

# Magical Engineering Technology in Ancient China, and Their Modern Scientific Research

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**Abstract:** As an ancient civilization with a long history, China has many magical engineering technologies. We explore six examples of different sizes and types: Tomb of Han Dynasty in Guishan, Longyou Grottoes, Hanging Temple, Dujiangyan, Yuanyang Terraces, the Great Wall, and research their modern scientific significance. Dujiangyan and Yuanyang Terrace are the sustainable water conservancy projects beyond 2,200 and 1,400 years. The Great Wall is also an ancient and effective rapid information-intelligence transmission system.

**Keywords:** Ancient China, engineering, modern science, sustainable development, information

## 1. Introduction

Ancient scholars proposed the seven miracles of the world, which have only the Egyptian pyramids in modern times. In recent years, seven new world miracles have been proposed, including the ancient city of Petra in Jordan, the Taj Mahal in India, the Roman Colosseum and the Great Wall of China, etc.

Needham studied systematically science and engineering of ancient China [1]. In fact, there are still many magical ancient engineering technologies with large or small scales in China. In this paper we explore six typical engineering of different sizes and types, and research their modern scientific significance.

## 2. Tomb of Han Dynasty in Guishan (龟山汉墓)

The Tomb of Han Dynasty in Guishan is located in Xuzhou City, northern Jiangsu, which is the tomb of the sixth generation Chu King of the Western Han Dynasty, Liu Zhu (located in 128-116 BC). The name of Guishan is origin of shape of this mountain like a turtle. The mountain is 327 meters long from north to south, 279 meters wide from east to west, and 76 meters above sea level. The underground tomb is 83 meters long from east to west, the widest 33 meters, and the total area of more than 700 square meters, which empty almost the whole mountain. The underground palace has tomb rooms, bedrooms, living room, stable, and kitchen, etc.

First, surprisingly, now when we just enter the tomb passage, and may see a pure red laser shooting directly from the inside of the secluded passage, which is particularly striking. In fact, this laser is to let everyone see the straight degree of this tunnel (Fig.1). The two tunnels are 56 meters long, 1.78 m high and 1.06 m wide, the maximum deviation along the middle line is only 5 mm. The two walls grinding like flat mirror, the accuracy of  $1 / 10000$ ; the two corridors are 19 meters apart, the angle of  $20'$ , the error is only  $1/16000$ . To the west, the intersection will be located in Xi'an, those age Chinese capital, 1000 km away. It is the highest precision tunnel in the world, such a magical underground engineering more than 2,000 years ago. When the two tomb passages are very straight, the main tomb chamber is directly below the top of the mountain. So far we

do not know how the ancients measured and built it.

Next, on the grass in front of The Tomb of Han Dynasty in Guishan have some huge stones, by which seal tomb ways (Fig.2). Each weighs six or seven tons, each channel is blocked by 26 plug stones in upper and lower two layers, 13 per layer. The boulders are tightly sewn, not even a coin. But even guarded and carefully designed, the tomb was stolen. How did the tomb robbers pull these huge stones out? They made full use of their wisdom and wisdom, cut the "hole like cow nose" of the outside side, tied the ropes with cattle, horses, with countless manpower to pull the boulder out of the tunnel. One piece is loose, the back is easy. But it is easy to pull they out, so how to put they in? More than two thousand years ago, the productivity was extremely low. Although the plug stone and the stone corridor had been polished relatively smooth, there was still great friction between the two. How did the craftsmen plug the boulders weighing a few tons into the corridor, and they were closely stacked in two layers? I personally guess that it is probably to grind the iron into very smooth pieces, and then put it around the stone bars below to reduce friction, then force the top bars into it, and finally pull the iron out. So now we can't see these iron pieces.

Moreover, in the final coffin tomb of Chu King, the westernmost wall of the north wall, very clearly shows a life-size shadow, who like a Chinese suit, and standing east, and seems to move to the west, and shows a bow to welcome guests. It is said that this phenomenon did not exist for time of opening tomb until around June 1994. So far this magical phenomenon cannot be explained.

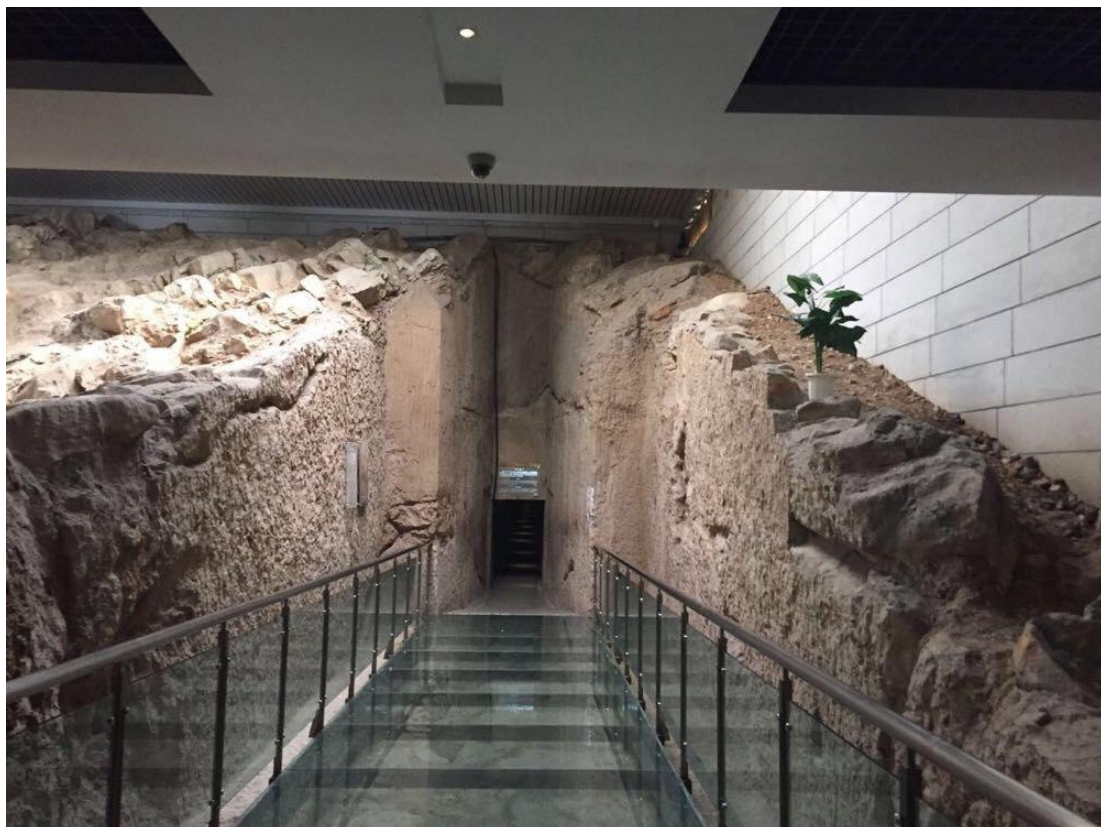


Fig.1 Straight tomb passage



Fig. 2 Huge stones sealed tomb

### 3. Longyou Grottoes(龙游石窟)

Longyou Grottoes locate in Longyou County, Zhejiang Province. So far its age of the construction is still unknown, and it is one of the largest ancient underground artificial buildings in the world (Fig.3).

From the seven grottoes observed, we known that these grottoes are magnificent engineering and basically unified. Style, pattern, style is the same, and have the overall view and reasonable distribution. The smallest Cave No.1 is about 300 square meters, Cave No.2 is about 900 square meters, Cave No.3 is about 1200 square meters, Cave No.4 is about 2000 square meters, Cave No.5 is only about 700 square meters. The five grottoes have a floor area of 5,100 square meters. It is understood that in the stone rock village around 1 square kilometers underground, there are a total of 23 similar grottoes, and in Longyou area 2.88 square kilometers underground estimated more than 50 to 70 basically similar grottoes. If each cave is calculated with an average area of 1000 square meters, a cave will be 20,000 cubic meters of stone, and 50 grottoes can be at least 1 million cubic meters of earthwork.

Since there is not accurate record of these constructions, there are various conjectures, among which the two main conjectures are:

**A.** Someone suggested that Longyou Grottoes are the mausoleum of ancient emperors. But soon the opposition, first, as the royal mausoleum or palace is the royal members of the resting place, why do not leave the burial

goods or palace relics in the grottoes; the second, the grottoes are empty, the four doors open without shelter, are not afraid of grave robbing; third, in the archaeological process of China, no similar tomb was found.

**B. Quarrying** (including collecting other mineral resources) conjecture. Some people believe that Longyou Grottoes are abandoned caves left by ancient people who collected stones. But, there are also objections, first, the safest and most economical method to collect stone should be open-air operation, which can ensure safety and facilitate mining, why carefully design such a way for underground excavation. Second, the stone in the cave is laterite sediment rock. According to visual observation, the exposed rock is easy to be weathered, so easy to weathered stone, why spend such a large project to mine. Third, underground operation requires certain equipment and conditions, such as excavation equipment, lighting equipment, handling equipment, etc., how to be solved at that time. Why no trace left. Fourth, since it is quarrying abandoned caves, why such regular modification.

So far it remains a mystery today.

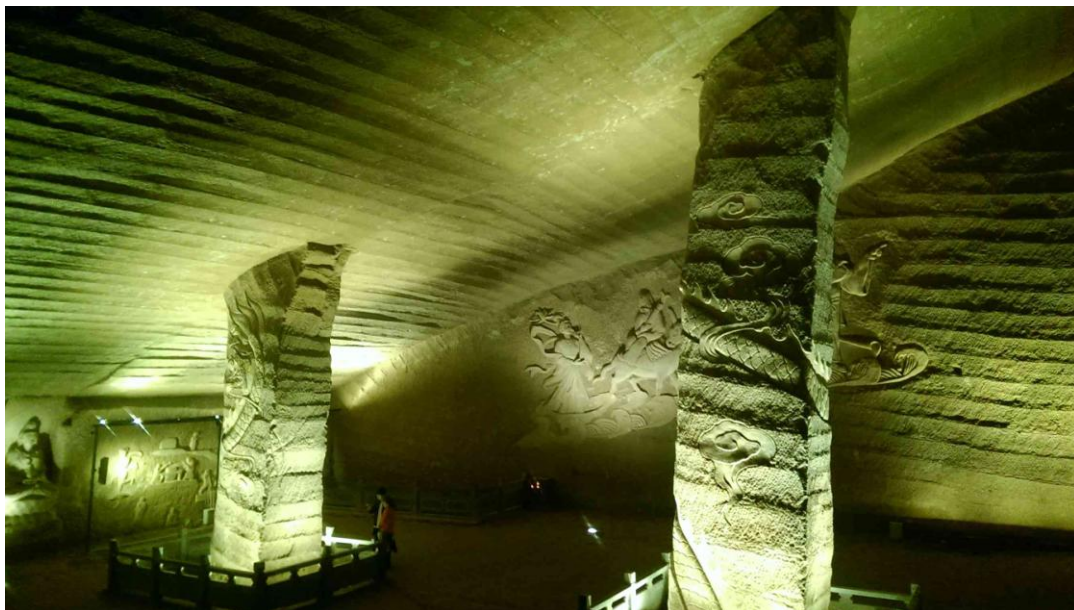


Fig.3 Longyou Grottoes

#### 4. Hanging Temple (悬空寺)

Hanging Temple is located in Hunyuan County, Shanxi Province. The whole temple is like hanging on a cliff (Fig.4). It was built in 491 AD, and is a unique temple integrating Buddhism, Taoism and Confucianism. The total length of the suspended temple is about 32 meters, and there are 40 pavilion halls. At the beginning of the temple, only a dozen wooden columns about thick, the height of 50 meters from the ground. The mechanical principle is based on the semi-inserted crossbeam. With the help of rock support, the corridor railing, upper and lower beams and columns are closely connected to form a whole wooden frame structure.

The magic of Hanging Temple lies not only in its structure, but also in Hunyuan County is in the earthquake-prone area. There have been many records in its history that more than six earthquakes occurred in the recent 40 years, including one that collapsed one third of the houses in Hunyuan city, causing great losses. But, Hanging Temple is safe and sound. Hanging temple dozens of tons of buildings, looks like just a dozen



rickety wooden pillars, and can hang on the 20-story cliff for 1500 years, because in addition to outside can see more than ten wooden columns. In fact, bear 27 into the mountain beam, before the beam inserted rock hole, the wooden beam into the end of a wooden wedge, wooden beam into the stone hole, such as wooden edge hit head, wooden beam edge like a small axe, the wooden beam split a swallow tail, two parts firmly hold the hole wall, which is similar with to modern expansion bolt a truth (Fig.5).



Fig.4 Hanging Temple



Fig.5 Wooden wedge

## 5. Dujiangyan(都江堰)

Dujiangyan is located in the west of Chengdu Plain on the Minjiang River. This was originally a region with severe water and drought disaster. At the last years of Qin Zhao King (about 256 BC), Li Bing (李冰) and his son organized on the basis of predecessors to construct Dujiangyan, which is a large-scale comprehensive water conservancy engineering integrating flood control, irrigation and shipping (Fig.6).



Fig.6 Dujiangyan(都江堰)

Dujiangyan is mainly composed of three main projects: fish mouth (鱼嘴), flying sand weir (飞沙堰) and Aquarius mouth (宝瓶口). The three organically cooperate, and restrict each other, coordinated operation, water diversion and irrigation, flood diversion and disaster reduction. The fish mouth is a stone ridge made of stones in the Minjiang River. It is a water-divided construction project that divides the water flow of the Minjiang River into two. The east is inner river (内江) for irrigation canal; the west is outer river (外江) as the current of Minjiang River. During construction, the inner river riverbed is lower than outer river. In autumn and winter, 60% of the water flows into inner river and 40% into the outer river; during spring and summer, 60% of the water and 40% into outer and inner rivers. It can achieve the purpose of drainage.

The function of flying sand weir is mainly used for sand discharge. In summer, the Minjiang River rises, fish mouth flooded, it became the second diversion. This is used the curve circulation and concave flushing and convex silt principle, a small amount of sediment water flows into inner river, and a large number of sand and gravel water flows into outer river. The water into the inner river will be clearer than that of outer river. And when the rainy season water flow reaches a certain amount, the excess water will flow from the weir to outer



river.

The most important role of Aquarius mouth is "drainage". It is controlling inlet flow, which may ensure that the water into the Chengdu Plain is appropriate. Inner river enters the irrigation system covered above the western Sichuan plain.

Historically, the constructions of Dujiangyan take local materials. The building materials are mainly bamboo, wood and pebbles, which are widely used in water conservancy construction practices such as water diversion, embankment protection, rescue and blocking, forming the unique traditional hydraulic technology of Dujiangyan. For more than 2000 years, Dujiangyan management has formed a unified standard format (Fig.4):



Fig.7 "Three-word classics" on water control of Dujiangyan

Dujiangyan is not only a water conservancy hub and an engineering system, but also a cultural embodiment on the unity of nature and man. Dujiangyan applies mountain terrain, and persists in the guidance rather than hinder confrontation, and adopts the traditional weir engineering technology, and avoids the destructive transformation for environment. This is based on the natural construction way, and makes unified engineering and natural environment, and become true-good-beauty as one of the human wisdom crystallization.

According to current conditions, taking the advantage of the situation and taking measures are the practical principle of water control culture in Dujiangyan. Dujiangyan follows the law of water from the Minjiang River, and the law of water and sand movement, and the law of river evolution, and grasps the natural geography and seasonal characteristics. The water system in the irrigation area is interwoven and interconnected, and shows the harmonious coexistence of man and water across time and space.

The water control concept and ecological wisdom of Dujiangyan follow the "harmonious coexistence between man and nature", and this is the successful application of water conservancy engineering and management technology, and also the vivid practice on the wisdom of the unified man and nature. In 2020 *Water Conservancy in China* (Nov. 3) some experts published many results for the commemorate 2275th anniversary of Dujiangyan.

Dujiangyan is a world cultural heritage. Built in 256 BC, it is the oldest, only retained and grand water conservancy project characterized by dam-free water diversion in the world. Now there are many cultural relics near Dujiangyan, and form a beautiful tourist resort.

## 6. Yuanyang Terraces(元阳梯田)

Yuenyang Terrace located in the south of Ailao Mountain in Yuanyang County of Yunnan. This is a wonder of terraced farming civilization created by people of all nations, mainly Hani, using special geography and climate. It is on a large scale and magnificent momentum. Terraced fields change with the terrain and take measures according to local conditions, while the slope is large, small slope and small fields, and even in the stone gap under the ditch. Therefore, the terraced fields are several mu (亩) and only large dustpan, and often thousands of mu on one slope. The landscape forms the changing symphony of heaven and earth, covering about 16,603 hectares from the southern section of Ailao Mountain along the Red River. Over the last 1400 years, a complex farming system has formed to transport water from hilltops covered virgin forests to layers of terraces. As a world cultural heritage, it is a masterpiece left by generations for more than 1,400 years. It is an idyllic landscape painting carefully carved on the Earth.

From the high mountain area above 2,000 meters above sea level to the river and dam area of 600-144 meters, the seven nations live roughly according to the sea levels, they construct and maintain together this human miracle. Among them, the Hani people live the upper mountain. They have cultivated terraced fields to plant rice since the Sui and Tang Dynasties and dug 4,653 backbone ditches on the mountain, solving the —— water conservancy problem on the lifeblood of terraced rice making. The highest series of terraces reaches 3000 levels.

Hani has formed a set of scientific and reasonable methods in terraced farming, water system and fertilization management.

This is a miracle created by the people of all nations mainly Hani for thousands of years. It is a magnificent and beautiful picture of the different four seasons written on the Earth with nature and human harmony (Fig.8).







Fig.8 Terrace landscape

The magnificent Yuanyang terraces not only solve the ecological problem of paddy fields, but also a model of artificial wetland, but also solve the world agricultural problem of reduced soil fertility, and entropy does not increase for thousands of years, and sustainable development.

According to the recycling economics and the sustainable development, society should keep a lower entropy state, so it can be sustainable development. Daly researched beyond growth from the economics of sustainable development [2]. This should be a harmonious development of society-economy-environment.

The sustainable development is related to the ecological economics [3]. New economics is based on human and the earth, and proposes that real wealth should be measured by increasing happiness and environmental sustainability, not just the accumulation of goods and consumption [4]. Thackara researched the next economy as designing tomorrow's world from soil, land and water to food, clothing, housing, health and so on [5]. New growth means that ecological diversity and watersheds are healthier. The most important thing is to have the ability of ecological thinking, a kind of life model as a whole ability to connect with each other. It corresponds to the unity of man and nature in Chinese traditional culture.

Chang proposed the Chinese cultural-social ecology, which may resolve the human crises. Its aim is that human and nature are completely harmonious, and reach the highest state of the unity of nature and human [6]. Dujiangyan and Yuanyang Terraces are two classical modes of sustainable development.

## 7. The Great Wall

The world-famous Great Wall was a military fortification in ancient China, a tall strong and continuous long wall used to block the invasion of nomadic cavalry in the north. The history of the construction of the Great Wall can go back to the Western Zhou Dynasty (1046~ 771 BC). During the Spring and Autumn Period and the Warring States, they defended each other. The construction of the Great Wall entered the first climax, but the length built at this time was relatively short. After Qin destroyed the six states and unified China, the First Emperor of Qin connected and repaired the Great Wall of the Warring States, which was first known as the Great Wall. The Ming Dynasty was the last dynasty to overhaul the Great Wall, running east from Shanhaiguan west to Jiayuguan, with a total length of 8851.8 km.

An important facility in the Great Wall system is the construction of a large number of beacons (beacon towers). This is the oldest but effective fast information-intelligence delivery system. In ancient times, there were two kinds of signals. When the enemy happened, smoke was placed during the day, fire was raised at night, and platforms were connected to deliver messages. Smoke during the day and fire at night, because the sun during the day, the light is not easy to see, the smoke is relatively noticeable; while the night smoke is not visible in a long distance, this is a very scientific method. Beacons buildings predated the Great Wall. But, since the emergence of the beacon towers along the Great Wall has been closely integrated with the Great Wall, it becomes an important part of the defense system. Some built on the Great Wall. Beacon towers are generally about 5 km apart, and the Ming Dynasty is also about 2.5 km away.

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