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ANCIENT MASONRY WORK IN EGYPT, CHINA, AND ROME: A COMPARATIVE STUDY

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Abstract

Technology has always been there to create masonry work since prehistoric times. Ancient masonry structures that are still standing today were built with a remarkable ingenuity that testifies to the effectiveness of materials and methods used, as well as to the originality and genius of those who designed, and those who built them. This paper presents selected case studies in three different pioneer civilizations: Egypt, China, and Rome. Types of materials, joints, mortars, and construction methods are presented, together with the challenges that faced those edifices. Information included was collected and analyzed by the author mainly through study abroad courses he offered in those regions in 2000, and 2001. Examples from Egypt include the Sak-kara Stepped Pyramid—first pyramid in history, and Khufu's (Cheops) Great Pyramid of Giza. The example from China is the Great Wall. From Italy, examples from Rome and Pompeii are discussed.

Key Words

Masonry, Brick, Pyramid, Great Wall, Coliseum, Pompeii.

1 Introduction

Masonry is one of the oldest building materials ever used in construction. The Egyptian pyramids, the Great Wall of China, and the Coliseum in Rome are some of the world's most significant structures that have been built with masonry. Masonry has both architectural and structural properties that distinguish it from other building materials in its applications as well as in its construction methods and techniques. Throughout history, builders have chosen masonry for its strength, beauty, versatility, and durability.

Natural stones were used first, and then people started to manufacture blocks from a variety of materials, mixes, shapes and sizes, making brick probably man's oldest manufactured building material (Anonymous, undated). Sun-baked clay bricks were used in the construction of buildings more than 6,000 years ago. Genesis, the first book of the Bible, mentions Cain, son of Adam and Eve, who "built a city," (Genesis 4:17), and later mentions people making "bricks and bake them thoroughly," and that "they had brick for stone, and asphalt for mortar," (Genesis 11:3). Obviously, baked bricks had more strength and

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durability than those sun-baked. The Exodus, the second book of the Bible, records the use of “mortar and brick,” and incorporating “straw to make brick,” (Exodus 5:6), probably to prevent distortion and cracking of the clay brick shapes.

2 Egypt

2.1 Background

It is reasonable to suggest that the scarcity of wood in the land of ancient Egypt, and an abundance of the Nile mud and sunshine made adobe the preferred building material. Meanwhile, the abundance of a variety of naturally occurring stones, and the will of great pharaoh builders throughout the ancient Egyptian history led to the construction of immense monuments, some of which are still standing today.

Most of the ancient Egyptian buildings, houses, palaces and city walls, built of sun-baked bricks made of Nile mud and straw, could not stand the test of time and virtually disappeared. A good number of temples and tombs made of stone survived so far (Deitsch 2002). Different kinds of rocks were quarried (Dollinger 2000), such as red, grey and black granite (near Aswan,) limestone (near Memphis in the Muqattam hills,) sandstone (in the Red Mountain,) alabaster, marble, black slate, basalt and dolomite. Some of these types, limestone above all (Al Gurna quarry near Thebes - present Luxor), were used in huge quantities. The Great Pyramid of Khufu alone contains about 2.3 million blocks of limestone and granite, each weighing an average of 10 tons, with average dimensions of 2x2x2 ms (6x6x6 ft.) Granite was used for the interior or core parts of the pyramid, while limestone was used for the exterior parts.

Questions have been raised as to how those heavy stones were cut and transported from the quarry to the building site. Unfortunately, no conclusive answers have been forthcoming yet. Quarrying with ancient tools must have been hard work. Even the relatively soft lime stone was difficult to cut with Old Kingdom copper saws and chisels. Hard stone, like granite, was worked with dolerite hammer-stones. There is evidence that holes were cut into the rock and wooden wedges driven into the slots then soaked with water. The expanding wood cracked the rock.

2.2 The Pyramid

The earliest form of pyramid, the step, dates back to the 3rd Dynasty (ca. 2800 B.C.), and consists of several steps (Edwards 1955). The first, and probably the only step pyramid ever completed, is that of King Netjerykhet Djoser (Zosser), Figure 1, at what is now Sak-kara, Egypt (Pittman 1994). Zosser's Step Pyramid is considered the first tomb in Egypt built entirely of stone. Apparently, the step type of pyramid soon evolved to the true pyramid shape, which was seen as an improvement on the step pyramid.

The first true pyramids were introduced in at the beginning of the 4th Dynasty (Gadalla 2002). The structure and the construction of a true pyramid are virtually the same as a step pyramid. Packing blocks (usually granite) are stacked until the dimensions were right, and then finishing blocks (usually limestone) were the outer last touch. There are numerous structures which have/had the shape of a pyramid. The genuine pyramids, however, are those which consist of solid core masonry and there are ten of them, located within 80km (50 miles) of each other. They were all built during the Third and Fourth Dynasties. In a little more than a century, over twenty-five million tons of limestone blocks were used to build these pyramids. Most famous pyramids are those three standing on the Giza Plateau, south west of Cairo. Those are the Pyramids of Khufu (Cheops), Khafre, and Menkaure.

Later, false pyramids were built during the Fifth and subsequent Dynasties. They were built of loose stone rubble and sand, sandwiched between stone walls. The inner structure of these later pyramids is totally different from the great older pyramids. The later ones have the normal spacious passages, offering rooms and other funerary features found in both earlier and later tombs. However, this type of construction rapidly deteriorated once the

casing was damaged or removed. Consequently, most of those false pyramids are now almost heaps of rubble.
The Great Pyramid of Khufu at Giza (Verner 2001) covers over 13 acres. It was 145.75 m (481 ft) high, but lost about 10 m (33 ft) over the years. Beautiful smooth limestone blocks, known as Casing Stones, used to encase the whole structure and cover its entire exterior. Only a few of those blocks are left in position on each side at the base, as most of the others have been lost. The slope angle of the pyramids sides is 51 degrees and 51 minutes. Each side is carefully oriented with one of the cardinal points of the compass (north, south, east, and west). The horizontal cross section of the pyramid is squared at all levels. The horizontal sides are measured at 229 m (751ft) in length, with an amazing maximum error recorded of less than 0.1%. The Great Pyramid mortar joints are consistently 0.51 mm (1/50 of an inch.)
The pyramid's entrance is on the side that faces north. There are many corridors, galleries, and escape shafts that may lead to the King's chamber. The King's chamber is located at the heart of the pyramid. The only way to enter is through the Great Gallery and an ascending corridor. The King's sarcophagus and the interior walls of the King's chamber are made of red granite, quarried near Aswan. Sharp-edged stones which are over 3 m (10 ft) long, 2.4 m (8 ft) high and 1.3 m (4ft) thick apiece serve as lintels over the main entrance. All interior stones are tight and compact -- not even a card would squeeze through.
Many theories were suggested to explain how the pyramids were built (Lehner 1997). However, no evidence supports any of them. A popular theory states that ancient Egyptians used temporary ramps to build the pyramids. It makes reference to the temporary mud ramp found at Sekhemket's Pyramid, in Sakkara. However, it must be noted that this ramp -- that was found at Sekhemket's Pyramid in Saqqara -- was only 7m (23') high where ancient Egyptians seemed to have been hauling blocks of 25 x 15 x 10 cm (9.8" x 5.9" x 3.3") weighing 22-45 kg (50 -100 pounds) apiece to build that Sekhemket's Pyramid. This can not be compared at all to the height of the Khufu's Great Pyramid at Giza that is 147m (481') and the stone blocks weighing from as low as 2 tons to as high as 15 tons apiece.

3 China

3.1 The Great Wall

China's Great Wall is one of the wonders of the ancient world, spanning across northern China from East to West and is claimed to be "one of the two man-made objects visible to the naked eye in space!" Some estimated that the materials used in the Wall are sufficient to build a wall of 2.4 ms (8 ft) tall and 1 m (3 ft) thick around the equator. It must have been a challenging task to quarry and transport the stone, and to shape, bake and bring away such enormous quantities of brick, even to carry away up over such heights the water needed for mixing the mortar (Zwick 2003).
The entire Wall and its extensions are almost 6,700 km (4,200 miles) long. However, a recent archaeological finding (China News, 2001) claims that the Great Wall is in fact about 500 kilometres (315 miles) longer than the earlier recorded length, making its total length about 7,200 kilometres (4,515 miles.) The portion of the Great Wall in eastern China was made of stone and brick, while most parts of the Wall in western China were made of yellow sandy soil and locally existing jarrah branches.
A more recent report (Viegas 2002) indicated that Chinese archaeologists announced at a current academic conference in Henan Province that they have just discovered a new portion of the Wall, measuring 795.39 km (497.12 miles) long, thought to be the first and oldest section of the Wall that was constructed in the central portion of the country around 688 B.C. This section of the Wall is in surprisingly good shape, considering its age and the fact that it was first constructed using only local stones, with no mortar or other adhesive. If this claim holds true, the Great Wall would be 5012.12 miles (8019.39 km) long, and over 400 years older than previously thought.
The Wall consists mainly of two parallel lines of substantial masonry about 6 ms (20 ft) apart on average, with the intervening space packed with earth and stones. Architectural features

of the Wall, like buttresses, were blocks that stick up from the Wall at regular intervals, where troops could store equipment. Buttresses included holes through which Wall guards could fire on invaders. In the old times, the crenellated battlements on the outer side of the Wall, called “Duo kou,” were effective shields for the Wall’s defenders, providing cover for archers who were able to fire onto the enemy through specially constructed slits. These were narrow on the inside but wide on the outside so that the archers had the advantage of a wide angle of vision while enjoying maximum protection.

Obviously, the Wall builders made maximum use of natural topography; hence the dragon-like appearance of the structure as it wends its way across the terrain. The average height of the Wall from the base upon which it was built is about 8 ms (26 ft), while it is about 6.5 ms (21.3 ft) wide at the base, tapering to 5.8 ms (19 ft) at the top. Along steep ridges which formed a natural defence, sections of the Wall ran as single parapet. Quite narrow, compared with the more substantial stretches, these parts of the structure varied from 2-4 ms (6.5-13 ft) in height. The so-called 'Heavenly Ladder' that can be seen in Simatai (190 km -120 miles - northeast of Beijing in the north of Miyun County) is a fine example.

The materials used in the construction varied according to what was available on site. For example, in mountainous country, where there are rocky outcrops, natural undressed stone was used in the construction. Consequently, while some sections were built using naturally occurring local stone (or manufactured, kiln-fired bricks) with an infill of crushed rocks or earth, others would be constructed of adobe or tamped earth encased between timbers. The contrasting styles of construction can be seen by comparing the stone faced walls near Badaling with the much less sophisticated rammed earth and adobe walls in the western desert region.

Construction of the Great Wall was started in the 7th century B.C. (Anonymous 2001). The vassal states under the Chou Dynasty in the northern parts of the country each built their own walls for defence purposes. After the state of Chin unified China in 221 B.C. (Halsall 2001), it joined those walls and extended them to more than 4,800 km (3,000 miles). There were three main dynasties which built and maintained most of the Wall. Those are Chin (221-206 BC), Han (202 BC-AD 220), and Ming (1368-1644 AD). The materials and the technology used varied in each period depending upon the terrain, social conditions and the engineering technology at the time. A major renovation was started in 1368 with the founding of the Ming Dynasty, the greatest Wall builders, which was completed in 200 years. The Wall we see today is almost completely the result of this effort. The Ming Wall crosses in some of the most difficult terrains, rising in places at an angle of 70 degrees. It is divided by today's Shanxi Province, into the eastern part and the western part. The Wall in the east winds its way along the ridges of mountains -- and here the Wall has a facing of brick and stone, while the section to the west of Shanxi was built from tamped earth with no covering.

Naturally, as scientific knowledge increased over time, different dynasties used different construction methods and materials. During the Chin Dynasty, the watchtowers were built first, and then the Wall was constructed in between. In this period, the seven-meter high Wall (23.30 ft) was made of layers of compacted earth on top of a foundation that comprised a layer of raw earth -- more than 1.5 ms (5 ft) thick at the bottom, with further loess above, some 3 ms (10 ft) thick. The tamped-earth process began with creating simple wooden frames that workers filled with loose earth which was then tightly tamped into a compact layer 10 cm (4 in.) thick. The process was repeated layer upon layer, and the Wall slowly rose 10 cm (4 inches) at a time. Detritus was mixed into the Wall to make it more solid.

Han’s Dynasty technology was not much improvement from the Chin’s, except that the Wall constructed in the Han Dynasty was more massive than that constructed in the Chin Dynasty. Meanwhile, the Han emperors not only reinforced the Chin Wall, but also extended it from Linzhao to the west part of China where much of the terrain is deserts. The poor quality of the sandy soil and the lack of bricks and stone through the Gobi Desert led the workers to build the Wall in this area by laying a bed of red willow reeds and twigs at the bottom of a wooden frame. Then, they filled the frame with a mixture of water and fine gravel, which was tamped solid. When the mixture had thoroughly dried, the wooden frame

was removed, leaving behind a solid slab of tamped earth, strengthened by the willow reeds -- just as modern concrete is reinforced by steel rods.

The greatest of all the Wall builders were the Ming, whose astounding construction accomplishments dwarfed what had been done earlier by the Chin and the Han. The Ming not only built a bigger, more solid and imposing Wall, but also added to it advanced fortification structures. Mass production of bricks by kilns was cutting-edge technology at that time in the world. Those bricks were as strong as modern day masonry blocks. The great progress made by the Ming is evident in the Wall being built with a tamped-earth interior, sandwiched or encased between two on-site kiln-fired brick and/or locally quarried stone slabs, forming the outer Wall layers. Workers mixed lime and sticky rice to create a glutinous paste that they used as a mortar between the bricks. This form of cement made the Wall solid. The popularly toured Badaling section in Beijing is of this type.

Utilizing bricks, stones, and mortar, the construction of the military fortifications on the Wall reached its peak. Double walls were built in some military zones with strongholds, reinforcements, and passes. Juyongguan Pass, Jinziguan Pass and Daomaguan Pass are three passes built on the double walls north of Beijing. Situated at key positions, usually on trade routes, passes were needed to allow controlled entry to- and exit from Chinese territory (Schwartz 2001). Complex constructions that could vary from a double wall to a virtual castle with a maze-like format were necessary to enable the defending forces to control any attempt at an invasion. Typically these would be two or three stories high to give the garrison the advantage of a lookout. Within the pass, ramps and ladders (called "Ma dao"), provided access for both horses and men to the top of the Wall. The ramp is 5-6 ms (16-20 ft) wide, with a wall or parapet (called "Nu chiang") approximately 1 meter (3.3 ft) high running on its inner side. The ramp has an incline of approximately 30^{o}. To give the horses a foothold, raised courses of bricks were set across the ramp bed. This was usually achieved by laying these rows of bricks side-on whereas the rest of the bricks were laid flat to form the main bed carriageway.

Along the Wall, and as close as 50 meters (165 ft) apart, watchtowers of various shapes and sizes served as beacons, fortresses, shelters or simply as a signal station. Stone, brick and mortar helped those towers to have large interiors for storing food and arms, while serving also as the living quarters for soldiers. A staircase from the interior led up to the top of the tower. On each side of the Wall were small holes for lookouts.

The stone and brick construction also permitted the builders to add a variety of refinements that gave the defending army cover and other advantages over their enemies. The ramparts were reinforced with double walls built of huge kiln-fired bricks and locally quarried stones, with earth and crushed rock in between as filler. Great bastions, that measured some 10 ms (33 ft) in height and up to 5 ms (17 ft) in width at the top, enhanced the protection afforded by the Wall. Steps leading to the top of the ramparts were created on the inside. Outer parapets were crenellated or battlemented to provide cover for archers, while openings enabled the guards keep a look out for any threat of invasion. For the safety of both men and horses on top of the Wall, a low wall or parapet (Nu chiang) of approximately 1 meter (3.3 ft) high was built and ran along the inner side of the wall.

At regular intervals of approximately 200 to 300 ms (650-1000 ft), three different types of platforms were set up. *The first type* was fairly simple with four walls topped with battlements for use by archers. *The second* was a two-story brick-built construction. The upper floor would be supported on a number of arches, while the outer facing walls, or barrier walls, had a row of embrasures built vertically to the main body of the Wall for archers. The rooms thus created were used by the soldiers as living quarters and store rooms. Depending upon the size of the platform, access to the upper level could be by stone or brick stairs or merely by a rope ladder. The platforms had gates in them so that soldiers could move along the Wall. *The third type* was a substantial blockhouse that was square, oblong or even rounded.

There were some 1,200 blockhouses and watchtowers along the stretch of Wall between Beijing and the Shanxi pass (Lindesay 1991). Utilizing bricks, stones, and mortar enabled the size of each to be large enough to accommodate 60 soldiers and officers, in addition to large jars of gunpowder and stock of other armaments. The Mutianyu section of the Great

Wall, 70 km (44 miles) northeast of Beijing, is linked to the Gubeikou section on the east and the Badaling section on the west. It is one of the best sections of Great Wall. The Mutianyu section is crenellated for watching and shooting at the invading enemy. Drainage channels and waterspouts were built at intervals through which the rain drained away. The waterspout usually extended for about one meter (3.3 ft) beyond the Wall, and a stone receptacle below it ensured the water was directed away from the foundations.

4 Rome

4.1 The Coliseum (The Flavian Amphitheatre)

At the time of its construction, the Coliseum was one of the most massive man-made structures in the ancient world (Allsopp 1965). It was inaugurated by Titus - Ceasar Vespasian's son in 80 AD (Anonymous 2002a). The Coliseum's proportions are huge, covering an area of 7.5 acres. The edifice's plan is a vast ellipse, measuring externally 188 m x 156 m (620 ft x 513 ft) (Brooks 1963). Its elliptical outer circumference measures 527 meters (1,730 ft) and is 57 meters (187 ft) high. The facade of three tiers of arches and an attic story is about 48.5 m (158 ft) tall— roughly equivalent to a 12-15 story building (Benson 2001).

The three tiers of arcades are faced by columns and entablatures; Doric in the first story, Ionic in the second, and Corinthian in the third. Above them is the attic story with Corinthian pilasters and small square window openings in alternate bays. At the top, brackets and sockets carry the masts and wooden poles from which the velarium, a canopy for shade, or sailcloth awning was suspended (Caggia 2002). At maximum capacity the Coliseum could accommodate up to 50,000 people, who entered the amphitheatre through 80 numbered arches (vomitoria) on the ground floor to their tiered seats (Halsall 2001). At the ends of the two main axes were special entrances for important spectators, while the northern entrance led to the imperial stand (Robert 1990).

The interior is divided into three parts: the cavea (seating area); podium (imperial terrace) and the central elliptical arena, measuring 46 x 76 meters (150 x 250 ft), in which the games took place (Wells 1984). Below the wooden arena floor, there was a complex set of masonry rooms, cages and passageways for wild beasts and other provisions for staging the spectacles (Casson 1998), the remains of which can still be seen today. Eighty walls radiate from the arena to support the vaults that hold up passageways, stairways and the tiers of seats. At the outer edge, circumferential arcades link each level and the stairways between levels.

Size specifications led Roman architects to use arches as structural supports for the building's framework. The arch configuration created open spaces that once had to be supported by a great deal of load-bearing columns. The Coliseum's extensive use of the arch system displays not only the structural importance but also the aesthetic pleasure of having open areas in which to engage in activity. Historians are not yet in full agreement about whether the Romans or the Ancient Egyptians are to be credited for inventing the arch design and construction system.

The construction of the Coliseum utilized a careful combination of materials' types: concrete for the foundations, travertine for the piers and arcades, tufa infill between piers for the walls of the lower two levels, and brick-faced concrete for the upper levels and for most of the vaults. The walls of the Coliseum were created using massive amounts of concrete poured into wooden moulds. The concrete was a mixture of pozzolana, which is a binding element created by volcanic ash, lime mortar, and temper to give in additional structural support. The temper was usually in the form of marble chips or stones. Upon hardening, the concrete structure was faced with brick and/or marble to enhance the building's appearance. When walls or arches were made of brick, the units were frequently laid at an angle to hold stucco.

Despite the ravages of time, three earthquakes, and pillaging of the stone structure for other building projects, the Coliseum has endured through the centuries. That the Coliseum is preserved at all is due to the conservation and restoration policy initiated by Pope Benedict XIV in 1749 to save the last remains, which today correspond to a third of the original

building. He forbade the use of the Coliseum as a quarry and consecrated the building to the Passion of Christ and declared it sanctified by the blood of the Christian martyrs who were thought to have perished there (Wistrand 1992).

4.2 Pompeii

The city of Pompeii was literally buried under the volcanic dust of Vesuvius and the subsequent pyroclastic flow in the first century A.D. (Anonymous 2002b). Parts of the city stand today intact as it stood 2000 years ago, giving a clear understanding of the Roman life and construction practices at that time. The excavations at Pompeii show how wide the use of brick has been in Roman construction, even more than cut stone (Bonechi 1995). Observing the ruins of the ancient city buildings, once inhabited by the middle class citizens; families, merchants and workmen with their houses, shops, and taverns where every-day life activities were carried on, gives a better understanding of how brick has presented many effective solutions in construction, as well as admirable decorative effects (Feder 1996). Stone and marble were generally used as a facing of special buildings or venerable monuments of Roman art.

At the time, pozzolana was used with clays as a reducing material for burned bricks. According to the Roman architect Marcus Vitruvius Pollio of the first century, chopped straw was sometimes added to the mix of sun-baked bricks for better bonding. Roman construction techniques in Pompeii included vaults, brick columns, brick faced concrete and rubble core walls that are covered with stucco (rubble consisted mainly of pumice, potsherds, broken bricks and stone.) In some instances walls were made of alternate layers of brick and rubble.

Romans constructed bearing walls with a variety of materials and methods (Giuntoli 1989). For example, there were all-squared-stones walls and all-brick walls (where surface bricks were often set at oblique angles in the walls for decorative purposes, or to hold stucco facing). Other types included mixed masonry walls consisting of brick and dressed stone, and a conglomerate enclosed between two facings of other material. The greater thickness of the latter type made possible the rapid and economical execution of the work. While the master masons, with care and skill, built the exterior surfaces of brick so as to form a sort of encasement, common labourers filled the “caementum” or the conglomerate formed of successive courses of mortar and rough unshaped stones which were tamped down as the work progressed.

The bonding of the interior nucleus to the exterior brick facing was achieved through the good quality of the mortar and the rough irregular inner surface of the broken brick or tile. In some instances, the external facing was built of triangular bricks with the apex laid inward, thus making an excellent bond with the internal caementum nucleus, which was then crossed at regular intervals by horizontal courses of large bonding bricks or tiles through the entire thickness of the wall. The use of these triangular bricks offered a better bond with the nucleus, a more uniform appearance on the wall face, and greater economy of material.

Because of its varied and ingenious applications, brick also played an important role in the construction of Roman vaults (Roccatelli 2001). The typical construction of the Roman vault was of the nature of the caementum described above. However, a method devised to lighten the concrete mass of the vault and consequently diminish the weight upon the piers was the insertion of terra cotta amphorae; earthenware jars or wine jars in the interior of the wall mass, especially in the groins -- sometimes set irregularly, as in the Stabian Baths.

Two other particular uses of brick in Pompeii are pavements and wall surfaces of baths. Pavements were generally made either of large flat tiles or of very small bricks set on edge in herringbone fashion. With two side walks along the street, rainwater frequently filled the “basin” in between, and larger blocks of stone were placed across the street at intervals and near intersections to serve as islands for walkers crossing the street. Adequate space, however, was left between each block to allow for the wheels of the Roman chariots travelling along the street.

In an inventive heating system, wall surfaces of baths (laconicum and calidarium) were constructed of one-celled hollow bricks, generally 8 x 13 x 33 cm [3.2 x 5 x 13 in.] in size, which provided passage for circulating smoke and hot air. Clay pipes were embedded in the walls of some houses to serve as heating ducts (hypocausts).
Brick was used from ancient times not only in construction but also for exterior decoration, especially in buildings of the modest architectural type where the real life of the common people and of the middle classes took place. A real development in architecture use of brick and terra cotta can be seen, along with the monumental architecture of imposing temples and sumptuous public edifices that are covered with rich decorations in stone and marble. Brick and terra cotta were widely used in houses, shops, taverns, and sepulchral edifices for decoration of wall surfaces artistically done, for simple and refined cornices, for panels, and the like.

5 Conclusion

Masonry is one of the oldest building materials ever used in construction. It remains one of the essential building materials of today's construction industry. Masonry has both architectural and structural properties that distinguish it from other building materials. Throughout history, builders have chosen masonry for its strength, beauty, versatility, and durability. Technology has always been there to create masonry work since prehistoric times. Ancient masonry structures that are still standing today were built with a remarkable ingenuity that testifies to the effectiveness of materials and methods used, as well as to the originality and genius of those who designed, and those who built them.

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Figure 1 Zosser's Step Pyramid of Sak-kara, Egypt.

Figure 2 The Great Wall of China.