terra LYON 2016
XIIe Congrès mondial sur les architectures de terre
XIIth World Congress on Earthen Architectures
XII Congreso mundial de las arquitecturas de tierra
ISCEAH · UNESCO · CRAterre · ENSAG · LABEX AE&CC
11-14 Juillet / July / de julio
Centre de Congrès
Lyon
France

Study on the rammed-earth building in the post-earthquake reconstruction of Southwest China: a case study in Ludian

XINAN CHI[1], WENFENG BAI[2], EDWARD NG[3] - 1,3. THE CHINESE UNIVERSITY OF HONG KONG; 2. KUNMING UNIVERSITY OF SCIENCE AND TECHNOLOGY

THEME 5.2: Heritage revitalization and valorisation

Summary

A shallow earthquake with a moment magnitude of 6.1 struck Ludian County (Yunnan Province, China) on August 3, 2014. The earthquake killed at least 617 people and over 12,000 houses collapsed. Accordingly, the villagers were worried about their traditional rammed-earth buildings, 90% of which were destroyed during this earthquake. The increase in reconstruction needs and poor traffic conditions that resulted after the earthquake led to the rapid increase in the prices of building materials, thereby exceeding the acceptable budget limit for most local villagers. However, transporting large quantities of unused earth was difficult. Thus, the research team decided to use the “local technology, local materials, and local labor” strategy to support families in constructing rammed-earth buildings. The traditional rammed-earth technology was improved by considering seismic capacity, thermal comfort, and construction cost. This strategy provided a reference for the local government to formulate rules for the reconstruction project.

Introduction

Ludian County is located between 568 m and 3356 m above sea level, and 87.9% of its total area comprise mountains and valleys. Such terrain makes transportation inconvenient and impedes the area’s development. After the earthquake, the challenges of reconstruction are as follows:

- Poor anti-seismic performance of traditional rammed-earth buildings,
- Significant increase in the prices of construction materials,
- Improper methods of dealing with construction waste of damaged buildings after earthquake,
- Poor thermal performance of brick–concrete buildings, and
- Lack of local labor.

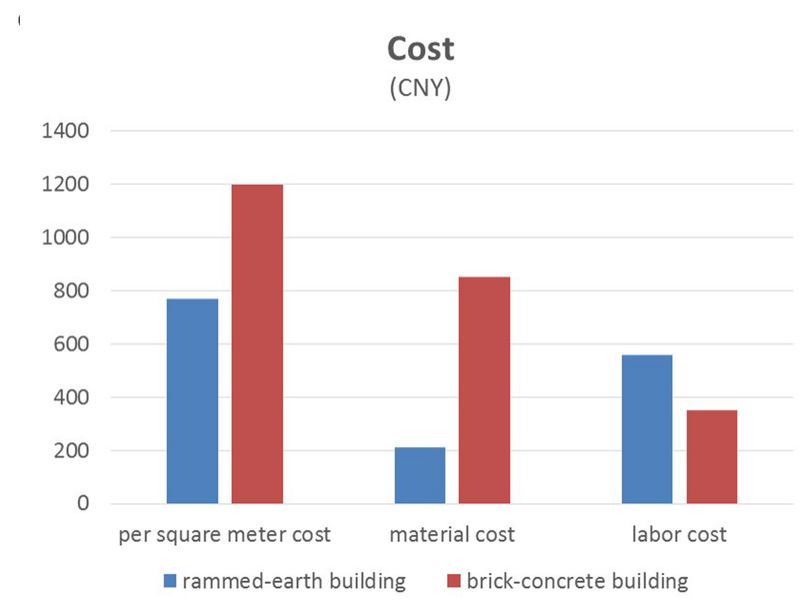
The villagers lost confidence in the performance of the traditional rammed-earth buildings. Thus, they showed eagerness to build houses that are anti-seismic, affordable, and comfortable. In collaboration with Professor Emily So of Cambridge University and Professor Bai of Kunming UST, our team launched a Village Rebuilding Assistance Programme in Guangming Village in October 2014. We aim to use the “local technology, local materials, and local labor” strategy to design an anti-seismic building with affordable traditional features but with an enhanced and comfortable living environment. Apart from rebuilding, we are optimistic in providing a basis for the local government to formulate reconstruction strategies.

Methodology

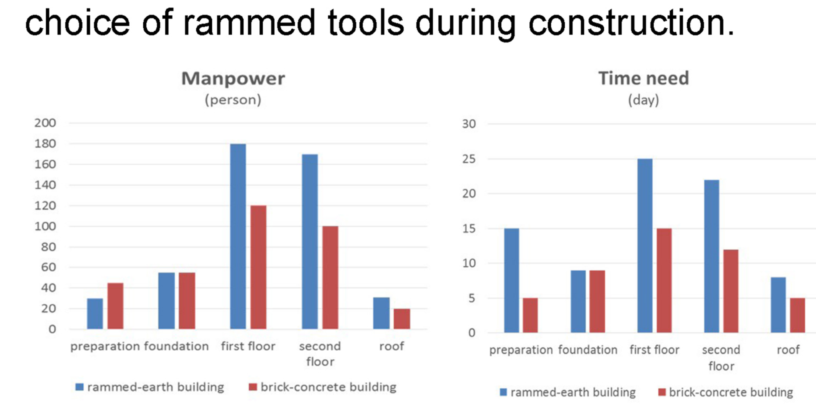
Using the Ludian situation as an example, our research team decided to use the “local technology, local materials, and local labor” strategy to participate in the reconstruction project. The traditional rammed-earth technology was improved by applying “high science and low technology” theory, which mainly focuses on seismic capacity, thermal comfort, and construction cost. We supported a family in constructing a rammed-earth building according to the “local” strategy. This demonstration project completely respected the traditional cultures and autonomy of the villagers, as well as rationally used local materials and technology to rebuild the rural communities. The concept of “collaborative construction” provided an opportunity for the local labor force to learn new skills, as well as reduced economic pressure on house construction. This demonstration project considered the reduction of environmental and ecological damages in the entire process. To verify the improved technology that we used in the reconstruction project, a shaking table test on a single-layered rammed-earth house pilot project was conducted. The results indicated that the anti-seismic performance of the improved technology was better than that of the traditional method.

Results

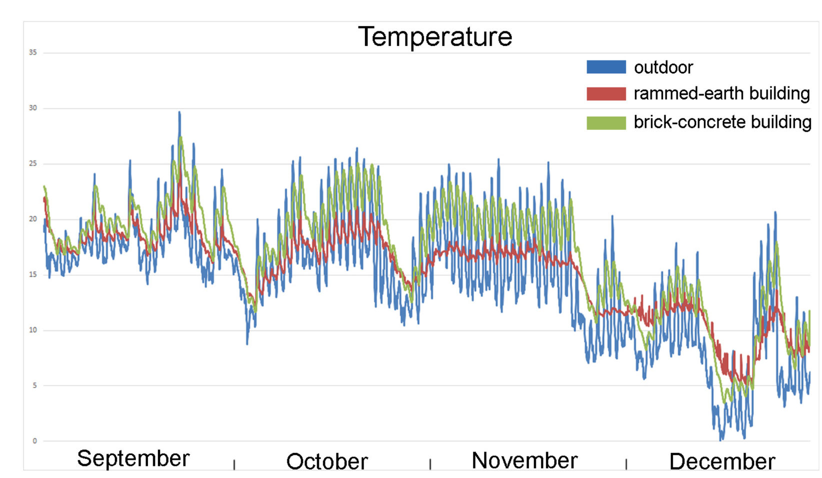
The cost analysis chart indicates that the average cost per square meter of the rammed-earth building is 34% less than that of the brick–concrete building, thereby indicating the cost advantage of the former. However, the material cost of the rammed-earth building is only half of that of the brick–concrete building, and the labor cost is 1.4 times less. Thus, the cost can still be reduced by optimizing manpower during



The manpower and time needs analysis charts show a significant difference in terms of manpower and time necessary between the first and second floor constructions. This difference is reflected in the project cost. In terms of construction preparation, sieving and ensuring soil moisture in the rammed-earth buildings took considerable time but did not require substantial manpower. Preparing and transporting bricks and steel bars for the brick–concrete buildings also require considerable effort but only need limited time. Thus, the necessary manpower and time can be reduced by optimizing the design and choice of rammed tools during construction.



The temperature analysis chart shows that the fluctuation curve of the rammed-earth building is significantly less than that of the brick–concrete building. Thus, the thermal performance of the former is better than that of the latter.



From the analysis, we determine that the demonstration building is a superior option for poor rural areas, although significant room for improvement is still necessary. Enhancing the durability of the rammed tools and formwork can significantly improve construction efficiency. The results of the shaking table test indicate that we can reduce the use of cement. Moreover, an alternative (e.g., lime) could be used to reduce project cost. “Collaborative construction” should be promoted in rural villages to enhance the enthusiasm of villagers and reduce costs by promoting exchange labor instead of hired labor.

Conclusion

The Ludian case study shows that local materials and technology should be rationally used in the reconstruction project, particularly in poor rural areas. This project completely respected the traditional cultures and autonomy of the local villagers, which comprise the core of local community development. “Collaborative construction” provides an opportunity for the local labor force to learn new skills, as well as reduces the economic pressure on housing construction.

The “local technology, local materials, and local labor” strategy emphasizes the concept of sustainability and focuses on the importance of considering the locals living in poor rural areas. This strategy suggests a self-sufficient and regional characteristic-based model that is suitable to the reconstruction situation of poor rural areas with limited transportation and backward economy. Furthermore, this strategy can reduce the dependence of communities on external assistance by emphasizing the use of local resources and traditional core values. The discussed local strategies can provide a systemic method to study sustainable reconstruction and community renewal in similar poor rural areas.