THE HISTORY OF CONSTRUCTION

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- Few things are more fascinating than how humans have changed the world around them.
- Mankind has **constructed** buildings and other structures since prehistory.
- The History of Construction is not limited to buildings but covers bridges, amphitheatres, dams, electricity pylons, road and canals to give just a few examples.

THE HISTORY OF CONSTRUCTION

- Today we take the incredible feats of engineering very much for granted but virtually all of the building materials we use today have a long history and some of the structures built thousands of years ago without the aid of modern technology still have the ability to amaze.
- The history of construction is related to, but not identical with, the history of structural engineering.

THE HISTORY OF CONSTRUCTION

- To understand why things were constructed the way they were, we also need to rely on archaeology to record the form of the parts that survive and the tools they used, economic history to inform us of how much they cost, social history to tell us about how the builders lived, and architectural history to tell us about the books and writings of the builders.
- It is a huge subject, but one that should interest anyone who wants to know more about how and why the built world around them is the way it is.

CHRONOLOGICAL DEVELOPMENT

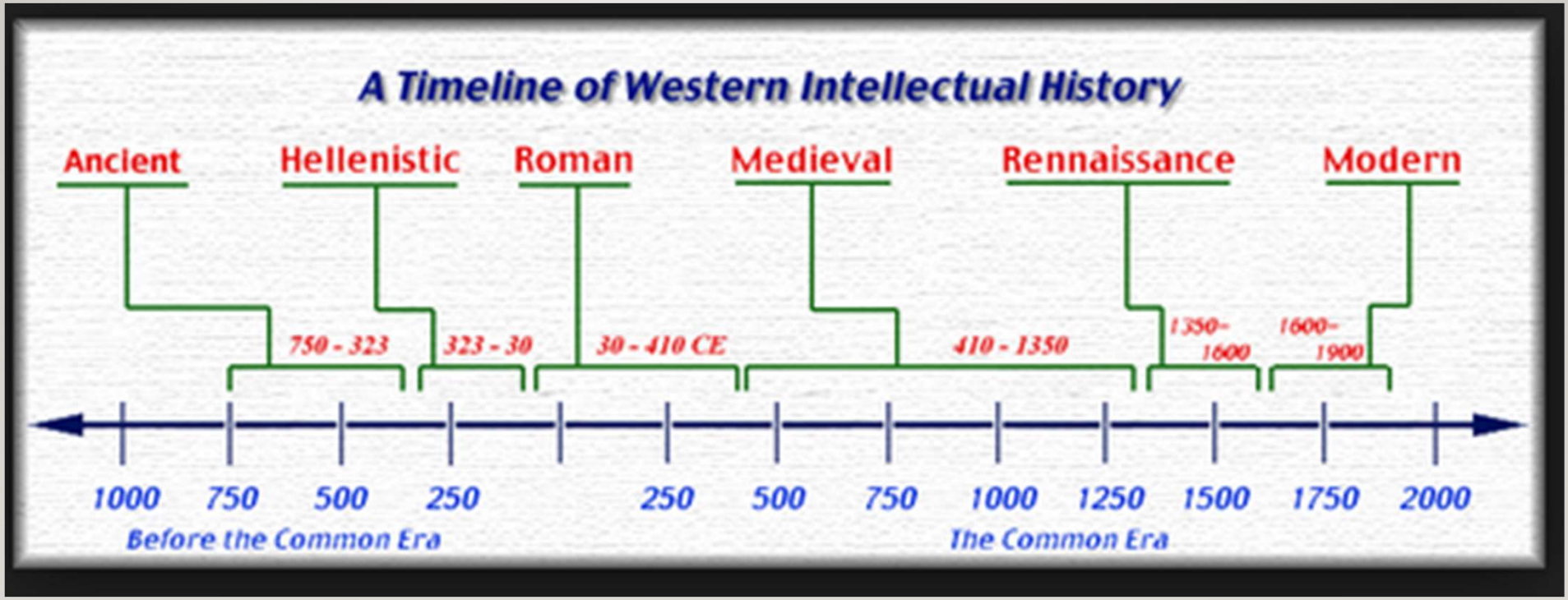
CHRONOLOGICAL DEVELOPMENT

- The history of construction is a complex subject encompassing the history of building materials, the history of engineering, the history of building techniques, economic and social history of builders and workmen, the history of construction machinery and temporary works etc etc.

CHRONOLOGICAL DEVELOPMENT

- Each of these has a complex literature devoted to it, but it perhaps worth providing the briefest of summaries here in the hope that others will start new more detailed pages.

HISTORICAL TIMELINE



GÖBEKLI TEPE
TURKEY, 10000-8000 BCE

LIST & IMAGES OF OLDEST KNOWN SURVIVING BUILDINGS

- https://en.wikipedia.org/wiki/List_of_oldest_known_surviving_buildings

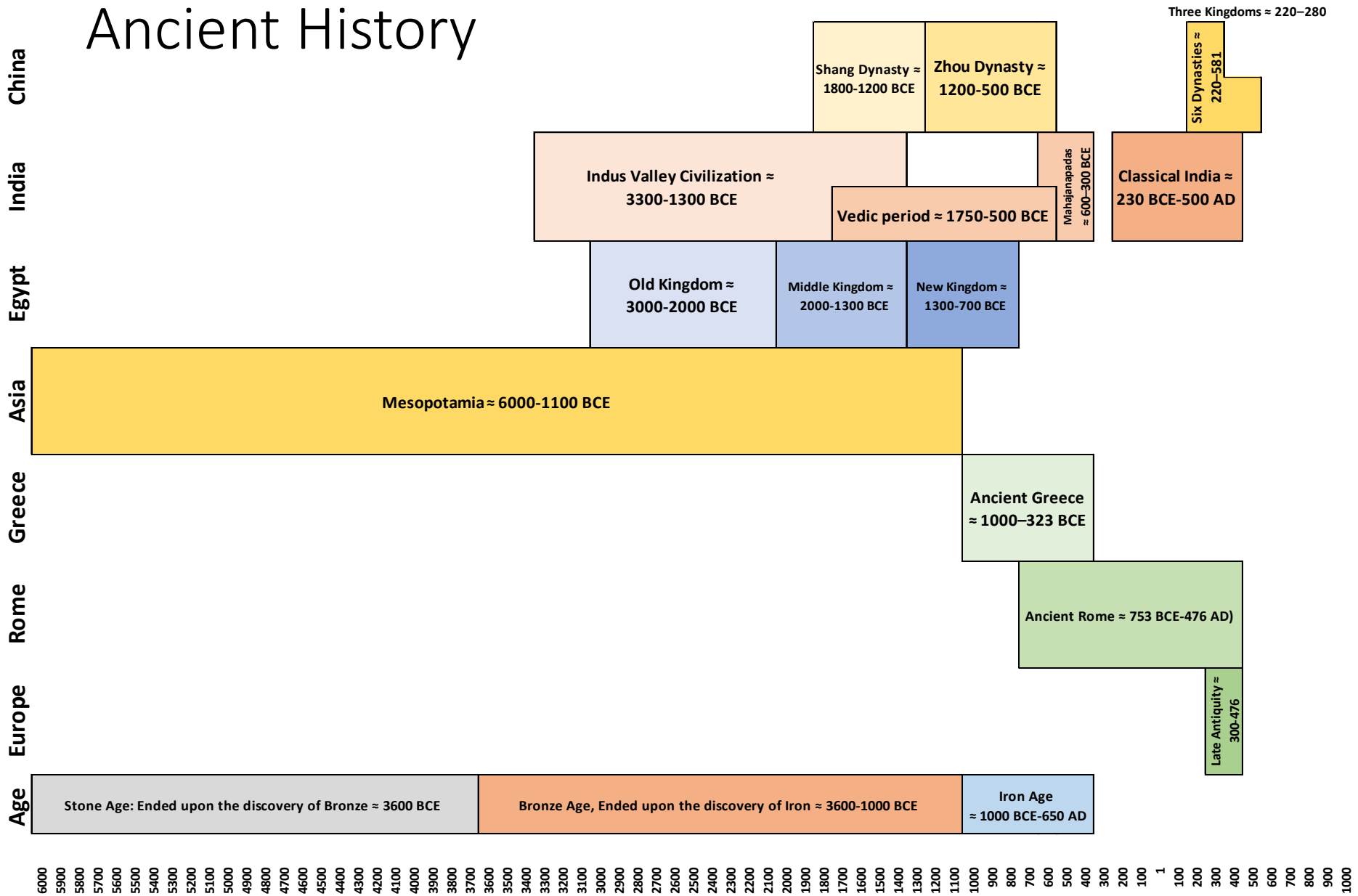
MAIDEN CASTLE IN ENGLAND IS ONE OF THE LARGEST HILLFORTS IN EUROPE.

HILLFORT AT COAÑA, ASTURIAS, SPAIN

EXTERIOR VIEW OF THE RINGFORT *GRIANAN OF AILEACH* SITUATED IN COUNTY DONEGAL, ENGLAND

DAUBARIAI PILIAKALNIS IN MAŽEIKIAI DISTRICT MUNICIPALITY, LITHUANIA

Ancient History



NEOLITHIC CONSTRUCTION

NEOLITHIC CONSTRUCTION

- **Neolithic buildings in Skara Brae**, Kara Brae is listed as a UNESCO world heritage site
- The first bridges made by humans were probably wooden logs placed across a stream.
- The first buildings were simple huts, tents and shelters meant to suit the basic needs of protection from the elements, built by their inhabitants.

NEOLITHIC CONSTRUCTION

- The very simplest shelters, tents, leave no traces behind them.
- Because of this, what little we can say about very early construction is mostly conjecture and based on what we know about the way nomadic hunter-gatherers and herdsmen in remote areas build shelters today.

NEOLITHIC CONSTRUCTION

- The absence of metal tools placed limitations on the materials that could be worked, but it was still possible to build quite elaborate stone structures with ingenuity using dry stone walling techniques.
- The first mud bricks, formed with the hands rather than wooden molds belong to the late Neolithic period and were found in Jericho.

NEOLITHIC CONSTRUCTION

- One of the largest structures if this period was the Neolithic long house.
- In all cases of timber structures in these very early cultures, only the very lowest parts of the walls and post holes are unearthed in archaeological excavations, making reconstruction of the upper parts of these building purely conjectural.

EXCAVATED DWELLINGS AT SKARA BRAE, SCOTTLAND

EVIDENCE OF HOME FURNISHINGS

CONSTRUCTION IN ANCIENT MESOPOTAMIA

CONSTRUCTION IN ANCIENT MESOPOTAMIA

- The earliest large scale buildings for which any real evidence survives have been found in ancient Mesopotamia.
- The smaller dwellings only survive in traces of foundations, but the later civilizations built very sizeable structures in the forms of palaces, temples and ziggurats, and took particular care to build them out of materials that last, which has ensured that very considerable parts have remained intact.

CONSTRUCTION IN ANCIENT MESOPOTAMIA

- **Materials:**
  - The chief building material was the mud brick, formed in wooden moulds (adobe).
  - Bricks varied widely in size and format from small bricks that could be lifted in one hand to ones as big as large paving slabs.
  - Rectangular bricks are found but square format bricks were also common.
  - They were laid in virtually every bonding pattern imaginable and used with considerable sophistication.

CONSTRUCTION IN ANCIENT MESOPOTAMIA

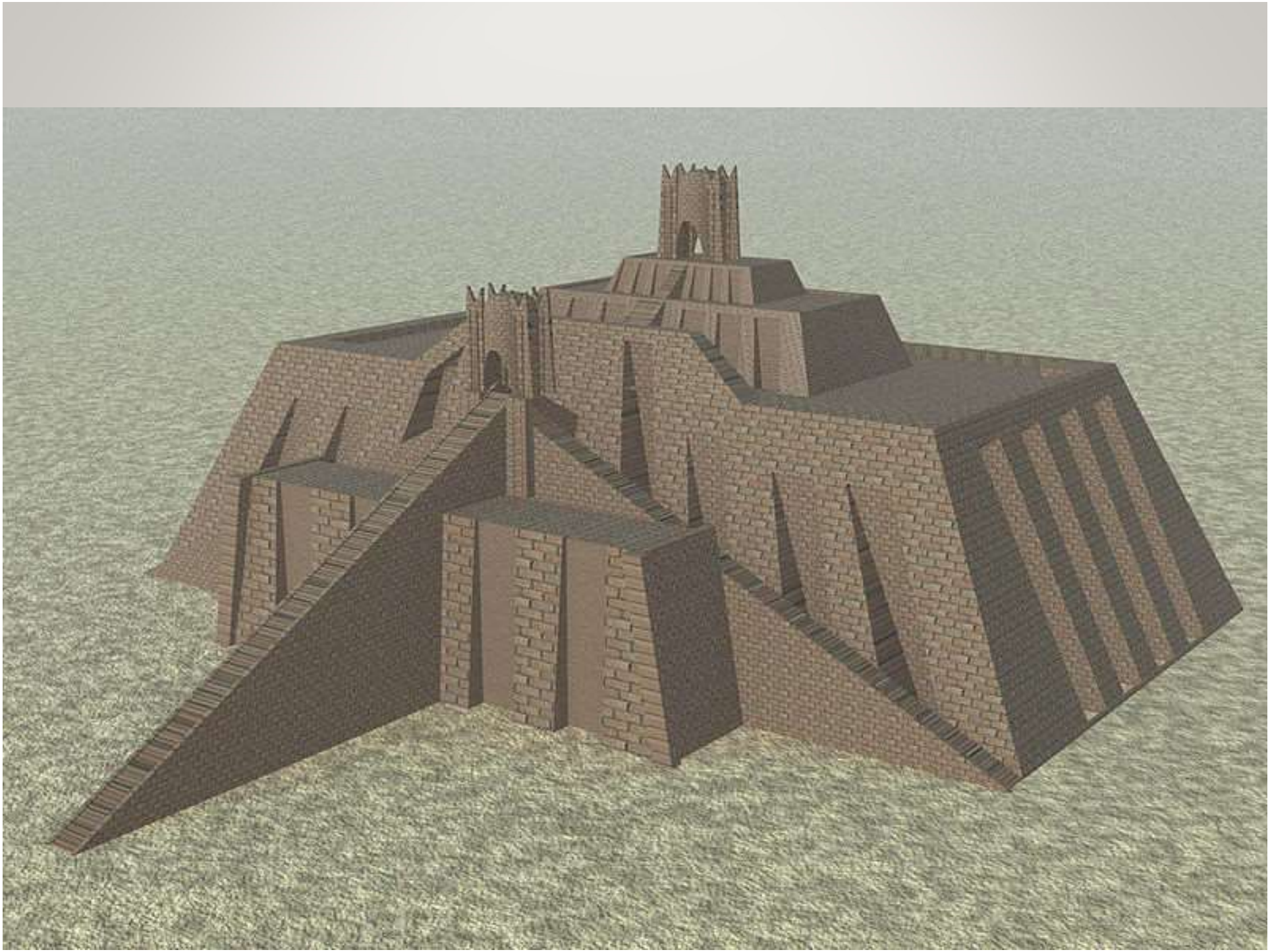
- Drawings survive on clay tablets from later periods showing that buildings were set out on brick modules.
- By 3500BC bricks were also being fired and records survives showing a very complex division of labor into separate tasks and trades.
- Life in general was governed by complex ritual and this extended to rituals for setting out buildings and molding the first bricks.

CONSTRUCTION IN ANCIENT MESOPOTAMIA

- Contrary to popular belief, the arch was not invented by the Romans, but was used in these civilizations.
- The later Mesopotamian civilizations, particularly Babylon and then Susa, developed glazed brickwork to a very high degree, decorating the interiors and exteriors of their buildings with glazed brick reliefs, examples of which survive in the archaeological museum in Tehran, the Louvre Museum in Paris and the Pergamon Museum in Berlin.

CONSTRUCTION IN ANCIENT MESOPOTAMIA

- **Major technical achievements:**
- The major technical achievements are in the construction of great cities such as Kruk and Ur.
- The Ziggurat of Ur remains one of the most outstanding surviving buildings of the period, despite major reconstruction work. Another fine example is the ziggurat at Chogha Zanbil in modern Iran.



CONSTRUCTION IN ANCIENT EGYPT

CONSTRUCTION IN ANCIENT EGYPT

- As opposed to the cultures of Ancient Mesopotamia which built in brick, the pharaohs of Egypt built huge structures in stone.
- The dry arid climate has preserved many of the ancient buildings largely intact.

CONSTRUCTION IN ANCIENT EGYPT

- **Materials:**
  - Adobe (sun-baked mud brick) construction was used for ancillary buildings and normal houses in ancient times and is still commonly used in rural Egypt today.
  - The hot dry climate was ideal for mud-brick, which tends to wash away in the rain. The Ramseur in Thebes, Egypt (Luxor) provides one of the finest examples of mud brick construction, with extensive storehouses with mud-brick vaults surviving, all constructed with sloping courses to avoid the need for formwork.

CONSTRUCTION IN ANCIENT EGYPT

- The grandest buildings were constructed in stone, often from massive masonry blocks.
- The techniques used to move the massive blocks often used in pyramids and temples have been subject to extensive debate.
- Some authors have even maintained that the larger blocks are not cut stone at all but actually artificial stone made using concrete.
- This theory is very controversial and not widely accepted.

CONSTRUCTION IN ANCIENT EGYPT

- **Technology**
  - Although the Egyptians achieved extraordinary feats of engineering, they appear to have done so with relatively primitive technology.
  - As far as is known they did not use wheels or pulleys.

CONSTRUCTION IN ANCIENT EGYPT

- They transported massive stones over great distances using rollers, ropes, and sledges, with large numbers of slaves hauling the loads.
- There are no surviving Egyptian manuals so there has been considerable speculation on how stones were lifted to great heights and obelisks erected.
- Most theories centre around the use of ramps.

CONSTRUCTION IN ANCIENT EGYPT

- **Outstanding Achievements**
  - The pyramids are chiefly impressive for their enormous size and the staggering manpower that must have been employed in their construction.
  - Of these the largest is the Great Pyramid of Giza which remained the tallest structure in the world for 3800 years.

CONSTRUCTION IN ANCIENT EGYPT

- The engineering problems involved were chiefly to do with the transport of blocks, sometimes over long distances, their movement into location and exact alignment.
- It is now generally agreed that the skilled building workers were respected and well treated, but undoubtedly very large numbers of laborers were necessary to provide much of the brute force.
- The methods used in the construction of the pyramids have been the subject of considerable research and discussion.

CONSTRUCTION IN ANCIENT GREECE

CONSTRUCTION IN ANCIENT GREECE

- The ancient Greeks, like the Egyptians and the Mesopotamians, tended to build most of their common buildings out of mud brick, leaving no record behind them.
- However very many structures do survive, some of which are in a very good state of repair, although some have been party reconstructed or re-erected in the modern era.
- The most dramatic are the Greek Temples.

CONSTRUCTION IN ANCIENT GREECE

- No timber structures survive (roofs, floors etc), so our knowledge of how these were put together is purely conjectural.
- The spans are in the main limited and suggest very simple beam and post structures spanning between stone walls.

CONSTRUCTION IN ANCIENT GREECE

- Fire clay was mainly restricted to roofing tiles and associated decorations, but these were quite elaborate.
- Fired bricks were not commonly employed.
- Very prominent buildings were roofed in stone tiles, which mimicked the form of their terracotta counterparts.

CONSTRUCTION IN ANCIENT GREECE

- While later cultures tended to construct their stone buildings with thin skins of finished stones over rubble cores, the Greeks tended to build out of large cut blocks, joined with metal cramps.
- This was a slow expensive and laborious process which limited the number of buildings that could be constructed.
- The metal cramps have often led to later failure through corrosion.

CONSTRUCTION IN ANCIENT GREECE

- Building structures used a simple beam and column system without vaults or arches, which based strict limits on the spans that could achieved.
- However, the Greeks did construct Arch Bridges.

CONSTRUCTION IN ANCIENT GREECE

- Greek mathematics was technically advanced and we know for certain that they employed and understood the principles of pulleys, which would have enabled them to build gibs and cranes to lift heavy stonework to the upper parts of buildings.
- Their surveying skills were exceptional, enabling them to set out the incredibly exact optical corrections of buildings like the Parthenon, although the methods used remain a mystery.

CONSTRUCTION IN ANCIENT GREECE

- Simpler decoration, such as fluting on columns was simply left until the drums of the columns were cut in place.
- The Ancient Greeks never developed the strong mortars which were to become such an important feature of Roman construction.

ROMAN CONSTRUCTION

ROMAN CONSTRUCTION

- In striking contrast to previous cultures, an enormous amount is known about Roman building construction.

ROMAN CONSTRUCTION

- A very large amount survives, including complete intact buildings like the Pantheon, Rome and very well preserved ruins at Pompeii and Herculaneum.
- We also have the first surviving treatise on architecture by Vitruvius which includes extensive passages on construction techniques.

ROMAN CONSTRUCTION

- **Materials:**
  - The great Roman breakthrough was the development of hydraulic lime mortar.
  - Previous cultures had used lime mortars but by adding volcanic ash the Romans managed to make a mortar that would harden underwater.
  - This provided them with a cheap material for bulk walling.

ROMAN CONSTRUCTION

- They used brick or stone to build the outer skins of the wall and then filled the space between with massive amounts of concrete, effectively using the brickwork as permanent shuttering.
- The concrete, being formed of nothing more than rubble and mortar was cheap and very easy to produce, requiring relatively unskilled labor, enabling the Romans to build huge on an unprecedented scale.

ROMAN CONSTRUCTION

- They not only used it for walls but also to form arches, barrel vaults and domes, which they built over huge spans.
- The Romans developed systems of hollow pots for making their domes and sophisticated heating and ventilation systems for their thermal baths.
- Glass was commonly used in windows.

ROMAN CONSTRUCTION

- **Organization of Labor:**
- The Romans had trade guilds.
- Most construction was done by slaves or freed men.
- The use of slave labor undoubtedly cut costs and was one of the reasons for the scale of some of the structures.

ROMAN CONSTRUCTION

- The Romans placed a considerable emphasis in building their buildings extremely fast, usually within two years.
- For very large structures the only way this could be achieved was by the application of vast numbers of workers to the task.

ROMAN CONSTRUCTION

- **Technology:**
  - Vitruvius gives details of many Roman machines.
  - The Romans developed sophisticated timber cranes allowing them to lift considerable weights to great heights.
  - The upper limit of lifting appears to have been 100 tons.

ROMAN CONSTRUCTION

- Trajan's column in Rome contains some of the largest stones ever lifted in a Roman building and engineers are still uncertain exactly how it was achieved.

ROMAN CONSTRUCTION

- **Outstanding technical Achievements**
- A list of the longest, highest and deepest Roman structures can be found at List of ancient architectural records.
- Roman building ingenuity extended over bridges, aqueducts, and covered amphitheatres.
- Their sewerage and water supply works were remarkable and some systems are still in operation today.

ROMAN CONSTRUCTION

- The only aspect of Roman construction for which very little evidence survives is the form of timber roof structures, none of which are thought to have survives intact.
- Nevertheless, its is generally agreed however that the Romans used triangulated roof trusses as this is the only way they could have covered the immense spans they achieved, the longest exceeding 30 meters.

MEDIEVAL CONSTRUCTION

MEDIEVAL CONSTRUCTION

- In the Middle Ages of Europe fortifications, castles and cathedrals were the greatest construction projects.
- The Roman building techniques were lost.

MEDIEVAL CONSTRUCTION

- **Materials:**
  - Most buildings in Northern Europe were constructed of timber until c.1000 AD.
  - In Southern Europe adobe remained predominant.
  - Brick continued to be manufactured in Italy throughout the period 600-1000 AD, but elsewhere the craft of brickmaking had largely disappeared and with it the methods for burning tiles.

MEDIEVAL CONSTRUCTION

- Roofs were largely thatched.
- Houses were small and gathered around a large communal hall.
- Monasticism spread more sophisticated building techniques.

MEDIEVAL CONSTRUCTION

- The Cistercians may have been responsible for reintroducing brickmaking to the area from Holland, through Denmark and Northern Germany to Poland leading to Backsteingotik. Brick remained the most popular prestige material in these areas throughout the period.
- Elsewhere, buildings were typically in timber or where it could be afforded, stone.

MEDIEVAL CONSTRUCTION

- Medieval stone walls were constructed using cut blocks on the outside of the walls and rubble infill, with weak lime mortars.
- The poor hardening properties of these mortars were a continual problem, and the settlement of the rubble filling of Romanesque and Gothic walls and piers is still a major cause for concern.

MEDIEVAL CONSTRUCTION

- **Design:**
  - There were no standard textbooks on building in the Middle Ages.
  - Master craftsmen transferred their knowledge through apprenticeships and from father to son.
  - Trade secrets were closely guarded, as they were the source of a craftsman's livelihood.

MEDIEVAL CONSTRUCTION

- Drawings only survive from the later period.
- Parchment was too expensive to be commonly used and paper did not appear until the end of the period.
- Models were used for designing structures and could be built in large scales.
- Details were mostly designed al full size on tracing floors, some of which survive.

MEDIEVAL CONSTRUCTION

- **Labor:**
  - In general, medieval buildings were built by paid workers.
  - Unskilled work was done by laborers paid by the day.
  - Skilled craftsmen served apprenticeships or learned their trade from their parents.

MEDIEVAL CONSTRUCTION

- It is not clear how many women were members of the guild holding a monopoly on a particular trade in a defined area (usually within the town walls).
- Towns were in general very small by modern standards and dominated by the dwellings of a small number of rich nobles or merchants and cathedrals and churches.

MEDIEVAL CONSTRUCTION

- **Techniques:**
  - Romanesque buildings of the period 600-1100 AD were entirely roofed in timber or had stone barrel vaults covered by timber roofs.
  - The Gothic style of architecture with its vaults, flying buttresses and pointed gothic arches developed in the twelfth century and in the centuries that followed ever more incredible feats of constructional daring were achieved in stone.

MEDIEVAL CONSTRUCTION

- The resulting thin stone vaults and towering buildings were constructed entirely using rules derived by trial and error.
- Failure were frequent, particularly in difficult areas such as crossing towers.
- The resulting buildings remain astounding tributes to their builders.

MEDIEVAL CONSTRUCTION

- The pile driver was invented around 1500.

MEDIEVAL CONSTRUCTION

- **Outstanding Technical Achievements:**
  - While the scale of fortifications and castle building in the Middle Ages was impressive, no buildings in this period can match the daring of the gothic cathedrals with their thin masonry vaults, and walls of glass.

MEDIEVAL CONSTRUCTION

- Outstanding examples are:
  - Beauvais Cathedral
  - Chartres Cathedral
  - King's College Chapel
  - Notre Dame, Paris.

CONSTRUCTION IN THE RENAISSANCE

CONSTRUCTION IN THE RENAISSANCE

- The Renaissance in Italy, the invention of moveable type and the Reformation changed the character of building.
- The rediscovery of Vitruvius had a strong influence.
- During the Middle Ages buildings were designed by the people that built them.

CONSTRUCTION IN THE RENAISSANCE

- The master mason and master carpenters learnt their trades by word of mouth and relied on experience, models and rules of thumb to determine the sizes of building elements.
- Vitruvius, however, describes in detail the education of the perfect architect who he said must be skilled in all the arts and sciences.

CONSTRUCTION IN THE RENAISSANCE

- Filippo Brunelleschi was one of the first of the new style of architects.
- He started life as a goldsmith and educated himself in Roman architecture by studying ruins.
- He went on to engineer the dome of Santa Maria del Fiore in Florence.

CONSTRUCTION IN THE RENAISSANCE

- **Materials**
  - The major breakthroughs in this period were to do with the technology of conversion.
  - Water mills in most of Western Europe were used to saw timber and convert trees into planks. Bricks were used in ever increasing quantities.

CONSTRUCTION IN THE RENAISSANCE

In Italy the brickmakers were organized into guilds although the kilns were mostly in rural areas because of the risk of fire and easy availability of firewood and brickearth.

Brickmakers typically paid by the brick which gave them an incentive to make them too small.

As a result, legislation was laid down regulating the minimum sizes and each town kept measures against which bricks had to be compared.

CONSTRUCTION IN THE RENAISSANCE

- An increasing amount of ironwork was used in roof carpentry for straps and tension members.
- The iron was fixed using forelock bolts.
- The screw-threaded bolt (and nut) could be made and are found in clockmaking in this period, but they were labor intensive and thus not used on large structures.

- Roofing was typically terracotta roof tiles. In Italy they followed Roman precedents.
- In Northern Europe plain tiles were used.
- Stone remained the material of choice where available for prestige buildings.