VAULT CONSTRUCTION

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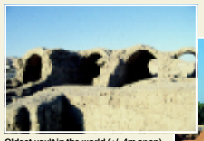
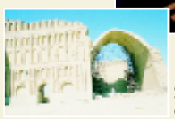


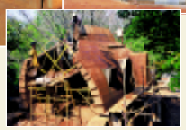
Oldest vault in the world (+/- 4m span), Ramasseum, Thebes (opposite Luxor) Egypt, +/- 1300 BC

School – Auroville, India (10.35 m span, 2.25 m rise)

Training centre Auroville, India



Ctesiphon, Iraq VIth century (21 m span, 30 m high)



Three points vault – 3.60 m span Auroville, India

Application of Vaults:
- Plain masonry built with blocks or bricks
- Floors for multi-storey buildings: they can be leveled flat
- Roofs: they can be left exposed and they will be waterproofed in a conventional way with a cement-lime-sand plaster
- Earthquakes zones: they can be used with a reinforced ring beam

Two Ways to Build Vaults:
- Using a form to support the bricks during construction: this form is either made of wood or steel, and it can be re-used
- Building "free-spanning", that means without form: this way is also called the Nubian technique

Timber Saving:
- Vaults can be built with adobe, burnt bricks, CEB or stones

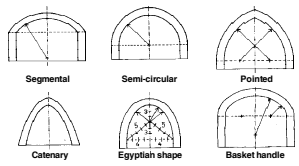
Stability Study:
- The shape of a vault is crucial for the stability, and a stability study is often needed; be careful, a wrong shape will collapse

Need of Skilled Masons:
- Building a vault requires delicate hands of trained masons
- Never improvise when building vaults, ask advice and specifications from skilled people
- Be careful, a badly built dome may collapse

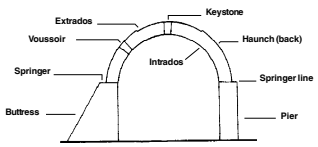
Need of Good Quality Materials:
- Vaults built with compressed earth blocks should be made of blocks of very regular thickness

BASICS FOR VAULTS

Variety of Shapes



Terminology

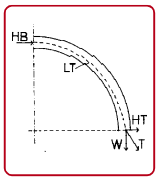


Basic Structural Principles

A vault is characterized by a thrust, which pushes on the walls

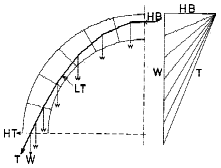
The thrust (T) is composed of two forces:
- A horizontal force (**HT**), which tends to push the walls apart
- The weight (**W**), which is the weight of the masonry

The line of thrust in the vault is preferably in the centre, or it must remain in the middle third of the masonry:
- A disregard of this rule will cause collapse



HB : Horizontal balance (balance of the 2nd half)
LT : Line of thrust
HT : Horizontal thrust
W : Weight of the masonry
T : Resultant of the thrust

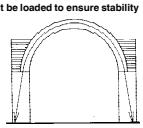
Typical Funicular study



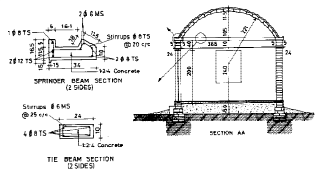
Stability Study of a Semi-Circular Vault

- The line of thrust passes in the inner third
- The back of the vault must be loaded to ensure stability

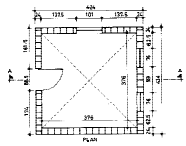
Loading the back is necessary to ensure stability



Typical Vault for Village House



- Section
- Plan



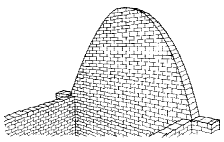
- These dimensions and specifications must be rigorously respected! Any disregard to them may cause collapse...

BUILDING WITHOUT FORM

1. Technique Basics

- The clay which is present in a soil binds a brick or block
  - This technique can use either adobe (sun dried bricks), stabilized CEB (compressed earth blocks), or fired bricks
  - The blocks must be dry before starting the block laying process
  - A wall to start leaning the blocks on is needed: the blocks on the 1st layer are stuck against it
  - The mortar is like a glue, it is very sticky; clay is the binder
    - The mortar contains more soil than sand, and some cement
    - The cement does not help for adhesion, the clay does it
    - Mortar proportions will vary according to the soil quality
    - The mortar thickness should not exceed 2-3 mm

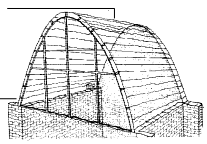
2. Building the Leaning Wall



- Build the back wall to lean the blocks on and draw on it the outside shape of the vault

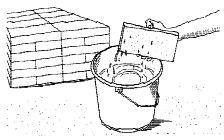
3. Fixing the Template and Strings

- Pull string lines from the template to the leaning wall
- Temporary provision to fix the strings outside the curve



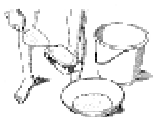
- This template will advantageously be the window

4. Soaking the Block



- Soak the block for 2 seconds just before laying it on mortar
- It will start a capillary action which will suck the glue in

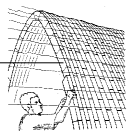
5. Laying the Glue



- The binder is the glue, which is made of soil, sand, a little cement and a lot of water
- Immediately after soaking the block apply 3-4 mm glue on it

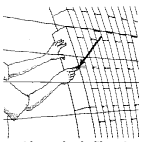
6. Stick the Block on the Masonry

- The previous course must be humid



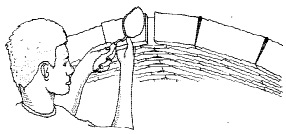
- The blocks must touch at the intrados = 0 mm mortar
- Check that the blocks do not touch the strings = 1 mm below

7. Wedge the Joints



- Extrados joints must be wedged with a stone chip or pebble
- The wedge is inserted by hand and must be tight in the joint

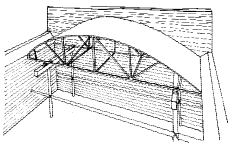
8. Laying the Keystone



- Adjust the keystone; it must be very tight: intrados = 0 mm
- Wedge tight the outside of the joint with a pebble

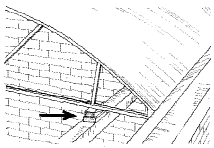
BUILDING WITH A FORM

1. Setting up the Form



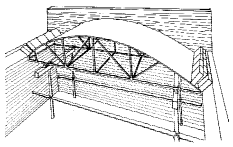
- Support the form by any means

2. Adjust the Form



- Place wooden wedges and check that the form is levelled

3. Starting the Vault

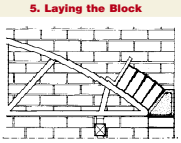


- Lay the blocks symmetrically; the mortar must be plastic

4. Laying the Mortar

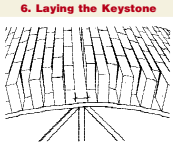
- Spread the mortar with a triangular shape: intrados = 0 mm
- Outside mortar thickness = little more than the finished joint
- Soak the block before laying it on the mortar

5. Laying the Block



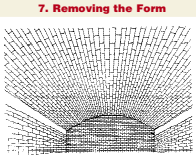
- The blocks must touch at the intrados = 0 mm mortar
- Check with a square angle that blocks are perpendicular to the form

6. Laying the Keystone



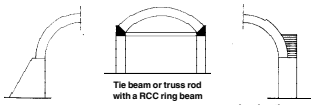
- Adjust the keystone, it must be well touching at the intrados
- The mortar outside of the joint must be really tight: press it firmly with a steel rod

7. Removing the Form



- Immediately after finishing the vault, clean the brickwork and slide the wedges back slowly; the form will go down

8. Balancing the Thrust



- Buttresses, tie beams, truss rods or load on the haunches can balance the thrust of a vault