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CHANGE OF 'YAO TONG' WHICH IS ONE OF RAMMED EARTH ARCHITECTURE IN CHINA

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*Toshiei Tsukidate, Professor, Department of Architecture
Hachinohe Institute of Technology, Japan.*

1. Introduction-Chinese Vernacular houses

There are various climates, such as north sub arctic climate, an arid region season of the Western Regions, and an alpine climate of Tibet, from the southern subtropical climate in the People's Republic of China (following, China). And each area have the characteristic dwelling as follows. For example, raised floor house made by wooden framework structure located in Yunnan. Wooden framework structure combined rammed earth wall are distributed widely in China. There are many log house covered with rammed earth wall in a northeast area of China. There is cave-dwelling called «Yao Tong» in Ochre Plateau. There is

the courthouse which accumulated adobe on the Western desert regions. «Pao» is one of the tent which combined felt and the branch of a willow in the prairie in Nei Mongol.

I investigated especially cave-dwelling «Yao Tong» distributed over Ochre Plateau. Cave-dwelling similar to Yao Tong is distributed over arid regions, such as Turkey, Italy, Spain Tunisia and etc. I report the characteristics of cave-dwelling «Yao Tong» in China and that's subject in this paper.

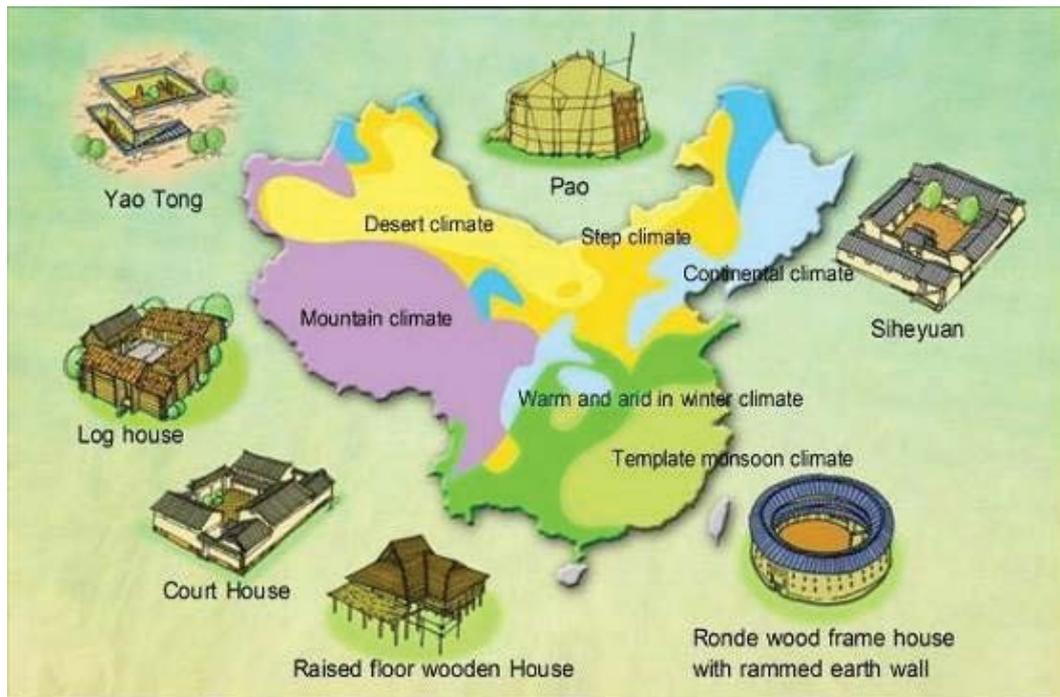


Figure 1. Climate zone and main dwelling type of Cina.

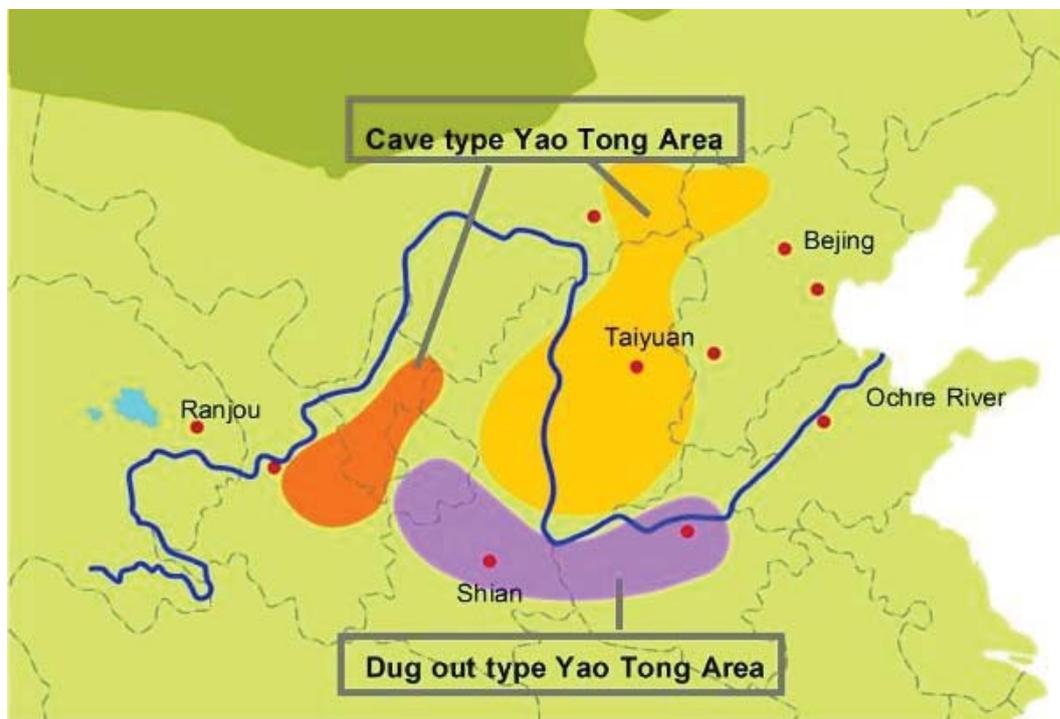


Figure 2. The distribution area of Yao Tong type.

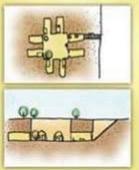
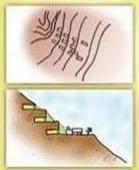
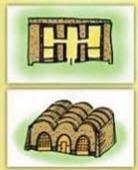
Type	Dug out type Yao Tong	Cave type Yao Tong	On the Ground Type Yao Tong
Main area	Ochre River Basin of Shansi and Henan province	Hillside of Ochre Plateau of Guanjou and Shansi province	Plain and Ochre Plateau of Shansi and Shensei province
Model Figure of Plan & Section			

Figure 3. Type of Yao Tong.

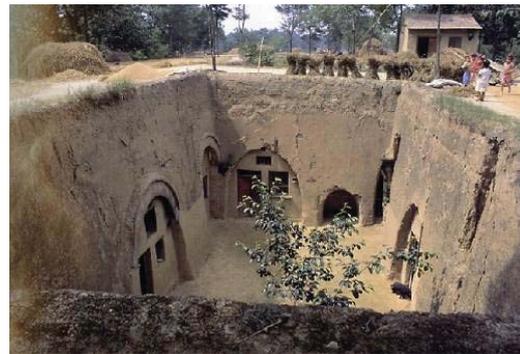


Figure 4. Dug out type Yao Tong in Shansi province.

2. Characteristics of Yao Tong and Environment of Ochre Plateau

2.1. Climate and vernacular houses of China

Yao Tong distributed over middle of Ochre River basin is cave-dwelling which dug deep the Ochre with about 200 m thickness carried from the Gobi Desert. Although Yao Tong was adapted for the environs of Ochre Plateau, there is also a fraction which does not suit present-day life.

2.2. Environments of Yao Tong in Ochre Plateau

In ancient day, Ochre River basin area were covered green. The Ochre Plateau basin where is distributed YaoTong is high land's semi arid area with a height of 700 to 1500 m. The width of Ochre Plateau is about 530,000 square km. In Ochre Plateau is divided three semi arid area: highlands desert, dry hilly area and the east plateau, half-humid area of the Hanzhong plain and basin of Wei river. About 40 million people live in Yao Tong now. Yao Tong which is the characteristic rammed earth architecture which dug Ochre Plateau deep. There are only few vegetation and thickly deposited in Ochre Plateau. Ancient People of the Han race who lives in Ochre Plateau made the dwelling cave-dwelling-Yao Tong who dug soft Ochre deep.

Yao Tong's history is not clear. Cave type Yao Tong in Shansi is said the oldest at 1271 A.D.-1368. There are 3 kinds of Yao Tong. The first

type Yao Tong is to dig deep pit and cave. The second type Yao Tong is to dig the cave deep on the slant-face. The third type Yao Tong is to build the house similar to the cave on the ground.

Three kinds of Yao Tong's main distribution areas are as follows.

Bug out type Yao Tong is mainly distributed over Wei river basin in southern Shensi prefecture and Shanxi, and the pain of Ochre River basin.

Cave type Yao Tong is distributed over northern Gansu, Ningsia and Shensi prefecture, the Shanxi south and middle area, Hebei Province, etc.

On the ground type Yao Tong is made as cave type Yao Tong's extension building in many cases in the northern Shensi prefecture and central Shanxi.

3. Characteristics of 3 type Yao Tong

3.1. Characteristics of Dug out type Yao Tong

Dug-out type Yao Tong is cave-dwelling which digs the inner court of about 10 m square and cave about 7 to 8 m deep for lining space. The caves of a living-room are about 3 m in frontage, about 3 m in height, and around about 8 m in depth. The cave is covered upper



Figure 5. Cave type Yao Tong of near Taiyuan.



Figure 6. On the Ground type Yao Tong of Ochre Plateau near Taiyuan.

side with Ochre about 5 m depth. The use of a cave differs according to uses, such as a bedroom, cook room and a storage etc. They use Kan which works as the heating system and cooking system. The fireplace of Kan is entrance room side for cooking and that's exhaust heat to warm the bed about 65 cm night the next bed room. There are apple trees and water well in courtyard of Dug-out type Yao Tong. Since Dug out type Yao Tong becomes heat and high humidity in summer, he has tried the modification which I ventilate on the ground from a chimney. As inside of Dug-out type Yao Tong becomes heat and high humidity in summer. Yao Tong is not comfortable to live. In China they tried the modification of ventilation on the ground from a chimney.

3.2. Cave type Yao Tong

Cave type Yao Tong is distributed over the summit-of-the-mountain division from the hillside in Ochre Plateau. The size of one cave is the frontage of about 3 m to 3.5 m, about 3 m in height, and the depth is 6 m to 8 m. Kan works as the heating system and cooking stove similar to Dug-out type Yao Tong too.

3.3. On the Ground type Yao Tong

On the ground type Yao Tong is the dwelling which imitated cave-dwelling on the ground, and was completed by a masonry structure with bricks. The ceiling of On the Ground type Yao Tong has similar to the tunnel like ceiling of Cave space with bricks. On the ground

type Yao Tong has Kan to work as the heating system and cooking stove similar to Dug-out type Yao Tong too. Sometimes On the ground type Yao Tong was extended to Cave type Yao Tong and composed court house.

4. Case study of courthouse combined Cave type Yao Tong and On the Ground type Yao Tong

I investigated Mr. chin and his wife's Yao Tong of Shanxi Taiyuan 10 years ago and report the features. This dwelling is consist of Cave type Yao Tong, on Ground type Yao Tong and brick house. There is a Cave type Yao Tong of the south orientation in a front face, and that external wall is covered with the brick. The chimney has come out on the cliff. There is on the Ground type Yao Tong in the east side, and there is modern brick house in the west side. Mr. Chin's family is composed of Mr. and Mrs. Chin, a grandmother and three children. Mr. and Mrs. Chin and grandmother are living On Ground type Yao Tong's bedroom. The elder child lives in a university's dormitory and younger children live in the modern brick house's bedroom.

Characteristics of each houses is following.

4.1. In case of Cave type Yao Tong

Cave type Yao Tong made about 200 years ago has a cook room, a bath and a bed room with Kan. External brick wall of Cave type Yao Tong

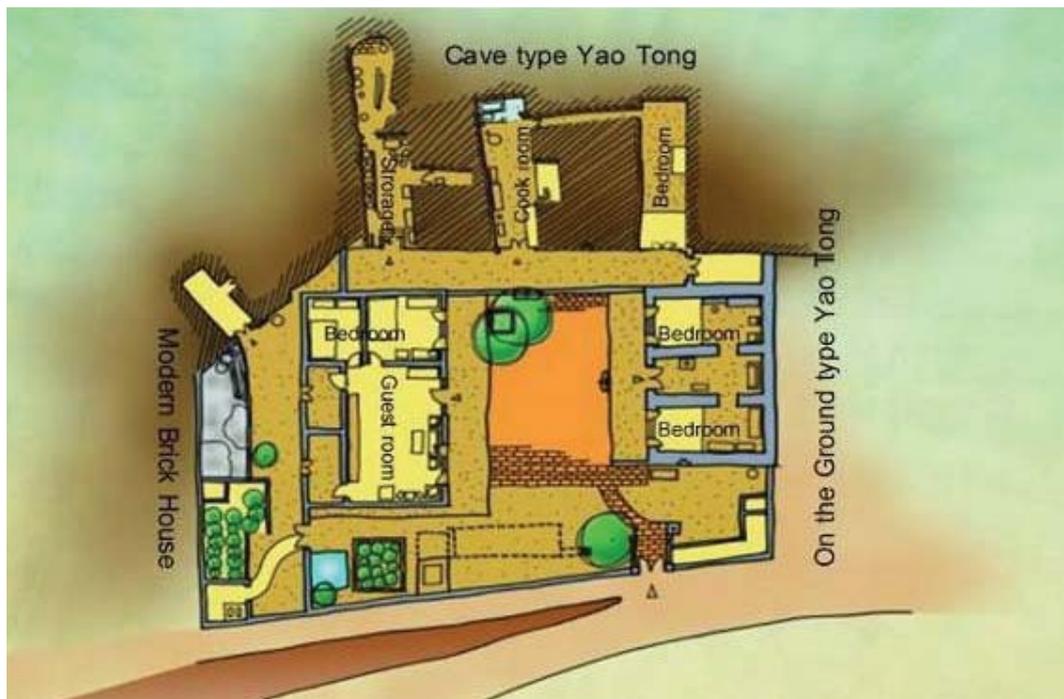


Figure 7. Mr. and Mrs. Chin's Yao Tong.

was made in 1988. Cave type Yao Tong has the entrance room with Kan and bedroom and one of Cave type Yao Tong has the bathroom. The size of Yao Tong with bedroom is about 2.7 m in frontage, about 2.7 m in height, and about 8 m in depth. The bathroom Yao Tong's size is about 2.4 m wide, about 2.7 m of ceiling heights, and the depth of a tunnel is about 7.5 m. Since Cave type Yao Tong is warmer than on ground type Yao Tong, Mr. and Mrs.. Chin and grandmother use only in winter.

Cave type Yao Tong for stockrooms is about 2.5 m width, about 2.7 m of ceiling heights, and about 6 m depth. The grain etc. which are mainly transmitted ancestor each generation are stored in this stockrooms of Yao Tong.

4.2. In case of On the Ground type Yao Tong

On Ground type Yao Tong which was built about 90 years ago is east side of Cave type Yao Tong and has 2 bedrooms and 1 guest room. The size of guest room is about 2.7 m width, about 2.8 m of ceiling heights, and the

tunnel with a depth of about 6 m. As a grand mother was suffering from smoke of Kan on Ground type Yao Tong, M.r. Chin converted into the radiator by the oil boiler without smoke.

4.3. Modern brick house

Modern brick house was built in 1988 in west side. House plan and room arrangement also differs from Yao Tong greatly. If the door is entered, there is with the frontage of about 7 m and a depth of about 5 m huge living room and TV, a motor-cycle, etc. are placed by the reception set. This brick house has a large room which is 7 m wide and 5 m depth is a bedroom of two children usually, sometimes use the guest room.

Three kinds of Gods are deified at Mr. and Mrs. Chin's dwelling and each houses have one god in the frontage wall.

Mr. Chin's Cave type Yao Tong had been built at about 210 years ago at the beginning. And On the Ground type Yao Tong was built about

Type	Dug out type Yao	Cave type Yao Tong	On the Ground Type Yao Tong
Main Area	Ochre River Basin of Shansi and Henan province	Hillside of Ochre Plateau of Guanjou and Shansi province	Plain and Ochre Plateau of Shansi and Shensei province
Plan & Seccion			
Size of Yao Tong	Width : About 3 - 4 m Hight : About 3 m Depth: About 6 - 8 m	Width : About 3 - 4 m Hight : About 3 m Depth: About 6 - 8 m	Width : About 3 - 4 m Hight : About 3 m Depth: About 6 - 8 m
How to build	1. Dig a pit for curt yard 2. make a slope or Step 3. Dig a cave court yard wall	1. Dig a cave hillside 2. Dig tunnel to join each cave 3. preparation of front yard	1. Build walls with bricks 2. tunnel ceiling like Yao Tong
Site Plan etc.	1. Similar site plan of Siheyuan 2. Various aprprch to court yard	1. No gate & Fence of Front yard 2. High density dwelling style of slant hillside	1. Detached House 2. Extention house of Cave type Yao Tong

Figure 8. Type Yao Tong's comparison table.

90 years ago, and built modern brick house in 1988. Mr. Chin house is a court house like a siheyuan of traditional Chinese house type now. Developments of Mr. Chin's dwelling suggest the Yao Tong's history and the future of Yao Tong.

5. Conclusion

Yao Tong is a one of cave dwelling widely distributed over Ochre Plateau in northern China.

Yao tong has very long history because of considering to be Yao Tong's template from Banpo ruin of about 7000 years ago.

There are three kinds of Yao Tong: Dug out type Yao Tong has pit court and cave for dwelling, Cave type Yao Tong was made at the slant-face in Ochre Plateau, On Ground type Yao Tong is made by masonry-structure similar to cave dwelling.

Dug out Type Yao Tong is similar to siheyuan.

There is a tendency that On Ground type Yao Tong is built to extend Cave type Yao Tong like siheyuan.

The area over which Yao Tong is distributed is arid or semi-arid climate and the continental climate of a large temperature range.

The inside of Yao Tong is kept at about 15 to 30 °C, and the outside air temperature is easing greatly the variation which is -20 to 35 °C.

Since traditional Yao Tong of ventilation are insufficient and not comfortable in summer because of high humidity, the modification which attaches a ventilation chimney to the roof is performed.

Because Yao Tong which was adapted for the severe environs of Ochre Plateau also has a fraction unsuitable for present-day life. Yao Tong is showing a tendency to change to On Ground type Yao Tong or modern brick house.