surface is not easy to hang on the large brick wall. There must be some method. The main points are as follows:

1) Roughening of the base: before applying the grass mud, draw a few lines on the brick wall with a hard tool to make the surface of the brick wall rougher, and then apply the grass mud to promote the combination of the grass mud and the brick wall;
2) Wet the base: wet the bricks with water before putting mud on the grass;
3) Water control: due to the strong brick water absorption, and in order to prevent the grass mud strength is not enough and dry crack phenomenon, the water should be larger when mixing the grass mud;
4) Thickness control: in accordance with the vertical situation of the flat surface of the base, the center of the wall is the midpoint, do ash cakes about one third of the corners from the wall, ash cakes about 50mm*50mm size, it is a control point of the thickness, the ash cakes are pulled up with a line, so that there is a thickness of the reference line when plastering mud. In general, 3-4 layers of grass clay, 30-40mm. Cold areas can be slightly thick to enhance insulation, about 40-50mm.

If a finished building is a brick or hollow block, metope have cement mortar plastering level off, smooth, not easy to hang live grass mud, this case is a good idea to draw some scratches on metope, rough surface easy to combine with grass mud, and then put a layer of glue adhesion agent, can be twice as much as 108 glue with water, because the glue is easy to kill, evaporation part when it's so wipe, part of the sequential daub, wipe out a small piece of metope, in this piece of lac wipe grass mud on the wall, or clay mortar, so the entire wall of one piece with grass mud or clay mortar, its thermal insulation performance is improved.

3.1.3. Combination with wooden board wall
In some parts of our country, the attic is a common architectural form, and these attic people are made of wood. Because of the poor insulation performance of the single-layer wooden wall, it is necessary to spread grass mud on the indoor surface of these attics to improve the insulation performance of the wall. Compared with stone wall and brick wall, wood wall is more flat and smooth, and grass mud is not easy to hang on it. So also must take some measure to undertake processing. There are two ways to spread grass mud on the board:

1) First, nail a few boards about 50mm thick on the board wall, and divide the larger board wall into several pieces.
2) Spread mud on a "straw mat" or wire mesh so that it is easy to apply. In this way, the binding force between the grass mud and the board is enhanced, and the heat preservation performance of the wall is also improved.
3) Finally, a layer of grass mud was applied and the surface was pretreated. It should be noted that the proportion of sand on the final coating layer was slightly higher than that of the previous one to prevent the grass mud from cracking due to drying.

Method 2:
1) Same as method 1, Nail a few about 50mm thick boards on the board wall, and then in each small cell inside the board wall, the spacing of the nail into about 3 cm long small nails, nails protruding surface part about 1-2 cm. Too long nails are easy to cut their hands in the mud, a thick network of nails forms on the surface of the wooden wall;
2) Then the hay mud into some piles, to the nail net flail hay mud stack, until the nail level. In this way, It not only enhances the binding force between the grass mud and the board, but also improves the insulation performance of the wall.
3) Hang the protective screen made of plant stem on the plastered grass mud, namely the net woven by crop fiber;
4) Finally, apply a layer of grass mud and apply the plaster.

3.1.4. Thermal analysis of grass-mud insulation wall

It can be seen from the above that the cold air permeates heavily in the original residential buildings. After the indoor application of grass-mud clay, it plays a role of caulking on the one hand and improves the thermal performance of the original walls on the other hand. Specific calculation and analysis are shown in table 3-1:

| material       | Thickness (mm) | Thermal conductivity (W/m·K) | Thermal resistance (㎡, K/W) | Heat transfer coefficient (W/m·K) |
|----------------|----------------|-------------------------------|-------------------------------|----------------------------------|
| A stone wall   | 500            | 1.51                          | 0.33                          | 3.03                             |
| Brick wall     | 300            | 0.7                           | 0.19                          | 5.25                             |
| Wall of wood   | 100            | 0.15                          | 0.67                          | 1.49                             |

The thermal conductivity of the mud is lambda = 0.58w/m·K, assuming 150mm of mud, and the thermal resistance of the mud is R=0.26. Calculation table 3-2 of heat transfer coefficient of each wall after renovation:

| material       | Grass mud thickness (mm) | Thermal resistance (㎡, K/W) | Heat transfer coefficient (W/m·K) | K value change |
|----------------|--------------------------|------------------------------|----------------------------------|----------------|
| A stone wall   | 150                      | 0.59                         | 1.69                             | 1.34           |
| Brick wall     | 150                      | 0.45                         | 2.22                             | 3.05           |
| Wall of wood   | 150                      | 0.93                         | 1.07                             | 0.42           |

As can be seen from table 3-1 and 3-2, the heat transfer coefficient of the transformed wall is significantly reduced. According to the energy saving standard, the heat transfer coefficient of the external wall of the house below floor 3 is under the condition of external insulation0.45. However, the temperature difference between day and night in the local area is large, and the economic and technical level is low. The existing houses are relatively simple, and the grass-mud clay belongs to the inner insulation layer. Compared with the original building, the external wall insulation has been greatly improved. At the same time, according to the actual situation, the thickness of the grass-mud wall can be increased to further improve the insulation of the wall.

3.2. Tightness of doors and Windows

Taking the climatic characteristics of jiaju Tibetan village in danba county, sichuan province as an example, the weather in winter is sunny and the solar radiation is heavy, which means it's very valuable to use solar energy here. If the thermal insulation and airtightness of the form can be improved, the indoor thermal environment can be greatly improved. In heating season, in addition to
the south to the window, the solar radiation north to the window are very few, and the heat loss of the window is just greater than the heat loss of the wall, and as a result, the north window should be as small as possible, but considering daylighting, the east-west window can be appropriately increased, but the area should not be greater than that of the window wall area of a quarter of all the direction of the window insulation to take necessary measures to prevent the collected heat loss at night during the day. For south window in the area with sufficient solar energy like jiaju Tibetan village, heat loss is still more than heat gain if using window of monolayer wood only or window of monolayer aluminium alloy only, but it will be a component that gets heat if using window of monolayer double glass or double layer only.

3.2.1. Reconstruction of the door gap
The door gap is a weak part of the house's thermal environment, which is a place where heat loss is serious. Therefore, it is recommended to add a door frame to increase the tightness of the door and avoid the occurrence of a cold bridge.

3.2.2. Renovation of window gap
The practice of reducing the gap between doors and windows is as follows:
1) Replace traditional wooden windows with plastic steel windows. The frame fans of the plastic-steel window are connected to each other, and the cold wind has to turn 2 to 3 bends. The heat loss resistance is much larger than the traditional flat wooden windows;
2) If wooden windows are still used, seal the window glass and sash joints or seal with putty. This practice is mostly applicable to wooden windows;
3) Add a sub-frame to the joint between the window frame and the sash, and attach a sealing strip;
4) The connection between the door and window frame and the wall is filled with fibrous material, and then the window hole is used to block the joint. This method is also a decorative and practical architectural vocabulary used by the vast Tibetan areas;
5) Adding curtains can improve indoor comfort. Because the heat is transferred from the indoor to the outdoor in the winter, the window glass has a hot barrier body, which acts as a resistance to heat transmission. There is one more layer of glass, that is, one more thermal barrier, and one curtain and one more thermal barrier. After the curtains are added, the temperature of the inner surface of the winter is of course much higher than that of the unsafe, which not only reduces the loss of heat outside, but also saves heat energy, and the heat exchange with the human body is much smaller, making the human body feel more comfortable. The characteristics of the curtains can be adjusted according to the needs of use. During the winter, the light and heat can enter the room, and the curtains can be closed at night to strengthen the insulation.
6) Adding curtains also has a good cold protection effect. The winter wind is high and the temperature is low. Even if the small window is not closed, it will lose a lot of heat. If the big door is not blocked, the cold wind will blow in directly, and the limited internal heat will be quickly lost to the outside. Although it may be just a stairwell or a corridor that leads directly to the outside, there are doors and partitions inside, but the inner and partition walls are generally not well insulated. That is to say, the heat preservation effect of the outer protective structure is abandoned, so that the cold air directly contacts the inner wall and the inner door which are much larger in area, the heat loss is multiplied, the temperature is lowered, and the comfort is deteriorated. If you can carefully hang the curtain and don't artificially destroy it, everyone will improve the thermal environment of the entire building.

3.2.3. Renovation of window sash
1) Increase the sash
   In addition to the caulking, most of the residential windows are single-story windows. When the windows are energy-saving, a second layer of glass is added to the single-story window to become a single-frame double-glazed window. The principle of heat preservation is to use a good thermal
insulation effect between the two layers of glass to obtain a large thermal resistance and save heating and heat consumption. Recently, some simple and reliable methods have been created, in which a second layer of glass is added to the wooden window. At present, there is no caulking measures for the wooden window glass of each village in Jiaju. Be sure to use a putty to seal the glass after fixing it with a nail. When the double glazing is added, the airtightness of the middle air layer is better. If the original window is a wooden window, then the wooden window frame is first nailed outside the wooden window, then the glass is glazed, and the nails and putty are finally nailed.

2) Transparent film
An economical way is to affix a transparent plastic film on the inside of the window frame to form an air gap between the film and the window glass of about 15 to 20 mm, which can save 60% of the heat transfer energy of the window. The room temperature is increased by about 2°C in winter, and condensation on the window glass can be avoided. In order to effectively set the transparent film, it is necessary to first select the film material. It is not suitable to use a film which is easy to age and brittle and gradually becomes milky white. It is the most suitable film for adding window. The tensile strength of polyester film is l/2~l/3 of steel, the impact strength is 3~5 times that of other films, and the film changes slightly with temperature. When the temperature is between 30°C and +30°C, the film size is basically unchanged, and when the temperature is higher, it is slightly shortened. This material can be used for many years, the price is much cheaper than glass, and its light transmission performance is similar. In the window glass, it is not easy to age, and the durability is very good. In addition, the chemical properties and water resistance of the polypropylene film are outstanding, and the elasticity, abrasion resistance, heat resistance and gas barrier property are good, and the transparency is superior to that of the ordinary flat glass. The price is quite low. Use on the window for 1~2 years. It is difficult to paste the above film. Do not use any adhesive. Do not stick them with a variety of adhesives. The easy way is to use tape, preferably double-sided tape. Before bonding the film, carefully check the window frame, repair the peeled glass putty, and clean the window frame and glass. If the inside of the window glass is not clean, it is inconvenient to clean after the film is applied. Such as bolts, handles, wind hooks, etc., those who obstruct the paste film should be removed first. If there is dust and dirt on the window frame, it should be cleaned first, otherwise it will affect the bonding effect of the film. The shape of the window frame is accurate, and the film is cut according to the size. The double-sided tape is cut into strips according to the width of the window frame, the anti-adhesive paper is peeled off, the tape is attached to the window frame, and the other side of the anti-adhesive paper is removed. The film can be pasted. When sticking, pay attention to tightening and avoid wrinkles, stick it from the upper left end, and gradually stick it to the lower right end. When wrinkles occur, the film can be slowly picked up, straightened and re-attached. Position is good. After that, you can't leave a gap, use your fingers. Press one by one to prevent dust from entering. Use a blade to cut off a slightly wider excess of the film. Finally, install the removed window fittings such as latches, handles, and wind hooks.

3.3. Roof permeability
The roof is the place where the grass is piled up. If there is no gable seal, if the roof is full, the grass has a certain heat preservation effect, but when the roof is used up slowly, it will no longer be warm, the heat will be taken away by the cold wind, and the indoor ceiling often condensation. The solution is to directly pour grass mud on the roof slab or make hanging items indoors. Use asbestos or rock wool as insulation ceiling. It is best not to use the Polaroid board for the ceiling, because the use of the Polaroid board will lose the characteristics and color of the Tibetan ceiling. The degree of sealing of the attic gable directly affects the thermal comfort of the top floor. If the hole is opened, the heat loss is too large, which may cause condensation on the ceiling of the top floor. It is best to strengthen the gable seal while thickening the attic floor. After all, when the tourist reception is made, the guest housing is more at the project level. And foreign guests are often much worse off than the locals. In fact, the local traditional roofing method with thickened mud layers is very good. If there are too
many storages in the attic, it is not convenient to thicken the ground. You can also use the ceiling of the top floor to add insulation ceiling.

3.4. Bathroom environment
Local houses usually have hanging toilets on the second floor. There is no toilet on the first floor. It is inconvenient to use. Therefore, the toilets can be set up on the upper and lower floors to form a prominent additional space. The upper and lower toilet positions are staggered, so that the excrement on the second floor falls directly. In the pit, people who do not affect the toilet on the first floor.

3.5. Solar energy utilization
In Danba County, Sichuan, there is sufficient sunshine and large temperature difference between day and night. Under this climatic condition, passive sunlight can be added on the outer side of the layer. The sunlight is the climate buffer zone to buffer the large temperature difference between indoor and outdoor. The advantages are as follows:

1) Simple structure, no complicated pipeline ventilation system is required;
2) Low cost, the engineering cost of the solar house is only 5% m12% higher than the ordinary project cost;
3) Maintenance and management is convenient, no professional technology is needed.

Personnel maintenance management. For the renovation of existing residential buildings, add additional sunlight, without changing the structure of the house, just add a sunny room at the entrance. The roof and walls of the sun can be made of glass or only the wall is made of glass. Although the transparent area of the transparent material will increase in winter, the shading problem in summer is not easy to solve, so most of the roofs are made of opaque materials.

4. Conclusion
The updated design of the traditional residential buildings of Jiarong Tibetans should be based on the principle of architectural culture inheritance and comfort improvement. It is most suitable to use local building materials, grass mud clay, and at the same time pay attention to the construction methods and steps during the transformation to give the best performance. Due to the serious infiltration of cold air from local buildings, strengthening the tightness of doors and windows is the key goal of renovation. Double-window windows should be used and film should be applied. In view of the rich characteristics of local solar energy resources, it is recommended to add sunlight in the south and pebble heat storage layer to maximize heat.

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