

SUMMARY ON TECHNICS OF RAMMED EARTH WALL

Chengbin Zhou

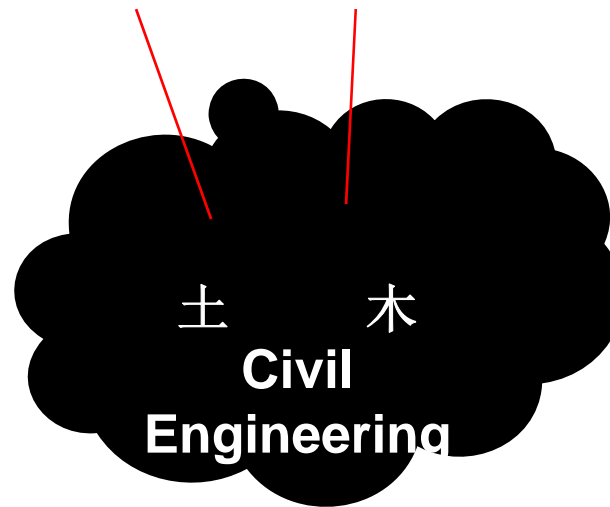
Outline

- **1. Introduction**
- **2. Traditional technics of rammed earth wall**
- **3. Contemporary practice and progress**
- **4. Key problems**
- **5. Conclusion**

Introduction

- Being an important traditional material, rammed earth has a long history in China, and civil engineering is named as “earth & wood” up to now.

Earth Wood



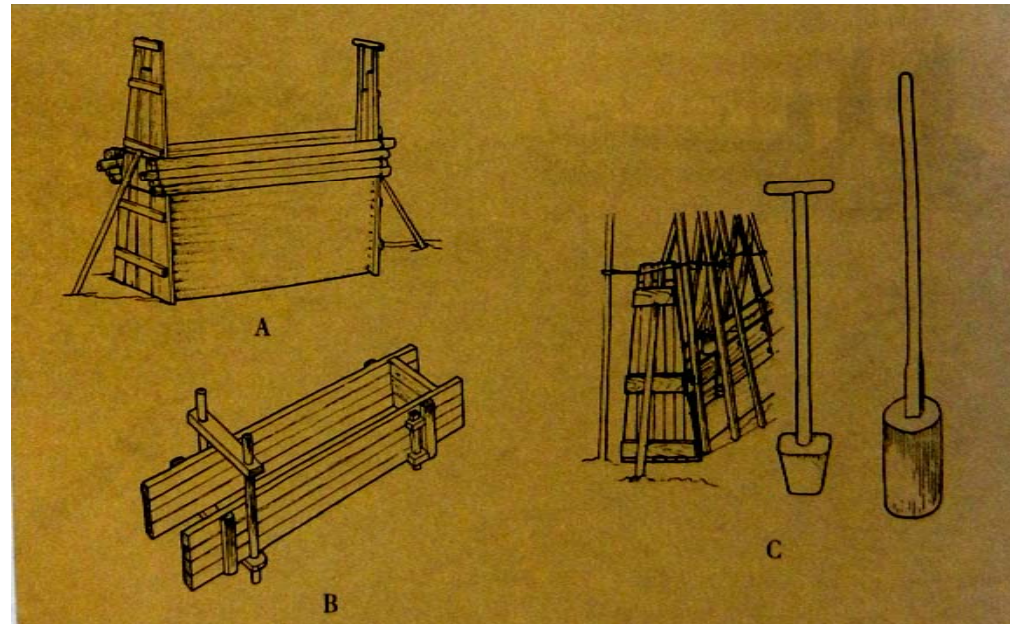
Introduction

- Rammed earth building is easy to obtain material from local sources with low cost, and the inner is warm in winter and cool in summer, so it is widely used. With the diffusion of modern material, rammed earth buildings decrease, and its technics stagnate, too. Nowadays, sustainable development has become the trend of the times, and the rammed earth buildings are faced with new chances because of its advantages of saving water and energy as well as recycling. Hence the technics of rammed earth wall is studied so as to enhance the level of it.

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A profile on traditional technics of rammed earth wall

- **One person:Fuyue**
- It's said that he created the construction technique of rammed earth wall which is named as "Banzhu". He is also the prime minister of Yin Danasty.



A profile on traditional technics of rammed earth wall

- **One person:Fuyue**
- Ruins of the Yin dynasty in north China



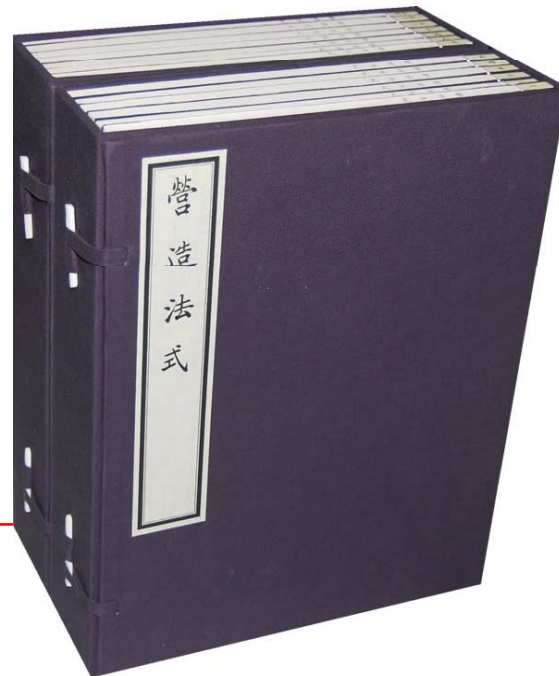
A profile on traditional technics of rammed earth wall

- **One person:Fuyue**
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A profile on traditional technics of rammed earth wall

- **One book:Ying Zao Fa Shi**
- In Ying Zao Fa Shi, an official building standard of Song Danasty, there is the provision of “the order of rammed earth wall is to enhance the height of wall nine inch when the thickness rises three”. Much attention is drawn to the control over thickness of each layer rammed earth and ratios of height to thickness of the whole wall.



A profile on traditional technics of rammed earth wall

- **One summit: Hakka Tulou**
- The Hakka Tulou in Fujian, which represents the technics summit of rammed earth wall, the ratio of height to thickness reaches the striking level of 25:1.



Contemporary practice and progress

- **Official force**
- In 2008, after the earthquake in Panzhihua, Ministry of Housing and Urban-Rural Development of the People's Republic of China united with Wu Zhi Qiao (Bridge to China) Charitable Foundation of Hongkong published the construction atlas of rammed earth rural house with seismic resistance in the reconstruction.
- It's the only technics standard of rammed earth edited under the leading force of government, which elaborates on the formwork, hammer, and earth to use in details and emphasizes the anti-seismic performance by bringing up some reinforced seismic resistance process especially.

Contemporary practice and progress

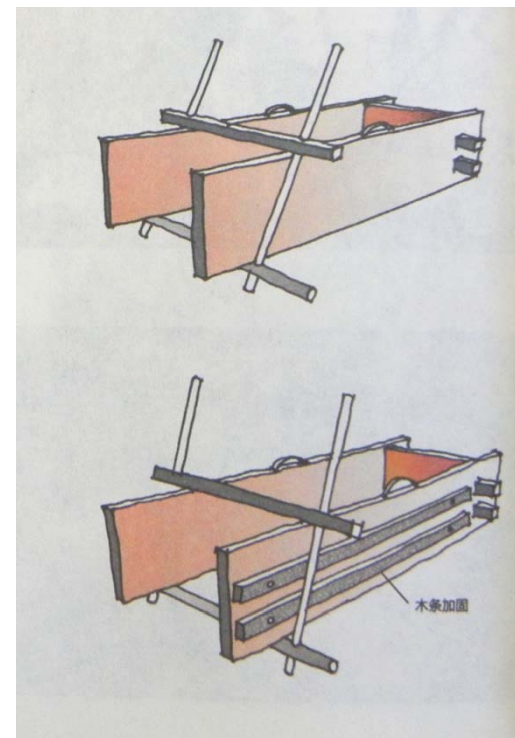
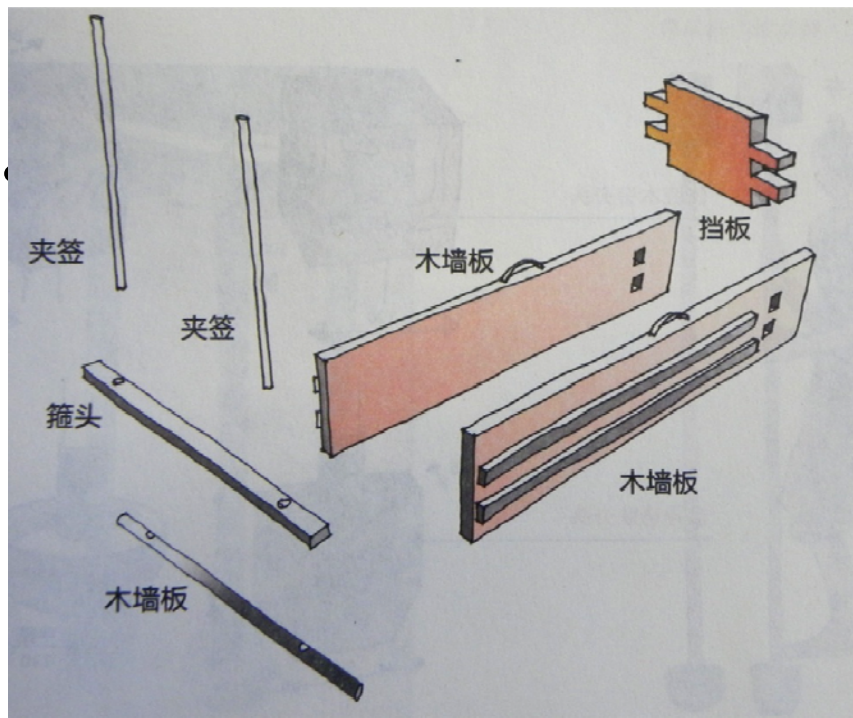
- Official force



- The wood pole to use

A profile on traditional technics of rammed earth wall

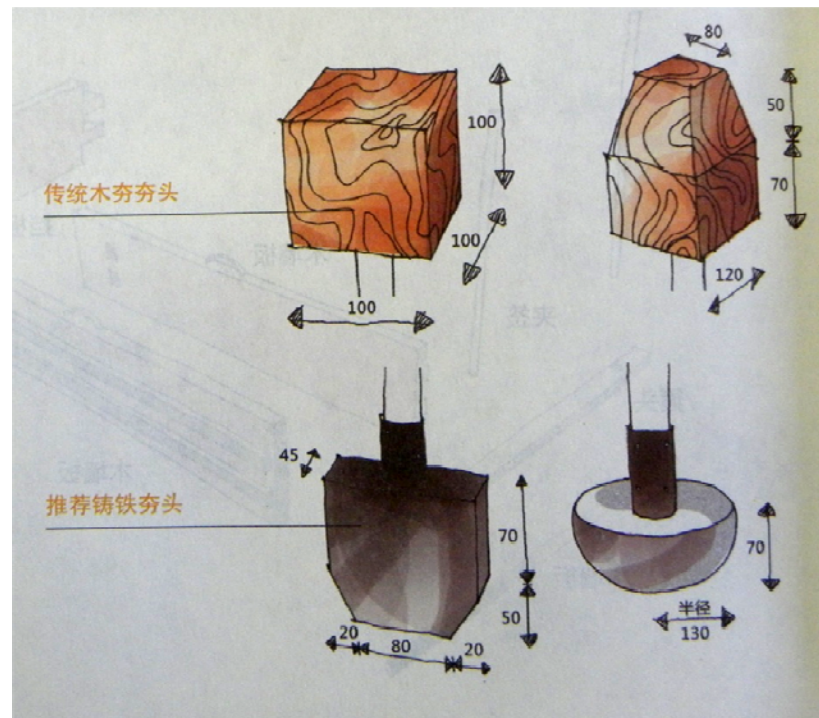
- Official force



- The framework

A profile on traditional technics of rammed earth wall

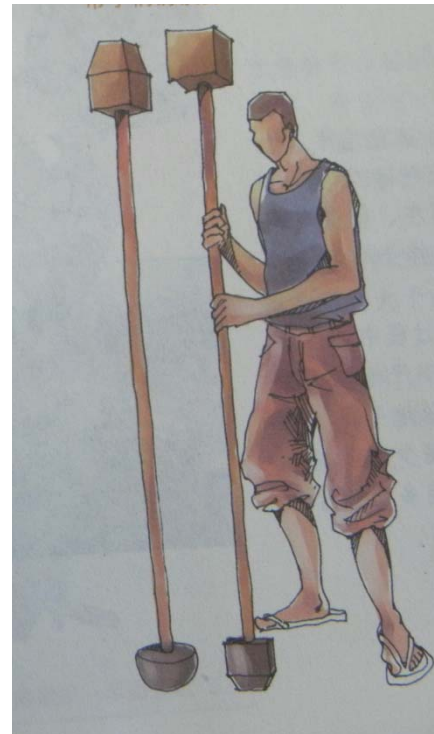
- Official force



- Use steel hammer instead of wood

Contemporary practice and progress

- Official force



- Use steel hammer instead of wood

Contemporary practice and progress

- **Official force**



- **Earth to use**

Contemporary practice and progress

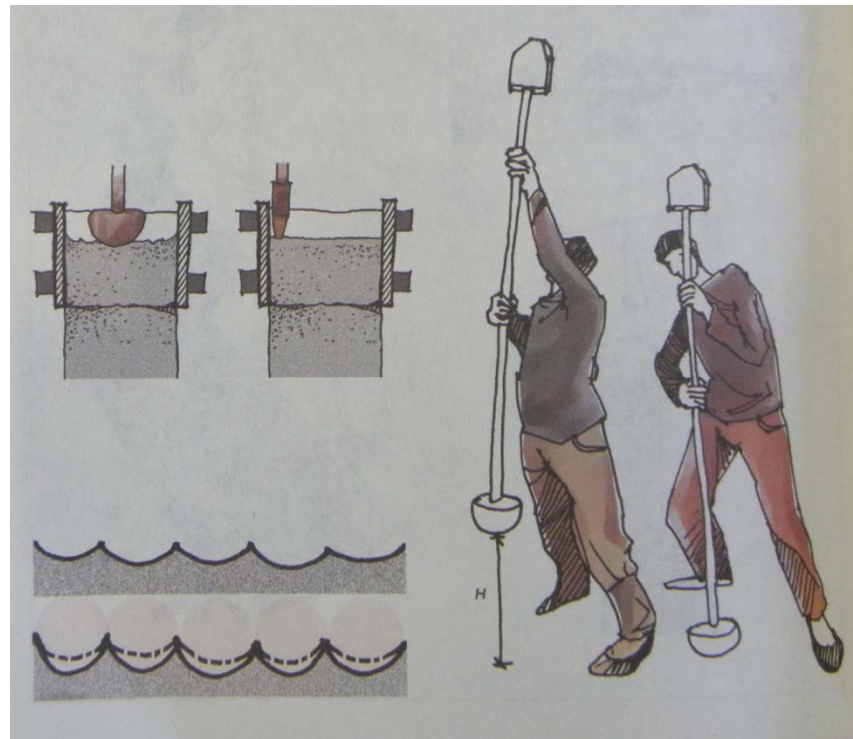
- Official force



- Each layer under 12cm

Contemporary practice and progress

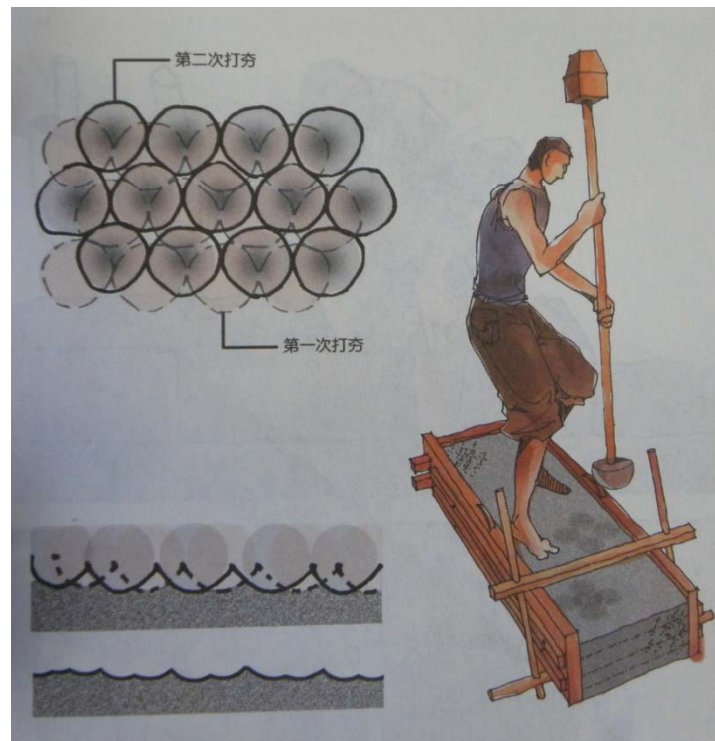
- Official force



- Use different shape hammer

Contemporary practice and progress

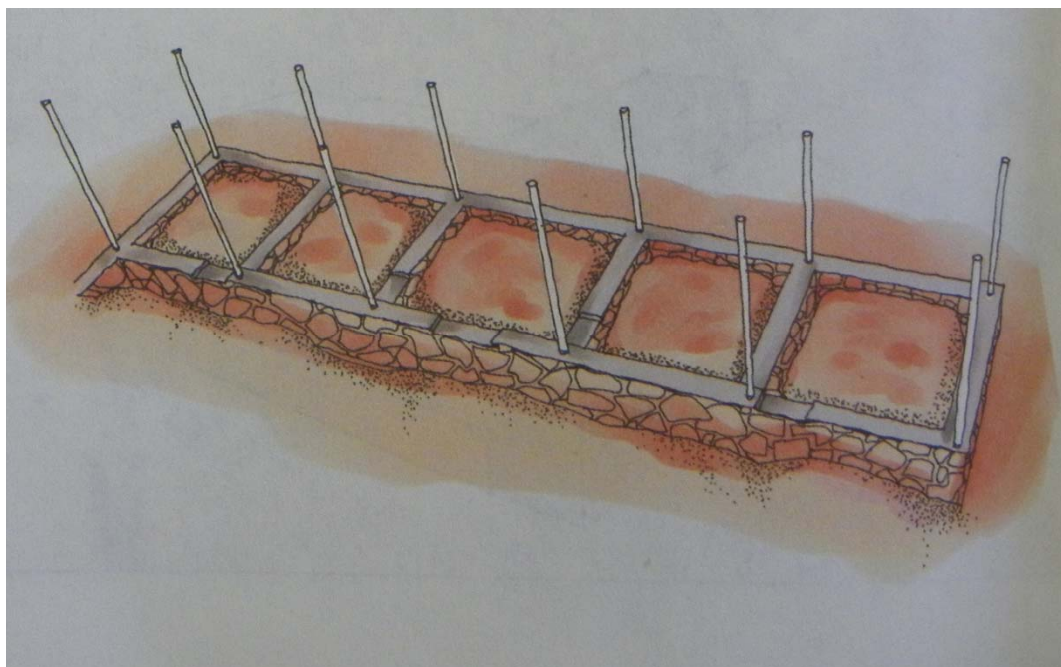
- Official force



- Ram evenly, no missing

Contemporary practice and progress

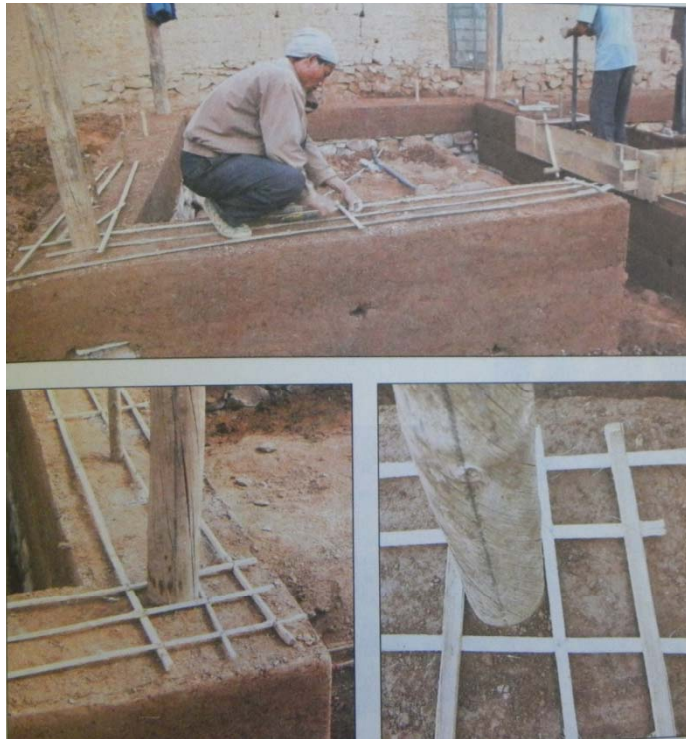
- Official force



- The seismic resistance process-1

Contemporary practice and progress

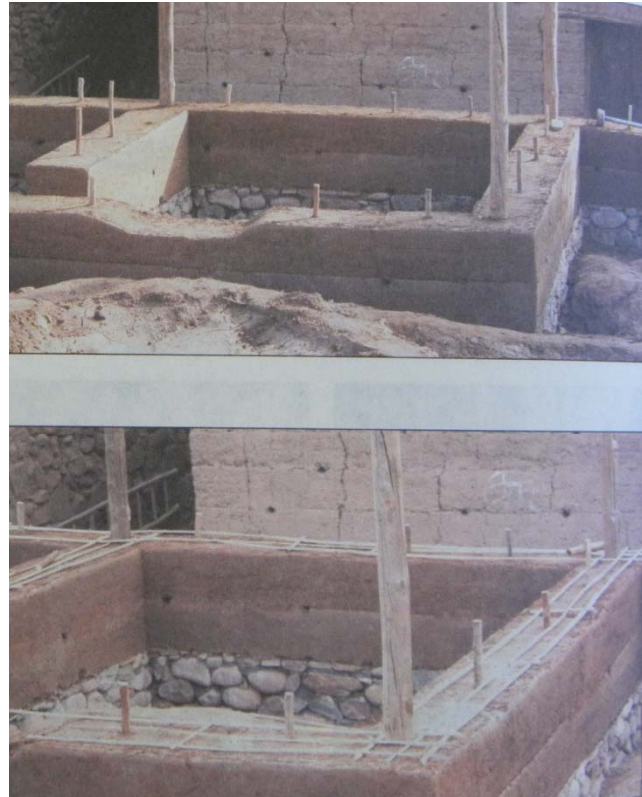
- **Official force**



- **The seismic resistance process-2**

A profile on traditional technics of rammed earth wall

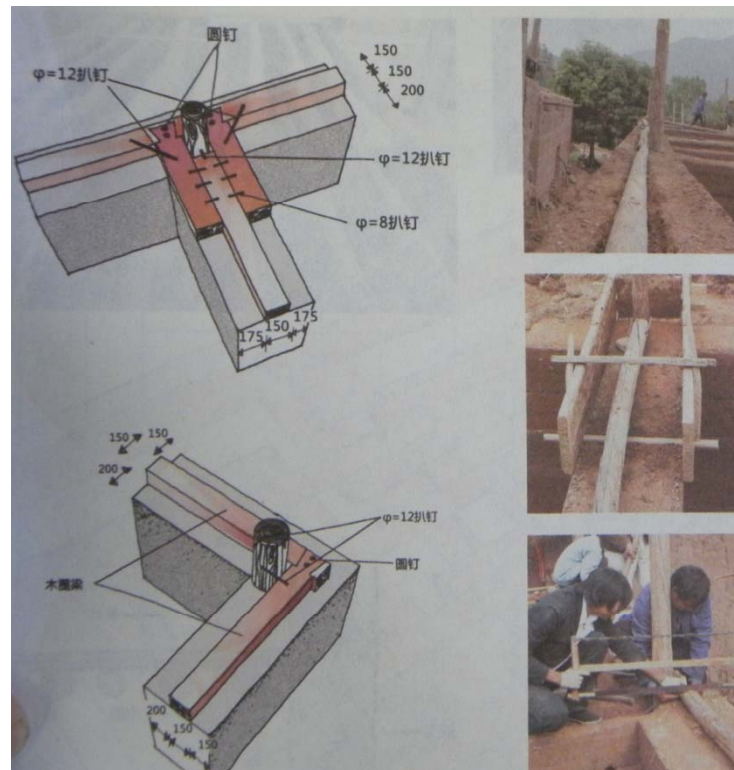
- Official force



- The seismic resistance process-3

Contemporary practice and progress

- Official force



- The seismic resistance process-4

Contemporary practice and progress

- **Folk force : nonprofessional**
- Instantly, the technics of rammed earth is often regarded as outdated technology, so the folk force aimed at the attempts of non-mainstream, and inheritance is more than innovation in the technics. Here are some cases.



- **Rammed earth hotel, Anji county, Zhejiang province**

Contemporary practice and progress

- **Folk force: nonprofessional**
- Ren Weizhong, civil environmentalist of Anji county in Zhejiang province, designed and built ecological houses including one hotel and three little houses by himself, which has caused nationwide repercussions. The material used is an ordinary local tabia with composition of earth, sand and white lime. (Among them, the earth and sand come from uncultivated soil under the allowance of the government) , the mix proportion is 5 :4 :1. The porosities and strength are reasonable proved by the experiment.

Contemporary practice and progress

- **Folk force: nonprofessional**
- The rammed earth used in Anji house, which has been stated earlier in this article, is studied, and found the rules as following (Tab. 1).

Tab. 1 Compression strengths of different proportioning composite soils

different proportioning [⊖] (earth, sand, lime) [⊖]	Compression strengths [⊖] (MPa) [⊖]
5:5:0 [⊖]	5. 123 [⊖]
5:4:1 [⊖]	6. 660 [⊖]
5:3.5:1.5 [⊖]	6. 603 [⊖]
5:3:2 [⊖]	6. 871 [⊖]

Contemporary practice and progress

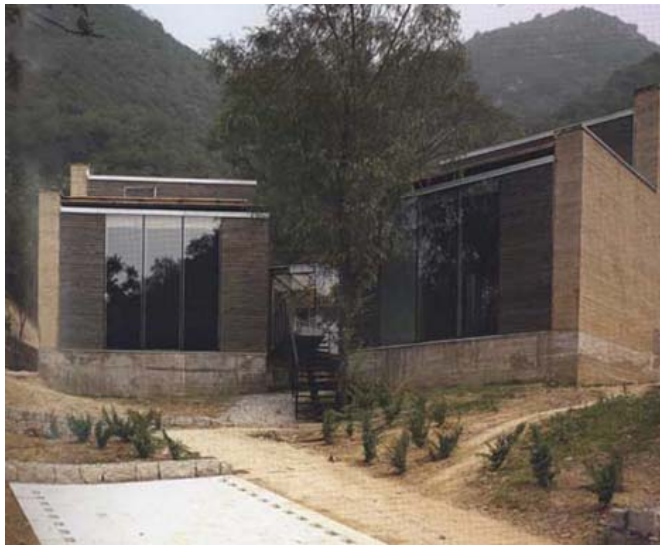
- **Folk force: professional**
- Wangshu, a famous architect, built a rammed little house in the park as a sculpture work with the technology innovation of using steel formwork. But the technics is somewhat random, and the wall even collapsed.



• **Construction site**

Contemporary practice and progress

- **Folk force: professional**
- Zhang Yonghe, built “split house” with rammed earth at the foot of the great wall . These are the very few conscious attempts of using rammed earth as building methods by the professional architect.



- **Construction site**

Contemporary practice and progress

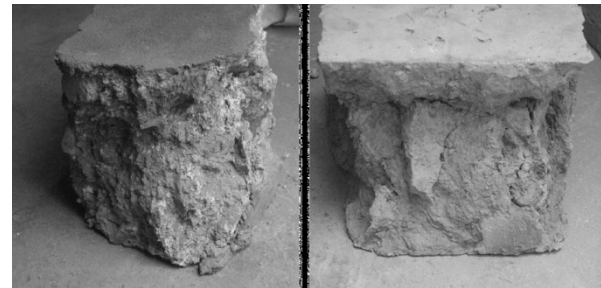
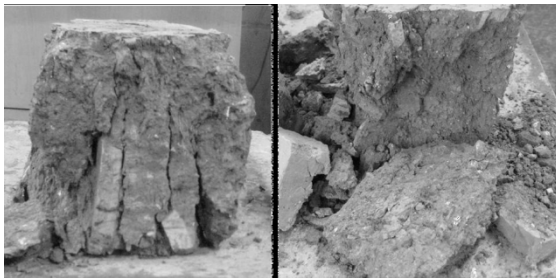
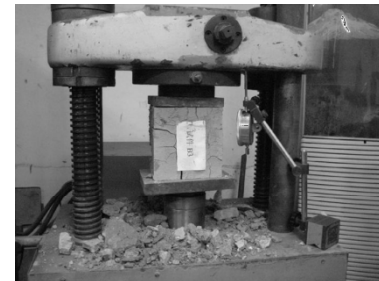
- **Folk force**
- After long time of **fading out**, much more attention is drawn to the appearance than the technics of rammed earth, no doubt these cases show the feasibility of revival under modern technology to the people.
- A traditional building technics faces modern technology and new needs. How to revitalize it? There are some key problems worthwhile discussing about rammed earth.

Key problems

- **1. Prescription and mix proportion**
- There are many kinds of local prescription with great difference.
- In southeast Sichuan, the material is loess or sandy soil uncultivated, while in the construction of rural houses in Hanzhong, straw and lime are added into the rammed earth.
- In the typical earth buildings in Fujian, it's advisable to use tabia, which is often named as “san he tu”, composed of earth, lime and sands.

Key problems

- **1. Prescription and mix proportion**
- Researchers studied the prescription and mix proportion of rammed earth in Fuzhou, and found with the increase of water amount and coarse aggregate size, the compression strengths decrease.



Key problems

- **1. Prescription and mix proportion**
- It's hard to make universal prescription and mix proportion due to the difference of local earth and other material.
- But it's possible and necessary to make standards for a certain area, and there are similarities in different region which are the basis of learning from each other.

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Key problems

- **2. Additive**

- There is little research on additive in rammed earth contrast with concrete. It's said that there is the approach of adding sugar, egg white, or sticky rice juice into rammed earth to enhance the cohesive property and strength, but it is rather suspectable considering the astonishing cost caused by the amount of the project.
- To find new additive without pollution to get high quality instead of mentioned above is real problem.

Key problems

- **3. Construction tools and measures of reinforcing**
- The contemporary tools are inherited from tradition which is of poor efficiency. It's easy to find new tools and construction ways from other material fields, especially reinforced concrete.
- To the measures of reinforcing, it is important to make further research because of its inherent shortcomings of non-watertight and lack of seismic resistance. It's recommended to use local organic material like straw, branches of tree, bamboo and so on in order to lower the cost and keep recycle.

Key problems

- 3. Construction tools and measures of reinforcing



Concluding remarks

- By using rammed earth wall instead of concrete or burned brick can keep up with the times trend of energy-saving & emission-reduction, and the rammed earth wall is sure to have wide utilization in certain fields, such as rural houses, ancient remnants restoration, and so on.
- To transplant modern technique of other building material fields into it with creativity is research topics worthy of carrying on which will enhance the strength and construction efficiency.

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Thank you!

