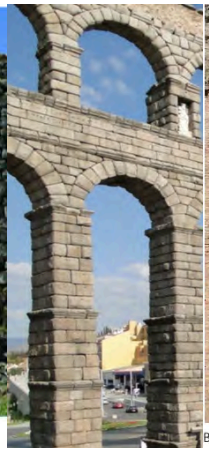
L4. Masonry.

Small Stones (dry construction)
- The nuraghe is one of the most primitive forms of construction requiring a complex organization of knowledge, management of local resources, equipment and labour.
- Local small granite stones are simply stacked to form a vertical but slightly tapered envelope. Larger stones form the base of the wall, stones progressively smaller are used for the upper layers.
- The stones are bound to one another only in virtue of their weight: there is no mortar, it is a dry construction method. The stones are only roughly worked to a convenient shape or not worked at all.
- The system works well in compression. But suffers to take tensional stress.
- A very difficult way to build a roof.

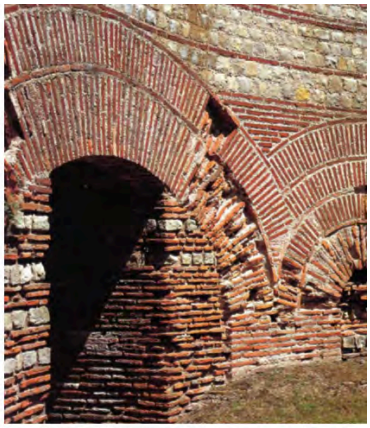
Stereotomy (dry construction)
- Stereotomy is the art of drawing and cutting stones to complex and precise geometries.
- It allowed the ancient civilisations to build large structures with larger elements.
- Stereotomy also allows the implementation of the structural principles of the arch, the vault and the dome (three-dimensional masonry).
- Intellectual knowledge (descriptive geometry) precise manufacturing and modular assembly allow more complex construction methods to develop.
- The Roman aqueduct of Segovia, Spain.

Clay Masonry
- Bricks combine the advantages of small stone stacking systems with the precision and spanning capacity of large stone masonry.
- Bricks are small enough to be held on one hand. At the same time their integration with concrete and stone allows to build very large structures.

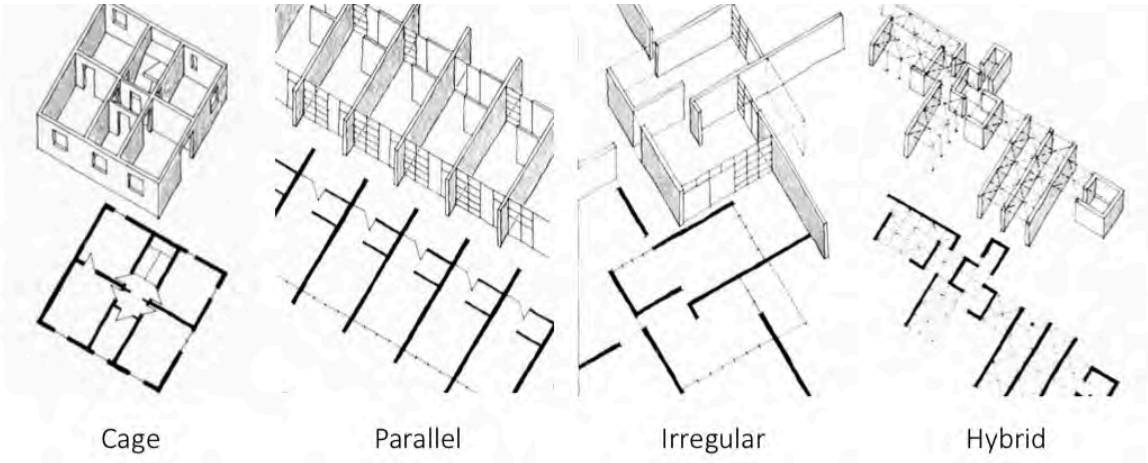

Nuraghe Losa, Abbasanta, Sardinia, 1200-1300 B.C.




Basilica Di Massenzio, Rome

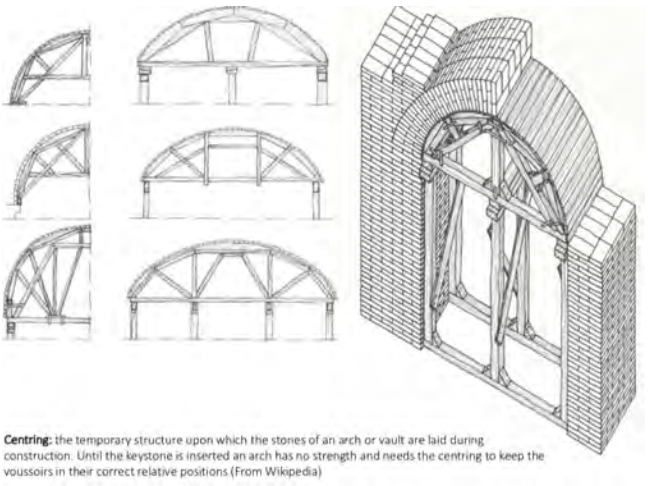

Imperial Baths, Trier (Source: Masonry Construction Manual)

Structural Configurations
Masonry with small modular elements liberates architects and builders from the cage system (structural walls can be separated from non-structural infills)



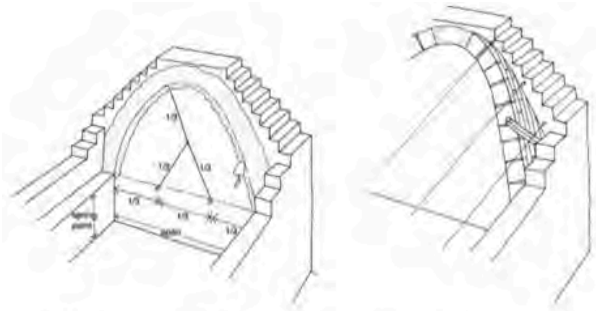
Centring: the temporary structure upon which the stones of an arch or vault are laid during construction. Until the keystone is inserted an arch has no strength and needs the centring to keep the voussoirs in their correct relative positions.

Nubian vaults
Nubian vaults are built without centrings. This is possible thanks to:
- the stickiness of the mud mortar.
- the shape of the vault.
- the inclination of the courses that are placed one upon the other (the earth bricks are laid leaning at a slight slope against the gable walls in a length-wise vault).
- the supporting wall which was thicker than the lateral walls.



Centring: the temporary structure upon which the stones of an arch or vault are laid during construction. Until the keystone is inserted an arch has no strength and needs the centring to keep the voussoirs in their correct relative positions (From Wikipedia)

The age-old Nubian vault technique was notably revived by the Egyptian architect Hassan Fathy in the 1940s with the building of a new village at Gourna, near Luxor.



- divide the span in three equal parts and fix in the two intermediate points two wire length of 1/3 of the diameter
- connect two wires to the other extremity and to this attach another wire of the same length

Here the two halves of the vault meet and the problem of how to have them meet precisely arises, thus often horizontal rows of bricks are used to close the space

MORTAR

- Mortar is the 'glue' of masonry construction. It is used to bond masonry units into a composite monolithic element that is capable to resist vertical and to some extent horizontal loads.
- Mortar seals the gaps and the imperfections between the masonry units and although it cannot be relied upon as an impervious waterproof element it does provides a first barrier from the penetration of wind and water.
- Traditionally mortar was obtained as a mix of lime, sand aggregate and water with lime (produced by crushing and burning limestone or seashells) acting as the bonding agent.
- In contemporary construction mortar is commonly a mix of cement, lime, sand aggregate and water with cement as the main bonding agent. Pigments can also be added to mix to obtained coloured mortars.

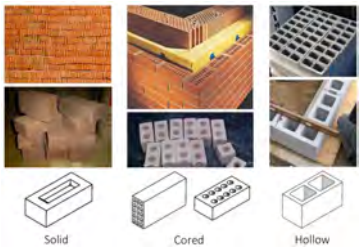
Mortar - Mix design and classes
- A mortar mix is designated by the proportions of its ingredients with cement being given as unit.
- For Example a mortar of class M2 as above can be designated as C1 : L2 : S9
- The standards AS 3700, AS 4773.1 and AS 4773.2 give the mortar grades required in order to ensure satisfactory durability in various exposure environments
- By far the commonest mortar grades are M2 and M3. Most masonry in housing and small-scale structures, where the environment is interior or mild exposure, uses an M2 mortar, while for general work and loadbearing walls an M3 mortar is more suitable. M4 mortar is used for applications where high compressive strength or high durability is required. M1 mortar can only be used in heritage or restoration work

Sand Water Lime Cement Pigments

Mortar Class	Mix proportions			Application	Strength
	Cement	Lime	Sand		
M1	1	3	12	Restoration work	Low
M2	1	2	9	Internal, chimneys, BBQs, above DPC	Moderate Low
M3	1	1	6	Ordinary	Moderate high
	1	0	5		
	1*	0	4		
M4	1	0.5	4.5	Reinforced brickwork and severe marine environments	High
	1	0	4		
	1	0.25	3		
	1*	0	3		

Mortar - Colour
- The colour of mortar can have a significant impact on the visual appearance of exposed masonry construction.
- Coloured mortars can be obtained by using aggregates or pigments.
- The use of coloured aggregates that do not weaken the mortar is generally preferable like white sand, ground granite, marble or stone.
- Alternatively, suitable pigments like iron oxides can be added to the mix or be included as premixed with cement.
- Colour uniformity can be affected also by other factors like quantity of water, brick moisture content, tooling, cleaning and weathering.

MASONRY UNIT



Masonry units are divided into human-made units and natural stone units.
The human-made units are divided clay bricks and concrete blocks, with solid, cored or hollow section

Masonry units – Bricks vs. blocks

Clay bricks
have been used for thousands of years as the principal masonry unit. A brick is typically sized to fit in one hand.

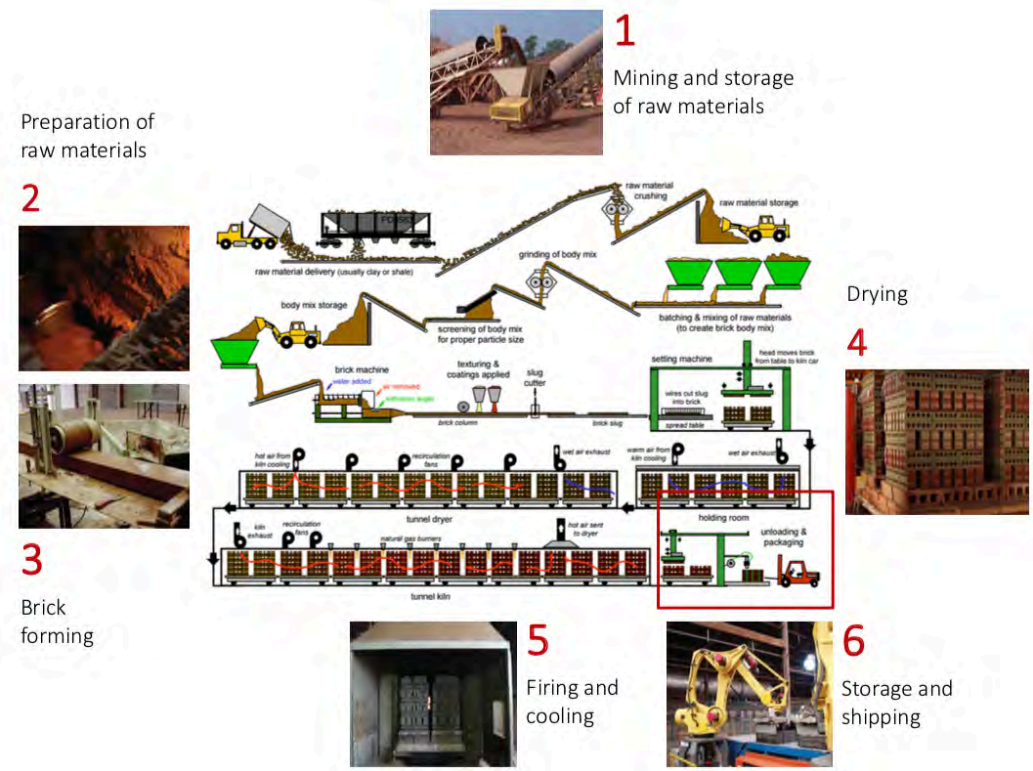
Standard (VIC): 230L x 110W x 76H
- Mortar beds: 10mm; Perpends 6 – 10mm
- Compressive Strength: 6 - 60 MPa.

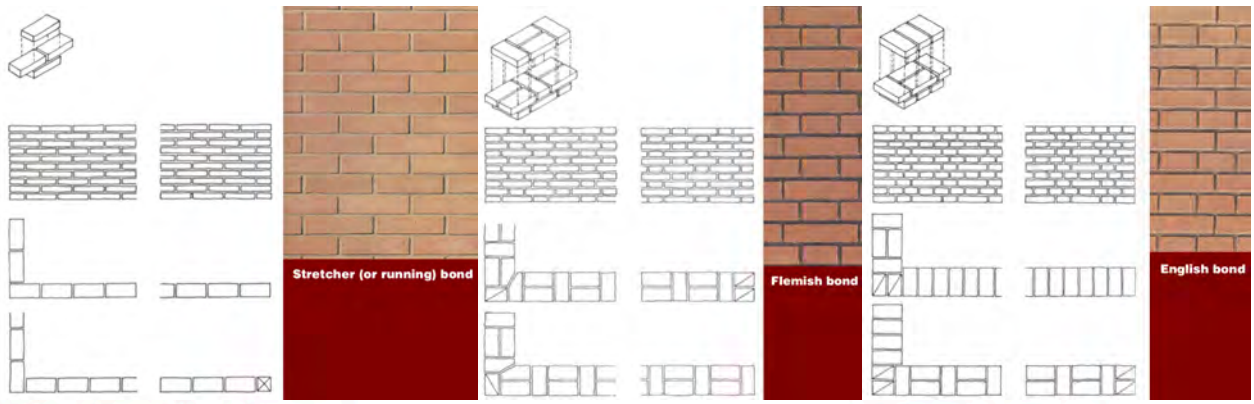
Concrete blocks
have become increasingly more diffused in the Australian building industry for their less labour-intensive requirements.

Standard Block: 390L x 190W x 190H
Mortar beds and perpends: 10mm
Compressive Strength: 3 - 35 MPa.

BRICK MANUFACTURING

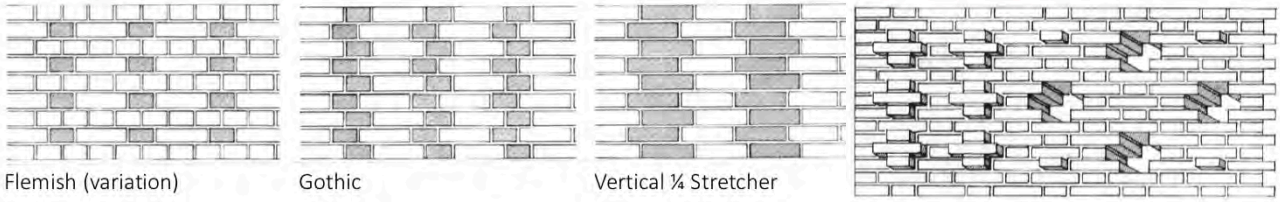
- Bricks are made of clay, one of the most abundant materials on Earth.
- Brick manufacturing plants usually not far from urban areas as brick transport can be quite expensive.



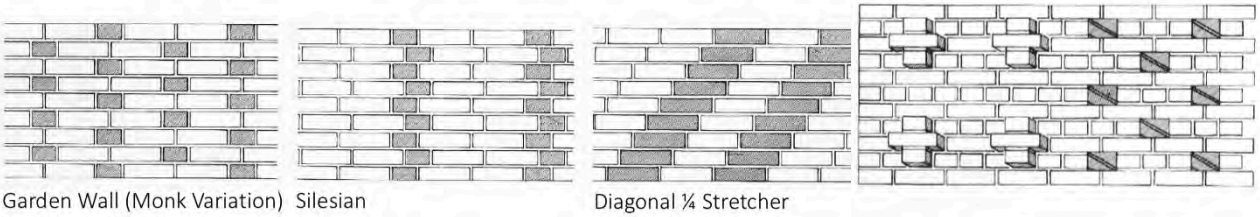


Less common bond types

Ornamental bonds

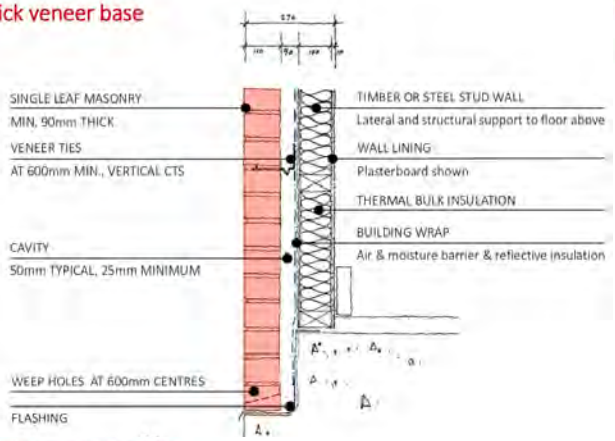


Flemish (variation) Gothic Vertical ¼ Stretcher

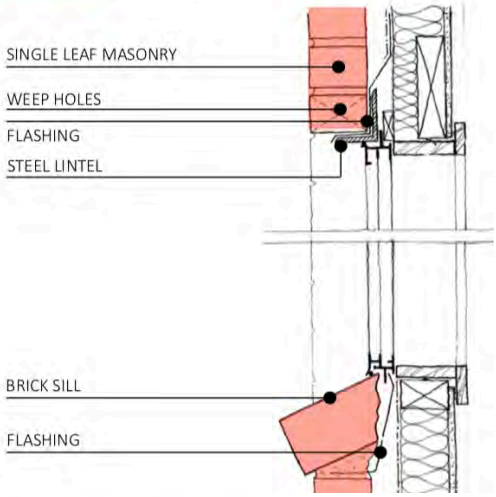


Garden Wall (Monk Variation) Silesian Diagonal ¼ Stretcher

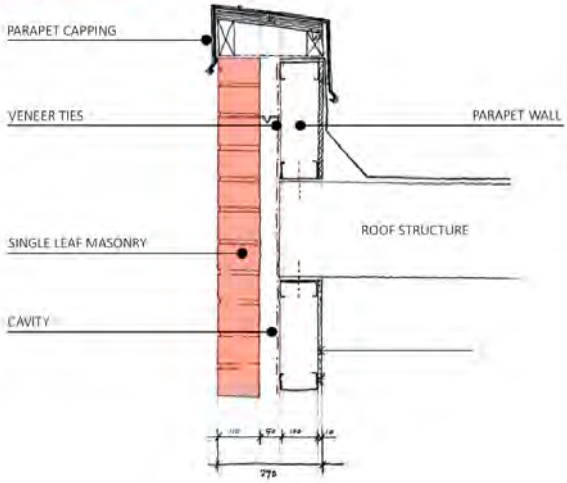
Brick veneer base



Brick veneer openings



Brick veneer capping



Wall insulation

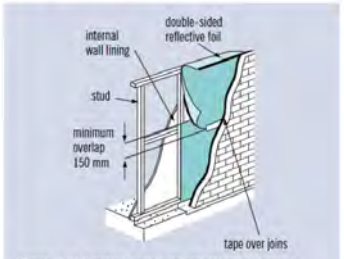


Figure 7.23: Framed walls with reflective foil (overall R value 1.3)

Framed walls with reflective foil laminate

By installing double-sided reflective foil on the outside of the framed walls (studs), achieves an overall R value of 1.3. This can be increased to R1.8 if combined with concertina-style reflective foil stapled between the studs as well (leaving at least 25 mm air space between them).

The use of reflective foil over framing is shown in figure 7.23. Suitable materials are double-sided reflective foil laminate and reflective building paper.

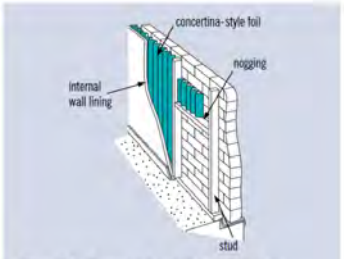


Figure 7.24: Framed walls with reflective foil batts (overall R value 1.4)

Framed walls with reflective foil batts

The use of reflective foil batts between framing is shown in figure 7.24. Suitable materials are concertina-style reflective foil laminate or single-cell foil batts, both stapled between the studs.

The overall R value is 1.4, and can be increased to 1.8 by using two layers of concertina batts stapled between the studs (leaving at least 25 mm air space between them), or by using double-cell foil batts stapled between the studs.