LINTELS AND ARCHES:

Definition functions and classification of Lintels, Balconies, Chejja and canopy. ARCHES: Elements and Stability of an Arch.

LINTEL:

A lintel is a horizontal member which is placed across the opening (window, door, almirah, wardrobes etc.) to support load of masonry coming over it. A lintel is thus a sort of beam, the width of which is equal to the width of the wall, and the ends of which are built into the wall. Lintels are easy to construct.

Lintels are made of either RCC, steel, timber or even stones (as granite, Kadapa slabs etc)

FUNCTIONS OF LINTEL:

Lintel is a beam supporting the load of masonry above it which is transmitted to the adjacent wall portions (jambs). The bearing (projection beyond the opening) of lintel beam should be the minimum of the following:

(i) 100 mm.
(ii) Height (thickness) of lintel
(iii) $1/10^{th}$ to $1/12^{th}$ of the span of the opening.

CLASSIFICATION OF LINTELS:

Lintels are classified into the following types, according to the materials used in their constructions:.

1. Timber lintels
2. Stone lintels
3. Brick lintels
4. Steel lintels
5. Reinforced brick lintels
6. Reinforced concrete lintels

1. Timber lintels

Timber lintels are oldest types of lintels, though they are not commonly used now – a days, except in hilly areas. Timber lintels are relatively costlier, structurally weak and vulnerable to fire. They are also liable to decay if not properly ventilated.

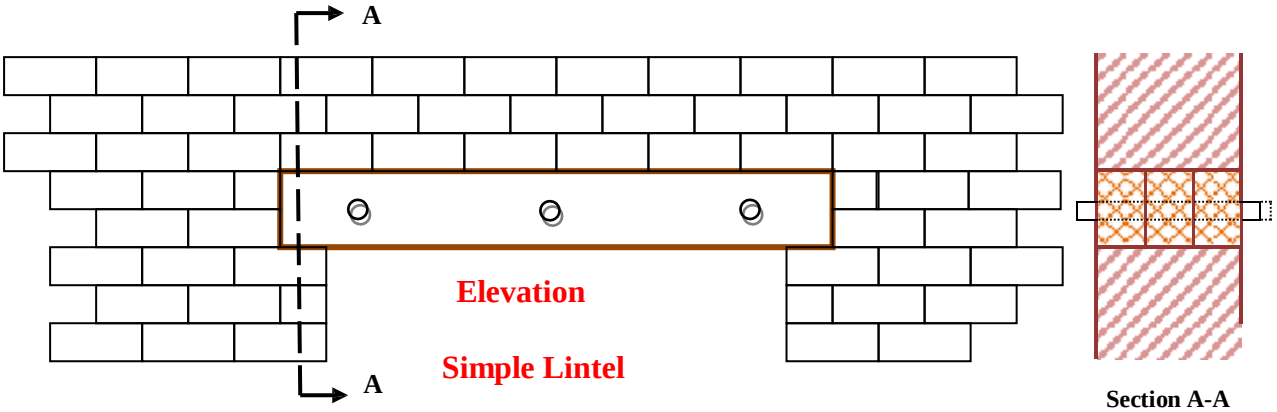
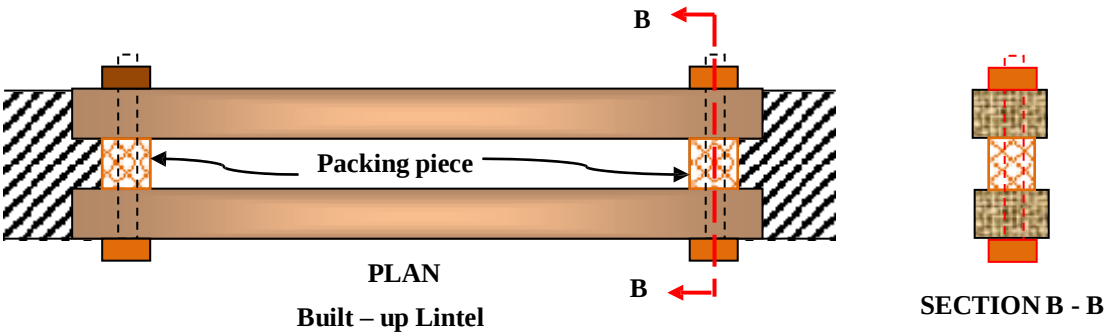


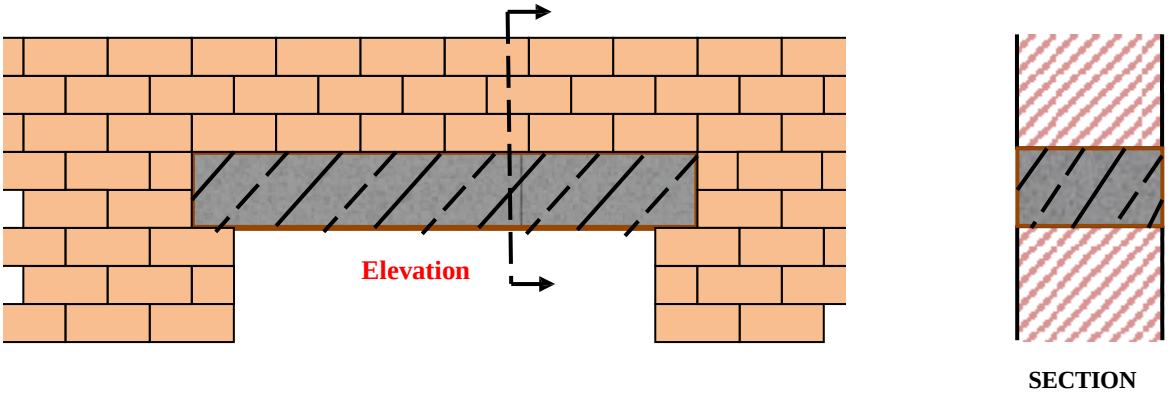
Fig shows a wooden lintel provided over the full width of the wall, by joining together three timber pieces with the help of steel bolts.



Built – up Lintel

Fig shows wooden lintel for a wider wall. The lintel is composed of two wooden pieces kept at a distance with the help of wooden distance pieces. Sometimes, timber lintels are strengthened by the provision of mild steel plates at their top and bottom, such lintels are called **flitched lintels.**

2. Stone lintels

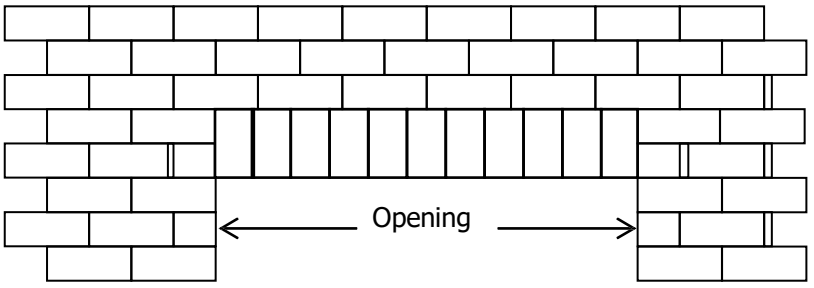


Stone lintels are the most common types. Specially where stone is abundantly available. A stone lintel consists of a simple stone slab of greater thickness. Stone lintels can also be provided over openings in brick walls. Dressed stone lintels give good architectural appearance.

Stone lintels may be used in the form of either one piece or more than one piece along the width of the wall. The depth of stone lintel is kept equal to 10 cm per metre of span, with a minimum of 15 cm. They are used upto spans of 2 m. For wider spans, stone slabs are kept on edge.

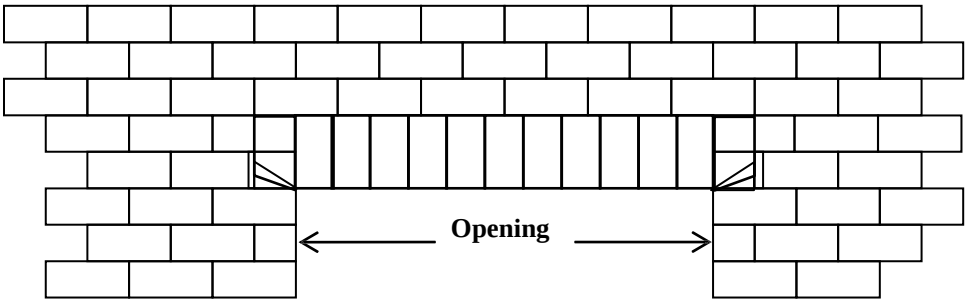
Stone is very weak in tension. Also, it cracks if subjected to vibratory loads. Hence stone lintels should be used with caution where shock waves are quite common.

3. Brick Lintels



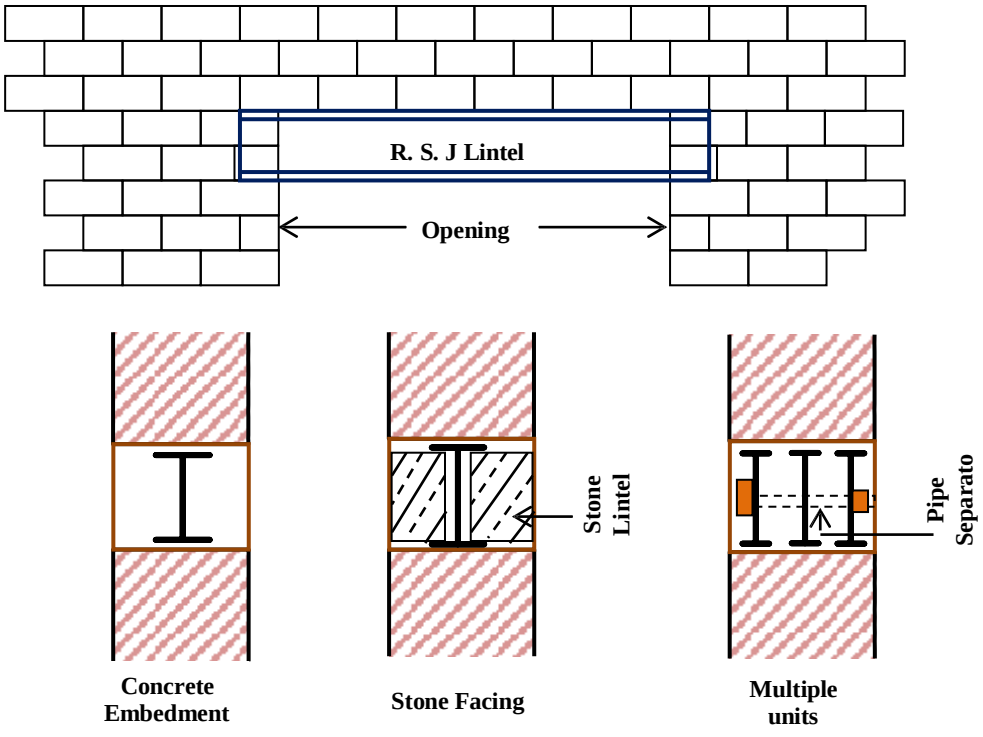
Brick lintels are not structurally strong, and they are used only when the opening is small (less than 1 m) and loads are light. A brick lintel consists of bricks placed on end or edge, as shown in fig. a better way of forming brick lintel is shown in fig.

The depth of brick lintel varies from 10 to 20 cm, depending upon the span. It is constructed over temporary wooden centering. The bricks with frogs are more suitable for the construction of lintel since the frogs, when filled with mortar, form joggles which increase the shear resistance of end joints. Such lintel is known as joggled brick lintel.

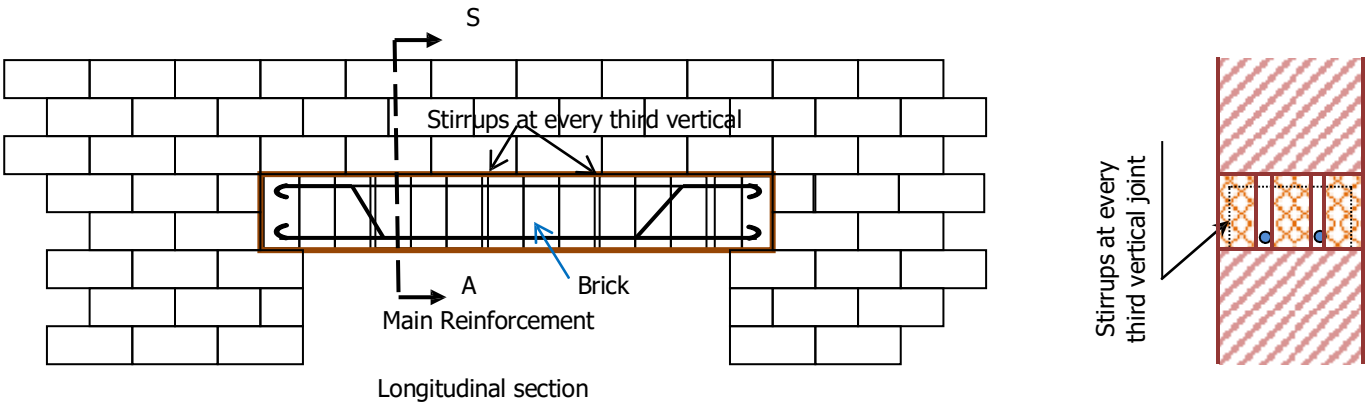


4) STEEL LINTELS:

Steel lintels are provided where the opening is large and where the super-imposed loads are also heavy. It consists of rolled steel joists or channel sections either used singly or in combination of two or three units. When used singly, the steel joist is either embedded in concrete, or cladded with stone facing, so as to increase its width to match with the width of the wall. When more than one units are placed side by side, they are kept in position by tube separators.



5) Reinforced Brick Lintels:



when brick lintels are to be used over large spans, they are reinforced with steel bars.

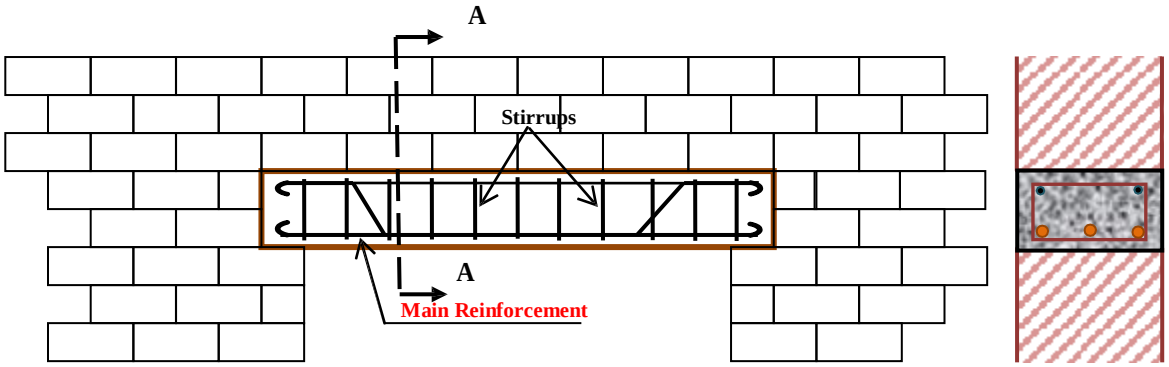
The depth of the lintel is kept equal to 100 mm or as multiple of 100 mm.

The bricks are so arranged that 2 to 3 cm wide space is left length-wise between adjacent bricks for the insertion of reinforcement (mild steel bars). The gap or joint is filled with 1:3 cement mortar. Vertical shear stirrups of 6 mm dia. Wire are provided in every third vertical joint. Main reinforcement, provided at the bottom of the lintel, consists of 8 to 10 mm dia. Bars, which are cranked up at the ends.

REINFORCED CEMENT CONCRETE LINTELS

Reinforced cement concrete lintels have replaced practically all other types of lintels because of their strength, rigidity, fire resistance, economy and ease in construction. These can be used on any span. Its width is kept equal to the width of the wall. The depth of R.C.C. lintel and the reinforcement depends upon the span and the magnitude of loading. Longitudinal reinforcement, consisting of mild steel bars, are provided near the bottom of lintel to take up tensile stresses. Half these bars are however cranked up near the ends. Shear stirrups are provided to resist transverse shear.

Fig. shows a typical R.C.C. lintel over a window, along with a chajja projection. R.C.C. lintels are also available as precast units. For cast-in-situ units, which are quite common, form work is required for construction.

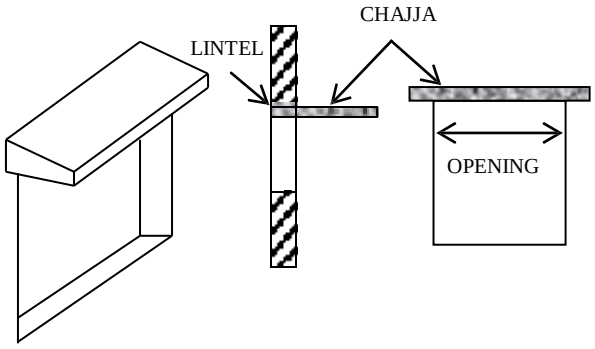


Longitudinal section

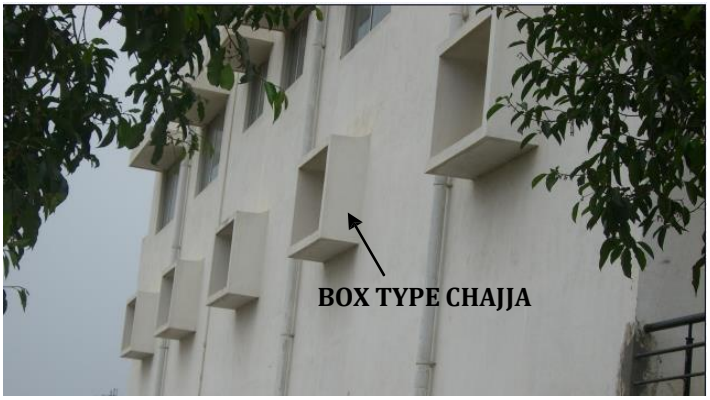
Cross Section

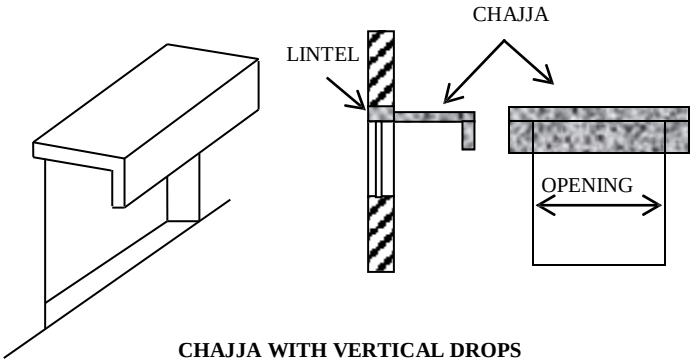
Chajja:

Chajja is sloping or horizontal structural overhand usually provided over openings on external walls to provide projection from sun and rain.

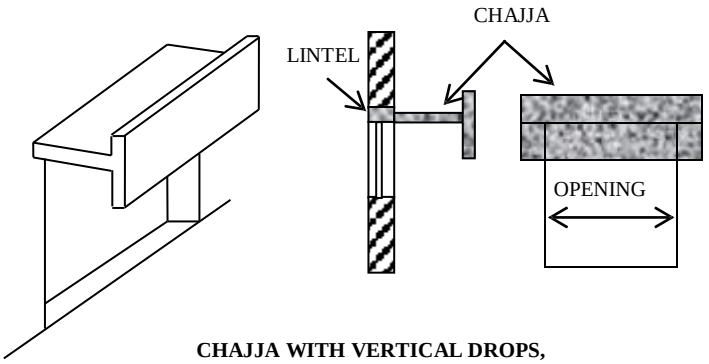


STRAIGHT CHAJJA PROTECTS FROM HIGH SUN AND RAIN

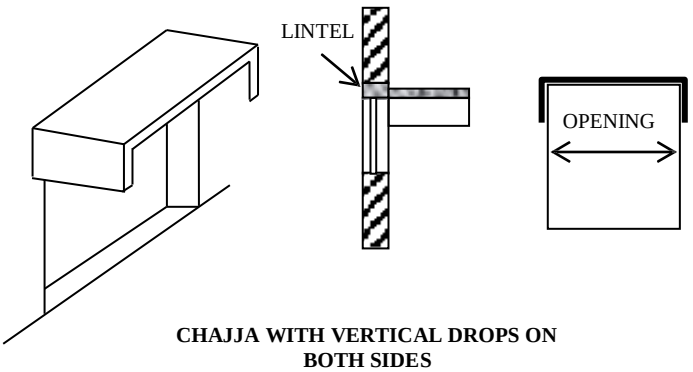




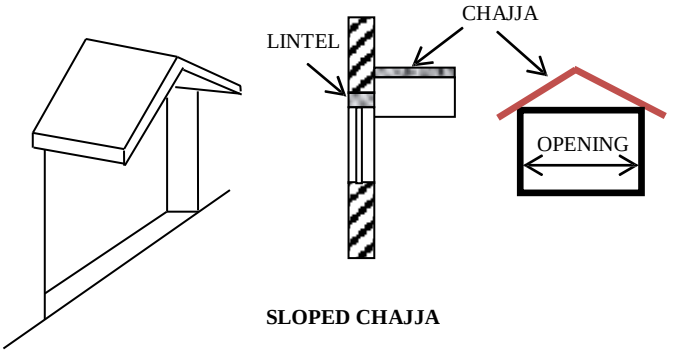
CHAJJA WITH VERTICAL DROPS



CHAJJA WITH VERTICAL DROPS, WITH PROJECTION ABOVE THE TOP OF CHAJJA



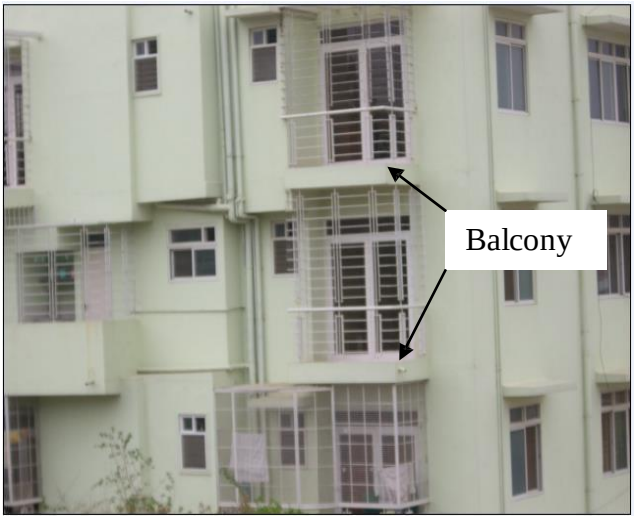
CHAJJA WITH VERTICAL DROPS ON BOTH SIDES

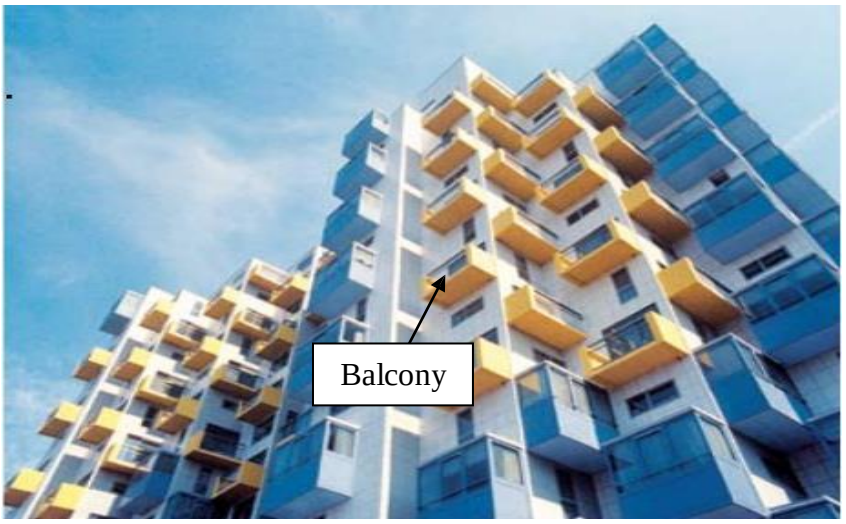


SLOPED CHAJJA

Balcony:

Balcony is a horizontal projection, including a handrail or balustrade, to serve as passage or sitting out place.

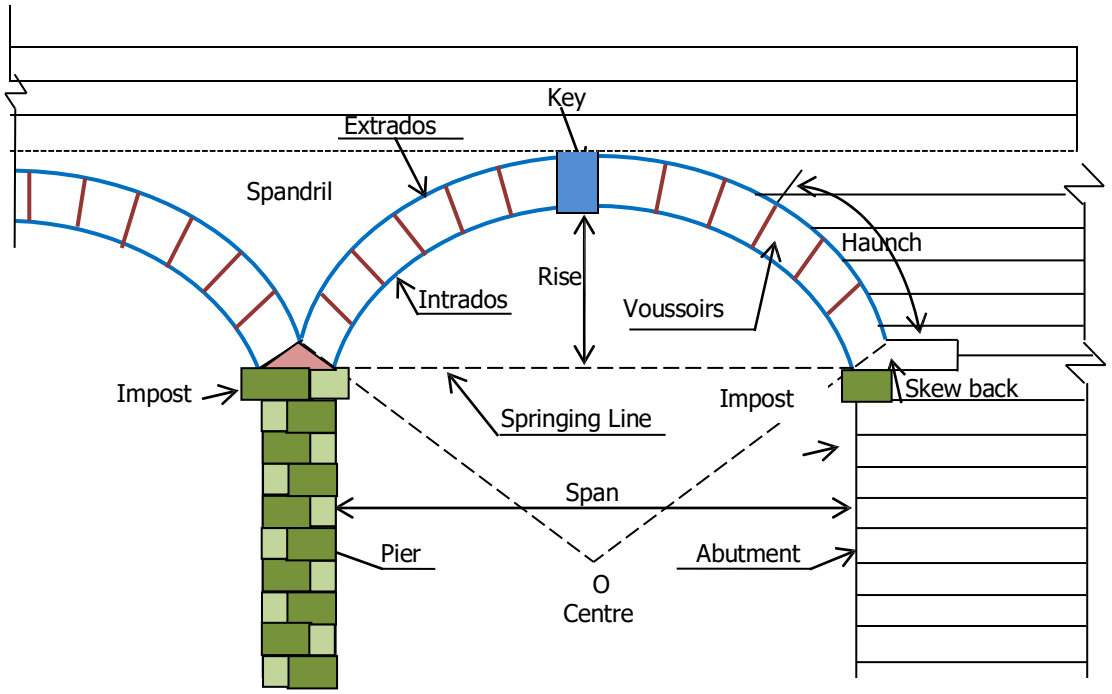




Canopy is an overhead roof or else a structure over which a fabric or metal covering is attached, able to provide shade or shelter from weather conditions such as sun, snow and rain.

ARCH:

An Arch is a structure constructed of wedge – shaped units (bricks or stone), jointed together with mortar and spanning an opening to support the weight of the wall above it along with other super – imposed loads. Due to wedge – like form, the units support each other, the load tends to make them compact and enables them to transmit the pressure downwards to their supports.



The following technical terms are used in arch work:

1. **Intrados:** This is the inner curve of an arch.
2. **Soffit:** It is the inner surface of an arch. Sometimes, intrados and soffit are used synonymously.
3. **Extrados:** It is the outer curve of an arch.
4. **Voussoirs:** These are wedge – shaped units of masonry, forming an arch.
5. **Crown:** It is the highest part of extrados.
6. **Key:** It is the wedge- shaped unit fixed at the crown of the arch.
7. **Spandril:** This is a curved – triangular space formed between the extrados and the horizontal line through the crown.
8. **Skew back:** This is the inclined or splayed surface or the abutment, which is so prepared to receive the arch and from which the arch springs.

9. **Springing points:** These are the points from which the curve of the arch springs.
10. **Springing line:** It is an imaginary line joining the springing points of either end.
11. **Springer:** It is the first voussoir at springing level: it is immediately adjacent to the skewback.
12. **Abutment:** This is the end support of a arch.
13. **Pier:** This is an intermediate support of an arcade.
14. **Arcade:** It is a row of arches in continuation.
15. **Haunch:** It is the lower half of the arch between the crown and skew back.
16. **Ring:** It is a circular course forming an arch. An arch may be made of one ring or more than one ring.
17. **Impost:** It is the projecting course at the upper part of a pier or abutment to stress the springing line.
18. **Bed joints:** These are the joints between the voussoir which radiate from the centre.
19. **Centre or striking point:** This is the geometrical centre point from where the arcs forming the extrados, arch rings and intrados are described or struck.
20. **Span:** It is the clear horizontal distance between the supports.
21. **Rise:** It is the clear vertical distance between the highest point on the intrados and the springing line.
22. **Depth or Height:** It is the perpendicular distance between the intrados and extrados.
23. **Thickness (breadth of soffit):** This is the horizontal distance, measured perpendicular to the front and back faces of an arch.

STABILITY OF AN ARCH:

An arch transmits the super-imposed load to the side walls (or abutments) through friction between the surfaces of voussoirs and the cohesion of mortar. Every element of arch remains in compression. It has also to bear transverse shear.

An arch may therefore fail in the following ways.

(i) Crushing of the masonry
(ii) Sliding of voussoir
(iii) Rotation of some joint about an edge and
(iv) Uneven settlement of abutment/pier.

If the compressive stress or thrust exceeds the safe crushing strength of the materials (i.e., masonry units and mortar), the arch will fail in crushing. Hence, the material used for construction should be of adequate strength, and the size of voussoirs should be properly designed to bear the thrust transmitted through them. The height of voussoirs should not be less than $1/12^{th}$ the span. For span upto 1.5 m, 20 cm thick arch ring is provided, while for span between 1.5 to 4 m, 30 cm

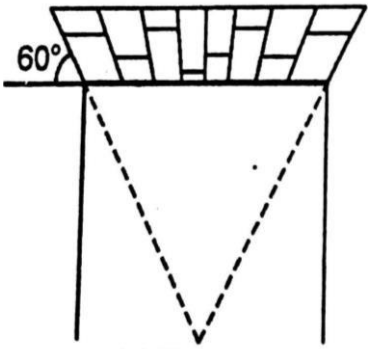
thickness is sufficient. For span between 4 to 6.5 m, 40 cm thickness should be provided while for span more than 6.5 m, the thickness at springing may be increased by about 20% of the thickness at the crown. Sometimes, voussoirs of variable heights are provided-less height near crown and more height at skew-back. To safeguard against sliding of voussoirs past each other due to transverse shear, the voussoirs of greater height should be provided. The uneven settlement of abutment may cause secondary stresses in the arch. Hence the abutment, which has to ultimately bear all the loads transferred to it through the arch, should be strong enough. The arch should be symmetrical, so that unequal settlements of the two abutments is minimized. Also, the abutment should be strong enough to take the thrust.

CLASSIFICATION OF ARCHES:

An arch can be classified according to (i) Shape, (ii) Number of centres, (iii) Workmanship, and (iv) Materials of construction.

(a) Classification according to shape

1. Flat Arch
2. Segmental Arch
3. Semi-circular Arch
4. Horse Shoe Arch
5. Pointed Arch
6. Venetian Arch
7. Florentine Arch
8. Relieving Arch
9. Stilted Arch
10. Semi-Elliptical Arch



(a) Flat arch

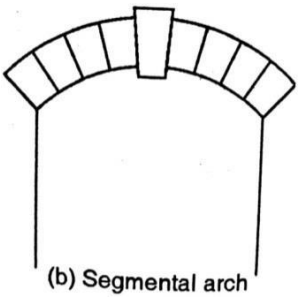
1) Flat Arch: This type of arch is similar in shape to that of a lintel but is constructed with a single centre and all the joints are radiated from the centre.

The skew back is sloped at an angle of 60^0 with horizontal.

The depth of the atch is made equal to some multiple of the courses of masonry.

At the time of construction, a rise of about 10 mm to 15 mm per metre span of the arch is given so that after removal of centering the intrados of the arch acquires a perfectly horizontal surface after allowing for slight settlement of arch.

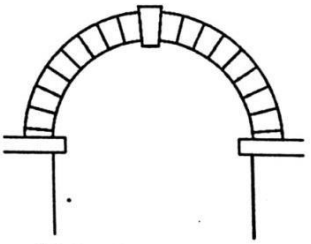
These are used only for light loads and for span upto 1.5 m, for face work.


(b) Segmental arch

2) Segmental arch: This type of arch is most common for opening of various size in buildings.

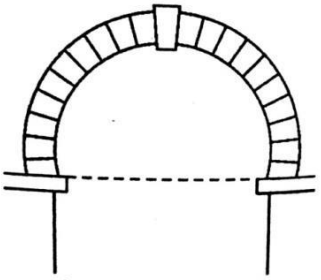
Its centre lies below the springing line. The depth of segmental arches may be 200 mm, 300 mm or any multiple of half bricks according to the class of work, width of opening etc. the thrust transferred to the abutment is in an inclined direction.

3) Semicircular arch: This is the modification of segmental arch in which the centre lies on the springing line. The thrust transferred to the abutments is perfectly in vertical direction since the skewback is horizontal.



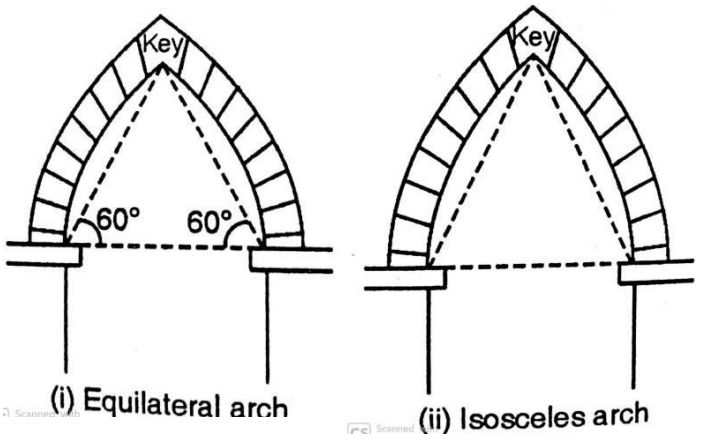
(c) Semi - circular arch

4) Horseshoe arch: The arch has the shape of a horse, incorporating more than a semi – circle. This arch is constructed for architectural point of view.



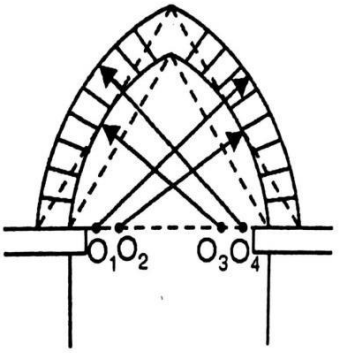
(d) Horse shoe arch

5) Pointed arch or gothic arch: Pointed or gothic arch consists of two arcs of circles meeting at the apex. The triangle formed may be equilateral or isosceles. Isosceles arch is also known as Lancet arch.



(i) Equilateral arch (ii) Isosceles arch

6) Venetian Arch: This is another form of pointed arch which has deeper depth at crown than at springing. It has four centres, all located on he springing line.



(a) Venetion arch

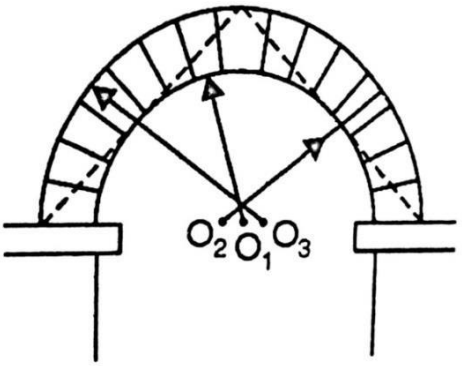
7) Florentine arch: This is similar to Venetian arch except that the intrados is a semicircle. The arch has, thus three centres, all located on the springing line.

8) Relieving Arch:

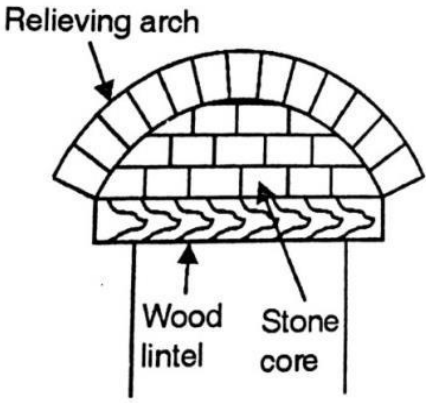
This arch is constructed on a flat arch or on a wooden lintel to provide greater strength. The ends of the relieving arch should be carried sufficiently into the abutments. The relieving arch makes it possible to replace the decayed lintel later, without disturbing the stability of the structure.

9) Stilted Arch:

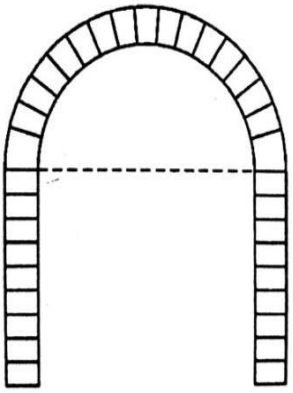
It consists of a semi – circular arch with two vertical portions at the springings. The centre of the arch lies on the horizontal line through the tops of the vertical portions.



(b) Florentine arch

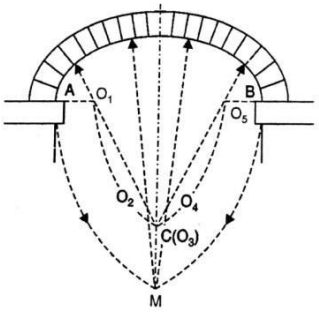


(c) Relieving arch



(d) Stilted arch

10) Semi – elliptical arch: This type of arch has the shape of a semi – ellipse and may have either three centres or five centres.

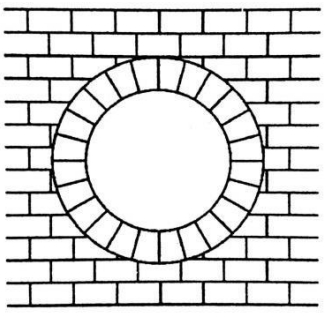


(b) Classification based on number of centres: The arches may be classified as :

1. One-centred arches
2. Two-centred arches
3. Three-centred arches
4. Four-centred arch
5. Five-centred arch

1) One – centred arches:

Segmental arches, semicircular arches, flat arches, horse – shoe arch and stilted arches come under this category. Sometimes, a perfectly circular arch, known as Bull's eye arch is provided for circular windows.



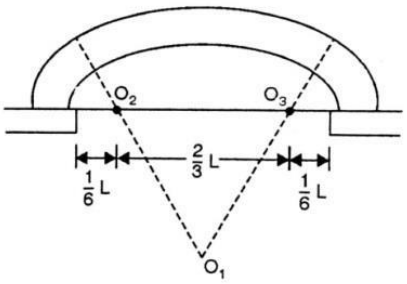
13.18. BULL'S EYE ARCH

2) Two – centred arches: Pointed arches come under this category. Semi-elliptical arch and Florentine arch come under this category.

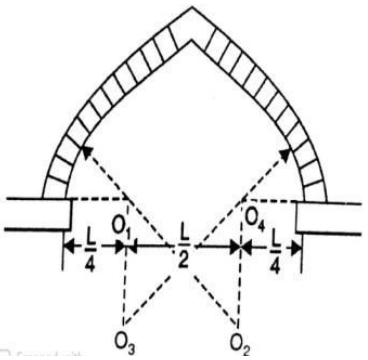
3) Three – centred arches: Elliptical arches come under this category.

4) Four – centred arch: It has four centres. Venetian arch is a typical example of this type. This is also called **Tudor arch**.

5) Five – centred arch: This type of arch is having five centres, gives a good semi – elliptical shape.



13.19. THREE-CENTRED ARCH (ELLIPTI



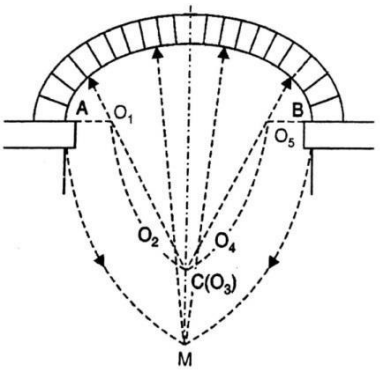


FIG. 13.21. FIVE-CENTRED ARCH (SEMIL-ELIPTICAL ARCH)

(C) Classification based on material and workmanship

On the basis of material of construction and workmanship, arches may be classified as follows:

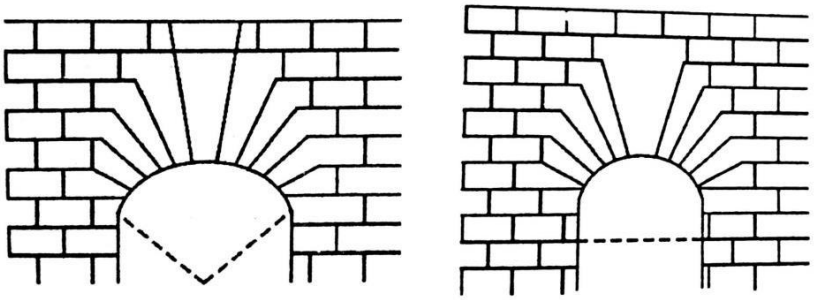
1	**Stone arches**	
	(i) Rubble arch	Stones of approximate wedge shaped units (voussoirs) used.
	(ii) Ashlar arch	Exact wedge shaped stone used.
2	**Brick arches**	
	(i) Rough arch	Bricks of uniform size used. Hence, joint is of increasing thickness from intrados to extrados.
	(ii) Axed or rough-cut arch	Wedge shaped brick used.
	(iii) Gauged Brick Arch	
	(iv) Purpose made Bricks Arch	
3	**Concrete arches**	
	(i) Precast Concrete block-units arch	Wedge shaped concrete blocks used.
	(i) Monolithic arch	Curved concrete beam without any joints.

Stone arches: Depending upon workmanship, stone arches are of two types: Rubble arches and (ii) Ashlar arches.

Rubble arches:

Rubble masonry arch is comparatively weak and is used for comparatively inferior work. These arches are made of rubble stones which are hammer dressed, royghly to shape and size of voussoirs of the arch and fixed in cement mortar.

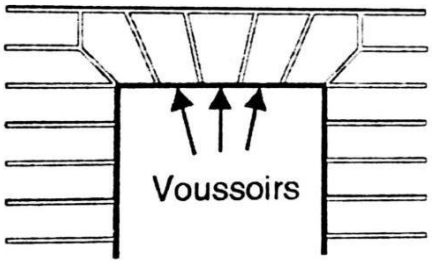
Rubble arches are used upto spans of 1 m. they are also used as relieving arches, over wooden lintels. Upto a depth of 37.5 cm, these arches are constructed in one ring. For greater depths (thickness), rubble stones are laid in two rings in alternate course of headers and stretchers.



Ashlar arches:

The stones are cut to proper shape of voussoirs, and are fully dressed, set in lime or cement joints with proper bed joints. Upto depth of 60 cm, the voussoirs are made of full thickness of the arch. For determining the wedged shapes of voussoirs, it is preferable to set out the arch on a level platform, marking on it the key – stone and voussoirs along with radial mortar joints.

Ashlar stone can also be used to make flat arches, in which the joints are either joggled or rebated as shown in fig.



(d) Flat arch

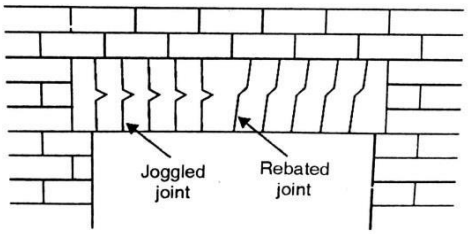


FIG. 13.23. JOGGLED AND REBATED JOINTS IN FLAT ARCH OF ASHLAR STONES

Brick arches:

Brick arches may be classified as rough brick arches, axed or rough cut brick arches, gauged brick arches and purpose made brick arches, depending upon the nature of workmanship and quality of bricks used.

Rough brick arches:

This type of arch is constructed with ordinary bricks, without cutting these to the shape of voussoirs. In order to provide the arch curve, the joints are made wedge – shaped, with greater thickness at the extrados and smaller thickness in intrados. Due to this, the appearance of the arch is spoiled. Therefore, this type of arch is not used for exposed brick work.

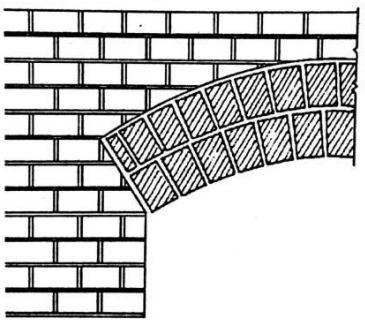


FIG. 13.24. SEGMENTAL ROUGH BRICK

Axed brick arches:

In this arch, the bricks are cut wedge – shaped with the help of brick axe. Due to this the joints are of uniform thickness along the radial line. However, the appearance of the arch is not very pleasant because the bricks cut to wedge – shapes are not finely dressed.

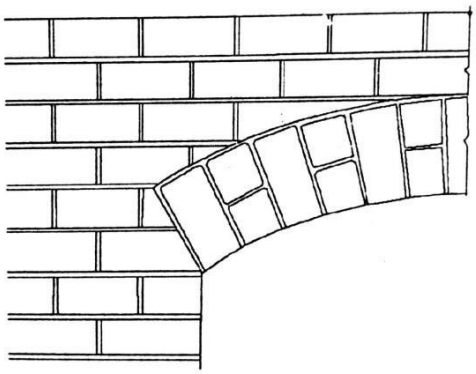


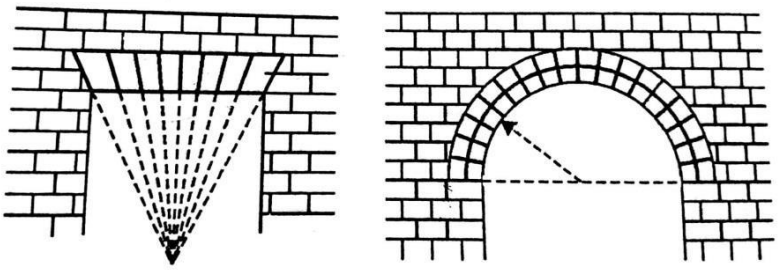
FIG. 13.25. AXED BRICK ARCH.

Axed Brick

Bus Shelter Near BDA Complex, Nagarbhavi

Gauged brick arch:

This type of arch is constructed of bricks which are prepared to exact size and shape of voussoir by cutting it by means of wire saw. The surfaces of the bricks are fine dressed with the help of a file. For this, only soft brick (called rubber bricks) are used. The joints formed in gauged brick arch are fine, thin (1 to 1.5 mm) and truly radial. Lime putty is used for jointing.



(a) Flat arch (b) Semi-circular arch

FIG. 13.26. GAUGED BRICKS ARCHES.

Purpose made brick arches:

In this type of arch, the bricks are manufactured, matching with the exact shape and size of voussoirs, to get a very fine workmanship. Lime putty is used for jointing.

Concrete arches:

Concrete arches are of two types: (i) Precast concrete block arches and (ii) monolithic concrete arches.

(i) Precast concrete block arches:

Such arches are made from precast concrete blocks, each block being cast in the mould to the exact shape and size of voussoirs. Special moulds are prepared for voussoirs, key block and skewbacks. Because of exact shape and size of blocks, good appearance of the arch is achieved. Also, joints, made of cement mortar, are quite thin. However, casting of blocks is costly, and such work is economical only when the number of arches is quite large. Cement concrete of 1:2:4 mix is usually used.

(ii) Monolithic concrete arches:

Monolithic concrete arches are constructed from cast – in – situ concrete, either plain or reinforced, depending pon the span and magnitude of loading. These arches are quite suitable for large span. The arch thickness is 15 cm for arches upto

3 m span. Form work is used for casting the arch, and is removed only when the concrete has sufficiently hardened and gained strength. The curing is done for 2 to 4 weeks.

Differences between Arch and Lintel

Sl No	Parameter	Arch	Lintel
1	Structural aspect	Curved structural member	Horizontal structural member
2	Nature of loads on supports	It exerts horizontal thrust and vertical pressure on its supports	It exerts only vertical pressure on its supports
3	Construction	It is difficult to construct since it requires complex form work	It is easier to construct
4	Abutment	Strong abutments (supports) are required to withstand arch thrust	Normal end supports are sufficient
5	Stability	Less stable compared to lintel	It is stable and it supports the load by beam action and transfer the loads vertically to the walls.
6	Head room to span opening	More	Less
7	Precast units	Precast voussoirs may be available but, Precast arches are not available	Precast Lintels are available
8	Bending Moment	Zero	More