ANJUMAN COLLEGE OF ENGINEERING & TECHNOLOGY
SADAR,NAGPUR
FIFTH SEMESTER
SUBJECT:-BUILDING CONSTRUCTION & MATRIAL

DEPARTMENT OF CIVIL ENGINEERING

Unit-III:

Stone Work : Stones, cutting and dressing, selection of stones types of stone masonary, principles of construction joints in masonary. Lifting heavy stones, common building stones in India.
Arches and Lintels : Terminology in contraction, types chajjas and canopies, pre cast Lintels & Arches.
Damp Proofing : Causes and effect of dampness. Various methods of damp proofing
Damp proofing in plinth protection, New Techniques of Damp Proofing Damp Proofing in Plinth Protection,New Techniques of Damp proofing. Epoxy etc

STONE WORK

In very strict sense, the term masonry is used to indicate the art of building the structure in stones. The masonry is used for the construction of foundations, walls, columns and other similar components of a structure. The basic advantage of the masonry for the load bearing structures is that it performs a variety of foundation like:

1) Affording architectural effect,
2) granting fire and weather protection,
3) Providing acoustic and thermal insulation
4) Subdividing space
5) Supporting load etc

Materials required for stone masonry

For stone masonry the following two materials are required:

1) Stones
2) Mortar.

Stones : Depending upon the availability , the stones are selected . the stones to be used in the work should be hard, durable , tough and free from any defect such as shake , vent mottle etc.

Mortar: The mortar is required to keep the stones in position. It is prepared by mixing lime or cement with sand and after adding water, it is placed in the joints. The type of mortar to be used will depend on the strength required, load coming on the structure, resistance desired for weathering agencies, etc. the usual varieties are: lime mortar,cement mortar, cement –lime mortar and lime- cement mortar.in cement –lime mortar, a portion of cement is replaced by hydrated lime. It spread more esily under the trowel and produces a more plastic material.

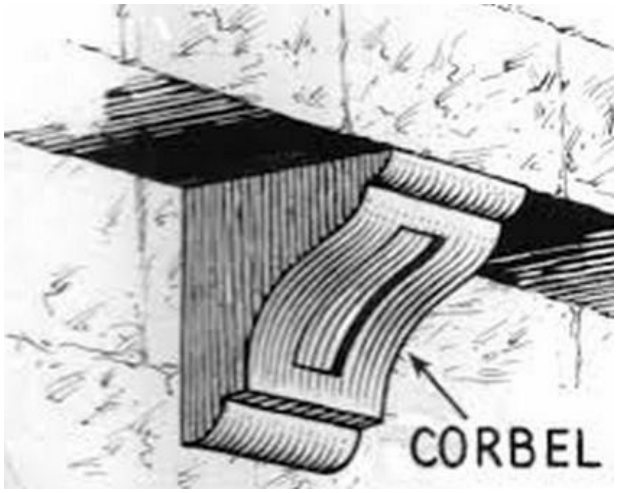
In lime-cement mortar, a portion of lime is replaced by cement . it makes the mortar stronger , more plastic and workable . Also the mortar sets earlier.the choices of mortar and its composition will be governed by several factor like type of masonry ,situation of structure

,intensity of load ,degree of exposure to weather ,type of bond ,durability desired and some other special requirements like fire resistance , insulation ,rate of hardening etc.

Some Definitions :-

The meanings, attached to some technical terms used in the masonry, are given below. some of these terms are commonly used in brick masonry.

1) **Natural bed:** The building stones are obtained from rocks .these rocks have a distinct plane of division along which the tones can easily be split. This plane represents the natural bed and in stone masonry, the general rule to be observed is that the direction of natural bed should be perpendicular or nearly so to the direction of the pressure
2) **Sill:** The bottom surface of a door or a window opening is known as a sill and the sill stones are so dressed that they prevent the entry of water to the interior of the building.
3) **Corbel :** A corbel is a projecting stone which is usually provided to serve as support for roof truss, beam, weather shed etc., the corbel are generally moulded and given ornamental treatment . The corbel should extend at least two-third of their length into the wall **Fig: corbel**



4) **Course :** A layer of stone or brick is known as a course and its thickness generally equal to the thickness of a stone or a brick plus the thickness of one mortar joint .
5) **Cornice :** A cornice is a course of stone provided at the top of the wall . t is generally moulded and given ornamental treatment . it is weathered and throated to dispose off rain water. In order to prevent the overturning of the cornice, sufficient bearing and extra weight at the top in the form of a parapet wall should be provided. **Fig: cornice**

6) **Coping :** A coping is a course of stone which is laid at the top wall so as to protect the wall form rain water.this course is generally provided at the top of a compound wall or a parapet wall and it is suitably weathered and throated . sometimes the term coping is used to refer to cutting of stone by means of feathers, plugs and wedges.

7) **Weathering:** the upper surface of stone used for sill, cornice and coping is dressed in a sloping way so that the water may flow off easily. This is termed as the weathering .the term weathering is sometimes used to denote the wearing of stone surface by the action of weather.
8) **Throating:** a groove is provided on the underside of sill, cornice and coping so that the rain water can be discharged clear of the wall surface. This is known as the throating.
9) **Plinth:** the projecting course at ground floor level is known as the plinth . it is also used to indicate the height of ground floor level from ground level. The plinth course protects the interior of a building from rain, water, frost etc. it is sometimes moulded and given ornamental treatment. The offset at plinth level is sometimes omitted for the architectural purpose.
10) **String course :** the horizontal course provided at suitable levels between the plinth and the cornice is termed as a string course . it breaks the monotony of a plane surface and it is sometimes moulded and given architectural treatment. The string course is suitably weathered and throated so as to throw off the rain water clear of the wall surface.
11) **Lacing course**: the horizontal course provided to strengthen a wall of irregular small stones is known as a lacing course. It may be in the form of either ashlar masonry or coursed rubble masonry or brick masonry.
12) **Spalls**: the chips of stones used to fill up the empty spaces in the stonemasonry are known as the spalls or snecks. They are obtained as a result of reducing big blocks of stone into the regular stone blocks.
13) **Quoins**: the external corners or angles of a wall surface are called the quoins and the stones or bricks forming the quoins are known as the quoin stoneor quoins bricks. The quoin stones are selected from large and sound stones and their beds are properly dressed.
14) **Bond**: A bond is an arrangement of layer of stones or bricks by which no continuous vertical joints are formed.the bond distributes the load coming on the structure evenly and prevents the formation of a vertical cracks.

Dressing of stone

Building stone has to be quarried out from the rock formation before it can be put into use. The quarry of stone may be done either by hand tools or with the help of explosives. In large quarries, machinery have to be used for the purpose. Rough blocks of stone, as obtained from quarry, are irregular in shape and non-uniform in size and as such they

cannot be used in masonry without proper dressing and cutting. The dressing of stone in done at the quarry itself, because stones, when freshly quarried, contain some moisture called " quarry sap" and in this state they are softer and can be easily worked upon.

Moreover , the local workmen are well experienced in the art of dressing.

Quarry dressed stones are thus economical and the reduced weight of the dressed blocks result in still further economy in transportation and handling costs.

The commonly used tools and implements for the cutting and dressing of stone blocks The dressed in a variety of finishes which depend upon the type of masonry and the kind of stone.

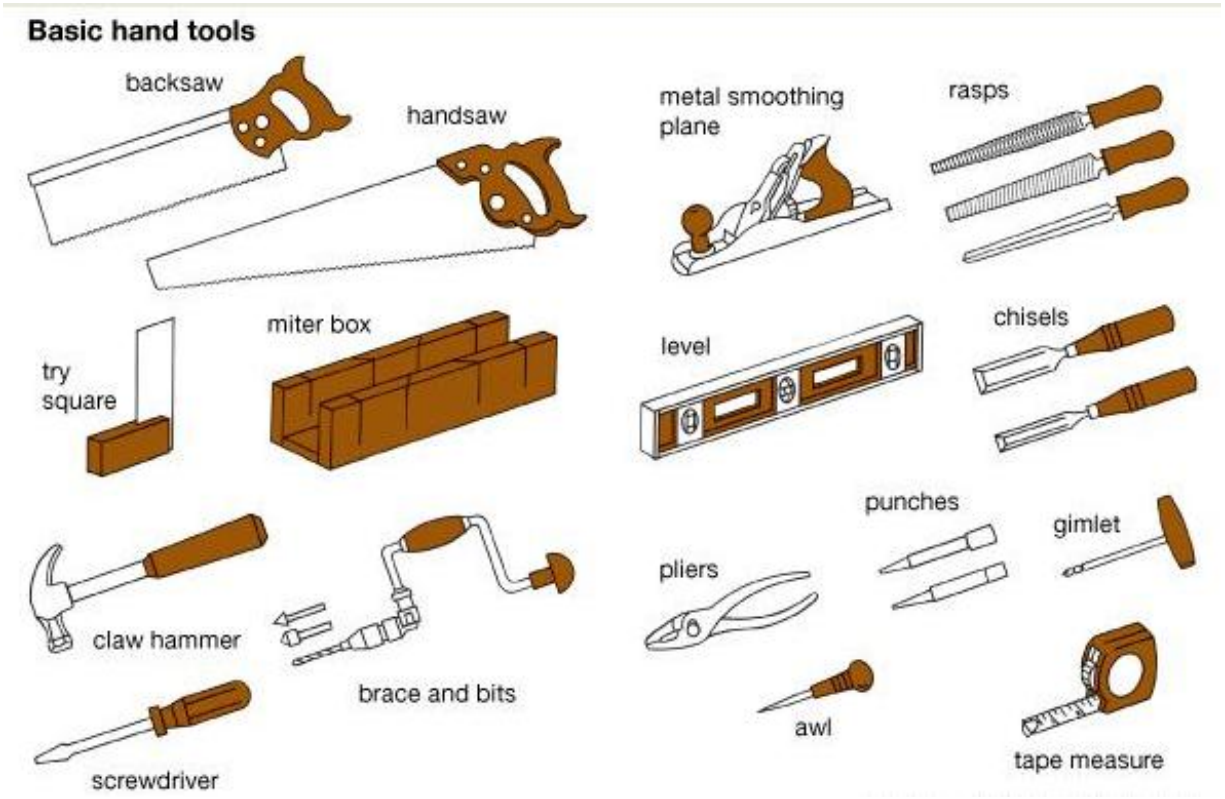


Fig:- Tools

It becomes easy and economical to carry out the dressing of stones at he quarry because of the following facts:

1) The local workers are well trained and experienced in the art of dressing
2) The freshly quarried stones contain some moisture known as the quarry sap and the stones in this state are quite soft for the dressing job.

3) The irregular and rough portions of the stones are removed which decrease the weight of stones and it also facilitate easy transportation of the stones.
4) It is possible to sort out stones for different works, if quarry dressing is practiced.
5) The natural bed surface of stones can be made promised during the quarry dressing.

Following are the varieties of finishes for stonework:

1) **Self-faced or rock –faced or quarry faced finish:** some stones , as obtained from the quarry , possess smoth surface and they canbe directly placed on the work. Such a stone surface is termed as the *self-faced* or *rock-faced* or *quarry faced* finish.
2) **Scabbling finish:** In this type of finish , the irregular projections are removed by a scabbling hammer and in this way , the stones are roughly dressed.
3) **Hammer- dressed finish :** in this type of finish , the stones are made roughly square or rectangular by means of a waller's hammer as shown in fig. The hammer so as

Hammer dressed finish

The hammer dressed stones have no sharp or irregular corners and have comparatively even surface so as to fit well in the masonry.

4) **Axed finish :** The surfaces of hard stones such as granite are dressed by means of an axe. Such a finish is termed as an finish.

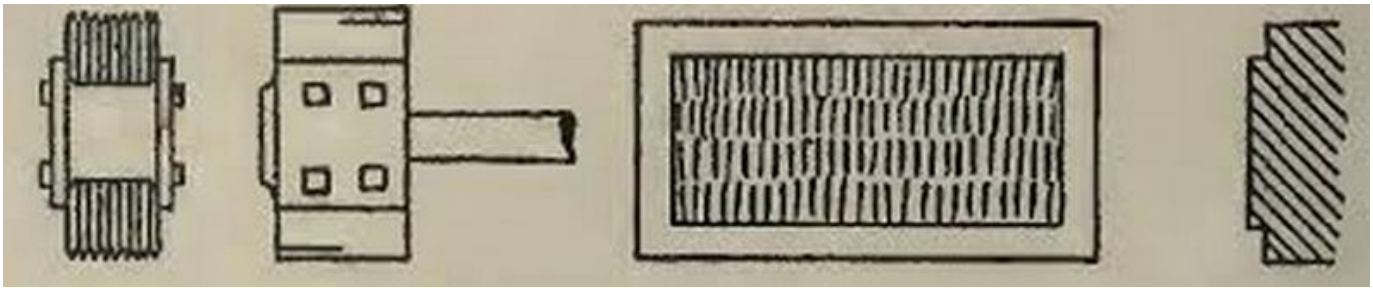


Fig: Axed finish

5) **Tooled finish :** The stones surface is finished by means of a chisel and parallel continuous marks, either horizontal or vertical or inclined , are left on the surface as shown in fig

Fig: tooled finish

6) **Punched finish:** on the stone surface, the depressions are made by using a punch. The surface takes the form of a series of hallows and ridges.

Fig: punched finish

7) **Furrowed finish:** in this of finish, a margin of about 20 mm width is sunk on all the edges of the stone and the central portion in small to project about 15mm .A number of horizontal and vertical grooves about 10mm wide are formed in this projected portion .this finish is generally adopted t make the quoins prominent.

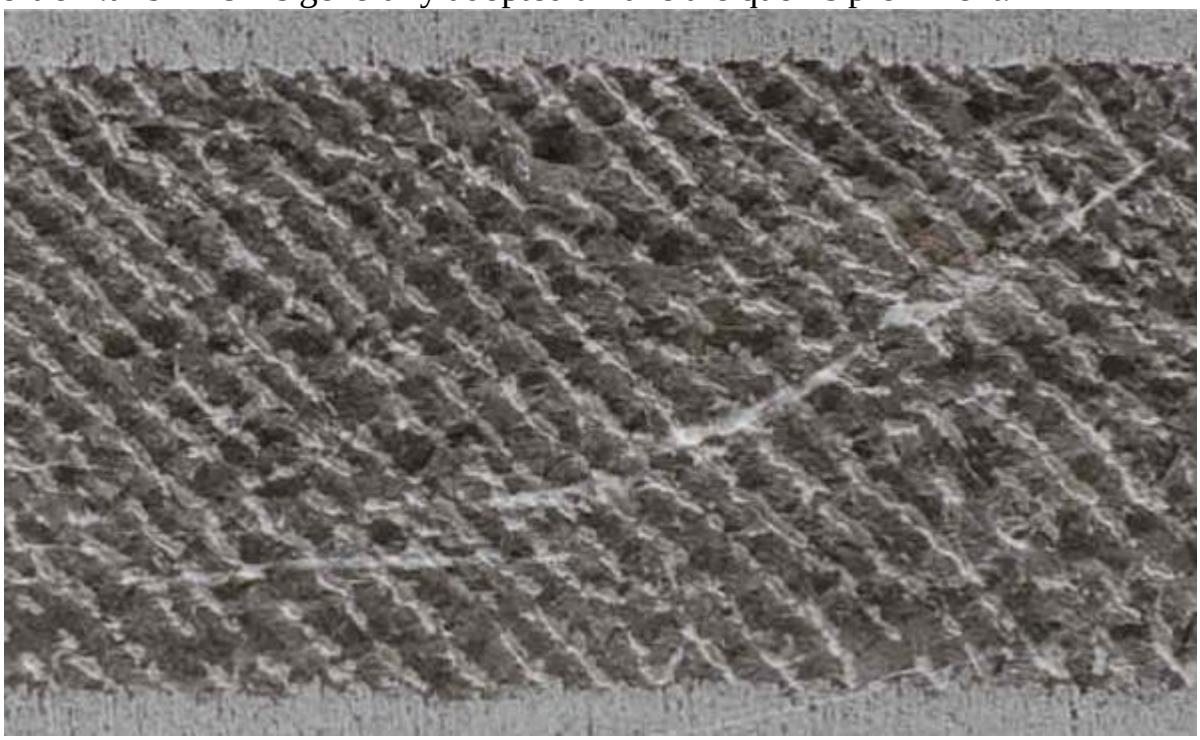


Fig: furrowed finish

8) **Reticulated finish:** this type of finish presents a net like appearance. A margin , about 20mm wide, is marked on the edges of the stone and irregular sinking are made on the enclosed space. A margin about 10mm wide ,is provided around the irregularly shaped sinkings, having a depth of about 5mm. A pointed tool is used to put the marks on the sunk surface so as to present a pockmarked appearance.

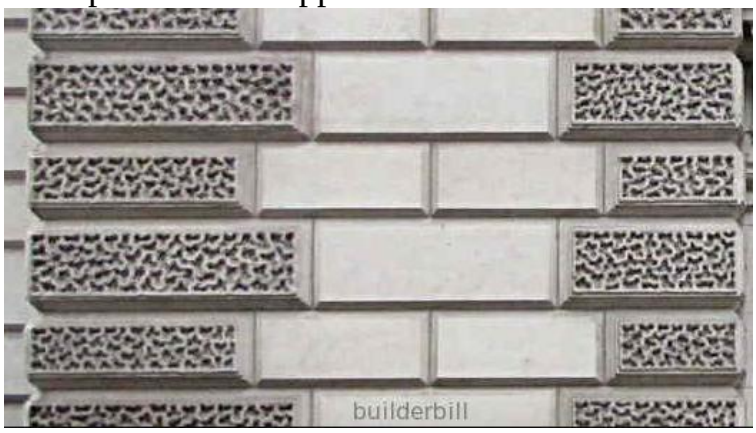


Fig: reticulated finish

9) **Vermiculated finish:** this finish is just similar to the reticulated type except that the sinkings are more curved .this finish presents a worm-eaten appearance.

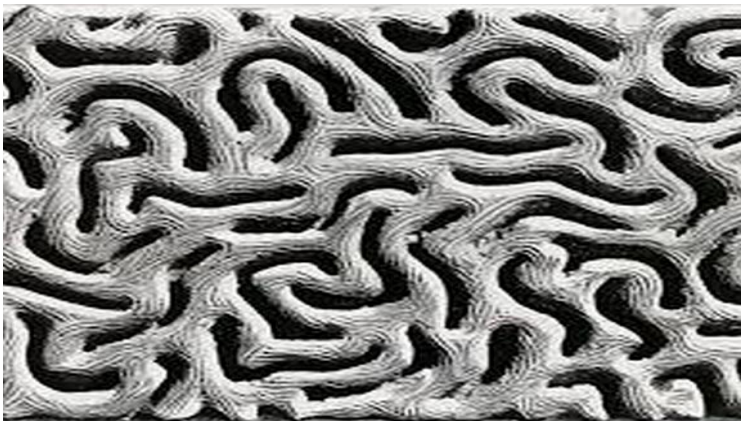


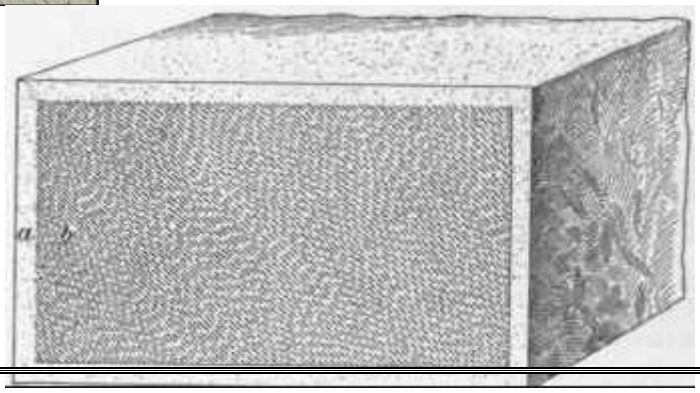
Fig: vermiculated finish

10) **Boasted or droved finish:** In this type of finish, the boaster is used to make non-continuous parallel marks on the stone surface . the marks may be horizontal,vertical or inclined. A boaster is a chisel having an edge of width.

Fig: droved finish

11) **Plain finish:** In this type of finish, the surface of the stone is made approximately smooth with a saw or with a chisel.

12) **Chisel –draughted margin** : In order to obtain uniform joints, the margin are placed which may be either squared or pitched.



13) **Dragged or combed finish**: In this type of finish , a drag or a comb,which is a piece of steel with a number of teeth, is rubbed on the surface in all directional. This finish is suitable for the soft stones only.

14) **Sunk finish**: This finish is obtained by sinking the surface below the original level in the form of wide grooves, chamfers, inclined surface etc.
15) **Rubbed finish**: This type of finish is obtained by rubbing a piece of stone with the surface or by rubbing the surface with the help of a suitable machine . the water and sand are freely used to accelerate the process of rubbing.
16) **Circular finish**: In this type of finish, the surface is made round or circular as in case of column.
17) **Moulded finish**: the surface of the stone can be moulded inany desired dhape so as to improve the appearance of the work.
18) **Polished finish**: the surface of stone such as marble , granites ,etc can be polished either by hand or with machine.

Classification of stone masonry

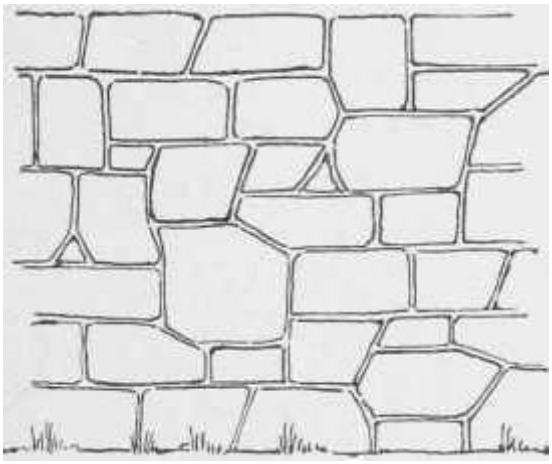
The stone masonry is classified under two categories as shown below:

Stone masonry

Rubble masonry	Ashlar masonry
1) Coursed rubble	1) Ashlar fine
2) Uncoursed rubble	2) Ashlar rough-tooled
3) Random rubble	3) Ashlar rock or quarry faced
4) Dry rubble	4) Ashlar chamfered
5) Polygonal rubble	5) Ashlar block-in course
6) Flint rubble	

1) **Rubble masonry :** In this type of construction, the stones of irregular sizes are used. The stones as obtained from quarry, are taken in use in the same form or they are broken and shaped in suitable sizes by means of hammer as the work proceeds. The strength of rubble masonry mainly depends on three factors:
   - **i)** The quality of mortar,
   - **ii)** The use of long through stones at frequent interval and
   - **iii)** The proper filling of the mortar between the space of stones

   The different types of the rubble masonry will now be briefly decribed.



i)Coursed rubble masonry : In this type of rubble masonry the height of stones vary from 50mm to 200mm. The stones are sorted out before the work commences. The masonry work s then carried out in courses such that the stones in a particular course are of equal heights. This type of masonry is used for the construction of public buildings, residential bildings, etc. the coursed rubble masonry is further divided into three categories.

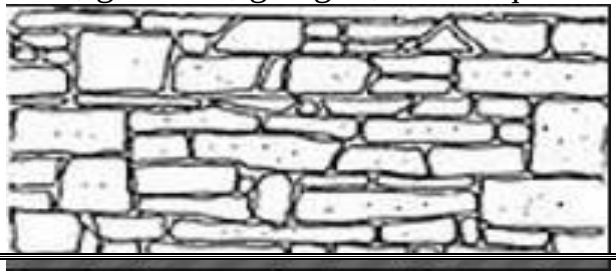
a) *coursed rubble masonry I sort* : IN this type , the stones of the same heights are used

and the courses are also of the same heights. The face stones are dressed by means of a hammer and the bushing do not project by more than 40mm. the thickness of maortar joint does not exceed 10 mm.

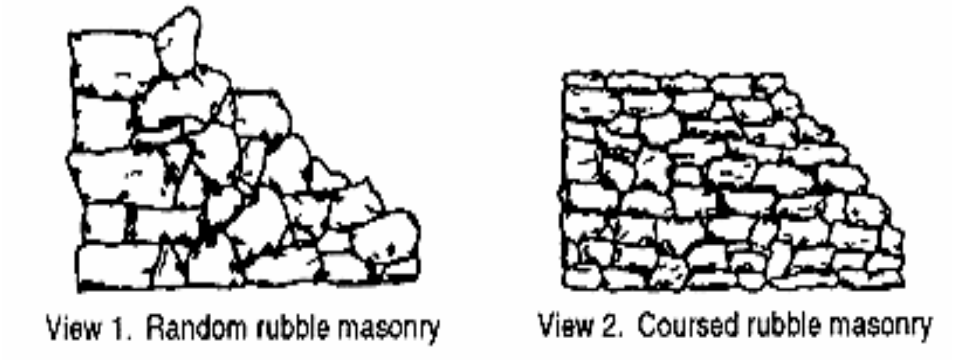
b) *coursed rubble masonry II sort*: It is similar to I sort except the following:
1) The stones to be used are of different heights.
2) The courses need not be of equal heights.
3) Only two stones are to be used to make up the height of one courses.
4) The thickness of the mortar joints is 12mm.

c) *Coursed rubble masonry III sort:* This type is similar to I sort except the following :
1) The stones to be used are of different heights , the minimum being 50mm.
2) The courses need not be of equal heights.
3) Only three stones are to be used to make up the heights of one courses.
4) The thickness of the mortar joints is 16mm.

ii) **Uncoursed rubble masonry**: In this type of rubble masonry , the stones are not dresses But they are used as they are available from the quarry , except knocking out some corners. The courses are not maintained regularly. The large stones are laid first and the spaces between them are then filles up by means of spalls or snecks . the wall I brought t alevel every 300mm to 500mm. this type of rubble masonry being cheaper , is used for the construction of compound walls, godowns, garages ,labours quarters,etc.



iii)Random rubble masonry : In this type of rubble masonry , the stones of irregular sizes and shapes are used .The stones are arranged so as to have a good appearance . It is to be noted that more skill is required to make this masonry structurally stable. If the face stones are chisel- dressed and the thickness of mortar joints does not exceed are hammer- dressed and the thickness of mortar joints does not exceed 6mm, it is known as the random rubble rubble masonry I sort. If the face stones are hammer-dressed and the thickness of mortar joints does not exceed 12mm, it is known as the random ribble masonry II sort. This type of masonry is used for the construction of residential buildings, compound wall, godowns etc.



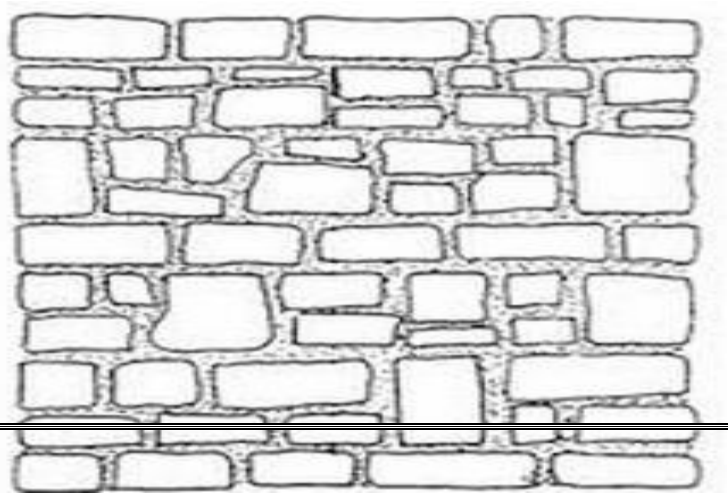
View 1. Random rubble masonry

View 2. Coursed rubble masonry

iii) Dry rubble masonry: This is just similar in construction to the coursed rubble masonry III sort except that no mortar is used in the joints. This type of construction is the cheapest, but it requires more sill in construction. It is extensively used for compound walls, pitching on bridge approaches, retaining walls, etc.In order to prevent the displacement of stones and to make the work more stable , the two courses at top and about 500mm length at the ends are sometimes built in mortar.

iv) Polygonal rubble masonry : In this type of rubble masonry,the stones are hammer-dressed and the stones selected for face work are dressed in an irregular polygonal shape. Thus the face joints are seen running in an irregular fashion in all directions. It is to be noted that more skill is required in the construction of this type of masonry. As the stones are of irregular shape, t is difficult to adjust them with regard to stability and appearance of the work as a whole.

v) Flint rubble masonry: In this type of rubble masonry, the stones are flint which are irregularly shaped nodules of silica. The width and thickness vary from 80mm to 150mm and the length varies from150mm to300mm. the stones are extremely hard. But they are brittle and therefore they break easily . the face arrangement may be either coursed or uncoursed . The strength of a flint wall is increased by introducing lacing coursed of either thin long stones or brick or tiles at vertical distances of one to two meters. This type of masonry is used st places where the flints are available readily and economically.

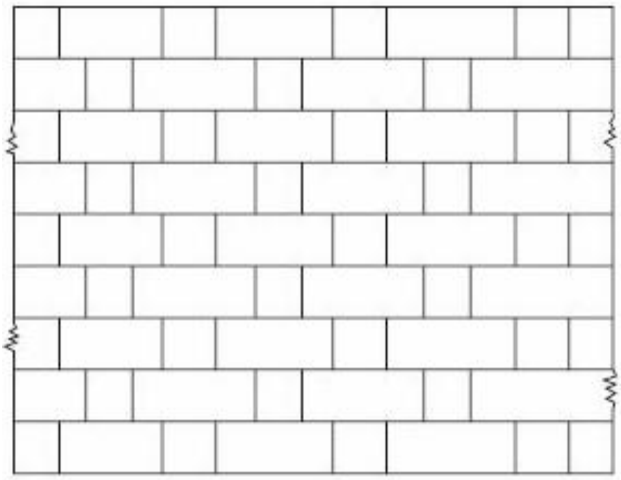


- **Ashlar masonry:** In this type of construction, the square or rectangular blocks of stones are used . the courses are not necessarily of the same height. The height of stones varies from 250mm to 300mm. the length of stones should not exceed three times the height and the depth into the wall should be at least equal to half the height.

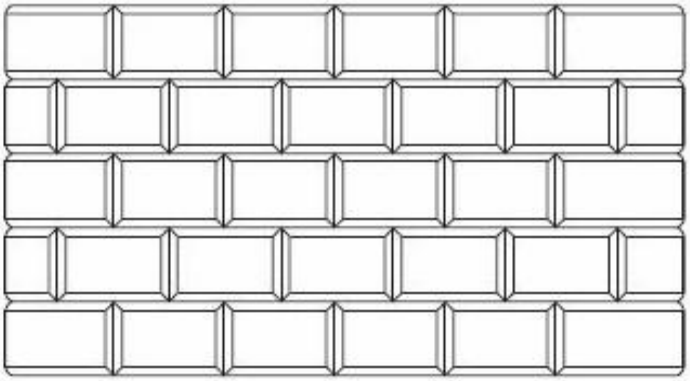
Following are the different types of ashlar masonry:

- **Ashlar fine masonry:** In this type of ashlar masonry, the beds sides and faces are finely chisel-dressed. The stones are arrangement proper bond and the thickness ofhte mortar joints does not exceed 3mm. this type of construction gives perfectly smooth appearance , but it is costly in construction.
- **Ashlar rough-tooled masonry:** In this type of ashlar masonry. The beds and sides are finely chisel-dressed . but the face is made rough by means of tools. A stri, about 25mm wide and made by means of a chisel , is provided around the perimeter of every stone exposed for view. The thickness mortar joints does not exceed 6mm. this type of work is alos knoen as the bastard ashlar.
- **Ashlar rock or quarry faced masonry:** In this type of ashlar masonry, a strip about 25mm wide and made by means of a chisel , is provided around the perimeter of every stone expose for view as in case of rough tooled ashlar. But the remaining portion of the face is left in the same form as received from quarry. Only projections on the face, known as the bushing, exceeding 80mm are removed by a hammer. This type of construction gives massive appearance.
- **Ashlar chamfered masonry:** In this type of ashlar masonry , the strip is provided as above. But it is chamfered or beveled at an angle of 45 degree by mean of chisel for a depth of about 25mm. Another strip 12mm wide isthen provided on the remaining exposed face as recevided from quarry. The large bushing projecting more than 80 mm are removed by a hammer. A neat appearance of the grooved joints is obtained with the help of this type of construction.
- **Ashlar block-in-course masonry:** This type of ashlar masonry occupies an intermediate position between the rubble masonry and the ashlar masonry. The faces of the stones are generally hammer –dressed and the thickness of mortar joints does not

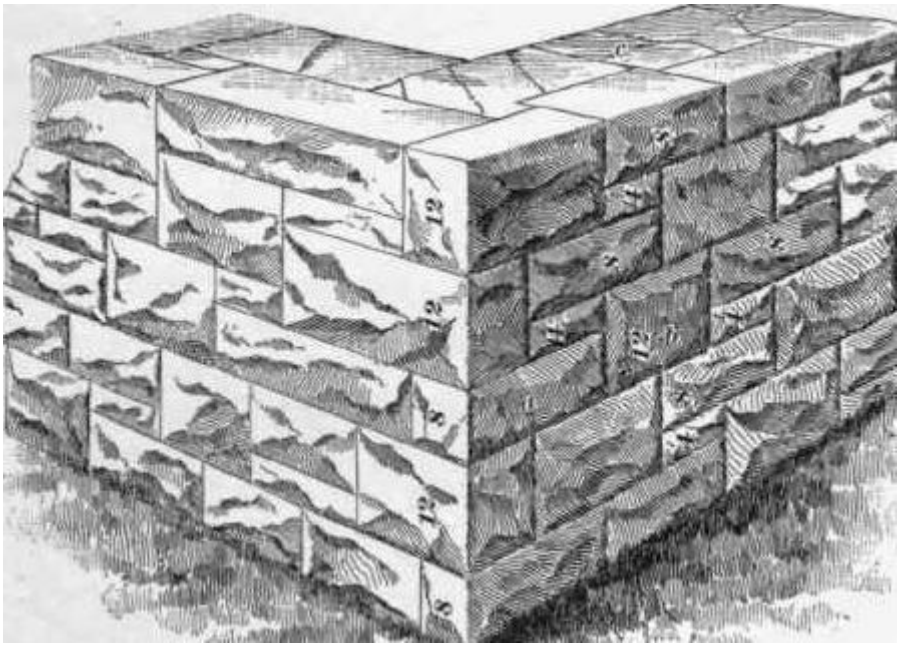
exceed 6mm. the depth of courses varies from 200mm to 300mm. this type of construction is used for heavy engineering works such as retaining walls, sea-walls, etc. and in some cases it may also be adopted for theatres, railways stations, temples, bridges, public buildings etc.



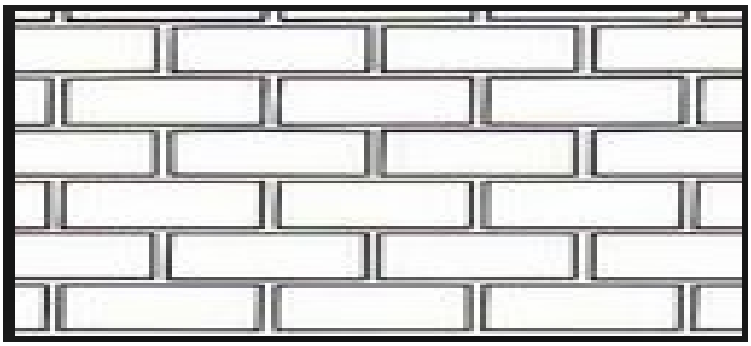
(a) Fine finished ashlar



(b) Ashlar chamfered



Ashlar rough tool masonry



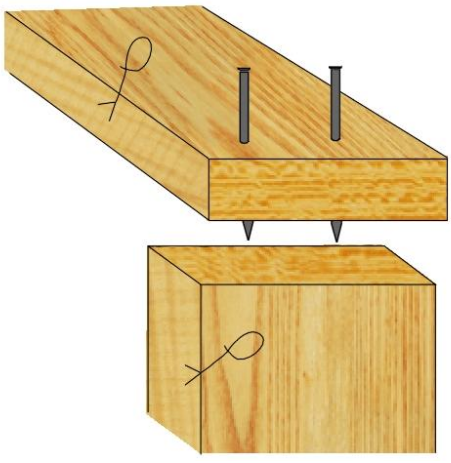
Ashlar block- in –course masonry

Joint in stone masonry

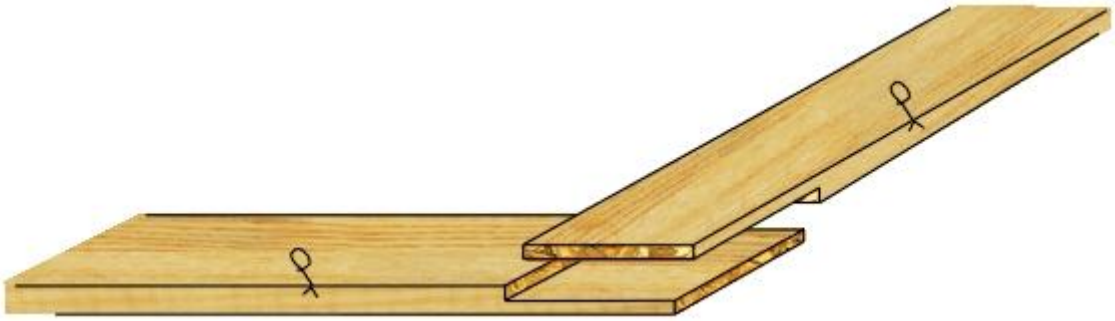
Following are the common type of joints provided in stone masonry, to secure the stone firmly with each other:

- Butt joint or square joint
- Rebated joint lap joint
- Tongued and grooved joint or joogle joint
- Bed joint or tabled joint
- Cramp joint
- Plugged joint
- Dowel joint
- Rusticated joint

a) Butt joint or square joint : this is most commonly joint in stone masonry . the dressed edges of two adjacent stone are placed side by side.



b) Rebated or lap joint: this type of joint is provided in arches , grables,coping etc. to prevent the possible movement of the stones. The length of the rebate or lap depends upon the nature of the work, but it should not be less than 70mm.

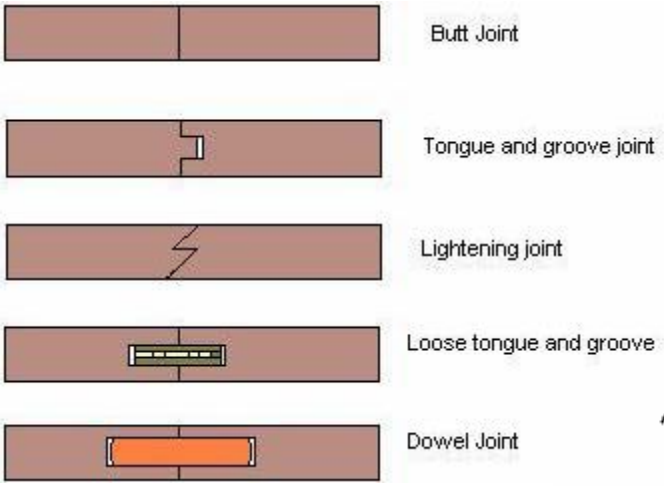


c) Tongue and grooved joint or joggle joint: This type of joint is provided to prevent sliding along the side joints. The joint is made by providing projection or tongue in one stone and a corresponding grooves or sinking on the adjacent stone.

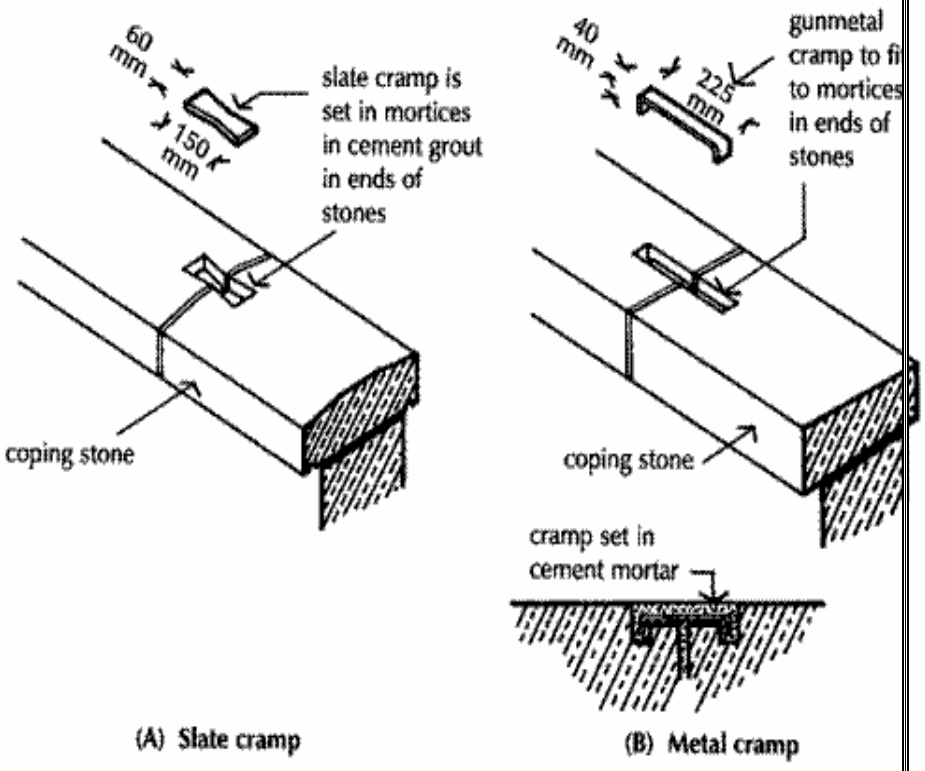
d) Tabled or bed joint: This joint is used to prevent lateral movement of stone such as in sea walls where the lateral pressure is heavy.The joint is made by forming a joggle in

the bed of the stone . the height of the projection is kept about 30 to 40mm, while the width is kept equal to above 1/3 the breadth of the stone.

e) Cramped joint : the joint uses metal cramp instead of dowels. Holes made in the adjacent stones should be of dovetail shape. The cramps are usually of non- corrosive metals such as gunmetal, copper etc., with their ends turned down to a depth of 4 to5 cm. the length , width and thickness of cramps vary from 20 to 30 cm, 2 to 4 cm and 5mm to 10 mm. wrought iron cramps may also be used but they must be either galvanized or dipped in oil while hot, to prevent their corrosion . After placing the cramp in position, the joint is grouted and covered with cement. Leaf or asphalt .cramps prevent the tendency of the joint to open out due to slippage of the same.

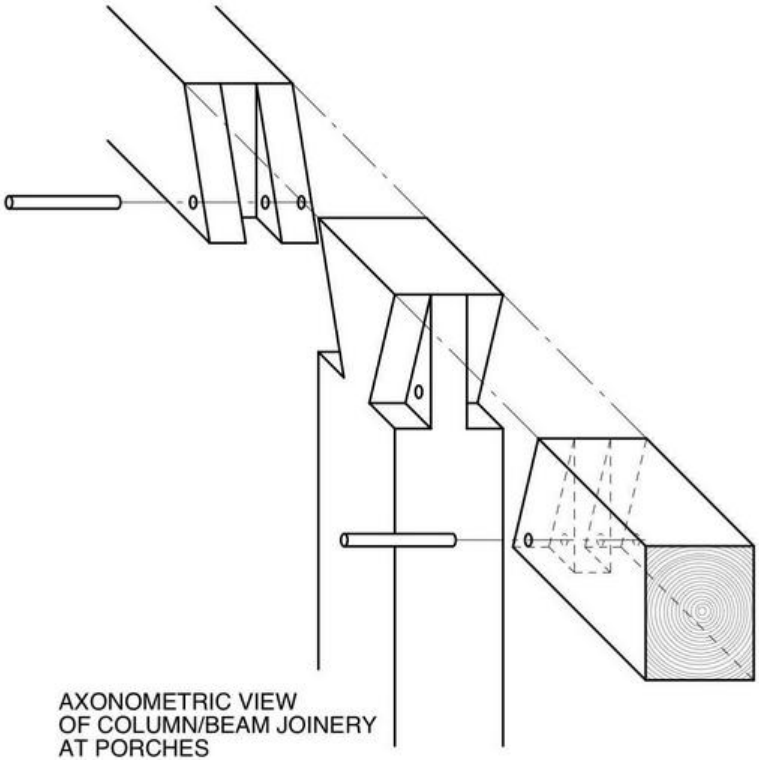


Cramped joint

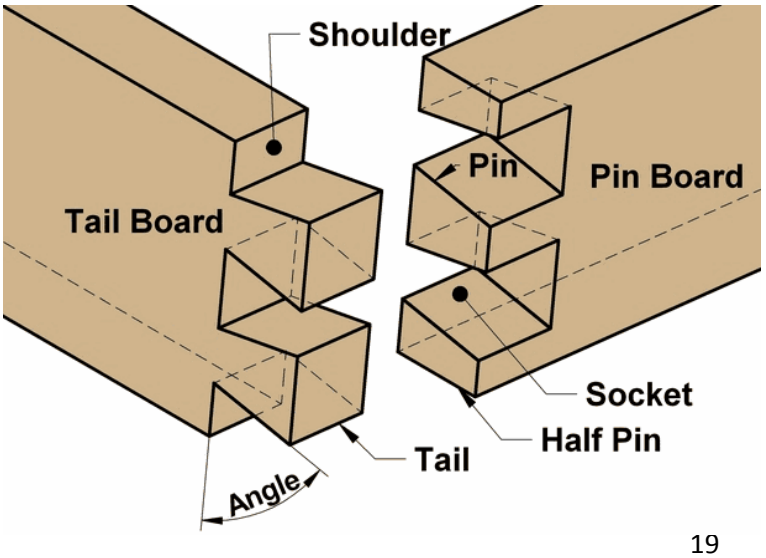


f) **Plugged joint:** This is an alternative to cramped joints. It consists of making plug holes of dovetail shape in the sides of adjacent stones. After placing the adjacent stones, a common space for plug is formed which is filled with molten lead. Sometimes, rich cement grout is used in the place of molten lead.

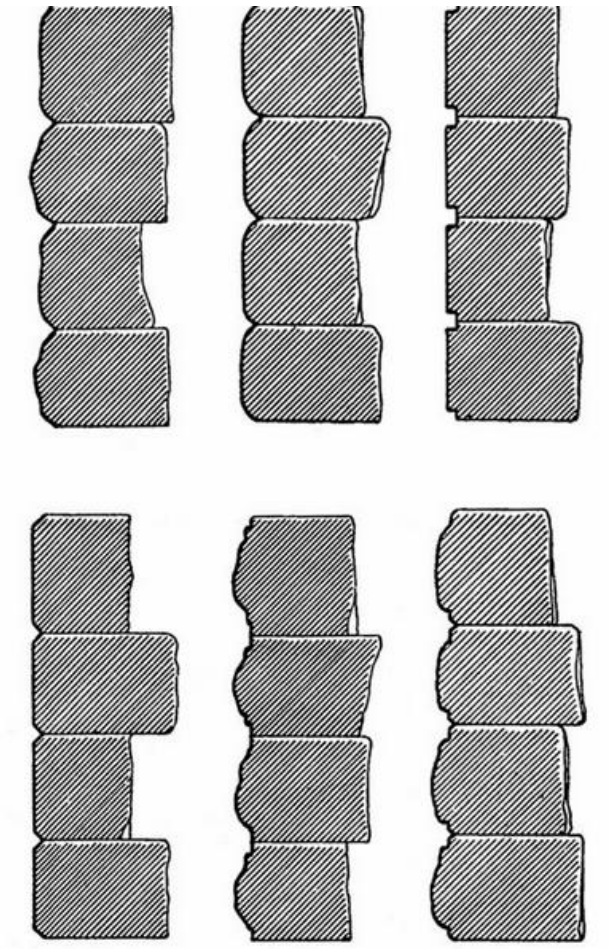
Plugged joint



g) Dowelled joint: This is a simple type of joint used to ensure stability of the adjacent stones against displacement or sliding. The joint is formed by cutting rectangular holes in each stone and inserting dowels of hard stone, slate , gunmetal, brass, bronze or copper. These dowels are set in cement mortar.



h) **Rusticated joint:** This joint is used in those stones whose edges are sunk below the general level, such as for plinth, quoin, outerwalls of lower storeys etc. such a joint gives massive appearance to the structure. Various forms of rusticated joints .



i) Saddled or water joint : such joint is used in cornices and such other weathered surfaces, to divert the water moving on the weathered surface away from the joint. The saddle is beveled backwards from the front edge.

Lifting heavy stones

The stone are to be lifted to their heavy weight and placed in position. In order to protect the stones during this operation, the various lifting appliances are found out. The stones of bigger size may be moved from one place t another by means of any suitable hoisting appliances such as crane, gantry etc.

Following are the appliances for lifting the stones:

1) **Chain or rope**
2) **Chain dog**
3) **Nipper or tongs or pincers**
4) **Lewis**
5) **Pins**

- **Chain or rope:** In order to protect the edges and corners, the stones are covered with gunny bags or timber battens and then a chain or a rope is passed round the stone. The chain is tied firmly to the stone and with the help of pulley block the stone is raised by manual labour. This is a very rough method and can therefore be used for lifting rough or hard stones.
- **Chain dog:** In this arrangement ,the dogs or hooks of suitable shapes area attached to the triangular chain. The hooks are fitted in the depressions made at the centre of each side of the stone. The depressions are about 20mm deep and they should lie above the centre of gravity of stone with a sufficient margin from the top. Usually , a distance of 80 mm to 100mm is kept. The dogs or hooks bite into the stone when the crane chain is wound up and thus a firm grip is obtained. The stone is then hoisted, moved and lowered in the required position. This arrangement is very suitable for lifting heavy long stones with narrow beds.

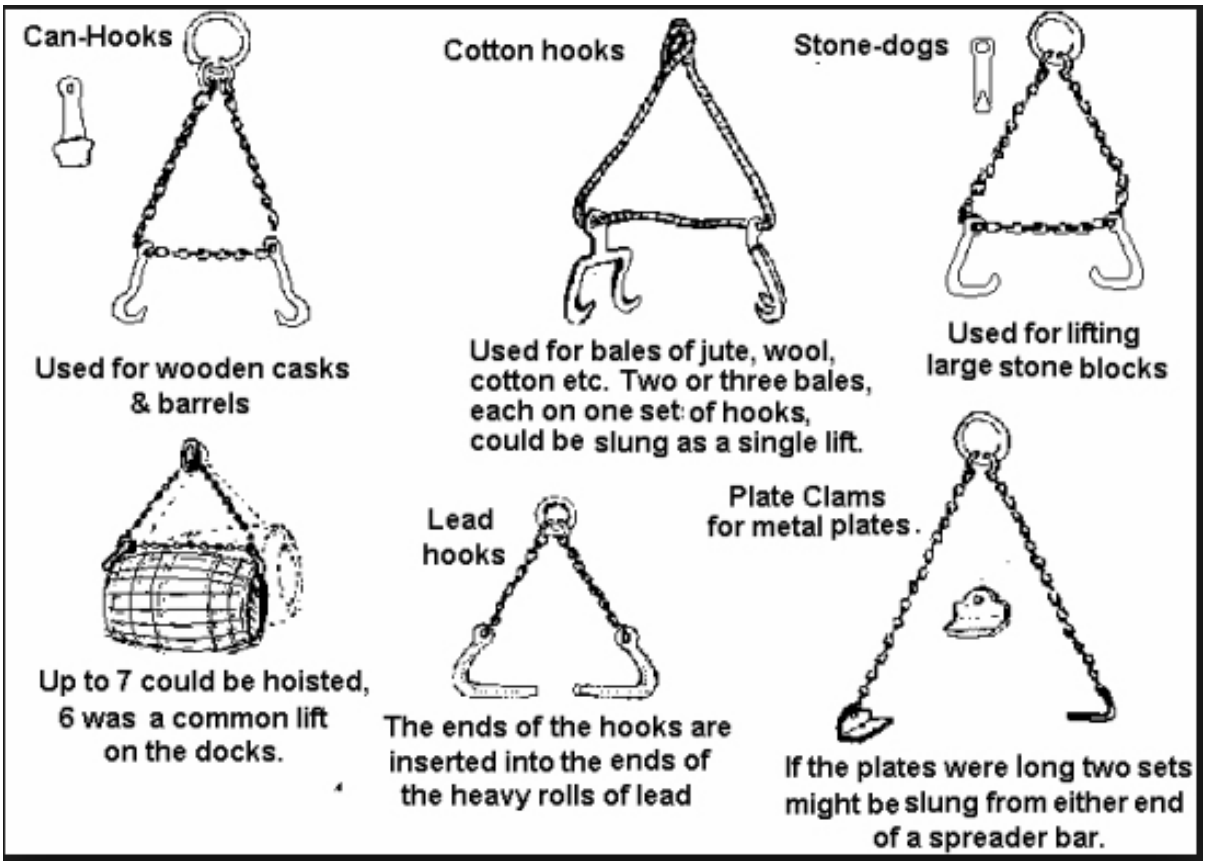


Fig: chain or rope lifting

- **Nipper or tongs or pincers:** This arrangement is just similar to the above except that the nippers or tongs or pincers are used for lifting instead of dogs or hooks. The nippers are formed of two curved arms which are pointed at their ends and which are rotating on a pivot
- **Lewis**: The various forms of lewises . The lewis can lift a stone of maximum weight of about one tonne. As it is easy to fix and to operate, the lewis is generally adopted as an appliance for lifting stones.
- **Pins:** In this arrangement apart of iron or steel pins is used to lift the stone. The pins are inserted lose in an

inclined manner and sloping towards each other. When the stone is being lifted, the pins tighten against the stone surface and it becomes impossible for them to come out. This arrangement is useful for the hard stones such as granite.

Points to be observed while supervising the stonework

Following points are to be carefully attended to while supervising the stonework:

1) The stones to be used should confirm with the requirement of the specification of the work.
2) The stones should be well-watered before use so that they do not absorb moisture from the mortar.
3) All the stones should be laid on their natural bed.
4) The dressing of stone surface should be properly carried out as per requirement of the specification of the work.
5) The stonework should be carried out in proper bond with sufficient number of through stones. The formation of continuous vertical joints should be avoided.
6) The stone masonry should comply with the requirements of the specification for the work. It should be seen that no tensile stress is developed in the masonry.
7) The mortar to be used for the work should be of quality and of proportion as specified.
8) As far as possible , the stonework should be raised uniformly. But when this is not possible or when a cross-wall is intended to be inserted after sometimes the steps or toothings or recesses should be provided .
9) In the stonework, the chips ,small pieces or broken stones should not be used.
10) The double scaffolding should be adopted to carry out as per line and level. The vertical faces should be checked by means of a plumb bob and the inclined surfaces, if any should be checked by means of wooden templates.
11) After construction , the stonework should be well-watered for a period of about two to three weeks, if lime mortar is used and for a period of about one to two weeks, if cement mortar is used.

Arches and Lintels : Terminology in contraction, types chajjas and canopies, pre cast Lintels & Arches