CONTENTS

WALL SYSTEMS

1. INTRODUCTION

- By definition a wall is a continuous, usually vertical structure of brick, stone, block, concrete, timber, or metal thin in proportion to its height and length.
- Wall is one of the most essential components of a building.
- The primary function of wall is:
  - To enclose or divide space of a building to make it more functional and useful.
  - To provide privacy and afford security
  - Give protection against heat, cold, sun and rain
  - Also to provide support to floors and roofs.

WALL SYSTEMS

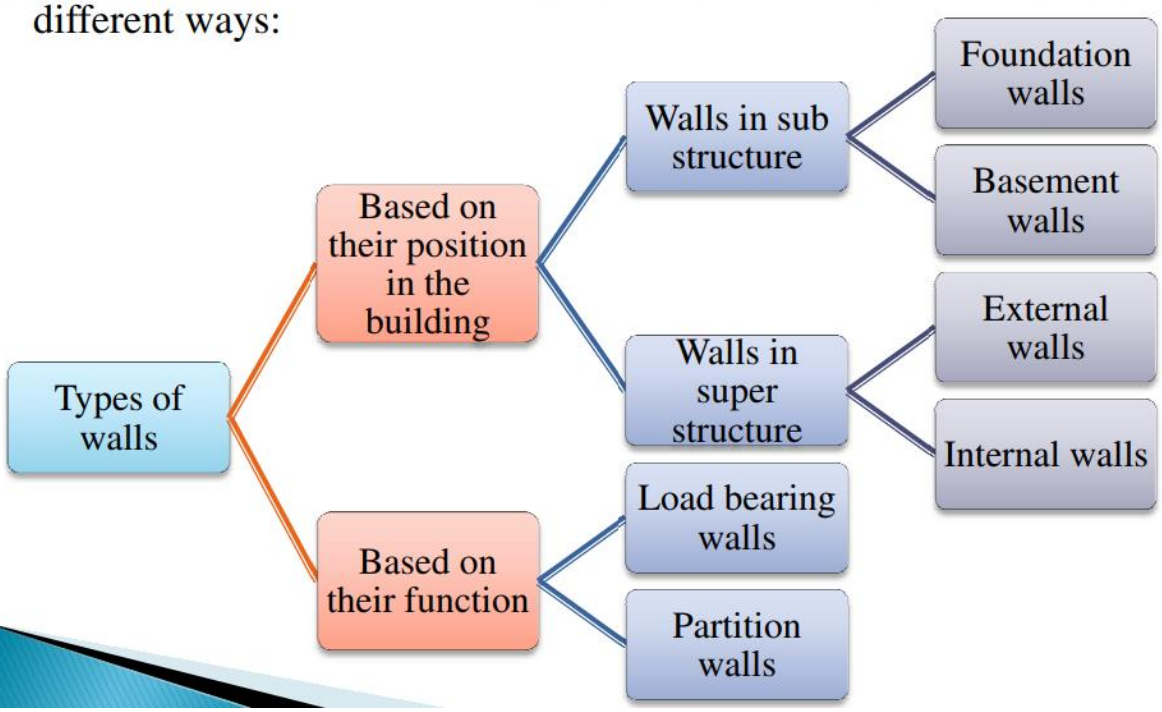
1. INTRODUCTION (cont...)

- The functional requirements of a wall are:
  - Strength and stability
  - Resistance to weather
  - Durability and freedom from maintenance
  - Fire resistance
  - Resistance to passage of heat
  - Resistance to passage of sound

WALL SYSTEMS

2. TYPES OF WALLS

- A distinction between various types of wall can be made in two different ways:



WALL SYSTEMS

2. TYPES OF WALLS (CONT...)

- Foundation walls
  - The function of foundation wall is to transmit loads coming from the super structure.
  - Load bearing capacity and resistance against effect of the underground, such as swelling pressure, uplift pressure and chemical attack should be taken into consideration.
- Basement walls
  - The function of basement wall is to:
    - Support vertical loads (if load bearing)
    - Resist lateral loads, and
    - Protect the building from dampness.

WALL SYSTEMS

2. TYPES OF WALLS (CONT...)

- External walls:
  - Must provide protection against wind and rain, should insulate heat
  - Be water repellent, fire resisting and capable of sound insulation.
- Internal walls:
  - Internal walls are basically required to separate rooms.
  - They should have sufficient sound and heat insulating capacity and should be water repellent.
- Load bearing walls:
  - The strength must be sufficient to carry the loads placed on it.
  - The loads are calculated from the live and dead loads on the structure supported by the wall
    - wind pressure must also be taken into account.

WALL SYSTEMS

3. EXTERNAL WALLS

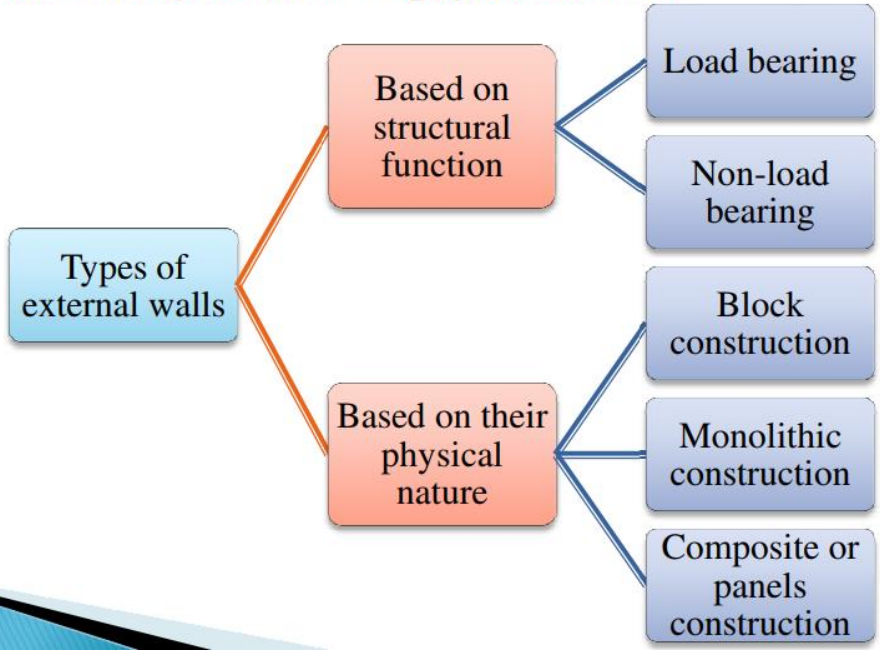
3.1 MATERIALS FOR EXTERNAL WALLS

- Different materials are employed for the construction of external walls such as: brick, stone, HCB, RCC, glass, metals and plastics, chika, etc.
- The materials employed depend on several factors such as:
  - Local availability of the material
  - The standard of the house planned
  - Climatic conditions
  - Cost of the material
  - Aesthetic requirements
  - Skilled labour availability
  - Function of the wall to be constructed
  - Fire resistance requirement

WALL SYSTEMS

3.2 TYPES OF EXTERNAL WALLS

- External walls can be classified in different groups according to their ***structural functions*** and ***physical nature***.



WALL SYSTEMS

3.2.1 WALLS OF BLOCK CONSTRUCTION

- Walls composed of stones, bricks or HCB are of block construction.
- They are formed from fairly small units set in matrix of cement mortar.
- The properties and strength of such wall depend on:
  - Quality of masonry material
  - Quality of mortar
  - Method of bonding used
- Walls made up of stone, brick, hollow and solid concrete blocks, etc. Are included in this category.

WALL SYSTEMS

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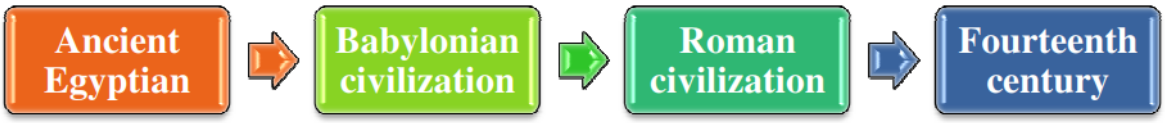
WALL SYSTEMS

A) BRICK WALLS

- Brick walls are widely used both as load bearing and as non-load bearing walls.
- Brick is a very old building material.



- The production of bricks for various purposes has advanced significantly and it is now excellent building material all over the world having:
  - Different shapes, sizes, color and characteristics.
- The practice of using bricks for construction in Ethiopia is not old.
- The process of brick production in Ethiopia is far from accurate and doesn't benefit from the current advances in brick technology.

WALL SYSTEMS

A) BRICK WALLS (CONT...)

Manufacturing of clay bricks

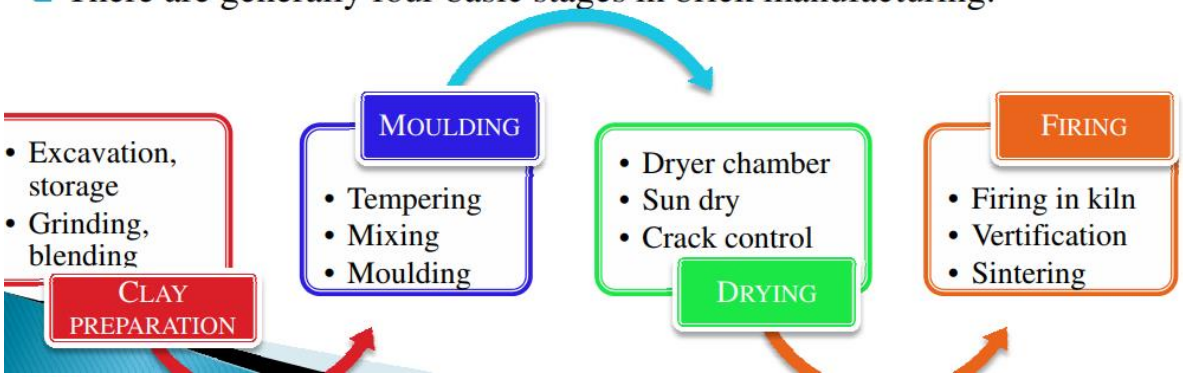
- Brick is manufactured from clay. Clay is a fine grained soil, which has resulted from weathering of rocks.
- Clay for the production of brick must possess some specific properties:
  - Plasticity: which permits it to be shaped or moulded,
  - Sufficient tensile strength: to maintain its shape after forming,
  - Must fuse together when subjected to rising temperature.
- Clay occurs in three principal forms having similar chemical composition but different physical characteristics. They are:
  - **Surface clay**: recent sedimentary formation
  - **Shale**: clay that have been subjected to high pressure
  - **Fire clay**: mined at deeper levels and have refractory qualities

WALL SYSTEMS

A) BRICK WALLS (CONT...)

Manufacturing of clay bricks

- Chemically all the three forms are compounds of silica and alumina with varying amounts of metallic oxides and other impurities.
  - Metallic oxides: acts as fluxes promoting fusion at lower temp.
  - Iron, magnesium and calcium: influence the color
  - Silicates: contribute for the strength and durability
- There are generally four basic stages in brick manufacturing:



WALL SYSTEMS

A) BRICK WALLS (CONT...)

Manufacturing of clay bricks

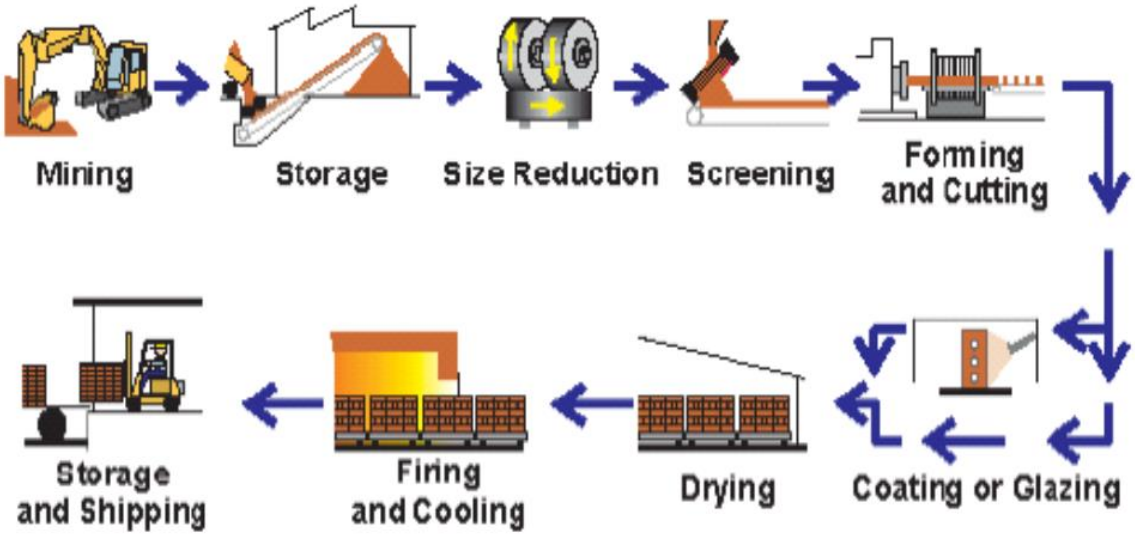


Figure 1

Diagrammatic Representation of Manufacturing Process

WALL SYSTEMS

A) BRICK WALLS (CONT...)

Types of clay bricks

- Different types of bricks can be produced depending on the types of clay, the moulding and firing process:

i. Common bricks
- Ordinary bricks
- Not designed to provide good finished appearance & highest strength
- The cheapest brick

ii. Facing bricks
- Designed to give attractive appearance
- Free from imperfections such as cracks & size variations

iii. Engineering bricks
- Designed for strength & durability
- High density & well fired

iv. Fire bricks
- Made of special fire clay
- Used for lining in fire places, furnaces, etc. where high temperatures are prevalent.

WALL SYSTEMS

A) BRICK WALLS (CONT...)

Tests for bricks

Field test for soils
- Balls of about 8cm are moulded with hands & allowed to dry.
- Moulding bricks of standard size

Field test for burnt clay bricks
- Appearance: shape, plainness, color checks
- Hammer test: properly burnt & free from cracks brick emits a metallic ring.
- Hardness test: scratching surface with a knife.

Laboratory tests
- Compressive strength: direction of loading same as that to be applied in practice.
- Water absorption: 24 hrs cold water or 5 hrs boiling water test.
- Efflorescence: results from dissolved salts & spoils the appearance .

WALL SYSTEMS

A) BRICK WALLS (CONT...)

Tests for bricks





WALL SYSTEMS

A) BRICK WALLS (CONT...)

Tests for bricks

MINIMUM COMPRESSIVE STRENGTH OF BRICK (ES C.D4.001)		
Class	**Average of 5 brick [MPa]**	**Individual brick [MPa]**
A	20	17.5
B	15	12.5
C	10	7.5
D	7.5	5.5

MAXIMUM WATER ABSORPTION (ES C.D4.001)				
class	**24-hrs immersion (%)**		**5-hrs immersion (%)**	
	Avg. of 5 bricks	**Individual brick**	**Avg. of 5 bricks**	**Individual brick**
A	21	23	22	24
B	22	24	23	24
C,D	No limit	No limit	No limit	No limit

WALL SYSTEMS

A) BRICK WALLS (CONT...)

Brick masonry

- Brick masonry is sometimes preferred over other types of masonry for the following reasons:
  - Bricks are of uniform size and shape, and hence they can be laid in any definite pattern.
  - Bricks are light in weight and small in size. Hence they can be easily handled.
  - Brick do not need any dressing.
  - The art of brick laying can be understood easily.
  - Ornamental works can be easily done with bricks.
  - Light partition walls can be easily constructed in brick masonry.

WALL SYSTEMS

A) BRICK WALLS (CONT...)

Terminologies

- **Course:** A course is a horizontal layer of masonry units.
- **Stretcher**: A stretcher is the longer face of a brick as seen in the elevation of the wall.
- **Header**: A header is the shorter face of a brick as seen in the elevation of the wall.
- **Lap**: Lap is the horizontal distance between the vertical joints of successive brick courses.
- **Bed**: Bed is the lower surface of the brick when laid flat.
- **Closer**: It is a portion of the brick with the cut made longitudinally and is used to close up bond at the end of the course.
  - **Queen closer**: It is a portion of a brick obtained by cutting a brick length wise into two portions.
  - **King closer**: It is obtained by cutting the triangular piece between the center of one end and the center of the other side.

WALL SYSTEMS

A) BRICK WALLS (CONT...)

Terminologies (cont...)

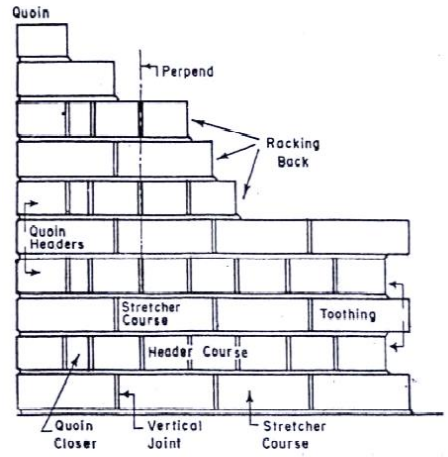
- **Bevelled closer**: A special form of king closer in which half width is maintained at one end and full width is maintained at the other end.
- **Mitred closer**: It is a portion of a brick whose one end is cut splayed or mitred for full width.

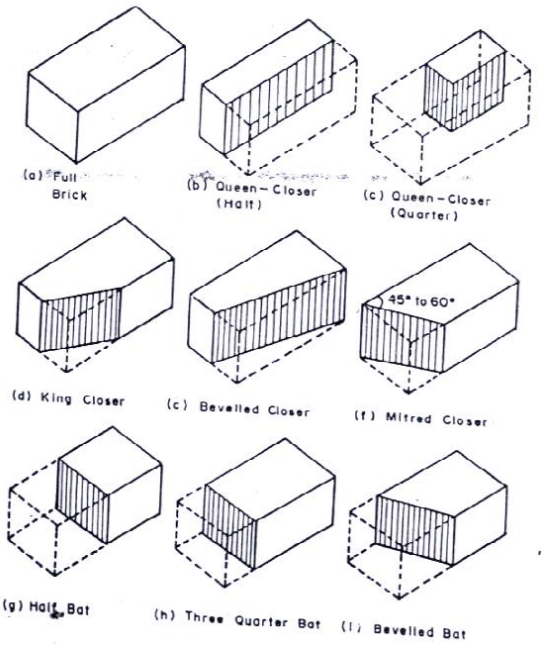
- **Bat**: It is the portion of the brick cut across the width. Thus, a bat is smaller in length than the full brick.
  - ***Half bat***: equal to half the length of the original brick
  - ***A three-quarter-bat:*** its length equal to three-quarters
  - ***Bevelled bat***: A bat with its width bevelled
- **Racking back**: It is the termination of a wall in a stepped fashion.
- **Toothing**: It is the termination of the wall in such a fashion that each alternate course at the end projects.

WALL SYSTEMS

A) BRICK WALLS (CONT...)

Terminologies (cont...)





WALL SYSTEMS

A) BRICK WALLS (CONT...)

Rules for bonding

- For getting good bond, the following rules should be observed:
  - i. The brick should be of uniform size. The length of the brick should be twice its width plus one joint.
  - ii. The amount of lap should be minimum ¼ brick along the length of the wall and ½ brick across the thickness of the wall.
  - iii. Use of brick bats should be discouraged, except in special locations.
  - iv. In alternate courses, the center line of header should coincide with the center line of the stretcher, in the course below or above it.
  - v. The vertical joints in the alternate courses should be along the same perpend.
  - vi. It is preferable to provide every sixth course as header course on both sides of the wall.

WALL SYSTEMS

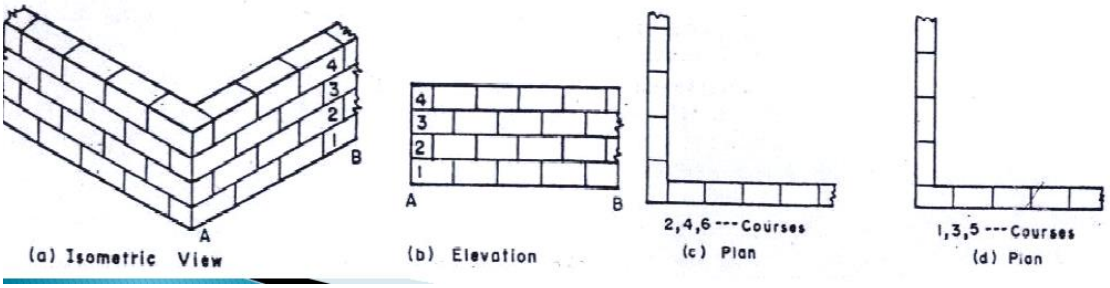
A) BRICK WALLS (CONT...)

Types of brick bonds

- Bond is the system of laying bricks in such a manner that there is no vertical joint in any row or course immediately above or below the one considered.

i. Stretcher bond

- Is the one in which all the bricks are laid as stretchers on the faces of the wall.
- This pattern is used only for those walls which have thickness of half brick. Used as partition walls, sleeper walls, chimney stacks, etc

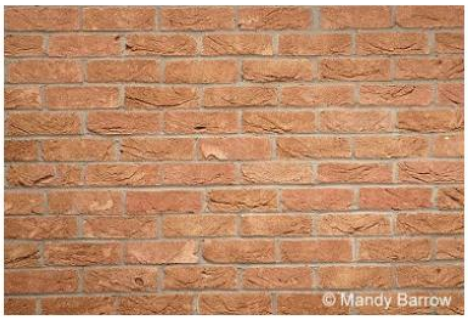


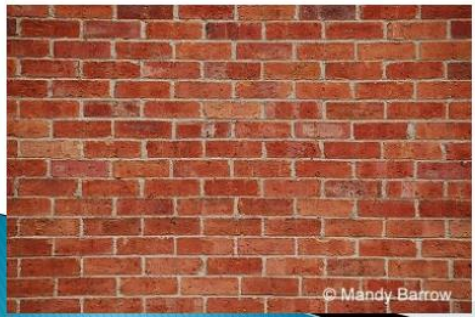
WALL SYSTEMS

A) BRICK WALLS (CONT...)

Types of brick bonds

i. Stretcher bond





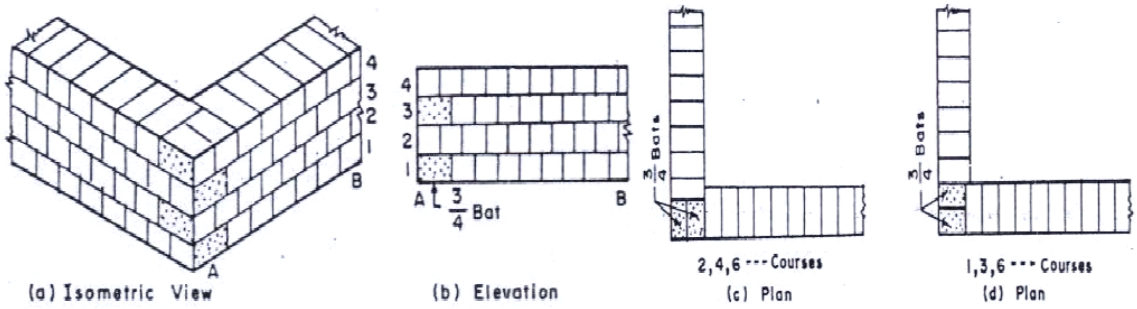
WALL SYSTEMS

A) BRICK WALLS (CONT...)

Types of brick bonds (cont...)

ii. Header bond

- Is the one in which all the bricks are laid as headers on the faces of walls. The width of the brick is along the direction of the wall.
- The pattern is used only when the thickness of the wall is equal to one brick.
- This bond does not transmit pressure in the direction of the length of the wall. Thus it is unsuitable for load bearing walls.



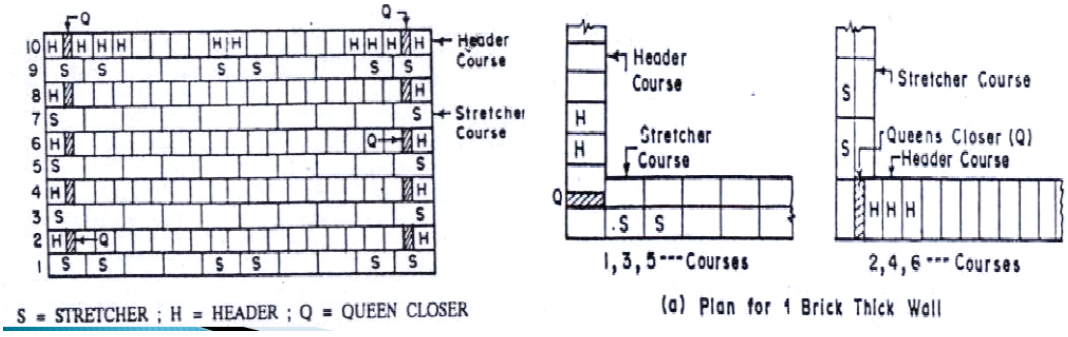
WALL SYSTEMS

A) BRICK WALLS (CONT...)

Types of brick bonds (cont...)

iii. English bond

- This is the most commonly used bond, for all wall thickness. And it is considered to be the strongest.
- The bond consists of alternate courses of headers and stretchers.
- The vertical joints of the header courses come over each other, the same goes for stretcher courses.

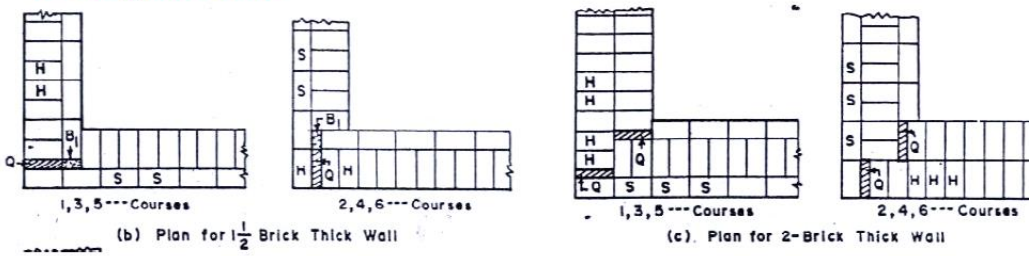


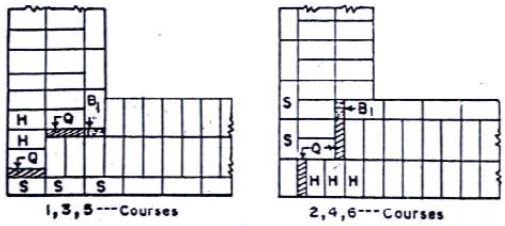
WALL SYSTEMS

A) BRICK WALLS (CONT...)

Types of brick bonds (cont...)

iii. English bond





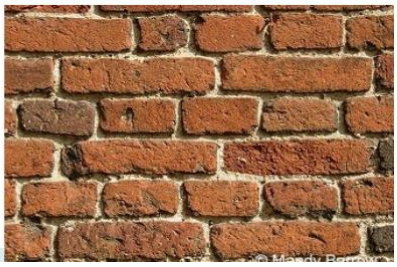
S = STRETCHER FACING ; H = HEADER FACING ; Q = QUEENS CLOSER ;
B_1 = QUARTER BAT (QUARTER QUEEN'S CLOSER)

WALL SYSTEMS

A) BRICK WALLS (CONT...)

Types of brick bonds (cont...)

iii. English bond



WALL SYSTEMS

A) BRICK WALLS (CONT...)

Types of brick bonds (cont...)

iv. Flemish bond

- Each course is comprised of alternate headers and stretchers
- Every alternate course starts with a header at the corner (i.e. Quoin header). Quoin closers are placed next to the quoin header in alternate courses to develop the face lap.
- Every header is centrally supported over the stretcher below it.

Double Flemish bond: each course presents the same appearance both in the front face as well as in the back face.

- Alternate headers and stretchers are laid in each course.
- It presents better appearance than English bond.

Single Flemish bond: Comprised of double Flemish bond facing and English bond backing and hearting in each course.

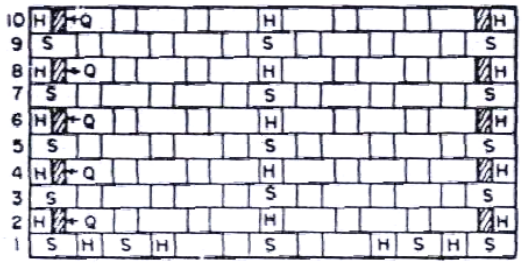
- It combines the strength of English bond and appearance of Flemish bond.

WALL SYSTEMS

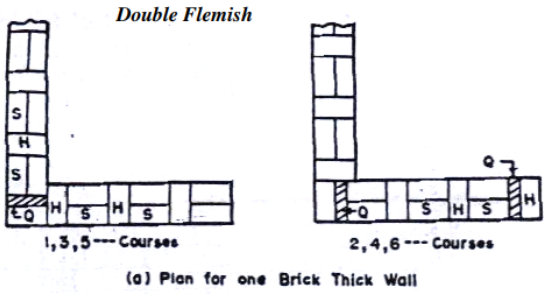
A) BRICK WALLS (CONT...)

Types of brick bonds (cont...)

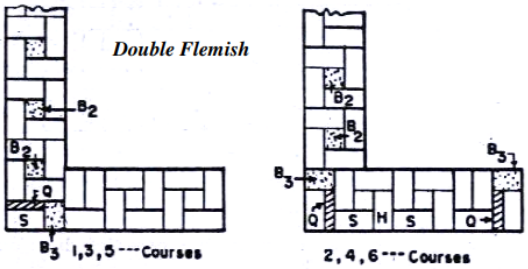
iv. Flemish bond



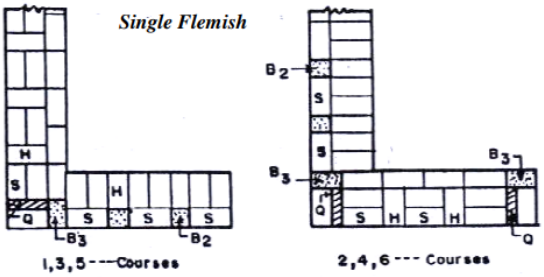
Elevation



(a) Plan for one Brick Thick Wall



(b) Plan for $1\frac{1}{2}$ Brick Thick Wall



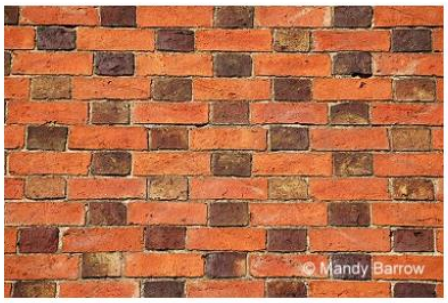
(a) Plan for $1\frac{1}{2}$ Brick Thick Wall

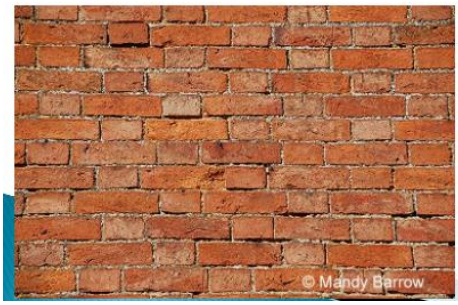
WALL SYSTEMS

A) BRICK WALLS (CONT...)

Types of brick bonds (cont...)

iv. Flemish bond





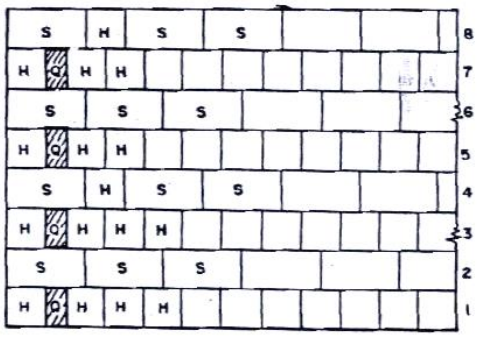
WALL SYSTEMS

A) BRICK WALLS (CONT...)

Types of brick bonds (cont...)

v. English cross bond

- This is the modification of English bond used to improve the appearance of the wall. It combines the requirements of beauty and strength.
  - Alternate courses of headers and stretchers are provided.
  - Queen closers are placed next to quoin headers.
  - A header is introduced next to the quoin stretcher in every alternate stretcher course.



H = HEADER ; S = STRETCHER ; Q = QUEEN'S CLOSER

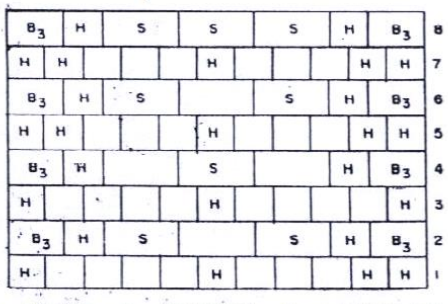
WALL SYSTEMS

A) BRICK WALLS (CONT...)

Types of brick bonds (cont...)

vi. Dutch bond

- This is another modified form of English bond. In this bond the corners of the wall are strengthened.
  - Alternate courses of headers and stretchers are provided.
  - Every stretcher course starts at the quoin with the three quarter bat.
  - In every alternate stretcher course, a header is placed next to the three-quarter brick bat provided at the quoin.



H = HEADER ; S = STRETCHER ; B_3 = 3/4 BRICK BAT.

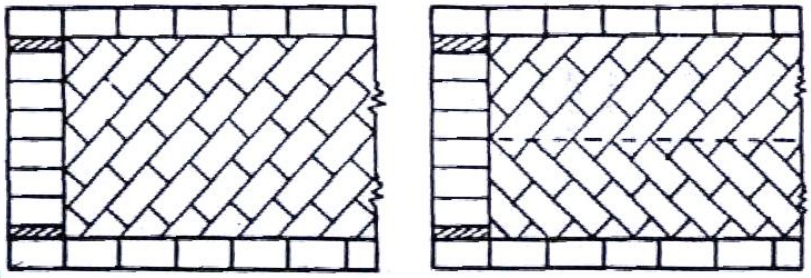
WALL SYSTEMS

A) BRICK WALLS (CONT...)

Types of brick bonds (cont...)

vii. Raking bond

- The bonding bricks are kept at an inclination to the direction of the wall. And it is used in thick walls.
  - The inclination should be in opposite direction in alternate courses of raking bond.
  - It is provided at a regular interval of 4-8 courses in the height of a wall
  - Raking bonds are of two types: ***Diagonal bond*** and ***Herring-bone bond***.



(a) Diagonal Bond (b) Herring-bone Bond

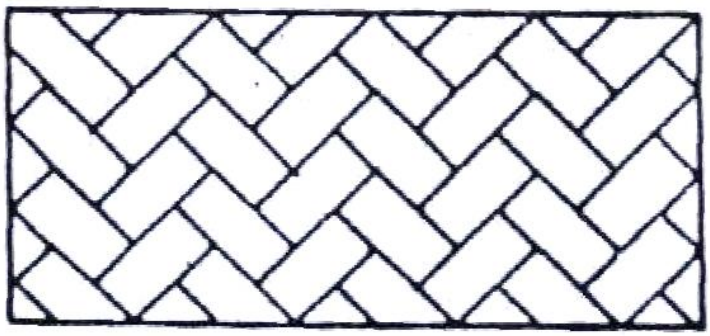
WALL SYSTEMS

A) BRICK WALLS (CONT...)

Types of brick bonds (cont...)

viii. Zigzag bond

- This bond is similar to herring-bone bond, except that the bricks are laid in zigzag fashion.
  - It is commonly used for making ornamental panels in the brick flooring.



Zigzag bond

WALL SYSTEMS

A) BRICK WALLS (CONT...)

Types of brick bonds (cont...)

ix. Garden wall bonds

- Is used for the construction of garden walls, boundary walls, compound walls where the thickness is one brick and the height doesn't exceed 2m.
- This type of bond is not so strong as English bond, but is more attractive.
- Garden walls are of three types:

Garden wall English bond: The header course is provided only after 3-5 stretcher courses.

Garden wall Flemish bond: Each course contains one header after 3-5 stretchers continuously placed, through out the length of the course.

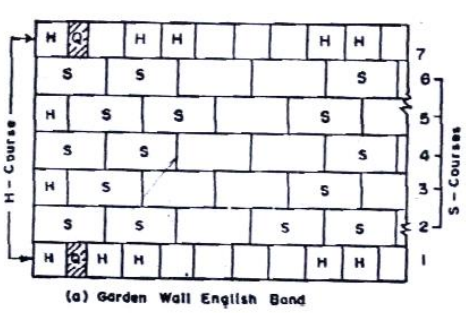
Garden wall monk bond: Type of garden wall Flemish bond in which each course contains one header after two successive stretchers.

WALL SYSTEMS

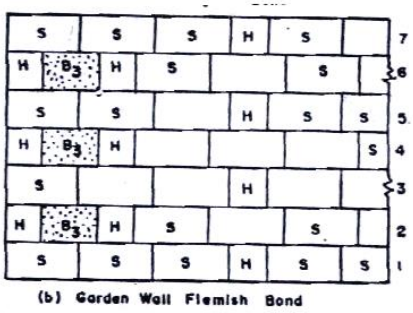
A) BRICK WALLS (CONT...)

Types of brick bonds (cont...)

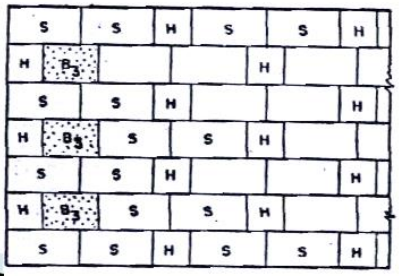
ix. Garden wall bond



(a) Garden Wall English Bond



(b) Garden Wall Flemish Bond



WALL SYSTEMS

A) BRICK WALLS (CONT...)

Strength of brick masonry

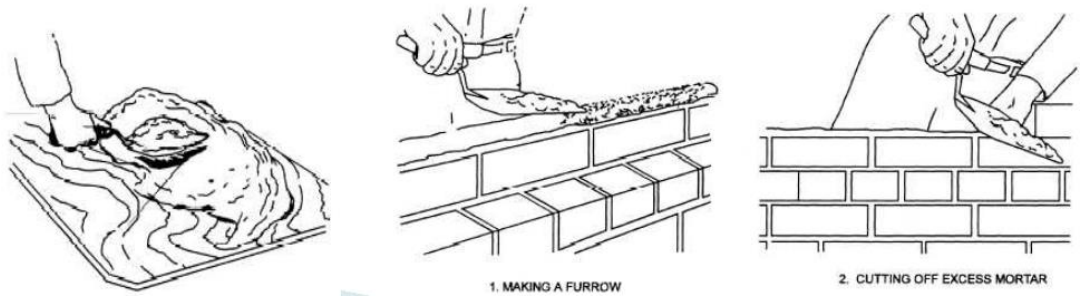
- The main factor governing the strength of brick structure are:
  - **Type and quality of bricks**: The strength of brick masonry primarily depends upon the type and class of bricks used and the basic compressive strength of bricks.
  - **Mortar mix proportion**:
    - It is essential that the mortar should be specified and prepared in relation to the brick with which it is to be used, and should be comparable in strength and density with the brick itself.
  - **Size and shape of masonry construction**: The strength of brick masonry depends upon **slenderness ratio** of masonry and **shape factor**.
    - **Slenderness ratio**: Effective height or length of the wall divided by its thickness whichever is less.
    - **Shape factor**: takes into account the effect of shape of the brick, i.e. Ratio of its height to thickness.

WALL SYSTEMS

A) BRICK WALLS (CONT...)

Joints in brickwork

- Joints are the weakest part of a masonry structure and they require special care in laying and finishing.
- The purpose of finishing joints is to improve the appearance of brickwork and to make it more water proof.
- The finishing of joints as the brickwork proceeds is termed as **jointing** whereas finishing of joints after the brickwork has been completed is called **pointing**.



1. MAKING A FURROW

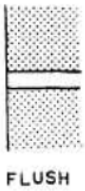
2. CUTTING OFF EXCESS MORTAR

WALL SYSTEMS

A) BRICK WALLS (CONT...)

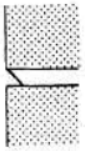
Types of pointing finishes

- Generally, brickwork is jointed by striking, raking or rubbing the mortar while it is green.
- Pointing consists of raking out the green mortar in the joint to a depth of about 20mm and then refilling the joint with fresh mortar.



FLUSH

- **Flush or flat pointing**: are formed by pressing mortar in the raked joint and by finishing off flush with the edges of masonry unit.
  - This type of pointing does not give good appearance, however, it is more durable since it does not provide any space for the accumulation of dust, water, etc.



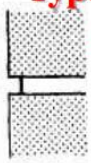
STRUCK

- **Struck pointing**: this is a modification of flush pointing in which the face of pointing is kept inclined, with its upper edge pressed inside.
  - The point permits water to drop off from the face off the brickwork. The appearance is not satisfactory.

WALL SYSTEMS

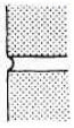
A) BRICK WALLS (CONT...)

Types of pointing finishes



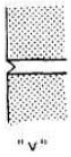
Recessed

- **Recessed pointing**: is done by pressing the mortar back from the edges by 5mm or more. The face of pointing is kept vertical by a suitable tool.
  - The pointing gives very good appearance in face-work for good textured bricks and good quality of mortar.



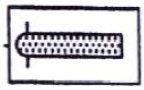
CONCAVE

- **Concave pointing (keyed)**: It is formed by a round jointer and it gives a very attractive appearance to the brickwork.



"V"

- **V-pointing**: It is made in a manner similar to concave pointing by forming V-groove in the flush-finishing face.
- **Projecting pointing**: a special type of pointing formed by a suitable slighted steel rod.
  - Such type of pointing gives good appearance but is liable to damage easily.

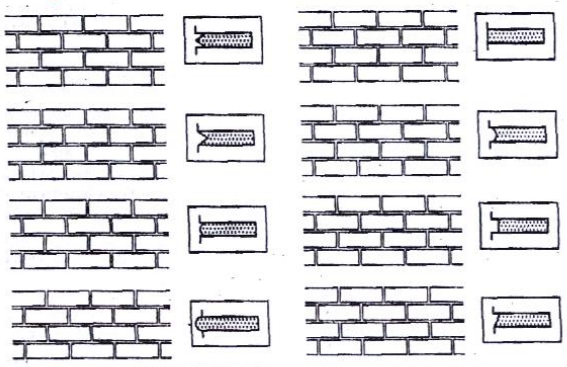


Projecting

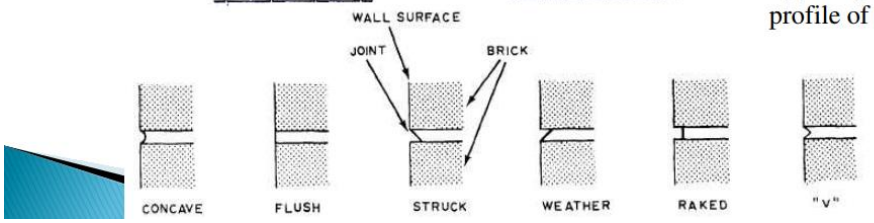
WALL SYSTEMS

A) BRICK WALLS (CONT...)

Types of pointing finishes



Typical pointing profile of brick walls



WALL SYSTEMS

A) BRICK WALLS (CONT...)

Reinforced brickwork

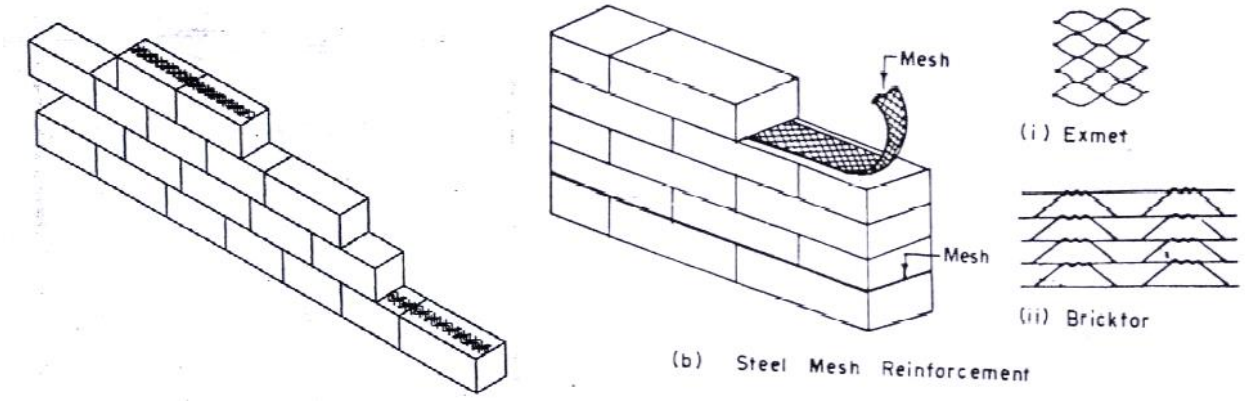
- Reinforced brick work is the one in which the brick masonry is strengthened by the provision of mild steel flats, hoop iron, expanded mesh or bars. It is adopted or used for the following circumstances:
  i. When the brick work has to bear tensile and shear stresses.
  ii. When it is required to increase the longitudinal bond.
  iii. When the brick work is supported on soil which is susceptible to large settlement
  iv. When the brick work is supposed to act as a beam or lintel over openings
  v. When the brick work is to resist lateral loads, such as retaining walls etc.
  vi. When the brick wall is to carry heavy compressive loads.
  vii. When the brick work is to be used in seismic areas.

WALL SYSTEMS

A) BRICK WALLS (CONT...)

Reinforced brickwork

- Brickwork can be reinforced in one of the following way:
  i. Reinforcement may consist of iron bars of expanded metal mesh. Usually the metal mesh is provided at every third course.



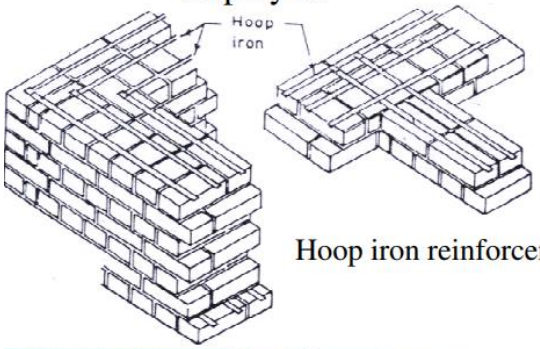
WALL SYSTEMS

A) BRICK WALLS (CONT...)

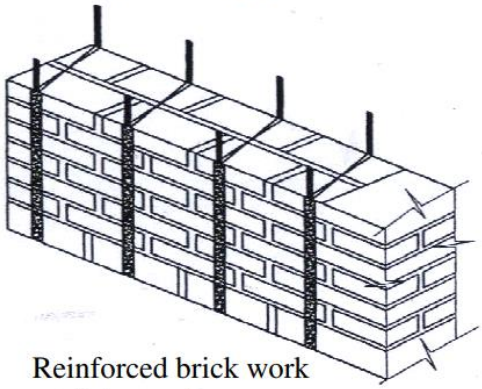
Reinforced brickwork

ii. Another type of reinforcement is hoop iron. Theses are steel flats about 2.5-3 cm in width and are from 1.5-2.5 mm in thickness.
   - Two strips of hoop iron are used for header bricks and one hoop iron for stretcher bricks, and every sixth coarse is reinforced

iii. For walls that have to withstand pressure vertical reinforcement passing through openings made in special types of brick is employed.



Hoop iron reinforcement



Reinforced brick work retaining wall

WALL SYSTEMS

A) BRICK WALLS (CONT...)

Causes of failure of brick masonry

- Brick masonry may fail due to the following three major causes:
  i. By crushing if it is overloaded
     - Can be prevented by providing adequate dimensions
  ii. By shearing along any horizontal plane
     - Can be prevented by providing a strong mortar
  iii. By rupture along a vertical joint under vertical loads.
     - Can be prevented by breaking vertical joints in brickwork

Defects in brick masonry

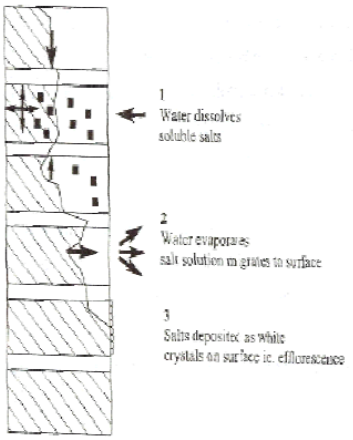
- Brick masonry may develop the defects due to the following reasons:
  - Sulphate attack
  - Crystallization of salts from bricks
  - Corrosion of embedded fixtures
  - Drying shrinkage

WALL SYSTEMS

A) BRICK WALLS (CONT...)

Maintenance of brickwork

- Brick walls can be maintained using alternative methods among which the following are widely used in practice:
  i. Re-pointing old brickwork
  ii. Repainting brickwork
  iii. Cleaning brickwork
  iv. Removal of efflorescence



Mechanism of efflorescence in brickwork

WALL SYSTEMS

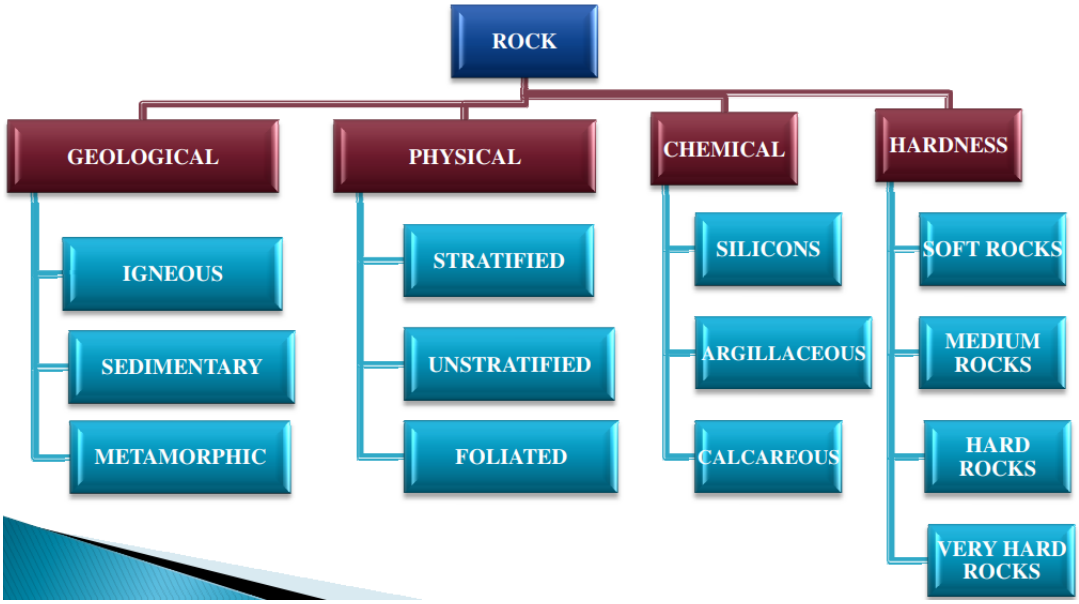
B) STONE WALLS

- The stones used for masonry should be **hard**, **durable**, **tough** and **sound** and free from weathering, decay or defects like cavities, cracks, sand holes, injurious veins, patches of loose or soft materials etc.
- Rocks from which building stones are obtained, are divided into three groups:
  - i. ***Igneous rock***: the chief building stones in this class are trachyte, basalt, granite, etc.
  - ii. ***Sedimentary rocks***: The principal building stones in this group are lime stones and sand stones. These are used in floors, steps, facing works, columns, walls etc.
  - iii. ***Metamorphic rocks***: the common building stones are slate and marble. Since marble is costly it is not used for masonry but used for flooring, facing work, steps, ornamental works etc.

WALL SYSTEMS

B) STONE WALLS

CLASSIFICATION OF ROCKS



WALL SYSTEMS

B) STONE WALLS

TESTS FOR STONES

- The building stones are tested for their different properties:
  - i. ***Attrition test***: This test is carried out to find out the rate of wear of stones (Daval's attrition test machine).
  - ii. ***Crushing test***: The compressive strength of stone can be found out with the help of this test.
  - iii. ***Hardness test***: To determine the hardness of a stone (Dorry's testing machine). Coefficient of hardness is determined.
  - iv. ***Impact test***: to determine the toughness of a stone. Toughness index is determined.
  - v. ***Water absorption test***: to determine the water absorption capacity of a stone.

WALL SYSTEMS

B) STONE WALLS

QUALITIES OF GOOD BUILDING STONE

- A good building stone should posses the following qualities.
  - i. ***Crushing strength***: The crushing strength of stone should be greater than 100 N/mm^2.
  - ii. ***Appearance***: stones for face work should be decent in appearance, capable of preserving their color uniformly and free from clay holes, spots of other colors etc.
  - iii. ***Durability***: A good building stone should be durable which depends up on its chemical composition, texture, resistance to environment and positioning.
  - iv. ***Facility of dressing***: It should be such that they are easily carved, moulded, cut and dressed.
  - v. ***Hardness***: The coefficient of hardness should be more than 17.

WALL SYSTEMS

B) STONE WALLS

QUALITIES OF GOOD BUILDING STONE (CONT...)

vi. ***Percentage wear***: The wear of stone should be maximum 3%.

vii. ***Specific gravity***: specific gravity of good stone should be minimum 2.7.

viii. ***Texture***: It should have compact fine texture free from cavities, cracks and soft fragments.

ix. ***Toughness index***: T.I. > 19 good stones, T.I < 13 poor stones.

x. ***Water absorption***: Different stones have different water absorption depending upon the porosity.

xi. ***Weathering***: A good stone should be able to resist the environment attack.

xii. ***Fire resistance***: A good stone must preserve its shape in case of fire.

WALL SYSTEMS

B) STONE WALLS

CLASSIFICATION OF STONE MASONRY (CONT...)

- Depending upon the arrangement of stones in the construction, degree of refinement used in shaping the stone and finishing adopted stone masonry can be classified as:

i. **Rubble masonry**:

- The block of stones used are either undressed or comparatively rough dressed.
- The masonry has wide joints, since stones of irregular sizes are used.

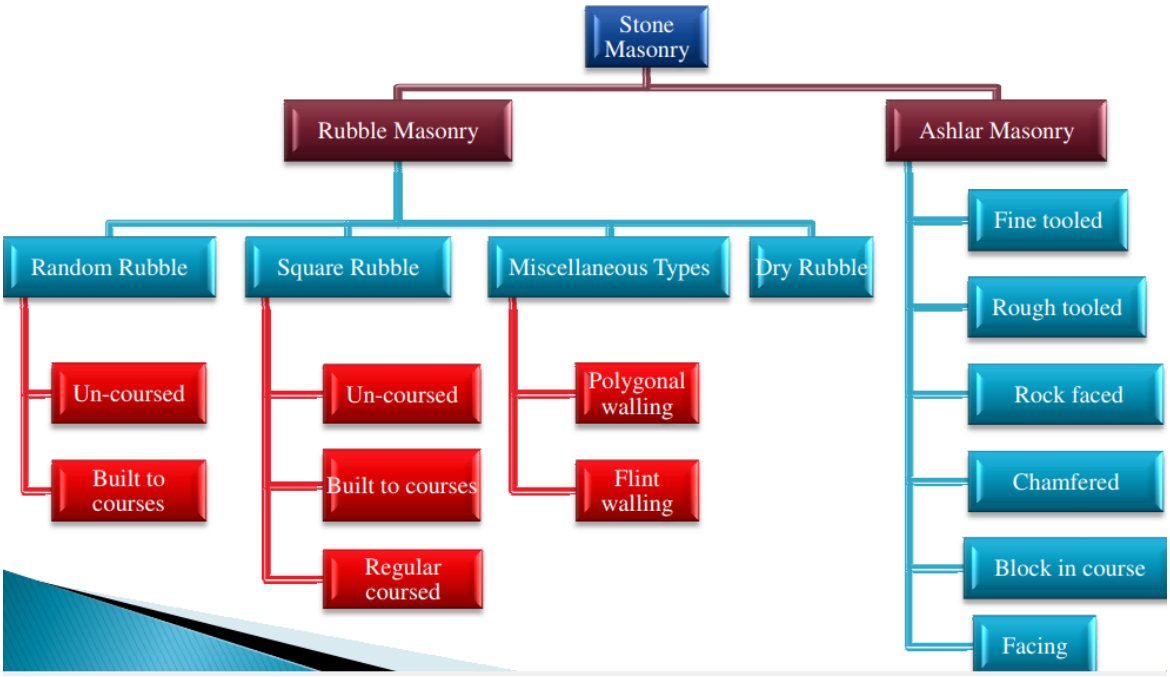
ii. **Ashlar masonry**:

- Consists of blocks of accurately dressed stone with extremely fine bed and end joints.
- The blocks may be either square and rectangular shape. The height of stone varies from 25-30 cm

WALL SYSTEMS

B) STONE WALLS

CLASSIFICATION OF STONE MASONRY (CONT...)



WALL SYSTEMS

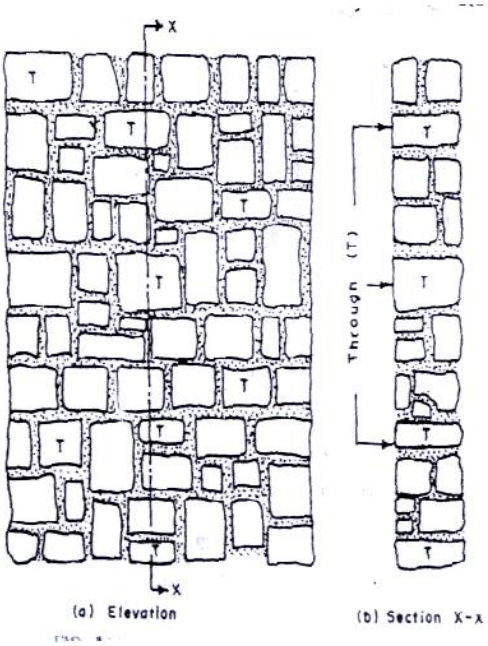
B) STONE WALLS

CLASSIFICATION OF STONE MASONRY (CONT...)

I. RUBBLE MASONRY

1. Random rubble: Un-coursed

- This is the roughest and cheapest form of stone walling. The stones used are of widely different sizes and shapes.
- Greater care have to be exercised in arranging the stones in such a way that they adequately distribute the pressure over the maximum area at the same time long continuous vertical joints are avoided.



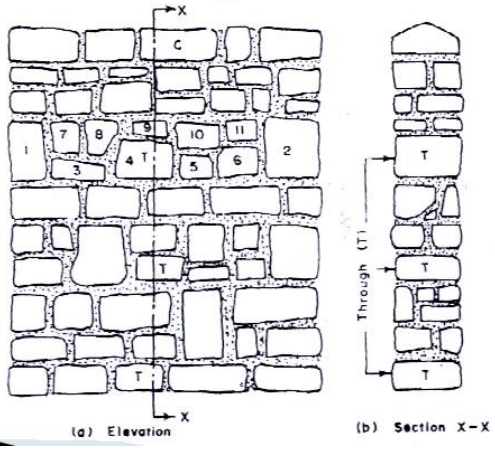
WALL SYSTEMS

B) STONE WALLS

CLASSIFICATION OF STONE MASONRY

CLASSIFICATION OF STONE MASONRY (CONT...)

- The work is roughly levelled up to form courses varying from 30-40 cm thick. All the courses are not of the same height.
- Quoins are built first and line (string) is stretched between the tops of quoins.



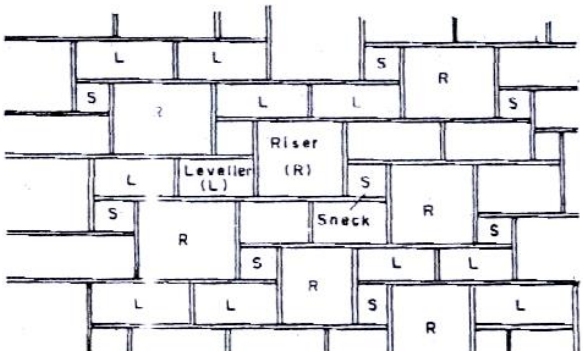
WALL SYSTEMS

B) STONE WALLS

CLASSIFICATION OF STONE MASONRY (CONT...)

3. Square rubble: Un-coursed (square-snecked rubble)

- Square rubble masonry uses stones having straight bed and sides. The stones are usually squared and brought to hammer dressed or straight cut finish.
- The stones with straight edges and sides are available in different sizes (heights) and are arranged on face in several irregular pattern.



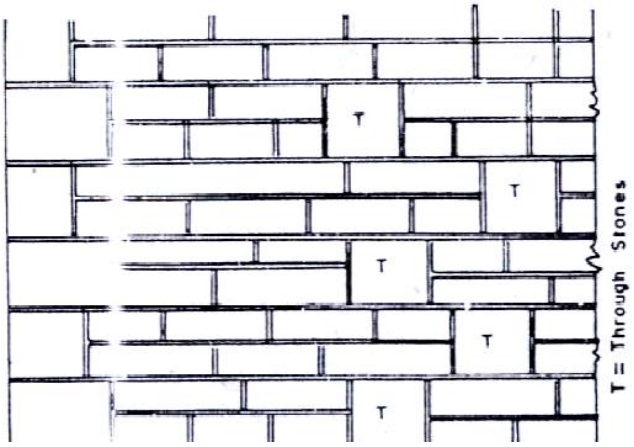
WALL SYSTEMS

B) STONE WALLS

CLASSIFICATION OF STONE MASONRY (CONT...)

4. Square rubble: Built to courses

- Use the same stones as used for un-coursed square but the work is levelled up to courses of varying depth. The courses are of different heights.



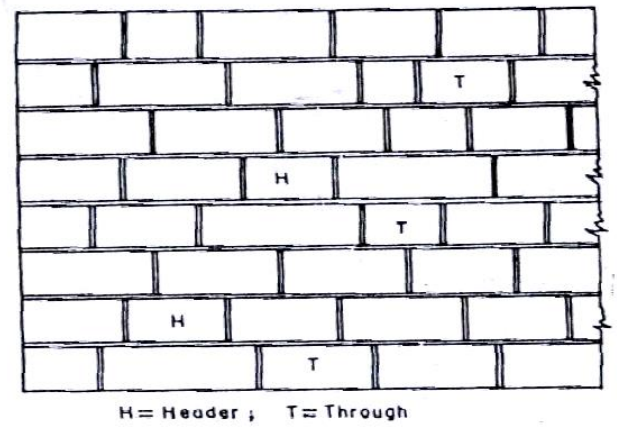
WALL SYSTEMS

B) STONE WALLS

CLASSIFICATION OF STONE MASONRY (CONT...)

5. Square rubble: Regular coursed

- The wall consists of various courses of varying heights, but the height of stones in one particular course is the same.



H= Header ; T= Through

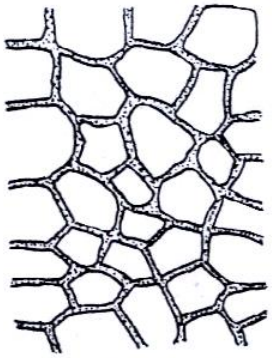
WALL SYSTEMS

B) STONE WALLS

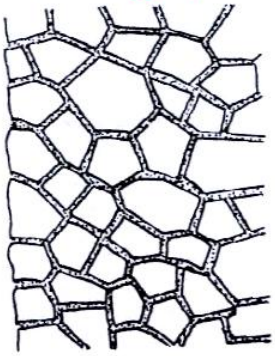
CLASSIFICATION OF STONE MASONRY (CONT...)

6. Polygonal walling: Polygonal rubble masonry

- The stones are hammered finished on face to an irregular polygonal shape. These stones are bedded in position to show face joints running irregularly in all directions.
- There are two types of polygonal walling: ***rough picked*** and ***close picked***.



(a) Rough Picked



(c) Close Picked

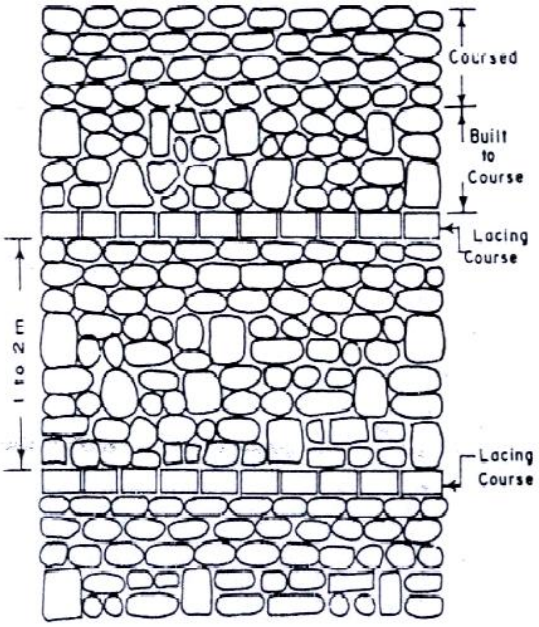
WALL SYSTEMS

B) STONE WALLS

CLASSIFICATION OF STONE MASONRY (CONT...)

7. Flint walling: Flint rubble masonry

- The stones used are flints or cobbles, which vary in width and thickness from 7.5-15 cm and in length from 15-30 cm.
- The face arrangement of the cobbles may be either coursed or un-coursed or built to courses. The strength may be increased by introducing lacing courses.



WALL SYSTEMS

B) STONE WALLS

CLASSIFICATION OF STONE MASONRY (CONT...)

8. Dry rubble masonry

- Dry rubble masonry is that rubble masonry, made to courses, in which mortar is not used in the joints.
- This type of construction is the cheapest, and requires more skill in construction.
- This may be used for non load bearing walls, such as compound wall etc.

WALL SYSTEMS

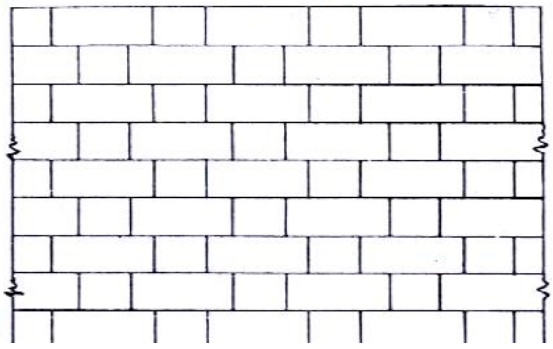
B) STONE WALLS

CLASSIFICATION OF STONE MASONRY (CONT...)

II. ASHLAR MASONRY

1. Ashlar fine tooled

- This is the finest type of stone masonry work. Each stone is cut to regular and required size and shape so as to have all sides rectangular.
- The thickness of course is generally not less than 15 cm. The width of stone is not kept less than its height.



WALL SYSTEMS

B) STONE WALLS

CLASSIFICATION OF STONE MASONRY (CONT...)

2. Ashlar rough tooled (Bastard Ashlar)

- The beds and sides of each stone block are finely chisel dressed just in the same manner as for Ashlar fine, but the exposed face is dressed by rough tooling.
- A strip, about 25mm wide and made by means of a chisel is provided around the perimeter of the rough dressed face of each stone.

3. Ashlar rock faced (Rustic or Quarry faced)

- The exposed face of the stone is not dressed but is kept as such so as to give rock facing.
- A strip, about 25mm wide and made by means of a chisel is provided around the perimeter of the exposed face of every stone.

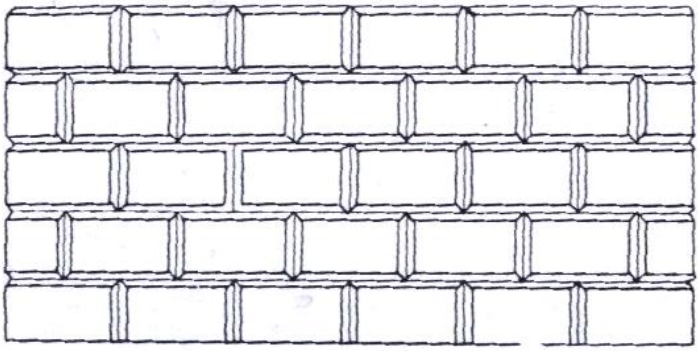
WALL SYSTEMS

B) STONE WALLS

CLASSIFICATION OF STONE MASONRY (CONT...)

4. Ashlar chamfered

- This is a special form of rock-faced Ashlar masonry in which the strip provided around the perimeter of the exposed face is chamfered at an angle of 45 .
- Due to the chamfering, a groove is formed in between adjacent blocks of stone.



WALL SYSTEMS

B) STONE WALLS

CLASSIFICATION OF STONE MASONRY (CONT...)

5. Ashlar block in course

- This type of masonry is intermediate between rubble masonry and Ashlar masonry.
- The vertical joints are not as straight and as fine as in Ashlar masonry.
- It is adopted in heavy works such as retaining walls, bridges, etc.

5. Ashlar facing

- Ashlar facing masonry is provided along with brick or concrete block masonry, to give better appearance.
- The sides and beds of each block are properly dressed so as to make them true to shape.

WALL SYSTEMS

B) STONE WALLS

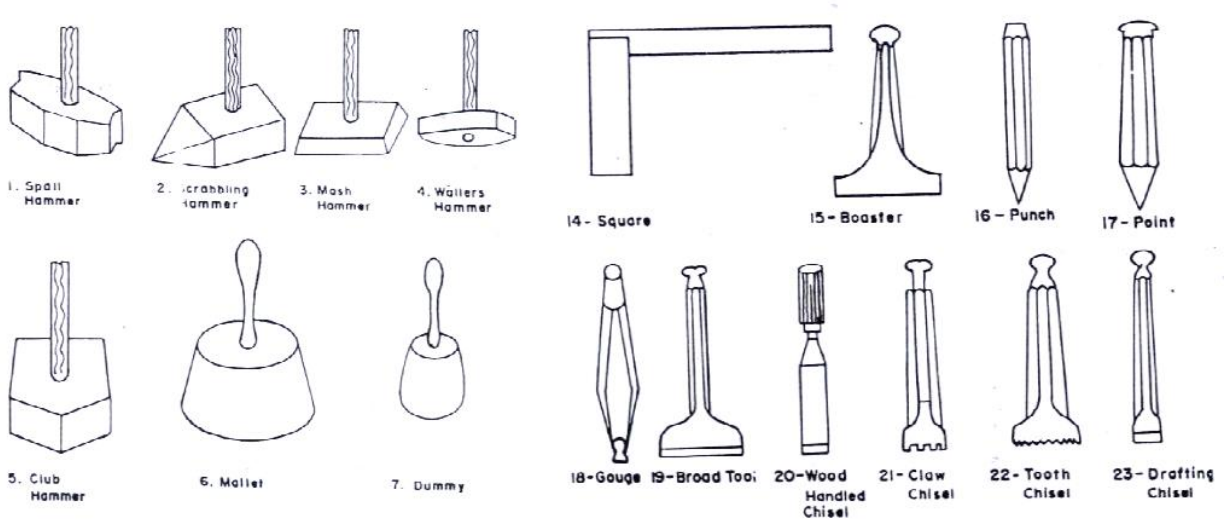
DRESSING OF STONES

- The surface of stones obtained from quarry are rough. The blocks are irregular in shape and non uniform in size. Hence their dressing is essential.
- It serves the following purposes:
  i. It gives desired aesthetic appearance.
  ii. It makes transport easy and economical.
  iii. It suits the desired requirements.
  iv. It helps taking advantage of locally available skilled labour

WALL SYSTEMS

B) STONE WALLS

TOOLS FOR DRESSING OF STONES



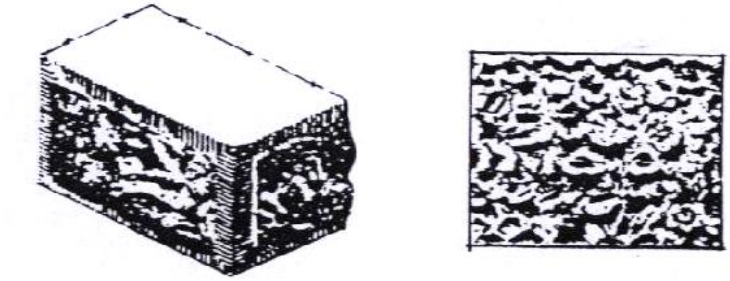
WALL SYSTEMS

B) STONE WALLS

DRESSING OF STONES (CONT...)

- Dressed stones may have the following types of surface finish:

1. ***Rock faced or quarry faced*** : The exposed face of the stone is not dressed, but is kept as such, except that the bushings exceeding 80mm in projection are removed by light hammering.
2. ***Hammer dressed finish***: The stone blocks are made roughly square or rectangular by means of Waller's hammer. The exposed face is roughly shaped by means of mash hammer.



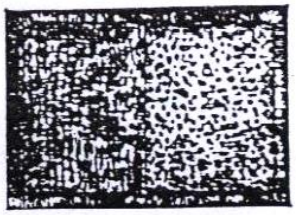
(a) ROCK FACED (b) HAMMER FINISH

WALL SYSTEMS

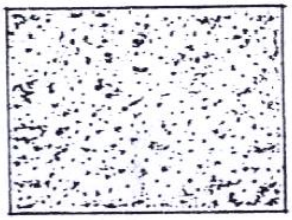
B) STONE WALLS

DRESSING OF STONES (CONT...)

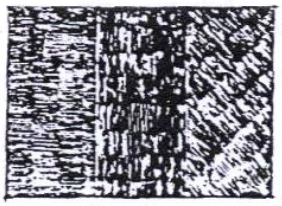
3. ***Punched, broached or Stugged finish***: The exposed face of the stone is dressed with the help of a punch thus making depression or punch holes at some regular distance.



4. ***Picked finish***: Similar to punch finish except that a point is used in the place of punch, thus forming a small pits on the exposed face.



5. ***Boasted or droved finish***: The dressing is done to form a series of bands of more or less parallel tool marks, which cover the whole surface.

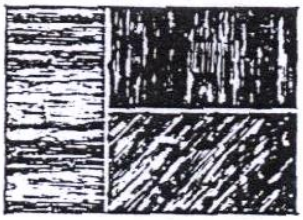


WALL SYSTEMS

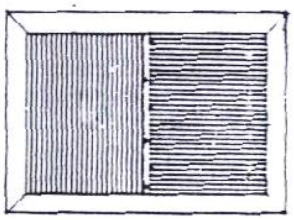
B) STONE WALLS

DRESSING OF STONES (CONT...)

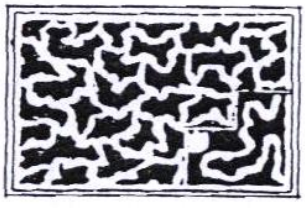
6. ***Tooled or batted finish***: This is done as a further step to boasting. A series of parallel fine chisel lines are formed. The lines are deeper & continuous.



7. ***Furrowed finish***: After boasting the surface and then rubbing it, 6-10mm wide flutes are formed by a gauge.



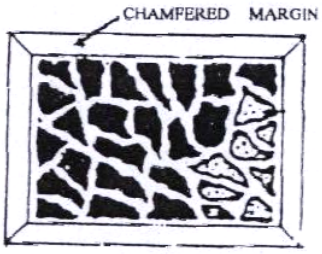
8. ***Vermiculated finish***: After having brought the face of the stone to a level and smooth finish, marginal drafts are sunk about 10mm below the surface.
   - The finish presents worm eaten appearance



WALL SYSTEMS

B) STONE WALLS

DRESSING OF STONES (CONT...)



9. Reticulated finish: This is similar to vermiculated except that the ridges or veins are less winding. This are linked up to form polygonal or irregular shaped reticules.

10. Plain finish: The Surface is made approximately smooth with a saw or chisel.

11. Rubbed finish: This type of finish is obtained by rubbing a piece of stone on the levelled surface. The rubbing can also be done with the help of a machine.

12. Polished finish: This type of finish is used in marbles, granites etc. These are polished either manually or with the help of machines.

WALL SYSTEMS

B) STONE WALLS

DETERIORATION OF STONES

- Various environmental and external agencies play an important role to deteriorate the stones:
  - ***i. Alternate heating and cooling***: Repeated contraction and expansion cause cracking of stones due to internal stresses.
  - ***ii. Alternate wetting and drying***: repeated wetting and drying result in wearing it out quickly.
  - ***iii. Thawing and freezing***: it results in entrapping of moisture which expand on freezing resulting in splitting of stones.
  - ***iv. Nature of mortar***: The mortar may react chemically with constituents of stone and leads to the disintegration of stones
  - ***v. Rain water***:
  - ***vi. Vegetable growth***:

WALL SYSTEMS

B) CONCRETE BLOCK WALLS

- One of the most common masonry units.
- It consists of hardened cement and may be completely solid or contain single or multiple hollows.
- It is made from conventional cement mixes and various types of aggregates. These include: sand, gravel, crushed stone, expanded shale or clay, volcanic ciders (Pozzolana), scoria, pumice, etc.
- Various types of blocks are manufactured to be used for wall construction.

WALL SYSTEMS

B) CONCRETE BLOCK WALLS

ADVANTAGES OF HOLLOW CONCRETE BLOCK MASONRY

A. Concrete blocks are regular in size, requiring no dressing work. Hence construction is very rapid.
B. Blocks are light and therefore easy to handle.
C. Because of their lightness, the loads transferred to foundations is much less than the stone masonry.
D. There is a great saving in the material.
E. Because of larger size of the blocks, the number of joints in the masonry is less. This results in saving in mortar.
F. Because of hollow space, the resulting wall has better insulating properties against sound, heat and dampness.
G. Blocks can withstand the atmospheric actions, and do not require plaster or any other covering.

WALL SYSTEMS

B) CONCRETE BLOCK WALLS

MANUFACTURING OF CONCRETE MASONRY BLOCKS

- The following points should be kept in mind while manufacturing the concrete masonry blocks:
  i. The cement-aggregate ratio should not be leaner than 1:6.
  ii. Blocks should be taken out from the moulds only when concrete has sufficiently set.
  iii. Machine casting is preferable to hand casting, to obtain better finish.
  iv. After taking the blocks out of mould they should be kept under shade for a week and should be properly cured 3 to 4 weeks.
  v. Bocks should be used only after about 3-4 weeks of curing.

WALL SYSTEMS

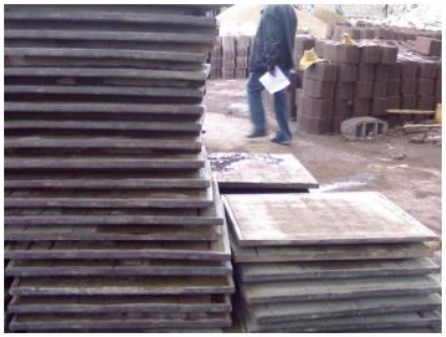
B) CONCRETE BLOCK WALLS

MANUFACTURING OF CONCRETE MASONRY BLOCKS

WALL SYSTEMS

B) CONCRETE BLOCK WALLS

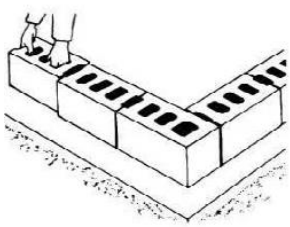
MANUFACTURING OF CONCRETE MASONRY BLOCKS



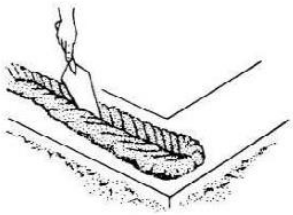
WALL SYSTEMS

B) CONCRETE BLOCK WALLS

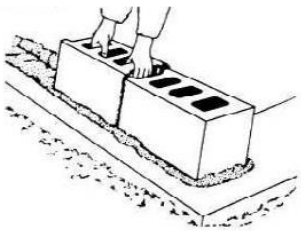
CONSTRUCTION OF CONCRETE BLOCK WALLS



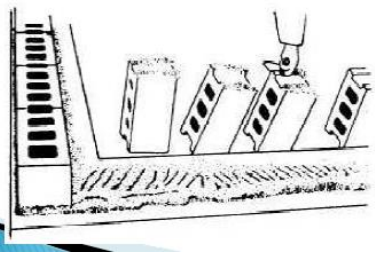
1. PLACING BLOCKS WITHOUT MORTAR (CHASING THE BOND)

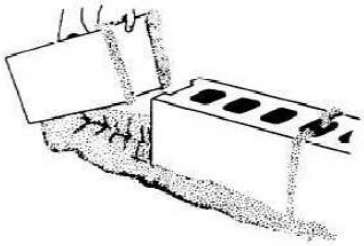


2. SPREADING AND FURROWING MORTAR BED



3. POSITIONING AND ALIGNING CORNER BLOCK

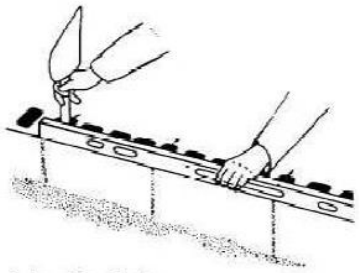




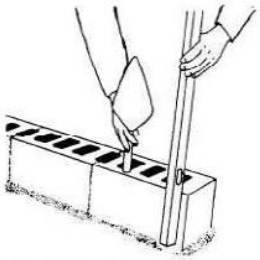
WALL SYSTEMS

B) CONCRETE BLOCK WALLS

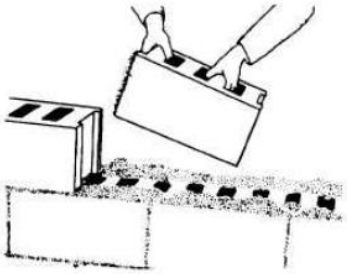
CONSTRUCTION OF CONCRETE BLOCK WALLS (CONT...)

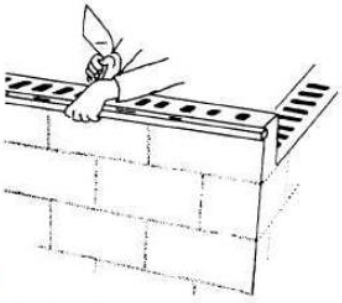


1. Leveling Block

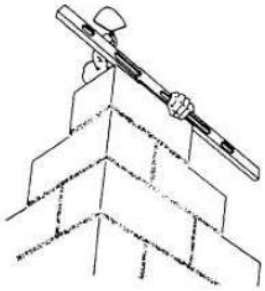


2. Plumbing Block

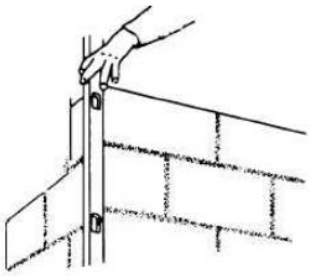




1. Aligning



2. Leveling

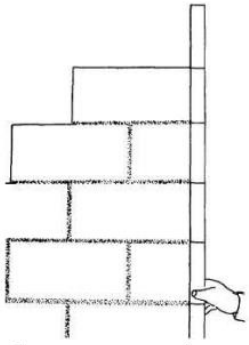


3. Plumbing

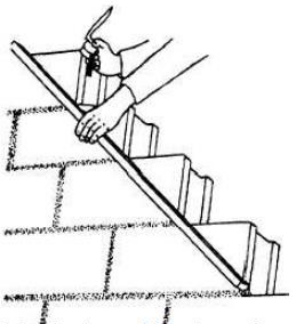
WALL SYSTEMS

B) CONCRETE BLOCK WALLS

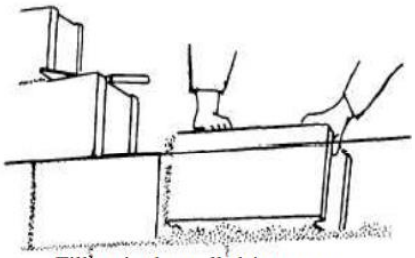
CONSTRUCTION OF CONCRETE BLOCK WALLS (CONT...)



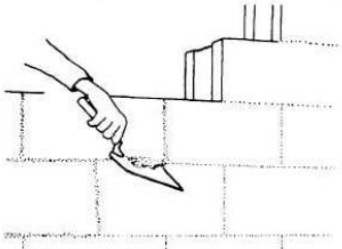
Story or course pole



Checking horizontal block spacing



Filling in the walls b/n corners

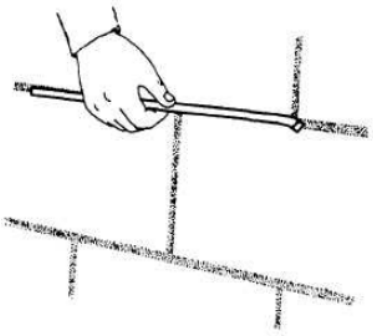


Cutting off excessive mortar

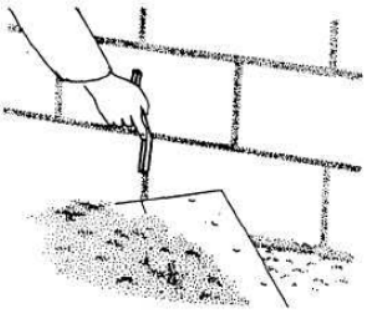
WALL SYSTEMS

B) CONCRETE BLOCK WALLS

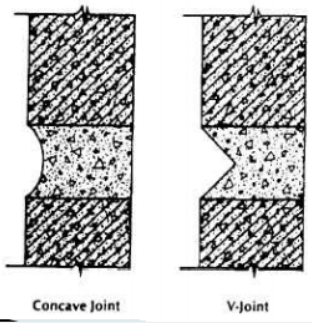
CONSTRUCTION OF CONCRETE BLOCK WALLS (CONT...)



1. Striking Horizontal Joints



2. Striking Vertical Joints



Concave Joint V-Joint

Tooled mortar joints

WALL SYSTEMS

3.2.2 WALLS OF MONOLITHIC CONSTRUCTION

- Walls of monolithic construction could either be load bearing or not.
- The modern concrete wall and the primitive mud wall are composed of materials, which are placed in a plastic state into a mould.
- Concrete walls can be plain or reinforced. The two greatest advantages of concrete wall are:
  - Strength, and
  - Freedom it gives in design.
- Freedom of design is expressed by the ease with which it can be made to take up curved or other complex shapes.
- Reinforced concrete wall thickness may be from 8cm up, and the cost is generally higher but the strength of the structure is considerably higher.

WALL SYSTEMS

3.2.2 PANELS OR COMPOSITE WALLS

- Panel walls are used whenever the load bearing functions of the wall are taken over by a framework, which leaves the spaces in the uprights to be filled.
- Generally they consist of two or more layers or sections each of which fulfils a specific purpose
- They are principally used with the object of reducing weight.
- Requirements to be fulfilled are:
  - Resistance to wind pressure,
  - Protection against wind and rain, and
  - Providing satisfactory appearance.
- Aluminum panels, Gypsum panels, etc.

WALL SYSTEMS

3.3 INTERNAL WALLS

PARTITION WALL

- A partition wall is a thin internal wall which is constructed to divide the space with in the building into rooms or areas.
- A partition wall may be either non load bearing or load bearing. Generally partition walls are non load bearing.

REQUIREMENTS TO BE FULFILLED

i. Should be strong enough to carry its own load
ii. Should be strong enough to resist impact to which the occupation of the building is likely to subject them.
iii. Should have the capacity to support suitable decorative surface.
iv. Should be stable and strong enough to support suitable decorative surface.

WALL SYSTEMS

3.3 INTERNAL WALLS

PARTITION WALL (CONT...)

REQUIREMENTS TO BE FULFILLED

v. Should be as light as possible.
vi. Should be as thin as possible
vii. Should act as sound barrier, specially when it divides two rooms.
viii. Should be fire resistance.

TYPES OF PARTITION WALLS

- Partition walls are of the following types:

- Brick partitions
- Clay block partitions
- Concrete partitions
- Glass partitions
- Metal lath partitions
- Solid plaster partitions
- Timber partitions
- Corrugated sheet partitions

WALL SYSTEMS

4. CAVITY WALLS

- Cavity wall or hollow wall is the one which consists of two separate walls, called leaves or skins, with a cavity or gap in-between.
- The thickness of the two leaves may be equal if it is non-load bearing wall or the thickness of the inner may be increased to meet the required structural strength.
- The inner and the outer leaves of the wall should not be less than 10cm in thickness through out the height of the wall.
- For a cavity wall to be effective, it is essential that the leaf is entirely disconnected from the outer leaf, except for ties.
- The cavity varies from 4-10cm.
- The two leaves are securely tied together with suitable bonding steel ties or sometimes with special bonding bricks.
- The ties should be placed at intervals not exceeding 1m horizontally and 40 cm vertically.

WALL SYSTEMS

4. CAVITY WALLS

ADVANTAGES OF CAVITY WALLS.

i. **Damp prevention**: cavity walls are able to prevent dampness effectively.
ii. **Insulation**: cavity walls have about 25% greater insulating value than the solid walls.
iii. **Acoustic**: cavity walls reduce sound and noise pollution.
iv. **Economy**: they are cheaper and economical.
v. **Load reduction**: loads on foundations are reduced because of lesser solid thickness.

WALL SYSTEMS

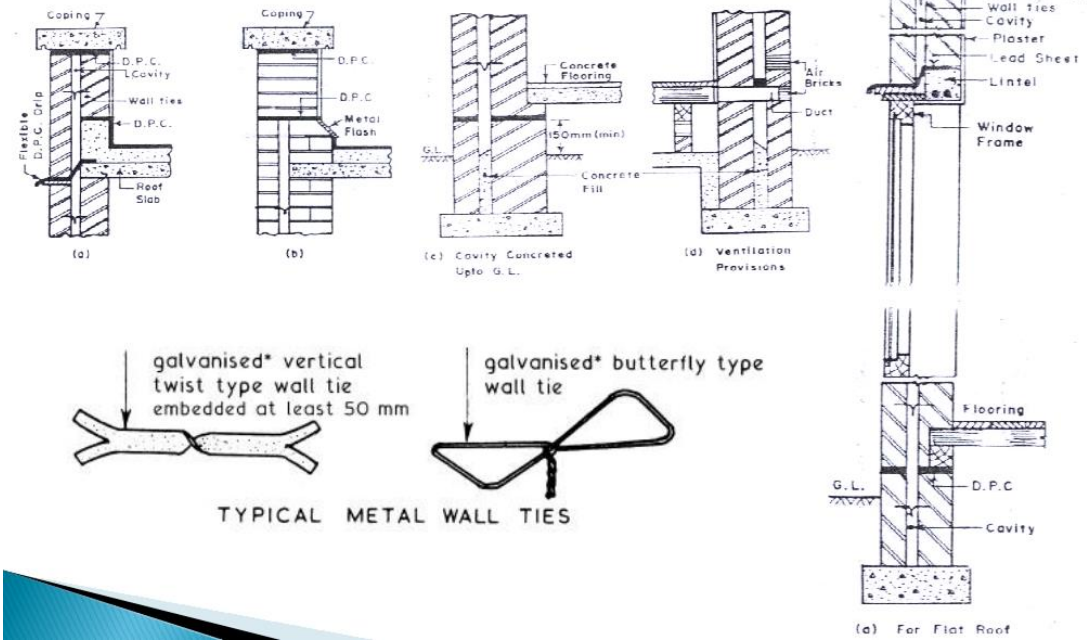
4. CAVITY WALLS

PRECAUTIONS ON CAVITY WALL CONSTRUCTION

i. Damp proof course should be built into separate widths under each leaf of the wall and divided by cavity.
ii. No mortar or any other thing should get accumulated in the cavity.
iii. Cavity should be free from projections.
iv. The contact b/n inner and outer wall should be least.
v. Head of openings should be carefully attended to for damp prevention.
vi. Ties must be of rust proof materials and should be able to prevent transmission of water from inner surface to the outer surface.

WALL SYSTEMS

4. CAVITY WALLS (CONT...)



WALL SYSTEMS

5. OPENINGS IN WALLS

- Openings are invariably left in the walls for the provision of doors, windows cupboards, etc.
- These openings are bridged by the provisions of either a lintel or an arch.
- Both lintels and arches are structural members designed to support the loads of the portion of the wall situated above the openings.

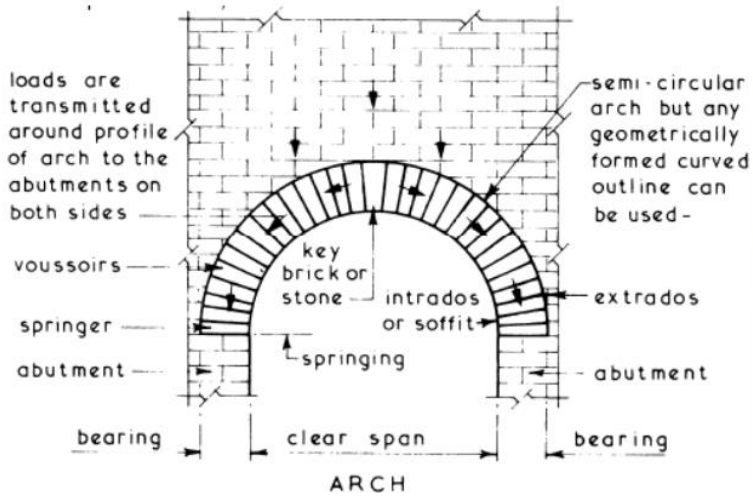
5.1 Arches

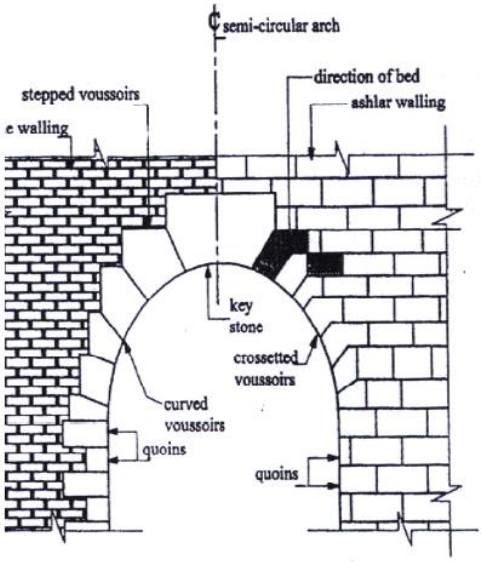
- An arch is normally a curved member of either stone. Concrete, steel, etc.
- Arches are constructed where:
  - Loads are heavy,
  - Span is large,
  - Strong abutments are available, and
  - Architectural appearance is required.

WALL SYSTEMS

5 OPENINGS IN WALLS

5.1 Arches (cont...)

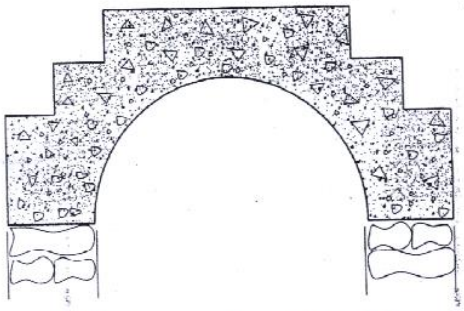




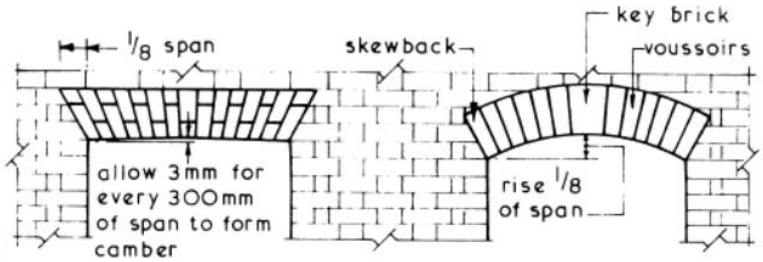
WALL SYSTEMS

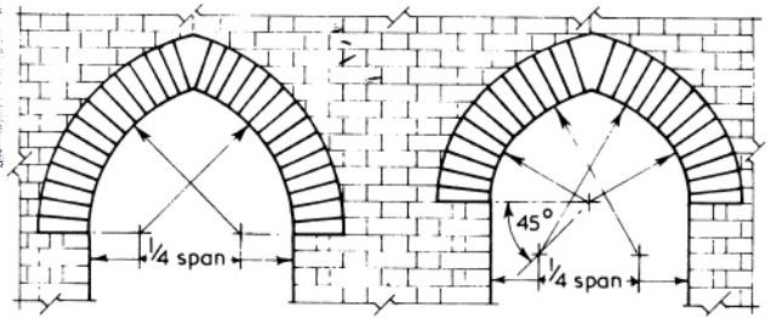
5 OPENINGS IN WALLS

5.1 Arches (cont...)



Precast concrete arch lintel





WALL SYSTEMS

5 OPENINGS IN WALLS

5.2 Lintels

- A lintel is a horizontal member, which is placed across the opening.
- Lintels are easy to build and the supporting walls need not be very strong.
- At least 10cm length of bearing is a minimum requirement.
- For very long spans, the bearing for the lintel end should be equal at least to its depth.

Types of lintels

- Lintels are classified according to the material of their construction.
  - a) **Timber lintels**: are the oldest type of lintels and are not commonly used nowadays. They can not take greater load and are vulnerable to fire and decay.

WALL SYSTEMS

5. OPENINGS IN WALLS

5.2 Lintels (cont...)

Types of lintels

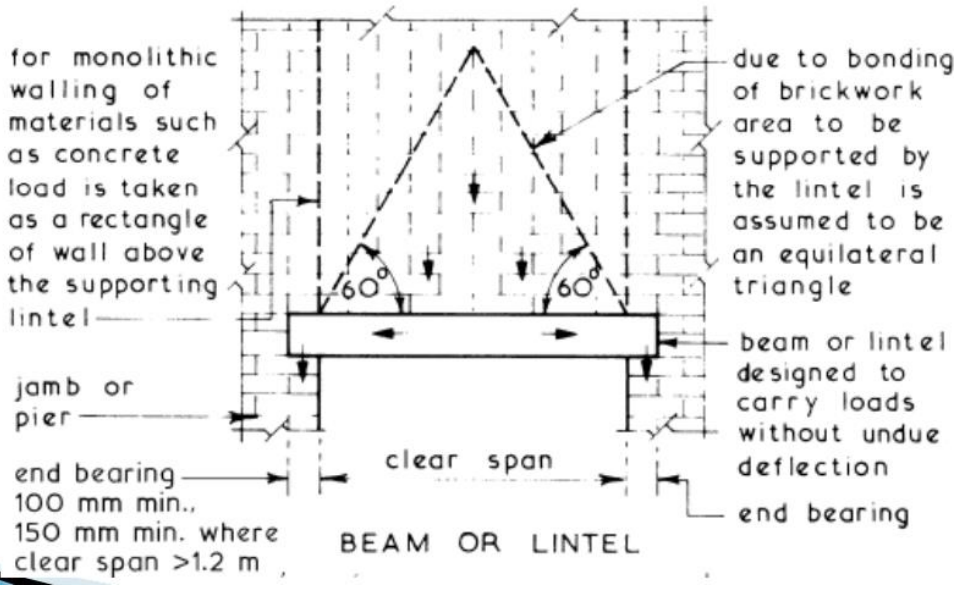
- Lintels are classified according to the material of their construction.
  - b) **Timber lintels**: not widely used as the stone used for this work is not available at all places.
  - c) **Brick lintels**: Plain brick lintels are not structurally strong and they are not used in large openings and where loads are heavy. Instead reinforced bricks are used.
  - d) **Steel lintels**: Are provided where the opening is large and where the superimposed loads are heavy.
  - e) **Reinforced concrete lintels**: have replaced practically all other types of lintels because of their strength, rigidity, fire resistance, economy and ease in construction. Can be used on any span and they may be cast in place or available as precast.

WALL SYSTEMS

5 OPENINGS IN WALLS

5.2 Lintels (cont...)

Types of lintels

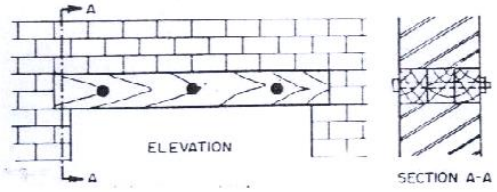


WALL SYSTEMS

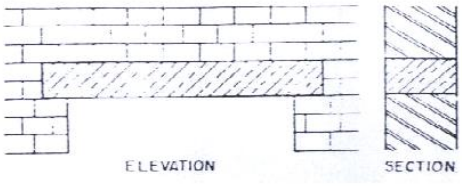
5 OPENINGS IN WALLS

5.2 Lintels (cont...)

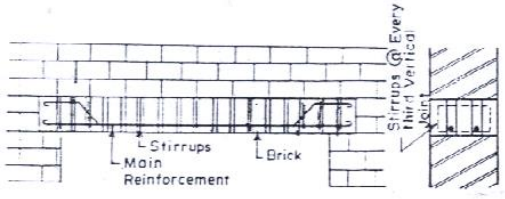
Types of lintels



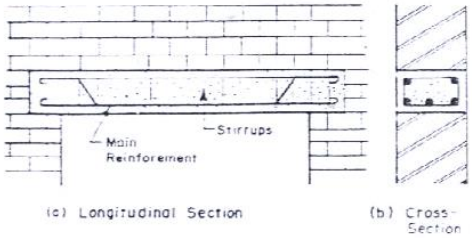
Timber lintel



Stone lintel



Reinforced brick lintel



Reinforced concrete lintel

6. REVIEW QUESTIONS

1. Explain in brief, the function of a wall.
2. Discuss the requirements that must be fulfilled for a wall to serve its function.
3. Briefly discus the different factors which affect the choice of material for wall construction.
4. Discuss a) manufacturing process of brick b)types of bricks and tests conduct on brick.
5. Show with the help of sketches various types of a) closer bricks b) brick bats.
6. Write short notes on a) Header bond b)Stretcher bond c)Dutch bond d) Garden wall bond.
7. Differentiate and compare English bond, Flemish bond and double Flemish bond.
8. Draw plans of alternate courses of i) 1½ brick wall, and ii)2-brick wall in a) English bond b) Double Flemish bond

6. REVIEW QUESTIONS (CONT...)

9. Write important points connected with the supervision of brick work.
10. Write a note on a) various defects in brick work b) failure mechanisms of brick work c) maintenance of brick work.
11. What do you understand by 'reinforced brick masonry'? When do you use it? Give examples.
12. Write a note on a) Classification of rocks b) tests conduct on stone c) qualities of good stones.
13. Classify various types of stone masonry. Draw typical sketches to illustrate the same.
14. Enumerate the different advantages that could be obtained by dressing of stones and the different types of surface finishes used in stone masonry.

6. REVIEW QUESTIONS (CONT...)

15. What do you understand by concrete block masonry? State the advantages of hollow concrete block masonry. State the various points that should be kept in mind both during production and construction of concrete blocks.
16. What do you understand by a) Walls of monolithic construction b) composite or panel walls?
17. Define a partition wall. Enumerate a) various requirements to be fulfilled by a partition wall b) different types of partition walls.
18. Define a cavity wall. What are its advantages? Explain with the help of sketches, general features of cavity wall.
19. Distinguish clearly b/n a lintel and arch. Classify various types of lintels and their relative use.
20. Describe where arches are recommended. Explain with the help of sketches various types of arches.