Investigation and Analysis of Earthen Architecture in the Dabie Mountain Area

Xinxiong LIU, Jie XU, Hao WANG

Department of Industrial, Huazhong University of Science and Technology, Wuhan, Hubei 430074, P.R. China

Abstract — Getting to know the real structure and present situation of the earthen architecture in different areas of our country and in different forms, and the different effects on the environment and human inhabitants, can provide a theoretical basis for future study of earthen buildings. There are many earthen buildings in Dabie Mountain area, we investigate and analyze it to learn more.

Keywords - earthen buildings; Dabie Mountain; investigate and analyze the earthen building; advantage and disadvantage

I. INTRODUCTION

Behind the prosperous culture of the modern building, there hiding the ecological and environmental health crisis. Nowadays, it is a major problem the construction industry faced that in the thriving construction market of traditional building gradually lost, the destroy of traditional architecture and the environment in the movement of city building, the shock of environment and traditional architectural culture from the globalization. Many contemporary landmark in China, ignore Chinese traditional architectural culture, and the inheritance and development of traditional earthen buildings, and give up exploring on the connotation of China traditional earthen architecture culture, which is the cause of the traditional earthen buildings have a tiny bit of land. In view of the strong architectural culture from current globalization, the traditional culture located in the "weak", may lose self creativity and competitiveness and be submerged in the tide that "architectural convergence", if lack the inherent vitality, have no clear direction of development and self-improvement consciousness, and have no protection and development of consciousness.[1]

Getting to know the real structure and present situation of the earthen architecture in different area of our country, and in different forms, and the different effects on environment and human, can provide a theoretical basis for future study of earthen buildings. It can also promote the popularization and use of earthen architecture, then it can form the standard. Then it can promote environmental sustainable development, and promote the development of economy, at the same time for environmental protection has also played a role in promoting. Earthen buildings as a kind of culture, they can influence each other with political and economic, human and environment, and promote culture, value, art be better together.

Earthen buildings as one of the earliest human form of construction, have been left in many ancient culture places, like ruins of the Great Wall, tombs of ancient and ruins of ancient city, we can see the traces which the ancient built buildings with earth. The raw soil construction widely were distributed almost all over the world. As a result of the different geographical and soil, the form, materials, methods of construction are also not identical. Due to the dry weather and little rain, the cold winter, the earthen buildings in the north of our country have low base and short eaves, thick walls, and mainly have a flat roof and low slope. The construction method is building the contour with wood and then the walls with mud brick. Mud brick is made of mud with water, straw, hemp material. The buildings have a base built by stones in mountain area, and mixed building wall. In the area of South China, due to more precipitation, the earthen buildings have high foundation, longer eaves, and larger slope which is good for drainage [2].
Through the investigation and visiting of the earthen architecture in Dabie Mountain Area, we can analysis and set forth the advantages and disadvantages of traditional earthen buildings in scientific and systematic way, and explore the way of transformation and the development trend in the future of construction technology of "earthen building" actively. Promote green living space, clear "the design concept of earthen buildings", truly based on environment, serve the people's common survival philosophy. With the rapid development of society, the global environmental problems have become increasingly prominent, face many problems. Nowadays, under such circumstances that all human in the face of climate change, common crisis of air pollution and resources shortage, sustainable has become the mainstream of contemporary social development. Due to construction activities consume a large amount of resources and create a large number of pollutants in the environment, the problem of development sustainable buildings need to pay more attention to. Under this background, the energy-saving emission reduction, construction intensive society was strongly advocated. Therefore, "earthen building" as one of the many environmental protection measures, will be presented.

II. THE INVESTIGATION CASE IN DABIE MOUNTAINS

The investigation of the earthen buildings in Dabie Mountain area, take the area from Hubei Xingkong city to Henan Xinyang city as the research object. Because most of the earthen buildings located in the mountain road, the transport is bicycle in the investigation, after twelve days of the long journey, finally we can be able to complete the investigation successfully, here, I would especially like to thank my teammates and tutor for the support and help from them. In the investigation, we obtain massive graphic and text information about the earthen buildings, which provides a lot of inspection basis for us to understand and study the earthen buildings. The following is part of the picture and text cases from our investigation.

The earth building is the first house I saw when I gone into the Dabie Mountains, the whole house has a construction area of about 80 square, the main building of 75 square, the interior is divided into three, respectively, two bedrooms, a living room, in the main building on the left is a 5 square kitchen, the house is owned to a old couple about 60 years old, the house has a history of forty years, although it's not a long time, but the damage situation of housing is more serious, especially the back of house wall appeared the phenomenon of inclined.

After careful investigation discovery, the construction of this earthen building is not very rigorous when it was been built, there existing significant technical problems. The building is divided into two parts of rammed earth construction and building walls, the general construction materials should be chosen stone or brick, but it was rammed by the loess, tighter with the low-lying, enhance the corrosion of rainwater on infrastructure, so the wall was damaged seriously.
The earthen house, located in the depths of the Dabie Mountain, has a history of over 70 years, civil combination of architectural form, windows and doors are made of pine, the whole house is made of pine as building skeleton, base construction is the stones, a single brick size is 35cmx35cmx15cm system, the whole wall thickness up to 45cm, material for making brick, the Lord is come from the surrounding loess and rice straw. Although it has 70 years of history, because the house at the time of construction technology research, house now seems still sturdy.

When we see the house, the real body has collapsed in half, this is a building designed by soil brick and burned brick with the construction, commonly known as mud brick package of architectural form, the whole wall up to 50cm in thickness, the thickness of soil layer reached 30cm, brick thickness reached 20cm. We know that from the old man only the rich landlords had enough money to build this house, after many aspects about the house, the original owner of the house is really a landlord, what's the exact time built even the old man in the village do not say not clear, we can imagine how long history it has.

The house built in this way has longer life to general house built with only soil, not only has the advantages of earthen house warm in winter and cool in summer, but also has the advantages of strong brick house.
This house is the most elegant earthen house I saw during the inspection. From the master of the house, we know that the house has one hundred years of history, and it is not difficult to find Anhui style architecture figures.

The whole building wall body and the wall base are made of stones, and the interior of the room is built with soil brick. The building load-bearing structure is built with pine, and the benefits of such a process are very large. Even decades later, adobe weathering, the building would not collapse, the owner only needs to replace the adobe, the house will have hundreds of years or even several hundred years of life.

III. MATERIALS OF EARTHEN BUILDINGS

Take earthen buildings in the Dabie Mountain Area as an example, the real body is mostly made up of local raw soil, need not reinforced concrete, the width of the foundation wall is 1 meters, the bottom wall thickness is 0.5 meters, to reduce the last, the top wall thickness is not less than 0.3 meters. Rammed the wall base, first dug deep and large wall trench, after compaction, bury huge stone as base, then build the wall with stones and mortar. Then use the hollow wall board rammed walls. Wall raw material is the local clay mixed with an appropriate amount of small stone and lime through repeated mash, and mix well, commonly known as the "mellow soil". Some of the key parts also mixed with an appropriate amount of glutinous rice to increase its viscosity. Rammed into the wall, to the middle embedded "wall bone" to increase the tension, the "stud" material is fir branches or bamboo. After repeated rammed, is built like a solid wall of reinforced concrete, adding lime anti wind and rain erosion on a layer of the
outside wipe, can have very good wind, earthquake resistant ability.

Among them, the main building materials are very common and simple, because different areas have different building materials, but its main, for example: gravel, sand, clay, straw, bamboo, stone, wood, hemp, lime, adhesive and water etc..

IV. CONSTRUCTION METHOD OF TRADITIONAL EARTHEN BUILDINGS

A. Laying method of earthen buildings

The raw soil is constructed by adobe, straw, soil clay mud drying molding made, and then use the brick build wall.[1] The method has the rolling, mud and other, more in the rice field place, do brick by adopting rolling mode. The procedure is to choose a piece of smooth, not far from the village of bay of rice, after received rice fields, ranging from the soil is too dry, use the stone roller, the surface layer of soil ground node in the field, this process with time principal, to repeatedly run to play ten more times, then it OK to be used. After grinding, while the soil is not dry, with the spade in the soil cutting - section of the joint, and then a special shovel, the front man pull, behind a person holding the special shovel, the earth scoop into a block of brick.

Mud way also has several, one is the suitable for the soil water brick, the cattle to the wet soil, into the mud, and then put into a special wooden mud, causing a block brick. When building walls, adhesion between brick and brick, also with mud.

Used adobe made wall, many years later, that wall is a good fertilizer, hard-working people, after some years, took in the old wall change again, put down the wall to the fields, this is one way to collect Manure.

B. Earthen building ramming method

Rammed earth buildings is most early and most common way in the raw soil construction. By semi wet (optimum water content) of the cohesive soil, in the wooden splint in subsection and layer (every 30 50cm) plate wall rammed into, also known as rammed earth wall [3]. Wall thickness varies from region to region vary, commonly used 40 - 60cm. In the 70's of last century, some local Chinese rural is still used this way. In the mountains, a kind of method is to use a special wooden box can be fixed on the wall, with a spade to the board on with soil, people standing on the wall, with a special hammer, made the soft soil consolidation to be strong; the other method is to use two long pieces of wood, planted on a few stakes, with the thick string the board is fixed, the formation of a trough, and then to fill the box with soil, with a wooden hammer to beat the tight special soil. This way into walls, like than ordinary brick masonry wall stronger. Some live for dozens of years, earth rammed into the wall just like rammed into the way newly. When demolish house at last, we need a lot of effort let that wall down.
C. Earthen buildings pouring method

Pouring process with respect to the above two kind of method is relatively simple, and rammed construction method is very approximate, is stirring composite slurry material good into advance to build a good model, using the model of wall of beating and vibration, the mud from the air, increasing the density of slurry, using this method, can also be materials to implant in the mud wall of bamboo, wood, hemp rope, increased wall’s connectivity, shock resistance, robustness. So to build houses good connectivity, integrated and strong, relatively strong, and the wall of the modeling is not restricted, can be the face can also be curved surface modeling is rich. At the same time, this construction method also has a great disadvantage, which one is the dry wall is relatively long, greatly increases the construction time limit for a project, and the construction way is not easy to implement in the summer, because summer temperatures are high, evaporation exuberant, wall too fast dehydration can cause cracking of wall body. In our country, the summer rain quantity is heavy, when the wall is not completely dry, the rain will cause excessive scour wall collapse.

Figure 8. Schematic diagram of pouring method

V. ADVANTAGES OF EARTHEN ARCHITECTURE

Green earthen buildings, all building materials are the source of the passage of time in the bounty of nature, a hundred years later, these buildings will return to the natural world, become a nourishing soil. No pollution, no damage, do true ecological balance and sustainable development.

Adobe buildings’ heat storage capacity and heat transfer performance is excellent, for thermal insulation in winter and summer refrigeration, ability of clay wall storage and radiation is very strong, can the indoor temperature stability in a comfortable range, of course, according to the thickness and the indoor air flow velocity and the wall body of indoor comfort temperature (19 -- 26 degrees). It is suitable for passive solar building design. The thermal performance of earthen buildings can also reduce fuel consumption and pollution caused by obviously.

Earthen building materials is readily available, easy to find suitable for building a house of soil at the occupant side, not because of the material transport and increase the construction cost, and the soil, as a building material, do not need too much mud processing, plus the strong plasticity, can be convenient for people to self built housing.

Earthen buildings have excellent sound insulation effect, thick adobe walls can bring quiet living environment, now affected by noise pollution brings people's life has been quite serious. The earth as a building material, the indoor humidity regulation than the general building materials is better, because the adsorption and adsorption capacity of the soil is very strong, the indoor humidity can often be maintained at around 55% (a comfortable indoor humidity of 50% - 65%).

Earthen building materials can bring another benefits, it is non-toxic, for allergic and indoor disease people, natural soil building is a new choice, can bring a healthy indoor environment.

Microbes in the soil are mainly bacteria, actinomycetes, fungi, in addition to the spiral body etc. Soil microorganism in the vast majority of people is beneficial, smart materials and the soil itself is life, is a kind of natural building material. The degradation of indoor harmful air can be good for people, interaction among the chemical constituents of microorganism can achieve the effect of fitness and disease prevention.

VI. EARTHEN BUILDINGS SHORTCOMINGS

"Radon" pollution, which is a kind of colorless, odorless gas, is produced in rock and soil gases, radioactive gas natural, indoor radon density is too large especially gas and...
cigarette mixing, breathing system on the human body especially the lungs causing serious harm.[4]

Because the earth is fluffy characters, from the soil to build walls, low strength, bending, shear and flexural strength is very low, since the major, so in the seismic performance is poor. However, as long as the structure design is reasonable, the structure measures properly, can satisfy the requirements of seismic design.

The base and the outer wall of water erosion, the durability is poor, with the passage of time, a lot of earthen buildings to collapse in high long rain erosion, lack of effective measures of the wall layer waterproof wall, causing severe erosion, part surface abscission, wall weathered severe corrosion, greatly reduce the bearing capacity of the wall.

There is the earthen buildings in its biological activity is frequent, especially the ant and rat harm to earthen buildings can not be ignored, so when the wall be considered the construction should have a certain preventive measures.

VII. CONCLUSION

Our study is to use the existing earthen buildings, make further system research in the future sustainable development for the human, can bring to the sustainable development of society and the natural environment benefit, so as to form a complete theoretical basis and scientific. And then promote earthen buildings to be used of.

Because our country has a long history in the vast territory, different regions, different soil, so the form, material, method of regional earthen buildings also each are not identical. Through the understanding and analysis of the traditional earthen building system, further systematic study of earthen buildings "past", "present" and "future" to form a complete, scientific theory.

We study the earthen buildings will finally be able to benefit our living environment; to find a practical way for can alleviate the increasingly serious environmental problems. Let our society, resources, environment and better balance, to find a sustainable development road.

When the earthen buildings as houses appeared, people have found some special properties, such as soil system construction, the corrosion resistance of the earthen buildings, in different geographical environment and soil preparation of building material enough to make a difference and so on. In the modern technology support, a lot of problems then can use the technology now resolved, making the performance of earthen buildings are optimized. The construction method is able to be solved today.

REFERENCES