

Historic Masonry Structures part 1

Pantheon in Rome
142 ft. diameter
125 AD

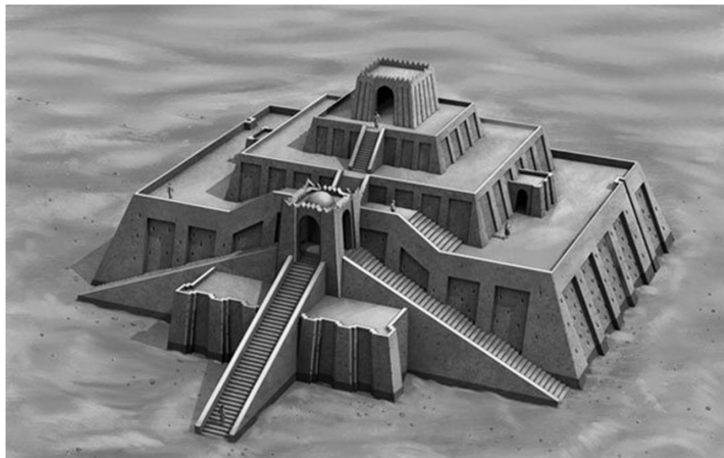


Ziggurat

Mesopotamian

The Great Ziggurat of Ur

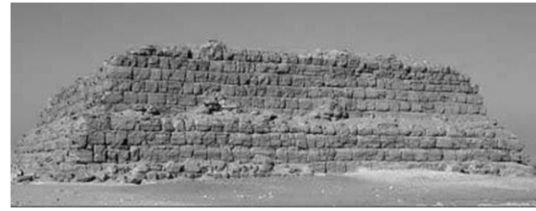
- In southern Iraq
- 2000 BC
- 210ft x 150ft x 100ft high
(64m x 46m x 30m high)
- Clay brick core
with fired brick skin
- Temple of moon god Nanna



Early Egyptian

Mastaba

- kings' burial sites
- Early (3000 BC) mud bricks
- By the 3rd Dynasty they used stone (2670 BC)



Mastabat al-Fir'aun of king Shepseskaf 2510 BC
Red sandstone 325 ft x 250 ft x 30 to 60 ft high

Early Stepped Pyramid

- Netjerikhet
- Made from stone
- 3rd Dynasty



The Step Pyramid of Netjerikhet is the oldest known building to be completely made of stone.

Early Egyptian

Bent Pyramid

- Initially 60° changed to 55°
- 2600 BC
- Cracking in base



Bent Pyramid at Dahshur



Early Egyptian

Bent Pyramid at Dahshur



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Great Pyramid

Egyptian

Great Pyramid at Giza

- Last remaining “wonder”
- For king Khnum-Khufu
- 2580 – 2560 BC
- Near the capital of Memphis
- 756ft x 756ft x 481ft
(230m x 230m x 147m)
- Slope of 51°



Bent Pyramid at Dahshur

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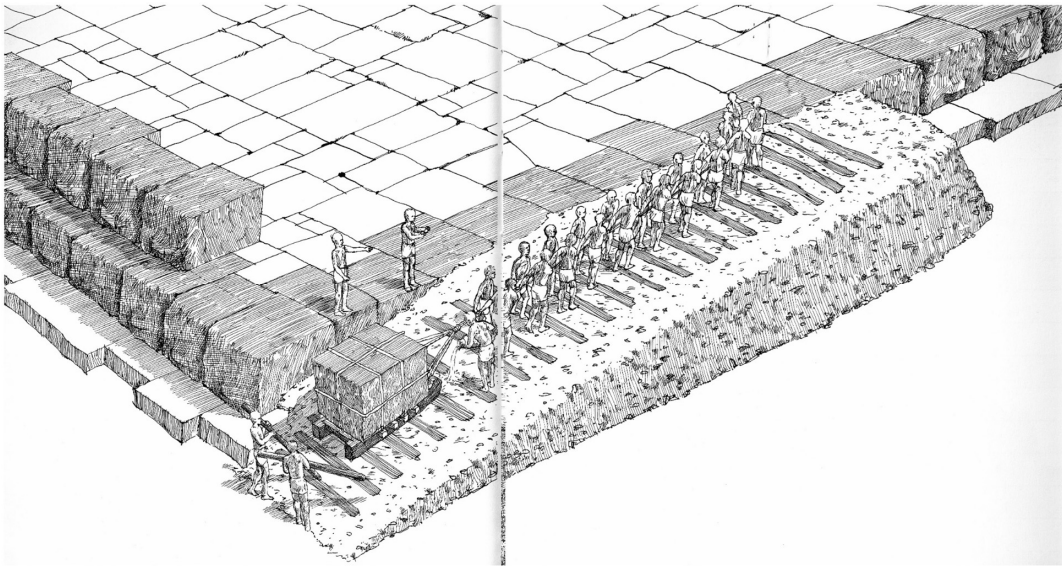
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Great Pyramid

Egyptian

Great Pyramid at Giza

- Construction in stone



From David Macaulay *Pyramid*

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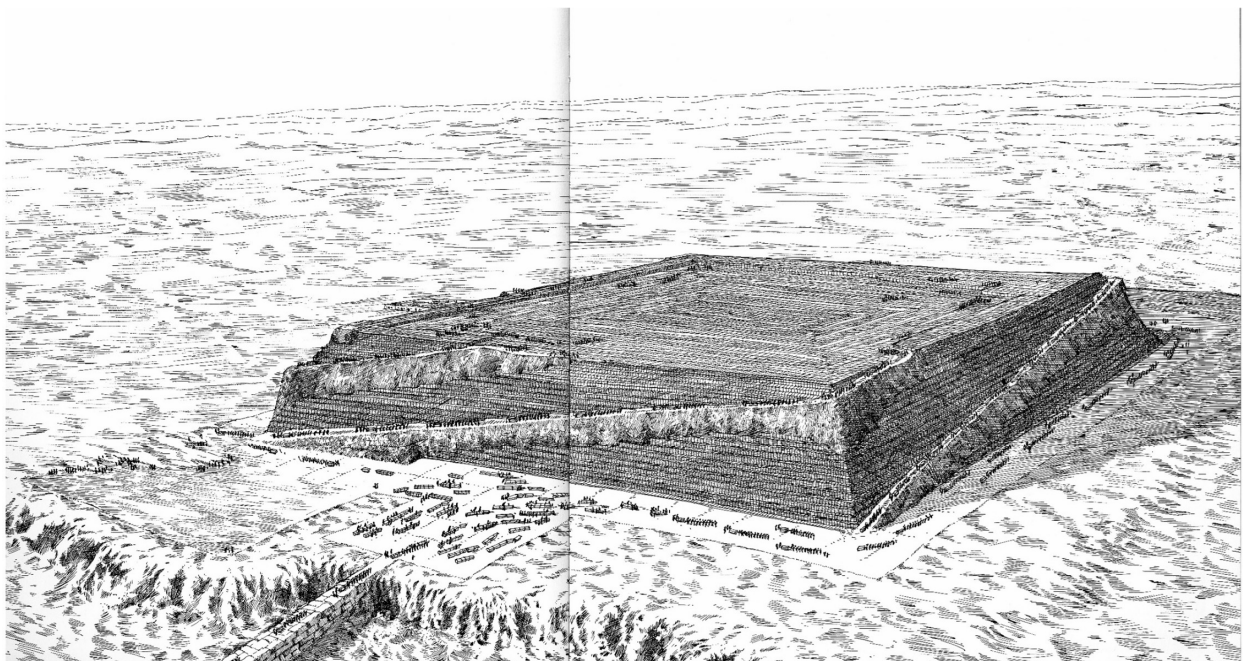
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Great Pyramid

Great Pyramid at Giza

- Construction in stone



From David Macaulay *Pyramid*

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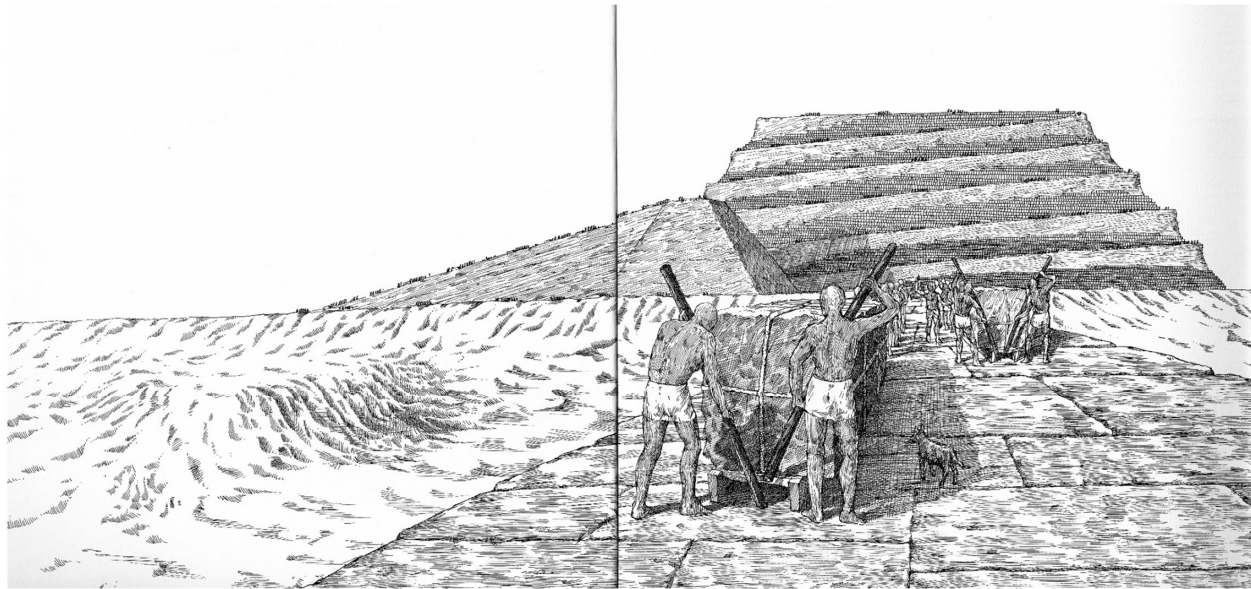
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Great Pyramid

Great Pyramid at Giza

- Construction in stone



From David Macaulay *Pyramid*

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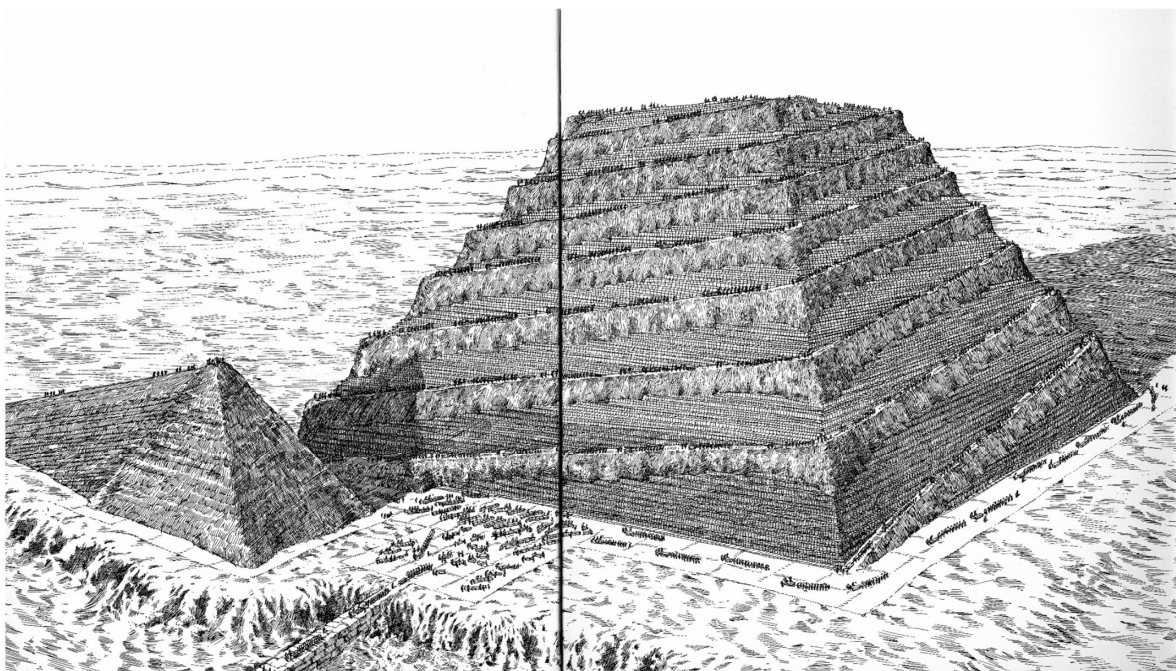
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Great Pyramid

Great Pyramid at Giza

- Construction in stone



From David Macaulay *Pyramid*

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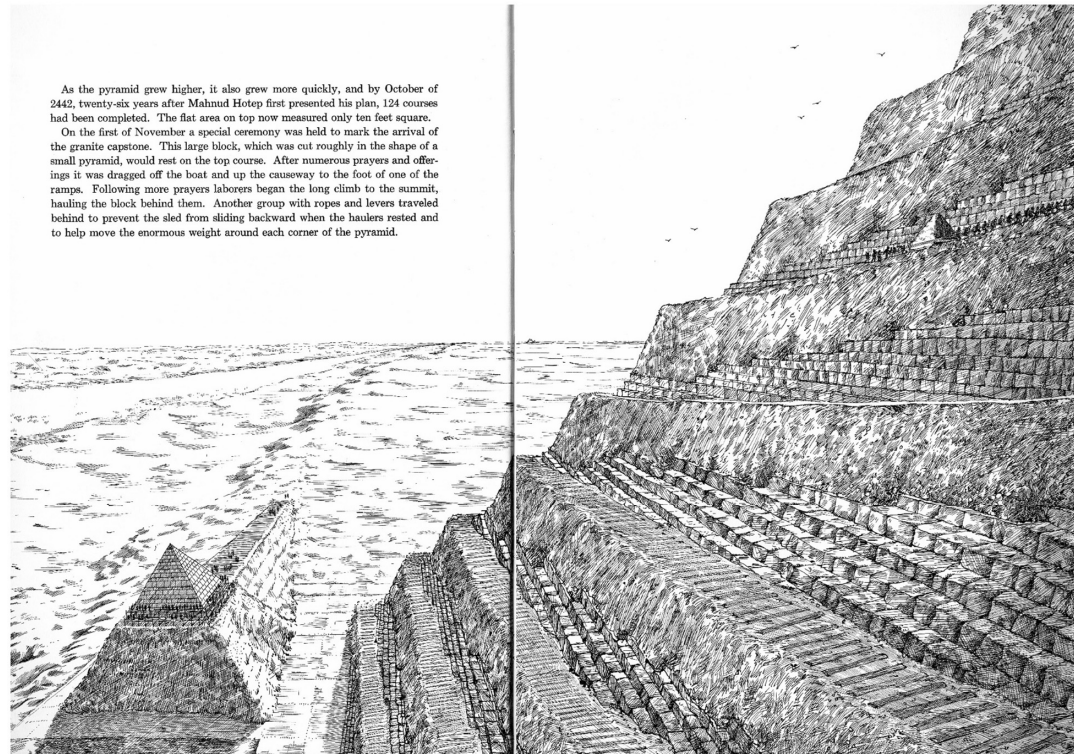
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Great Pyramid

Great Pyramid at Giza

- Construction in stone



From David Macaulay *Pyramid*

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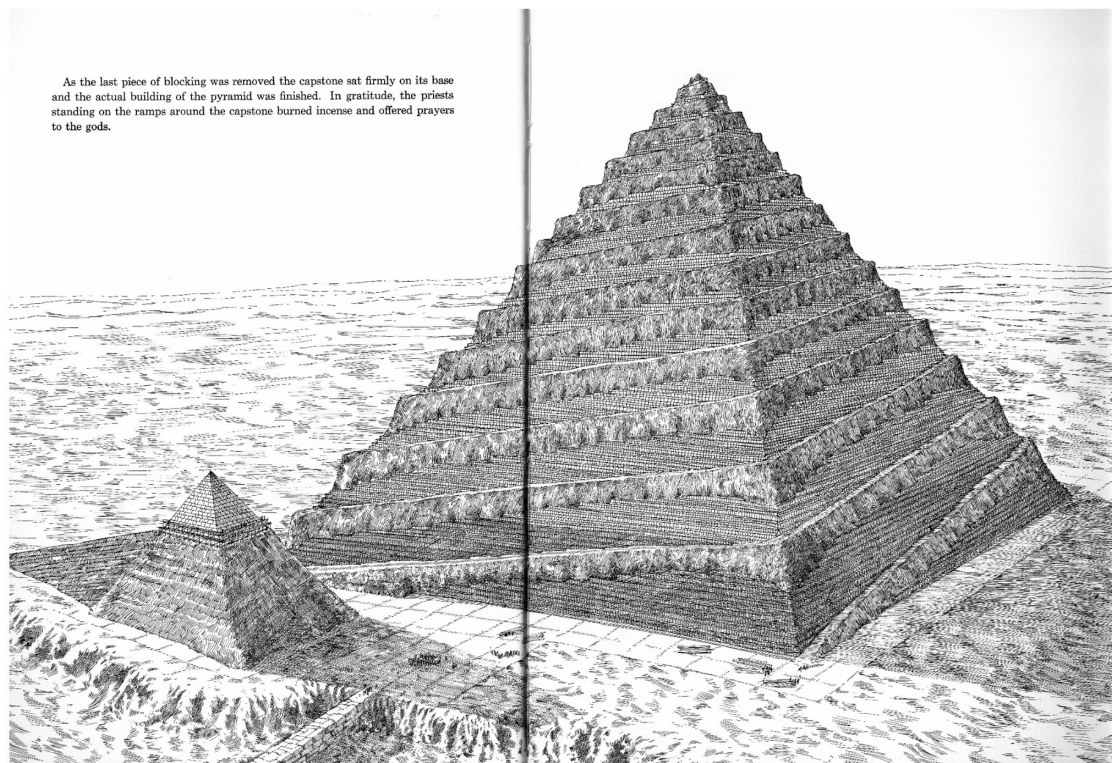
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Great Pyramid

Great Pyramid at Giza

- Construction in stone



From David Macaulay *Pyramid*

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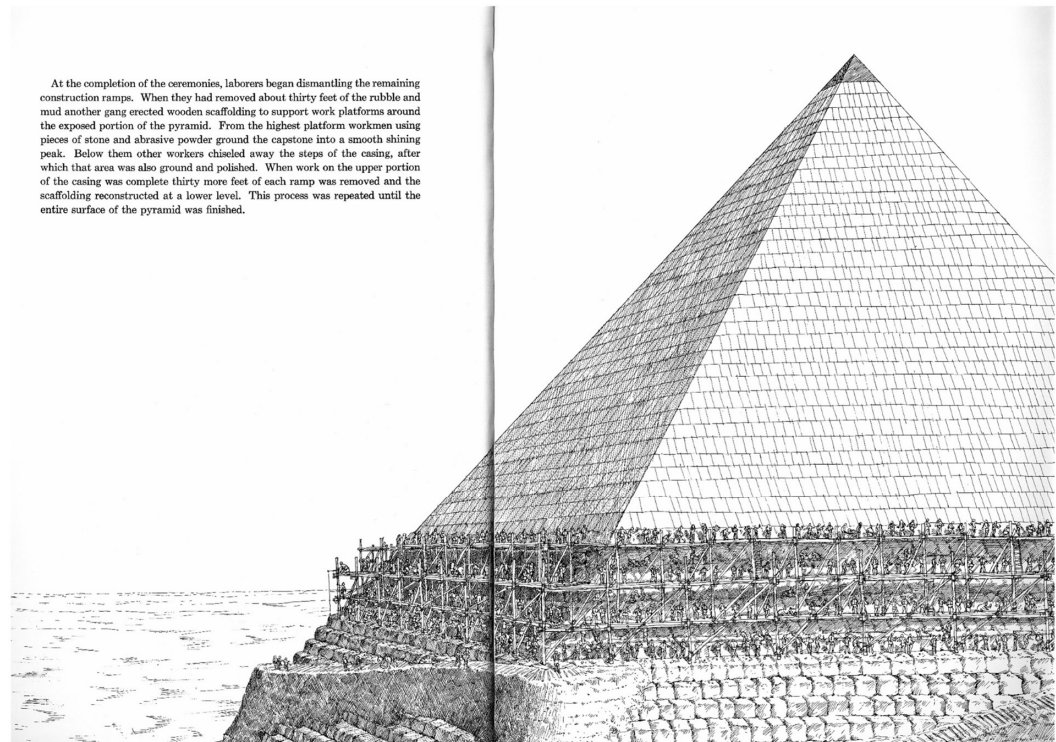
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Great Pyramid

Great Pyramid at Giza

- Construction in stone



From David Macaulay *Pyramid*

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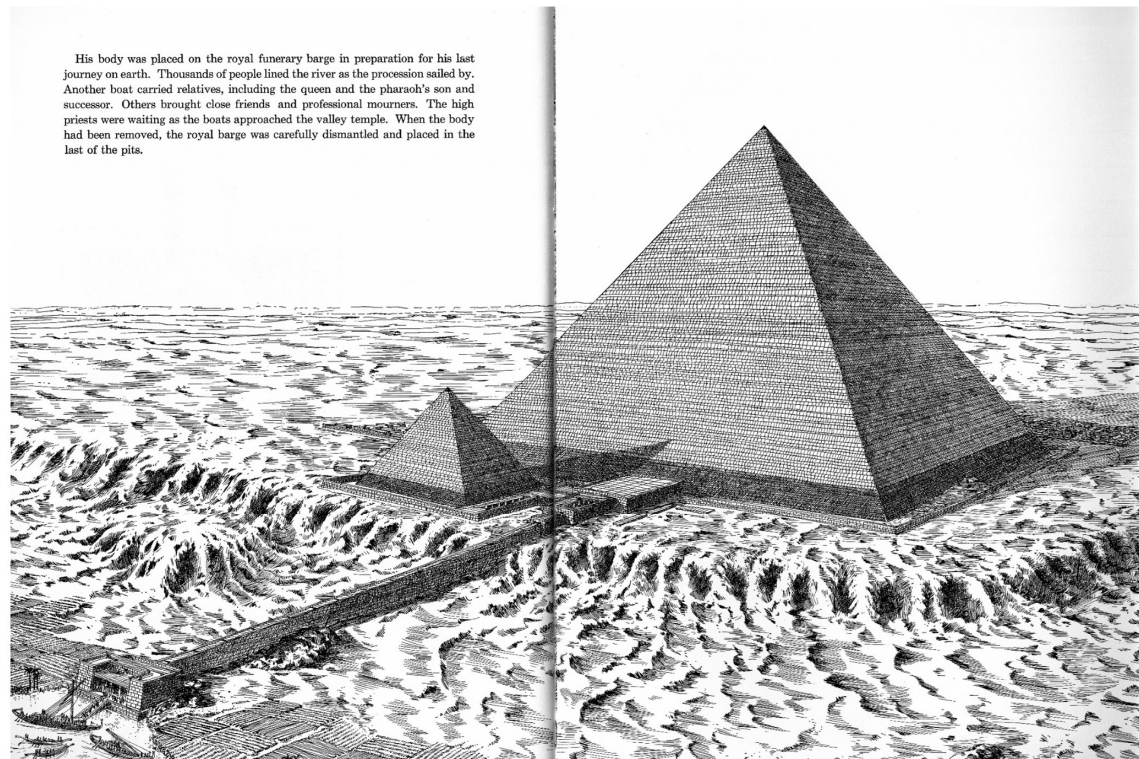
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Great Pyramid

Great Pyramid at Giza

- Construction in stone



From David Macaulay *Pyramid*

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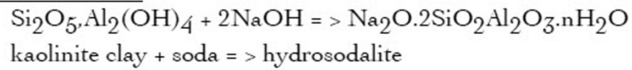
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Great Pyramid

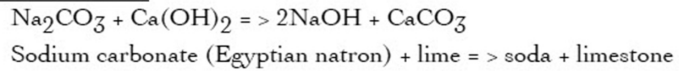
Great Pyramid at Giza

- cast “stone” ?

Chemical reaction 1:



Chemical reaction 2:



References:

Summary of the re-agglomerated stone binder chemical formula:

clay + natron + lime => feldspathoids + limestone (i.e. a natural stone)

pro

Joseph Davidovits, *Why the pharaohs built the Pyramids with fake stones*, 2009

<https://www.geopolymer.org/archaeology/pyramids/are-pyramids-made-out-of-concrete-1/>

or

con

Donald Campbell and Robert Folk, “Ancient Egyptian Pyramids – Concrete or Rock?”, *Concrete International*, Vol 13 Issue 8, August 1991

Great Pyramid

Great Pyramid at Giza

- Or cast “stone”

From Joseph Davidovits' book

Joseph DAVIDOVITS

Why the Pharaohs built
THE PYRAMIDS
with fake stones

The ULTIMATE scientific proofs
The rise and decline of a technology

GEOPOLYMER

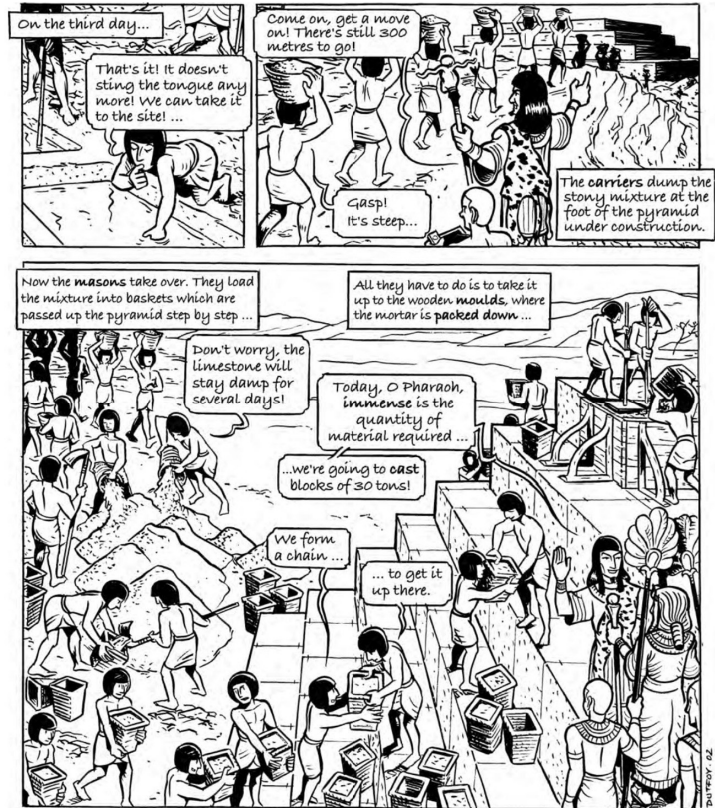


(1) Wadi : a desert watercourse that dries up periodically

Great Pyramid

Great Pyramid at Giza

- Or cast "stone"



From Joseph Davidovits

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Pyrament

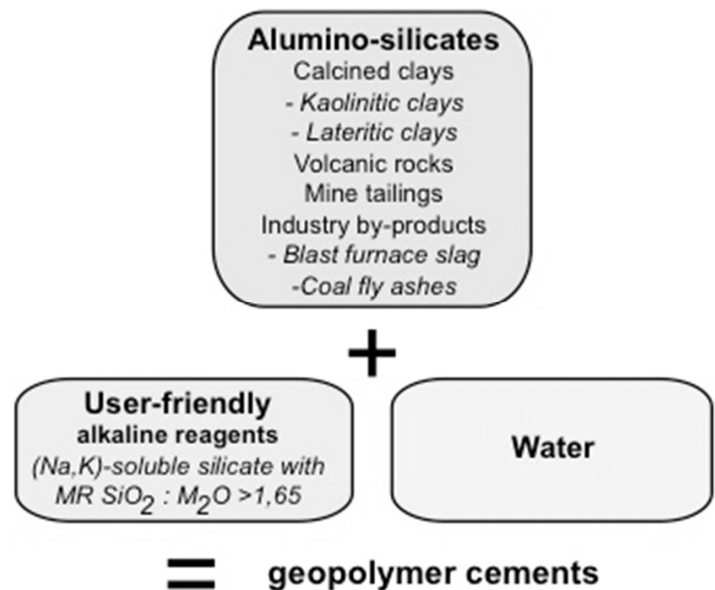
Pyrament from Lone Star

- Geopolymer cement
- Cures faster
- High strength

Used in bridge decks in

Kentucky ~ 1995

https://uknowledge.uky.edu/ktc_researchreports/846/



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Corbeled Arch

Greek

Lion Gate

- Mycenae
- 1250 BC
- Corbeled “arch”
- Stone lintel
- 3 ft thick
- 30 ton



Corbeled Arch

Greece

Treasury of Atreus at Mycenae

- 1250 BC



Syria

Royal Palace of Ugarit

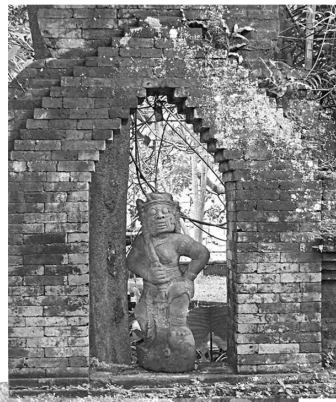
- 1400 - 1200 BC



Corbeled Arch

India

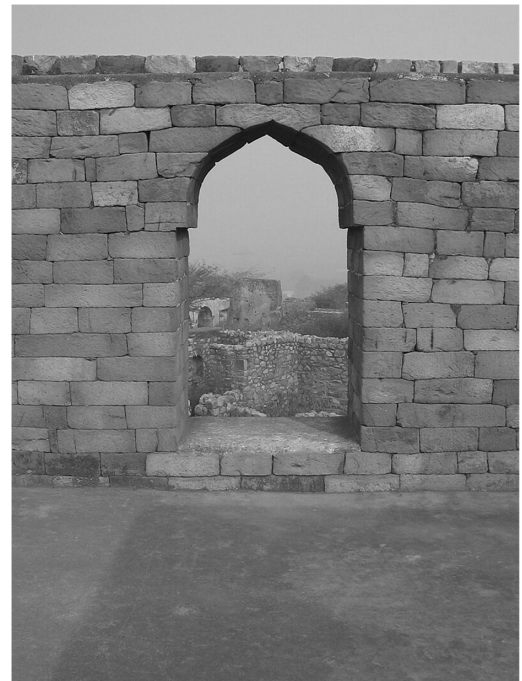
Billbee-ubud



Maya

Cahal Pech

- 250 AD



Trabeate Arch – New Delhi

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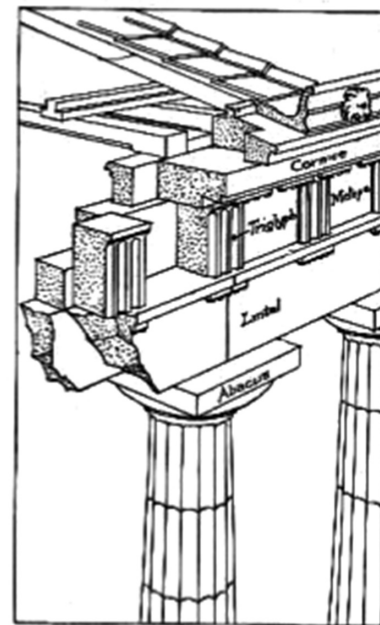
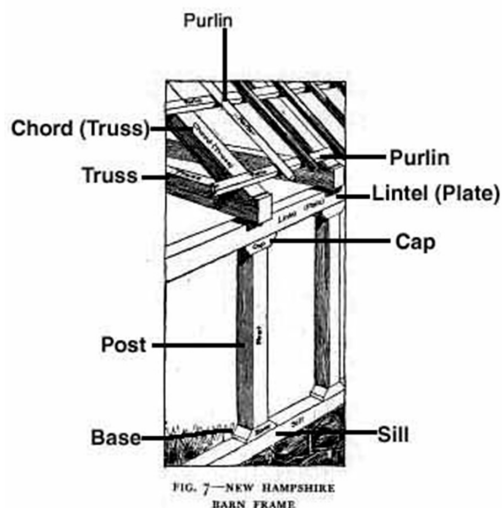
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Post & Lintel

Greek

Temple form

- Derived from wood construction
- “architecton” is master carpenter
- Stone replaced wood by 700 BC



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Post & Lintel

Greek

Parthenon

- 447- 438 BC



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Post & Lintel

Nashville

Parthenon

- Original in wood 1897
- 1925 exterior
- 1931 interior
- 1990 statue



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Wall Construction

Roman

Fired brick used in walls

- Solid masonry
- Infill with concrete (pozzolanic)

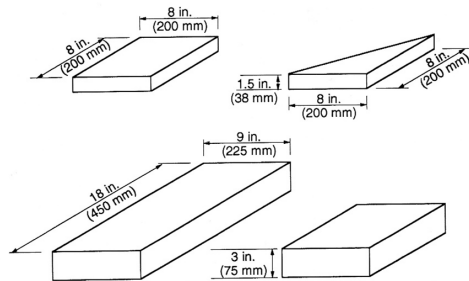
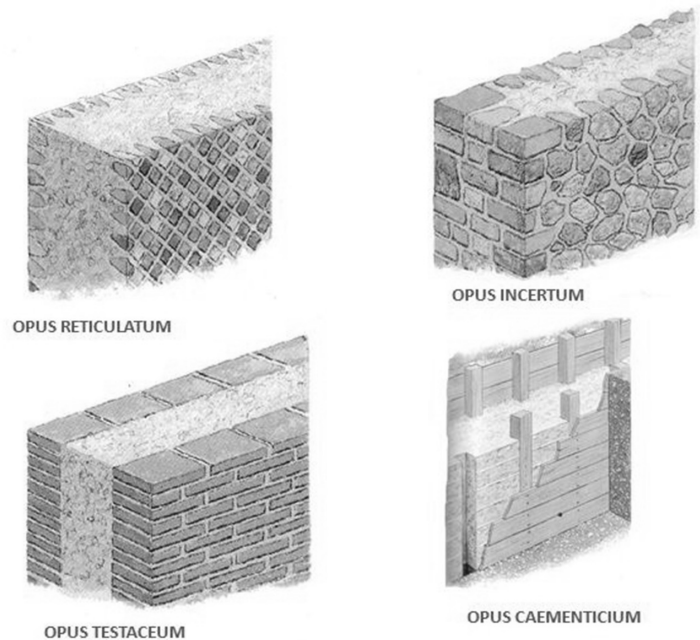


Figure 1.3 Roman bricks made in a mold.



Wall Construction

Roman

Fired brick used in walls

- Solid masonry
- Infill with concrete (pozzolanic)

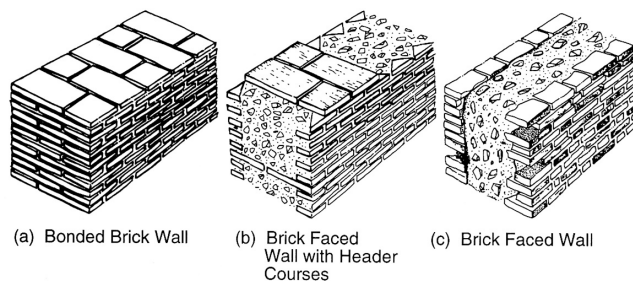
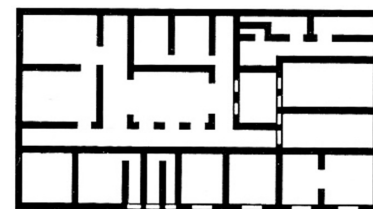


Figure 1.7 Roman masonry walls.



Elevation



Plan

Apartments in Ostia

Arches

Roman

The arch

- First to use
- Circular form
- Braced sides

Ostia



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Masonry

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Arches

Arch forms

- catenary
- parabolic
- circular

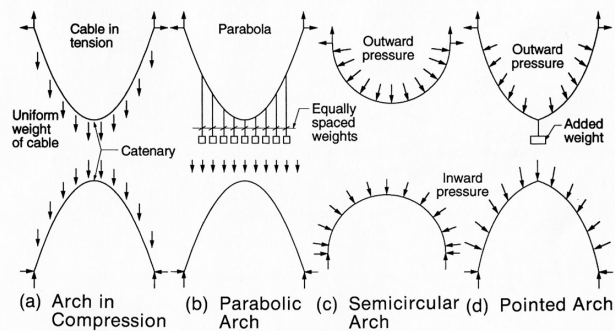


Figure 1.16 Cable-arch analogy.

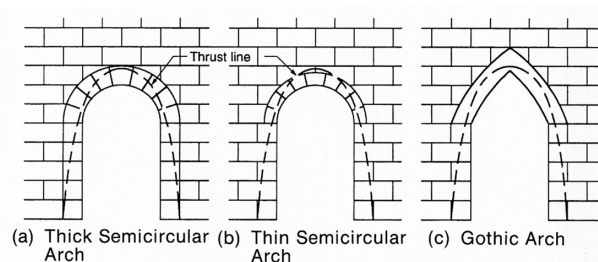


Figure 1.17 Thrust lines in common arches.

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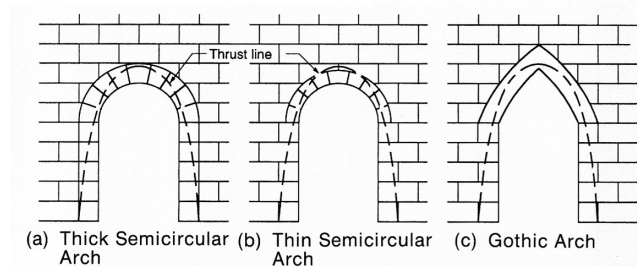
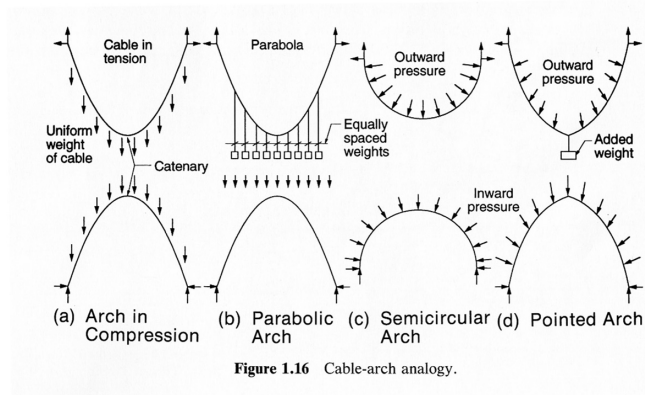
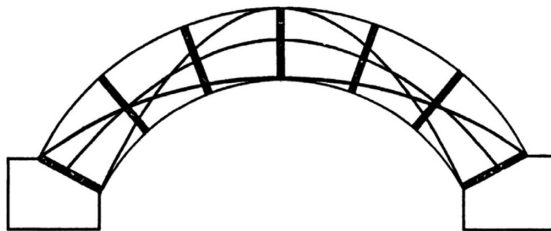
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Arches

Arch forms

- catenary
- parabolic
- circular



Arches

Arches – thrust line calculation

- Sum moments at section

TWO COUPLES ARE EQUAL

$$W \times \frac{L}{4} = R \times h$$

$$R = \frac{WL}{4h}$$

TRACE THE THRUST LINE
BY CUTTING A SECTION.
 ΣM TO FIND α

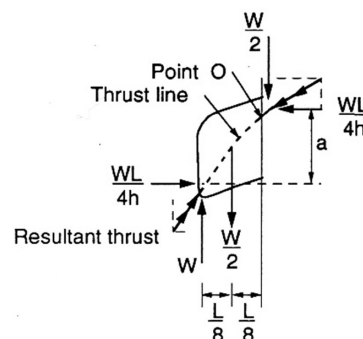
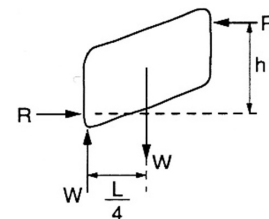
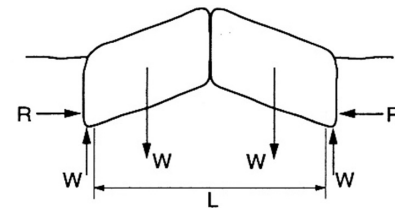
$$\Sigma M_{O_0} = 0$$

$$-\frac{WL}{4h} \alpha + \frac{WL}{4} - \frac{WL}{2} \beta = 0$$

$$\frac{WL}{4h} \alpha + \frac{WL}{4} = \frac{WL}{2}$$

$$\alpha = \frac{3}{4} \frac{WL}{h}$$

$$\alpha = \frac{3}{4} h$$

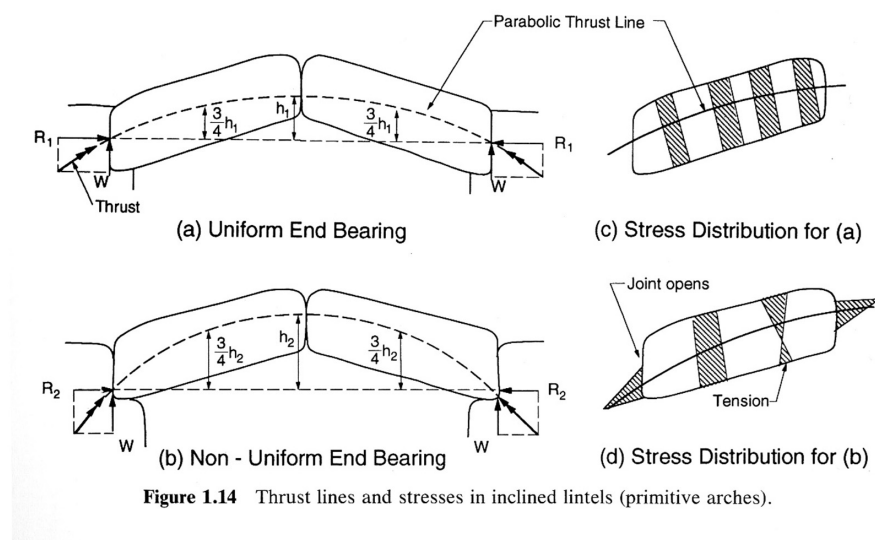


Arches

Arches – thrust line calculation

- Sum moments at section

Two examples with different contact bearing points



Arches

Roman

The arch

- First to use
- Circular form
- Braced sides





Vaults

Vault forms

- single
- parallel
- cross
- pointed (gothic)

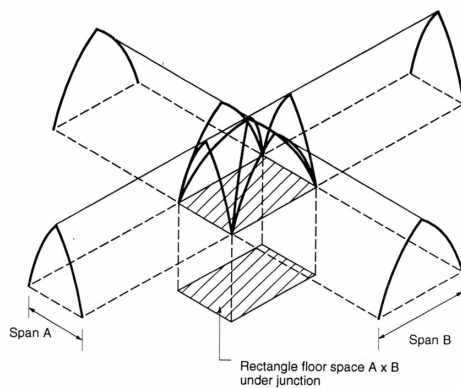


Figure 1.27 Intersection of pointed vaults.

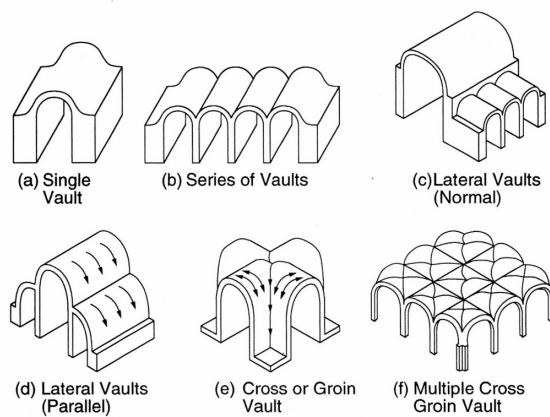
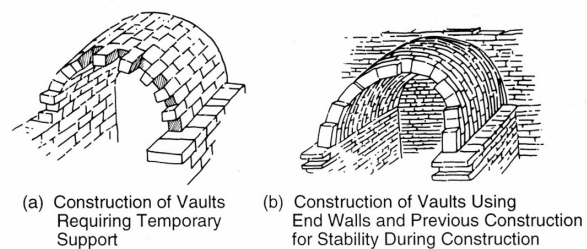


Figure 1.25 Examples of combined barrel vaults.



Domes

Arch forms

- catenary
- parabolic
- circular

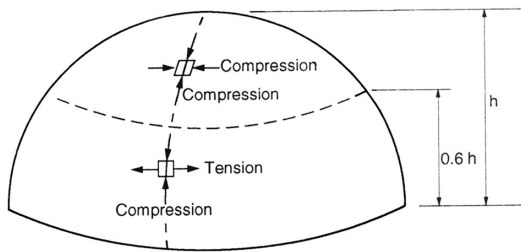


Figure 1.22 Stress in a hemispherical dome under its own weight.

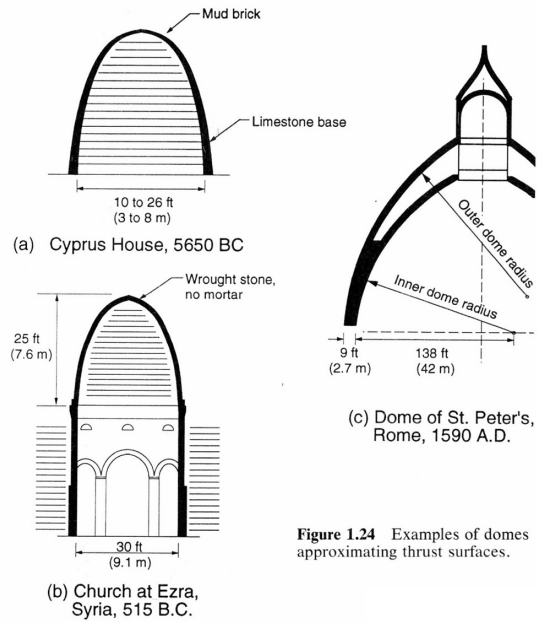


Figure 1.24 Examples of domes approximating thrust surfaces.

Domes

Roman

The masonry dome

- First to use
- Spherical form
- Braced sides



Pantheon 124 AD

Domes

Roman

Pantheon 125 AD

- First to use
- Spherical form
- Braced sides

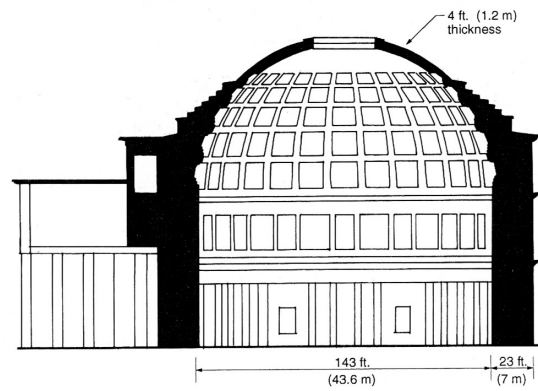


Figure 1.23 The Pantheon in Rome (A.D. 123). (Redrawn from Ref. 1.9)



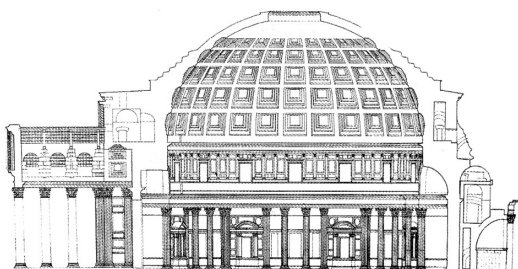
Domes

Roman

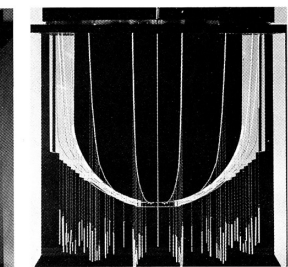
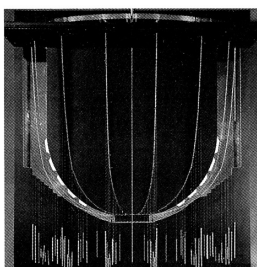
Pantheon

- Thrust line
- Catenary models

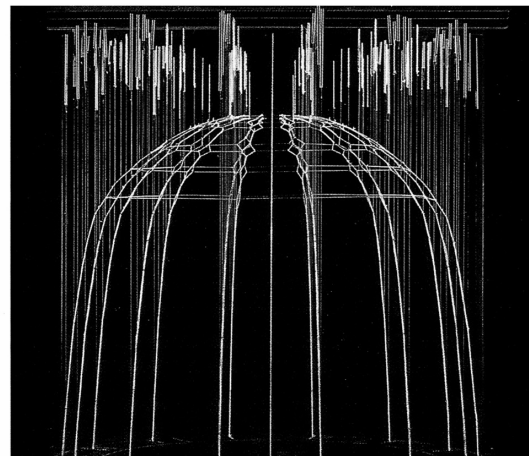
Institute for Lightweight Structures (IL)



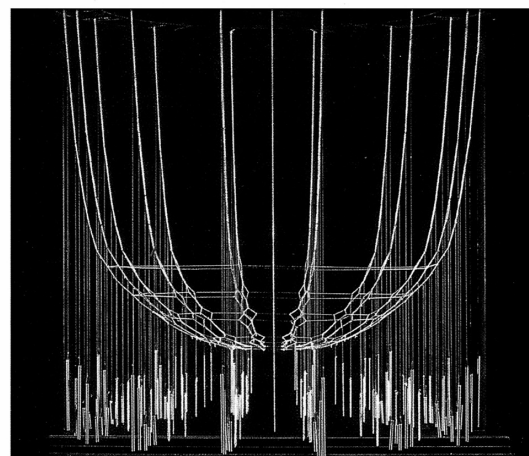
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