Building Construction

2011-2012

General introduction about building

1-1 Building construction steps

a. Specify the project target:

Each project has a specific target and use such as schools, offices, commercial buildings, residential buildings, roads, bridges, dams …etc.

At the beginning of any project must locate the building site and utilities such as water supply, electrical power and sewage drain lines…etc.

Any project must have a budget, which play an important role in design and construction.

b. Project requirements:

After specify the idea, target and uses of any project, project documents must be prepared which include different activities such as necessary information about costs, construction time, construction materials to prepare the preliminary design and specifications.

c. Engineering design:

It means all architectural, civil, electrical, mechanical…etc. drawings which include: site plan, buildings plans and details.

The drawings must be satisfy the specifications and codes and depend upon soil investigation report to (Limit type of soil and soil bearing capacity to choose the appropriate foundation type), forms of contract, the bill of quantities for each item and schedule which include all the work categories and the execution time.

d. Execution of project:

The construction and execution of any building demand a contract form such as direct execution…etc. and many steps must be achieved after the construction documents were complete.

The first step in the construction process is the application for the a building permit, then is all plans and details are submitted to the building department where they are reviewed for compliance with local zoning ordinances and building codes, when the review is complete, a permit for construction is issued.

Preparation of the building site for construction include, cleaning the site and extending utilities such as water, electrical power and sewage drain to the building.

1-2 Types of buildings:

Buildings may be classified according to:

a. Execution method:

I. Site execution:

Most of the construction items executed in site location.

These types of execution needs more workers and prepare all construction materials in site location.

The designer especially the architectural engineer has a wide range in selecting the building style and finishing materials. Disadvantage of this type are lost of raw materials and more execution time.

Site execution used in residential buildings and houses.

II. Precast or prefabricated buildings:

Precast panels are fabricated in special factories outside the site location, then transferred to the site and composed or installed together according to specified engineering details.

Precast panels include slabs, beams, columns, walls…etc. These panels may be concrete, steel or composite.

This type of execution characterized by high or good quality control, less number of workers and minimize the project execution period. The precast buildings are lighter than the traditional buildings.

b. Construction design:

Buildings are designed according to the types below:

I. Frame building:

It is consist of bearing frame which include beams, columns that transfer the loads of slabs, floors, walls to the foundations.

The frames are reinforced concrete, steel and composite frames (Concrete & steel).

Steel frame characterized by:

- High compressive & tensile strength, that means the required cross sectional area of steel sections is smaller than the required cross sectional area of other materials, so reduce applied loads on the foundation and offered more areas and spaces.

- Steel frames need fire protection & continuous maintenance against weathering conditions.
- All steel section used in building construction are imported and increase the construction costs.
- Local manufacturing materials may be used instead of imported materials to gain an economic construction.
- Steel frames installed in a short time compared with other materials.

Reinforced concrete frame characterized by:

- All raw materials excepting reinforcing steel bars are locally manufacturing.
- These frames may be cost in site or precast in special factories.
- Concrete frames give the construction designer more ideas about the style of construction.
- These frames characterized by high durability and fire strength.
- Disadvantages of these frames are heavy weight; need long time to construct it and quality control to the manufacturing and execution process.
- These frames are permanent construction.
- Frame building walls executed after complete the frame construction and can remove it without affect upon building.

II. Bearing wall buildings:

Applied loads are transferred to foundation by bearing walls which can't remove after construction.

This type of execution used in houses with low height.

The bearing walls are constructed before casting the slabs.

III. Frame & bearing walls buildings:

Steel & reinforced concrete columns & beams in one part of the building and the other part consist of bearing walls.

This type of construction used for economical, architectural and construction requirements.

1-3 Building construction development:

It needs the following requirements:

a. Good design
b. Suitable construction materials
c. Good execution
d. Materials quality control and used modern methods of execution

Reference:

1. انشاء المباني – آرتين ليفون – زهير ساكو
2. Aspect of civil engineering contract procedure, by Marks, R.J., etal.

Earthworks

Each construction project has a specific earthwork which classified to two types:

1. Excavations
2. Earth filling

The objective of earthworks is to reach the required level as shown in the drawings. This level is required to start latter item such as foundations, floors, sewer…etc.

1. Excavations:

Excavation works include foundations, basements, trenches…etc.

Excavation down by hand or mechanically or both together depend on many factors such as soil conditions, shape of cut section, ground water and time required to complete the job.

1.1 Hand excavation:

It's done by using simple tools. This type of excavation can be used for small job such as continuous wall foundation, isolated foundation, short trenches, and shallow combined foundation and also to complete the excavation done mechanically to reach the proper level.

Hand excavations don't used with rock soil. The soil carted away to a tip. If the soil is inert it could be spread over low levels on the site, while the big quantities carry out of the site. During excavation, a path of 70-100cm wide between sides of pits and removal soil must be left to allow the concrete works to be easy done.

Sides of trenches and pits are important to be stable to keep the workers and concrete safe and these depend on:

a. Type of soil
b. Water ground and its movement
c. Deep of excavation
d. Loads

In loose, wet or sandy soils, the sides of trenches sometimes may be supported by open timbering, close-boarded timbering or sheeting as shown in Fig. 2-1.

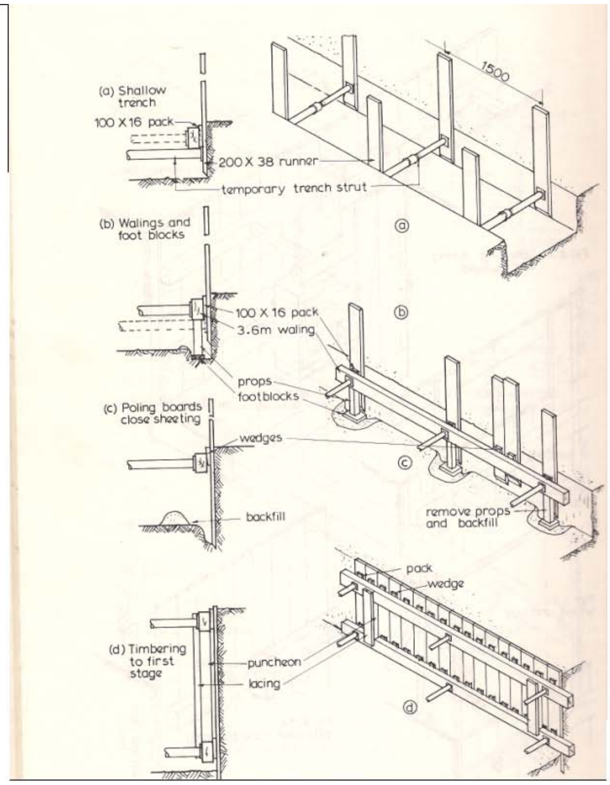


Fig. 2-1 Timbering to trench

For the high cost of timber in Iraq and it's difficult to be reused for several times and it's hard maintained, prefer to replace timber by vertical sheeting. The supports used for narrow trench and excavation only, while for wide excavation, open cut method shall be used because it's more economic, although it needs more quantity of refill.

1.2 Mechanical excavation:

This type of excavation used for big quantity and when all soil carries away from the site and when the time plays important role to complete the job.

A popular machine is the industrial tractor with shovel, backacter or blade attachment. This can deal with most earthmoving operations on site and bucket sizes can be changed at will. Care must be taken not to over- excavate as the earth will have to be replaced with weak concrete.

Removal of ground water:

The control of ground water during excavation is essential in some sites. An indication of the way this should be done can often be gained from the site investigation report on trial pits. The popular methods are:

a. Direct remove:

It's the cheaper one and done by making trenches at lowest level of excavated pits and their sides and leave the water to accumulate by slopes away from the pits.

b. Pumping remove:

The method of pumping and discharge must be considered carefully, because continuous pumping from an excavation could cause settlement to adjoining buildings. Also, some authorities will not permit muddy water to be discharged direct into their road gullies. However on open sites the problem is not serious.

Ground water normally lowered by pumping from open sumps within the excavation, the sumps being sheet-piled or close-timbered. They should be deep enough to drain the excavation. It is important that they be cleaned and dredged regularly so that they do not clog. Some form of filter may have to be provided to prevent excessive mud and grit from being sucked up. This normally takes the form of a strainer at the end of suction pipe.

c. Well points system remove:

For heavy work this system is used. It consists of group of metal pipe with 40mm diameter and about 4.5m length around the site with filter and valve at the end. These pipes pilled vertically at the required depth. All pipes joining together with horizontal pipe ended with lift and force diaphragm pump which suck the water to the system and pump it away. This system has the following facilities:

1. Ability to use more than one cycle of pipe discharge around the excavated area to control the water removes.
2. Ability to locate the space between the pipes and their depth.
3. Ability to lower the water within the excavation.
4. This system is very expensive compare with other methods.
5. This system prefers to be used in sandy soil and never used in rock soil.

2. Earth filling:

All buildings need refilling to refill for example sides of foundations, trenches and floor to reach proper level. This involves demolition, if any, the removal of rubbish and waste to 15cm depth of topsoil to reach the good and clean soil. All filling shall be deposited in layers, not exceeding 20 cm. loose depths. In the general, the contractor shall mix fertilizer into the top layer and then sow the grass seed and lightly compact. For landscaping and planting only grass plants, bushes and trees which are known to thrive in the soil and climatic conditions of the site are to be used. The planting is to be carried out in well prepared ground, watering, rolling, racking, fertilizing, protection, etc.. is to be carried out where necessary to ensure that the landscaping scheme is successful. For roads yards and parking areas, all filling up to underside of the Sub- base shall be of a material suitable for rolling compaction and have as low capillary pressure as possible. Filling shall be in layers not exceeding 20cm. If the work is of lesser extent lighter rollers may be permitted if the thickness of the layers is brought down. All timbering and rubbish shall be removed from the excavation prior to back filling and no soft clay or mud will be permitted as filling. Backfilling shall not commence without the approval of the Engineer. Backfilling shall generally consist of excavated material excluding upper layers of top soil. Back-fill shall be placed and compacted in 0.20m. Horizontal layers to achieve a proper field dry density. Mechanical tamping may be necessary to achieve the required density but no extra will be paid to the contractor on this account. Material for refilling around buildings and other zones may consist of excavated material but no rubbish material to be permitted. Refilling for ground floor slabs shall be compacted. Material which is either classified as unsuitable or not required shall be used as directly by the engineer or where shown on drawings.

Reference:

1. انشاء المباني – آرتين ليفون – زهير ساكو
2. Construction Technology , Level Two Part 1, by R.L.Fullerton

Foundations

The foundations of buildings bear on and transmit loads to the ground. Foundation can be built in various types of material. Generally bricks, stones, concrete, steel…etc, and are used in different forms for construction the foundation of building. The foundation is that part of walls, piers and columns in direct contact to with and transmitting loads to the ground. In practice, the concrete base of walls, piers and columns is described as the foundation.

Depth of foundation:

Depth of foundation influenced by the following factors:

1. Types of soils and its layer which can carry loads of building.
2. Climate situation and how to avoid the affect of freeze and extension and contraction, so the foundation must be not less than 30cm depth to avoid these affects.
3. Groundwater level and how to construct foundation above water table level
4. Foundation location on the building and if there is basement, shelter, car park …etc. in the building.
5. Existing building foundation close to new foundation..
6. Underground services and their relationship with the depth of foundation.
7. Provision of existing trees.

Site investigation and exploration:

To select a foundation from tables or to design a foundation it is necessary to calculate the loads on the foundation and determine the nature of the subsoil, its bearing capacity, it's likely behavior under seasonal and ground water level changes and possibility of ground movement. Where the nature of subsoil is known from geological surveys, adjacent building work or trial pits or boring and the loads on foundations are small, as for single domestic buildings, it is generally sufficient to excavate for foundations and confirm, from the exposed subsoil in the trenches, that the soil is as anticipated.

The choice of foundation will depend on type condition and bearing capability of the soil. These are normally taken to be:

Compact gravel, solid chalk	>600kN/m^2
Compact sand	>300kN/m^2
Clays, stiff	150-300kN/m^2
Clays, firm	75-150kN/m^2
Loose gravel	<200kN/m^2
Loose sand	<100kN/m^2

Soft silt, clays	75kN/m^2
Very soft silt and clay	<75kN/m^2

Soil can be classified according to its bearing capacity to two types:

1. Soil not able to compact: Like rock soil with high bearing capability which can be constructing over it without foundation if it empty of cracks, pockets and high porosity when they present cause slip and settlements.
2. Soil able to compact: Include all other types except rock soil and need foundation to distribute loads according to their bearing capability.

Types of foundation:

1. **Wall footing:**

It uses to carry applied loads that transfer through bearing wall. A footing may have a base course of concrete or may be entirely built up of one material (bricks or stones). Bearing wall transfer applied loads to footing at angle equal to 45° which causes shear stresses, so the width of footing with thickness (Y) equal (X+2Y) where X is the wall thickness (Fig. 3-1 A), where the minimum value of Y is 15cm for ordinary concrete footing and 20cm for reinforced concrete footing.

Sometimes the width of footing is more than (X+2Y) to carry the loads within the bearing capability of soil, so to prevent shear stress effect, considerably one of the followings:

a. The bricks are project in steps: It should be noted that the number (width) of projections equals the number of half bricks in width. Further the thickness of the steps equal to twice the thickness of brick course (Fig. 3-1 B).
b. Increase the thickness of concrete base (Footing) from Y to Y1 or the base concrete has to be finished in steps (Fig. 3-1 C, D).
c. Add reinforced steel bar to the footing and keep all dimensions of the footing constant
   Steel reinforcement must be added in one bottom layer in two directions (Fig. 3-1 E), or two layers for top and bottom layer (Fig. 3-1 F) in case where suggest to differential settlement or bending moment at the openings of large doors and windows or the refill place and ground water level changes and possibility of ground movement.

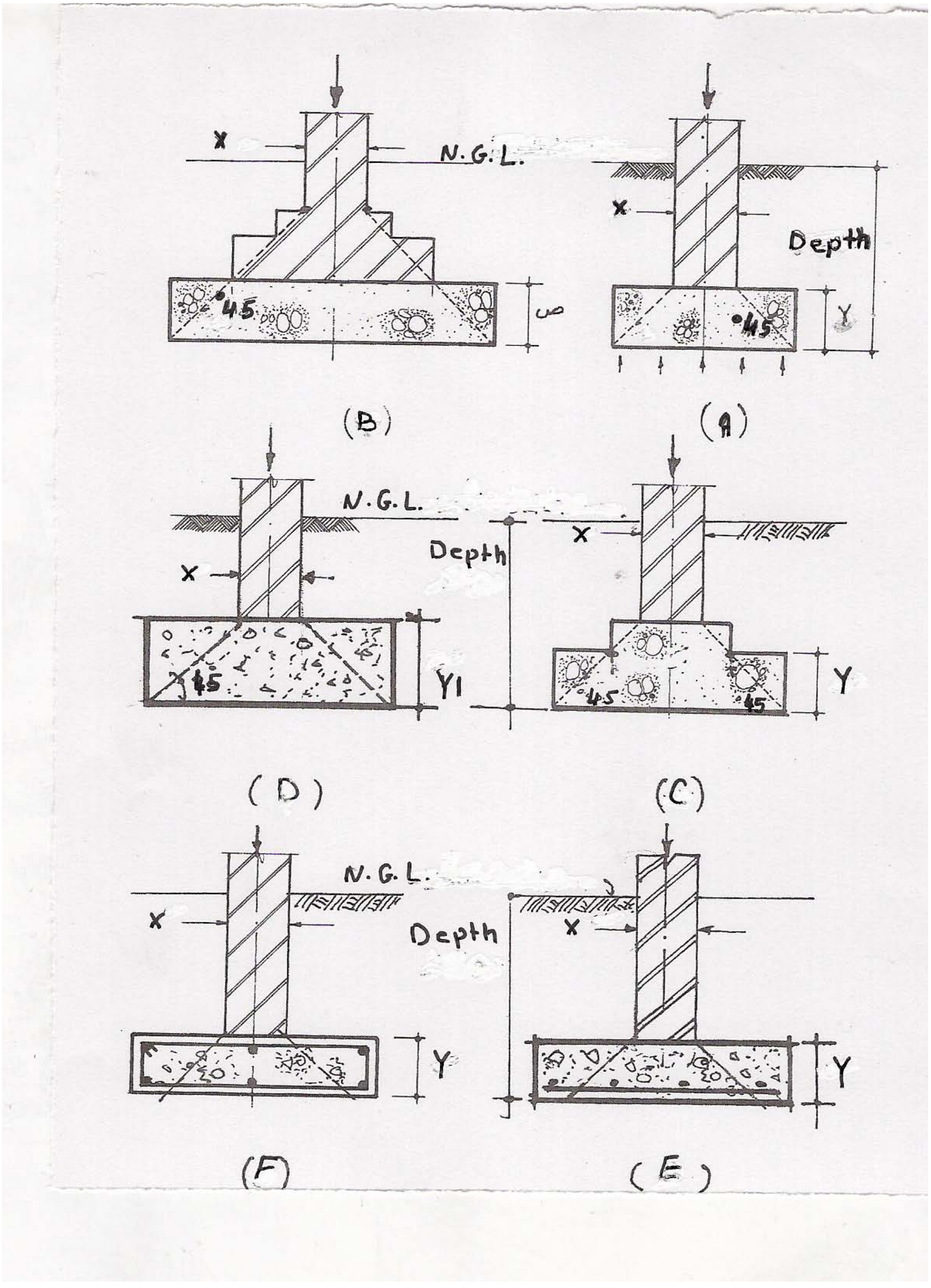


Fig. 3-1 Wall Footing

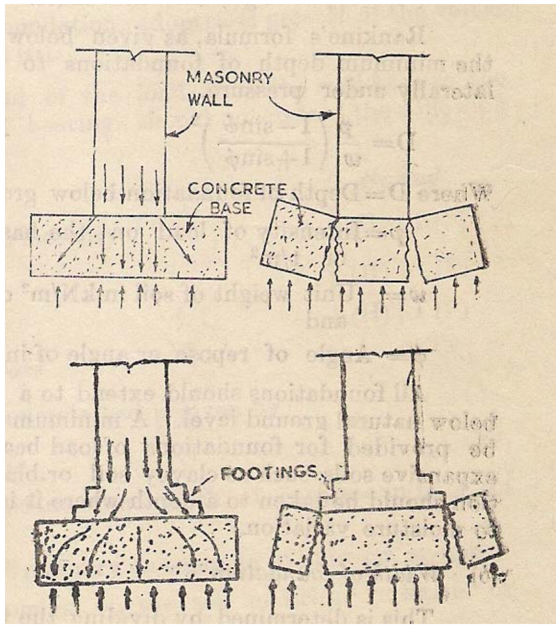


Fig. 3-2 Failures for footings without steps and with steps

Wall footing designed to bear central axial loads from wall bearing without bending. When there is bending moment especially for footing at boarder of site close to existing building as shown in Fig. 3-3, it need to treat this situation by neutralize the bending moment by one of the followings:

a. Neutralize the bending moment by the loads of foundation and layers of refill and floors above it.
b. Use of tie-beam from concrete or steel to carry the effect of bending moment to nearest walls.

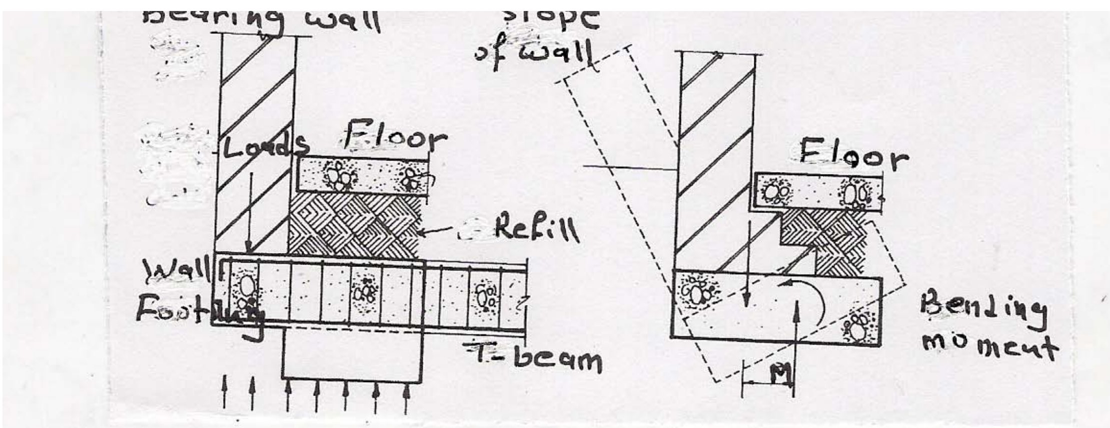


Fig. 3-3 Wall footing with bending moment

The foundation of walls on sloping site may at step to economize in excavation and foundation walling. The step in the foundation should be uniform and equal to the thickness of the foundation concrete and a multiple of brick courses. The steps should extend over and unite with the lower foundation not less than the thickness of concrete foundation and in no case less than 300 as illustrated in Fig. 3-4

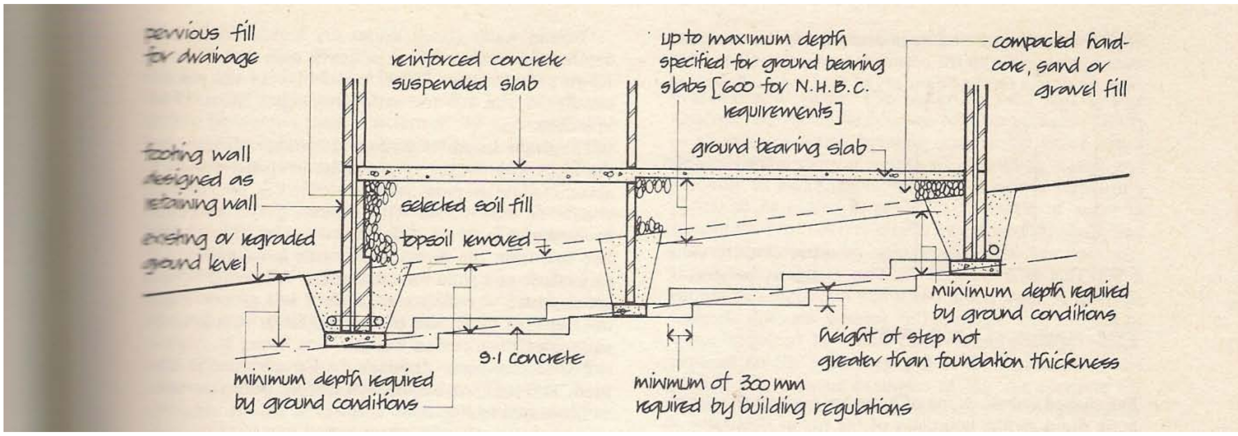


Fig. 3-4 Step Foundation

2- Strip Footing:

It consist of a continuous, longitudinal strip of concrete designed to spread the load from uniformly loaded walls of brick, masonry or concrete to sufficient area of subsoil. The spread of the strip depends on foundation loads and the bearing capacity and shear strength of the subsoil. The thickness of the foundation depends on the strength of the foundation material. Strip foundation with a wide spread are commonly of ordinary or reinforced concrete.

The strip footing is so constructed to the following:

a. Save time compare with other foundations.
b. To play as damper for ground water movement and water proof for vertical movement of damp.
c. Work as deep girder to prevent differential settlement and bending moment at the openings of large doors and windows.

Reference:

1. انشاء المباني – آرتين ليفون – زهير ساكو
2. The construction of building , Part 1&4, by BARRY
3. Building construction, by S.K. Sharma

Foundations (Cont.)

3- Isolated Foundation:

The foundation which receives concentrated loads from one column or pier and transmits the load to the ground. The footing shape is square or rectangular depend on the column shape to resist the applied bending moment.

The isolated foundation is made from ordinary or reinforcement concrete, timber section for temporary structure and from steel section and called grillage foundation as shown in Fig. 3-5.

The area of this type of foundation depends on the loads on the foundation and the bearing and shear strength of the subsoil and its thickness on the strength of the foundation material. Tie beams in one or both directions may be added to the isolated foundation to avoid differential settlement as shown in Fig. 3-6.

Pedestal can be used with isolated foundation with large area to distribute the loads on isolated foundation and to decrease its thickness as shown in Fig. 3-7.

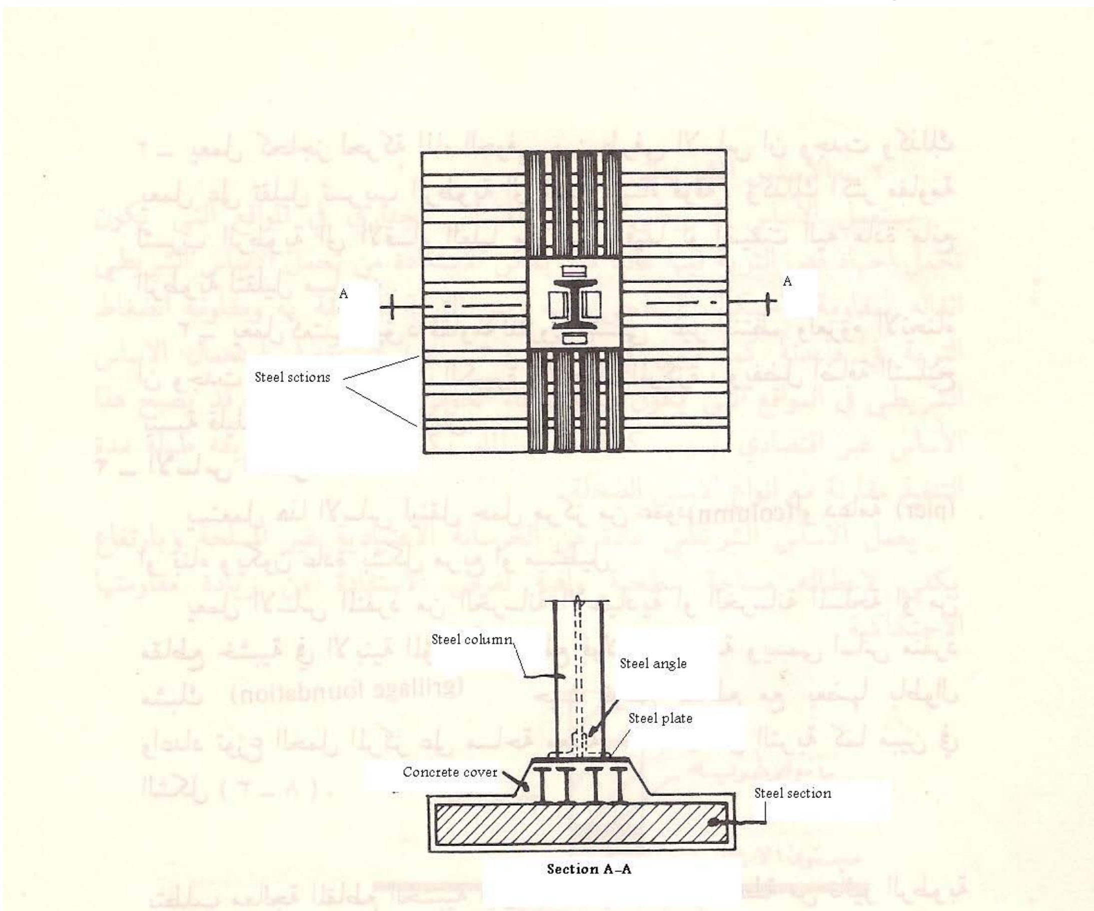


Fig. 3-5 Grillage foundation

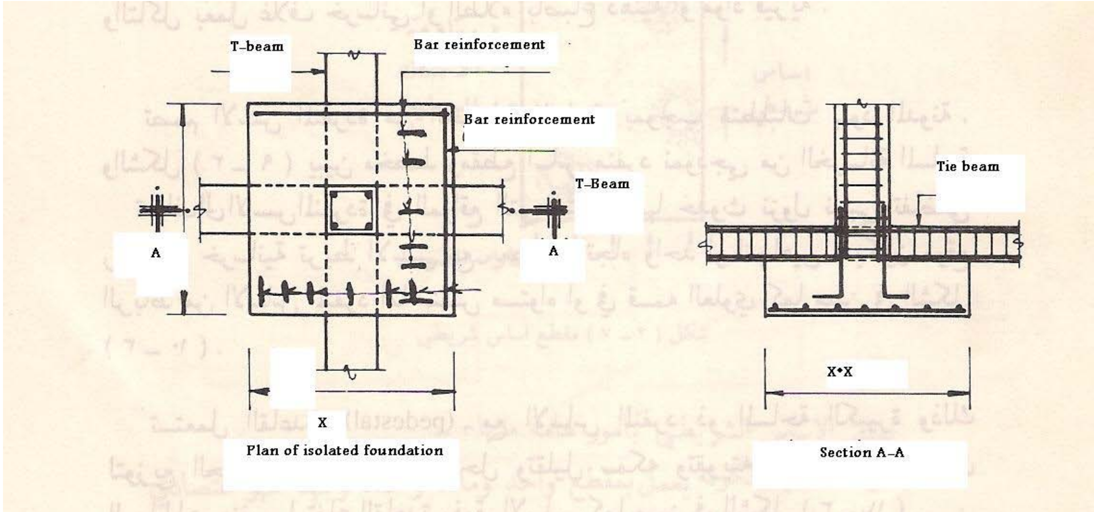
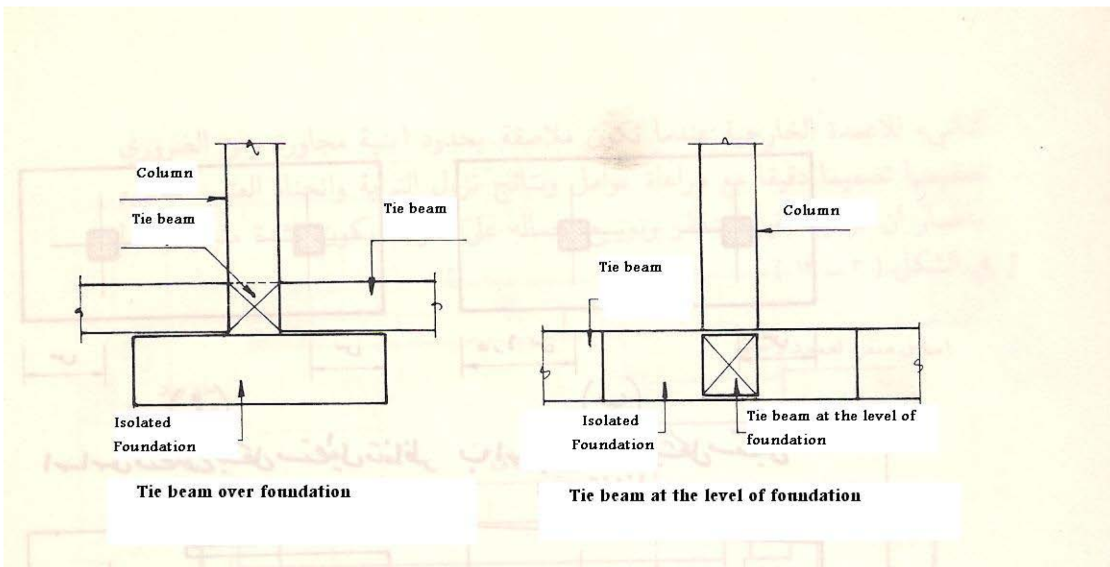


Fig. 3-6 Isolated foundation with tie beams



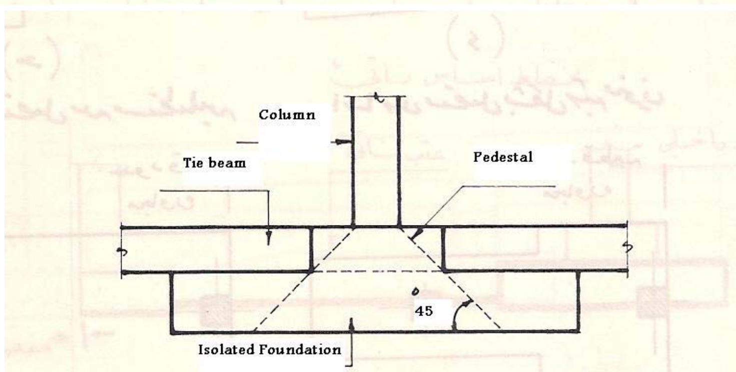
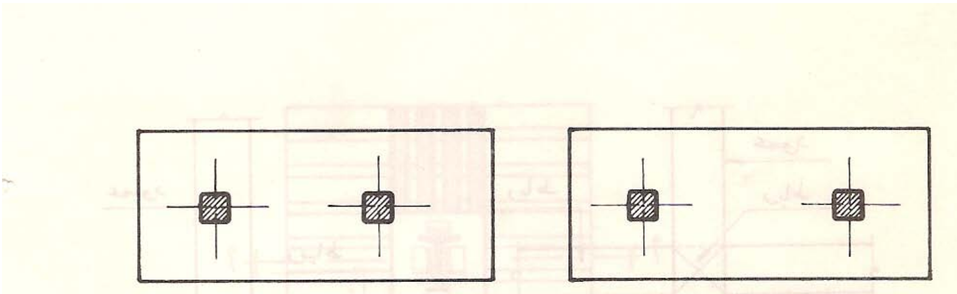


Fig. 3-3 Isolated foundation with tie beams and pedestal

4- Combined Foundation:

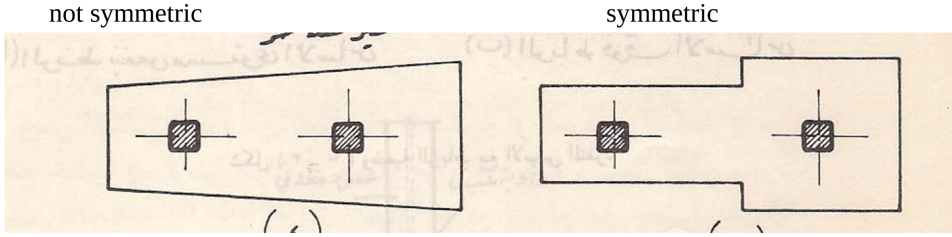
Where there is a wide spread of pad foundation to a framed building due to the low bearing capacity of the subsoil or the close spacing of columns, such that the edge of adjacent separate foundations would be close together, it may be economical and convenient to form one continuous foundation as shown in Fig. 3-8. Combined foundation receives concentrated loads from two columns.

The footing shape is rectangular if columns loads are equal and take trapezoidal shape if the loads are unequal or one of the columns close to the site boundary.



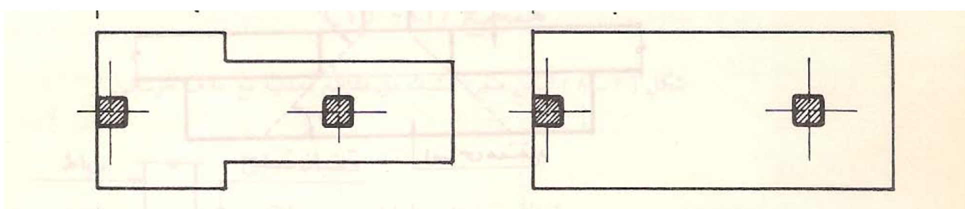
a- Combined foundation with rectangular shape not symmetric

b- Combined foundation with rectangular shape symmetric



c- Combined foundation with trapezoidal shape

d- Combined foundation with two rectangular shape



e- Combined foundation with two rectangular shape with one columns close to the site boundary

f- Combined foundation with rectangular shape not symmetric with one columns close to the site boundary

Fig. 3-8 Some types of combined foundations

5- Cantilever Foundation:

Where a framed building is to be erected alongside an existing building it is often necessary to use a cantilever foundation for the columns next to the existing building, so that pressure on the subsoil due to the base may not so heavily surcharge the subsoil under the foundation of the existing building as to cause it to appreciably. Fig. 3-9 and Fig. 3-10 show cantilever foundation.

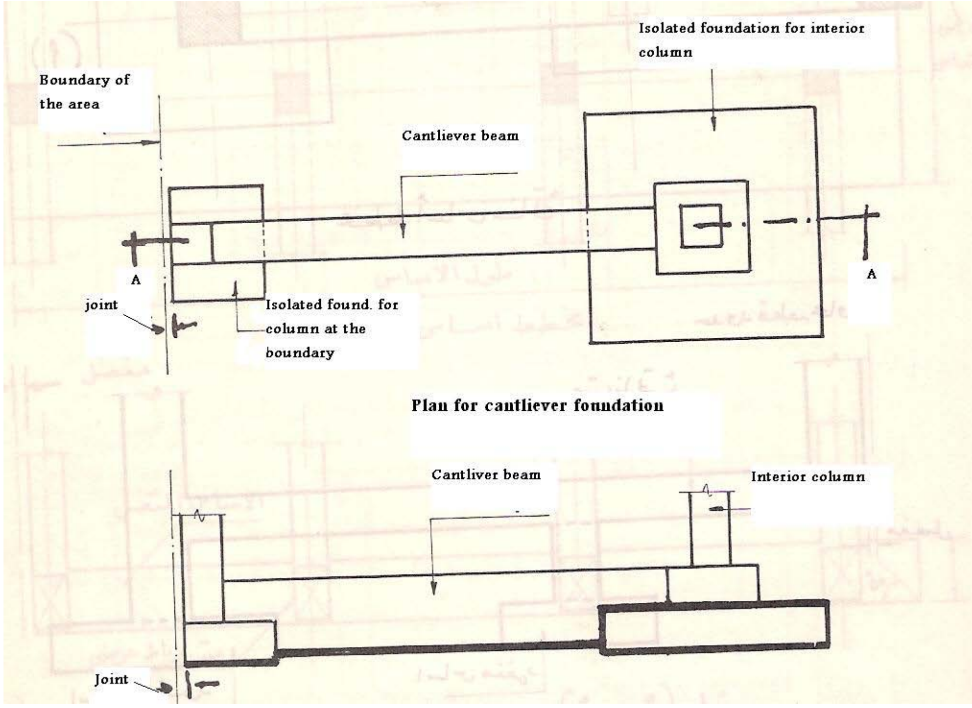


Fig. 3-9 Cantilever foundation

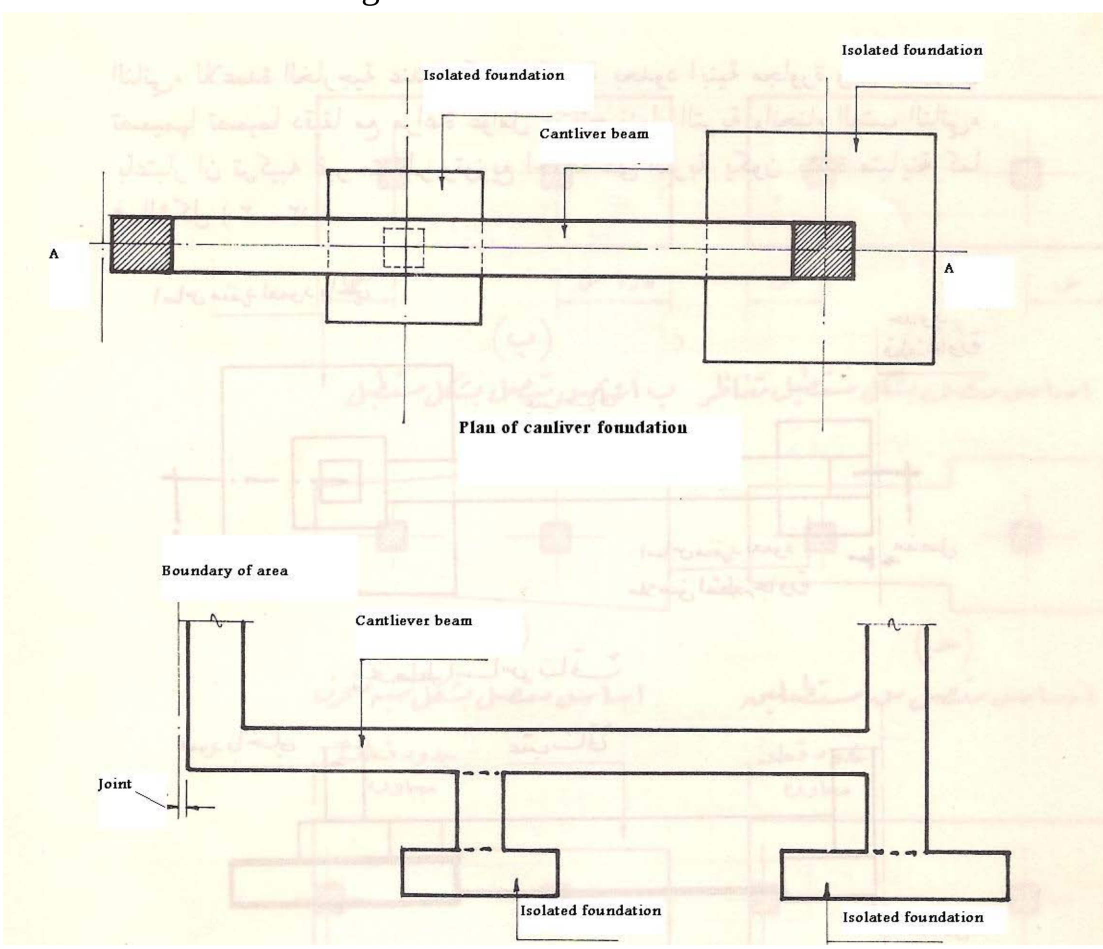


Fig. 3-10 Cantilever foundation

6- Continuous Foundation:

It receives concentrated loads from more than two columns at the same axis. The footing shape is rectangular with constant width and length equal the sum of all length between centers of columns plus convenient length at either edges or one of them where the other is close to the site boundary. Soil pressure is the main factor for design continuous foundation, in spite the pressure under columns is more than the pressure away from columns and this affect on compact soil, so it is necessary to use tie beam as shown in Fig. 3-11.

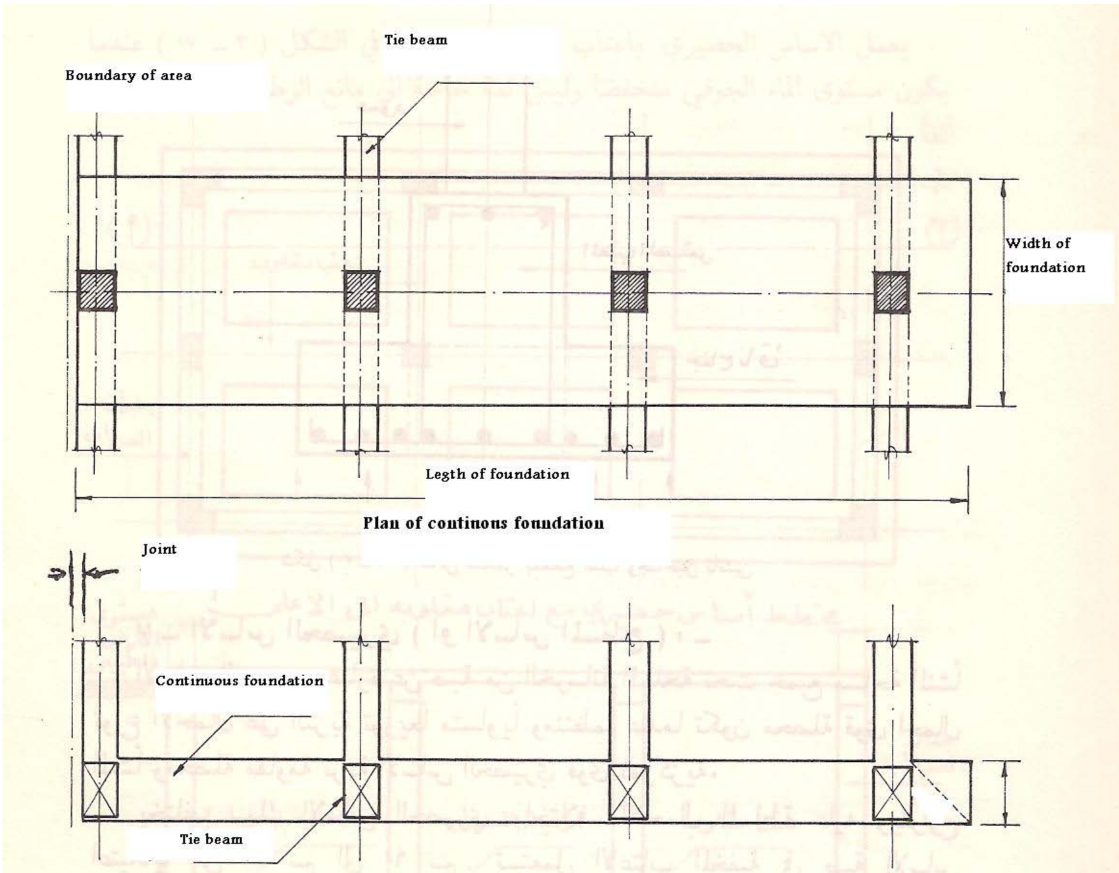


Fig. 3-11 Continuous foundation

Some times continuous foundation can be use with medium girder and two cantilever wings as shown in Fig. 3-12, but it is necessary to cast both parts in the same time.

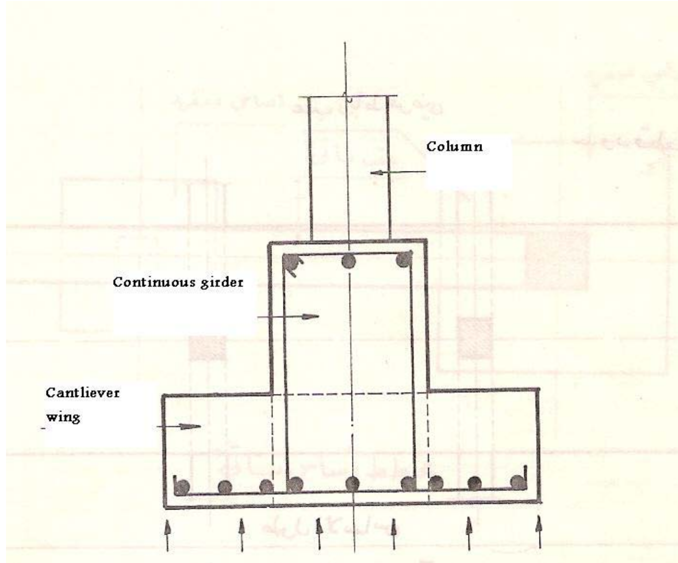


Fig. 3-12 Continuous foundation with medium girder and two cantilever wings

Reference:

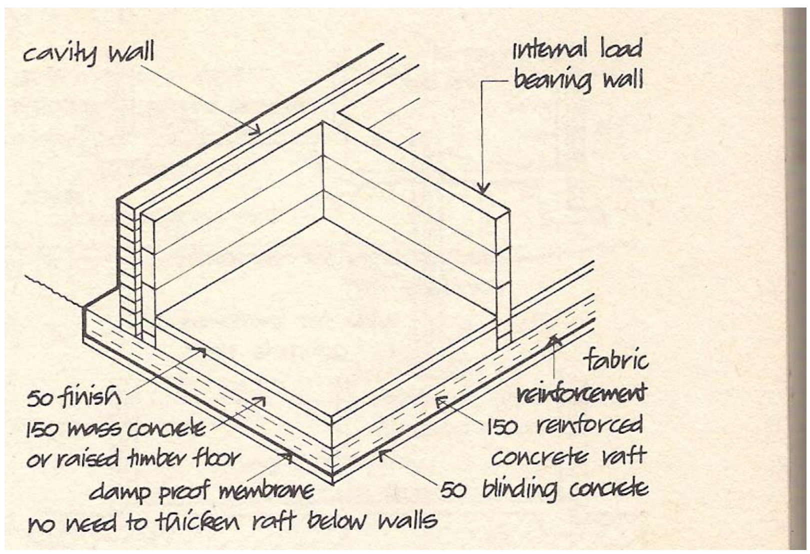
1. انشاء المباني – آرتين ليفون – زهير ساكو
2. The construction of building , Part 1&4, by BARRY
3. Construction Technology, by R.L.Fullerton

Foundations (Cont.)

7- Raft Foundation:

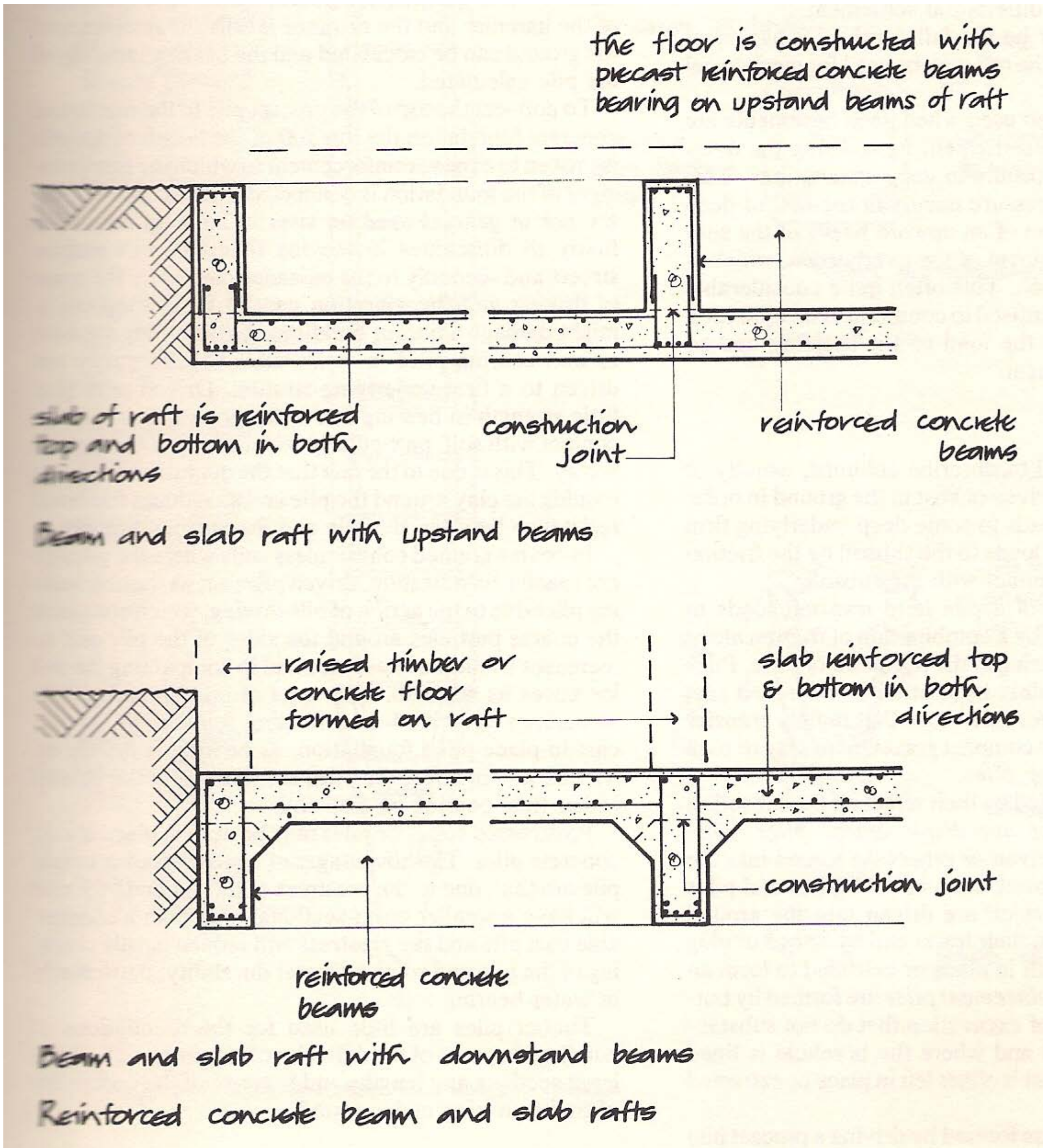
Raft foundations consist of a raft reinforced concrete under the whole of the building designed to transmit the load of building to the subsoil below the raft. Raft foundations are used for buildings on compressible ground such as very soft clays, alluvial deposits and compressible fill material where strip foundations would not provide a stable foundation.

The two types of raft commonly used are the flat raft and the slab with beam raft foundation as illustrated in Figs 3-13 and 3-14. The flat slab raft is cast on a bed of blinding concrete and a moisture-proof membrane to prevent damp rising through the slab. As will be seen from Fig. 3-13 the slab is reinforced top and bottom and is of uniform in thickness. Where the ground has a reasonable bearing capacity the raft may not need to be reinforced. For small buildings, such as two storey houses, there is no need to thicken the raft either under the external or internal load bearing walls.



Figs 3-13 Flat raft foundation

Where the ground has poor compressibility the slab with beam raft foundation which is to support the heavier loads of walls or columns a solid slab raft would require considerable thickness. To make the economical use of reinforced concrete in a raft foundation supporting heavier loads it is practice to form a beam and slab raft. This raft consists of up stand or down stand beams that take the loads of walls or columns and spread them to the monolithically cast slab which bears on natural subsoil.



Figs 3-14 Slab with beam raft foundation

8- Buoyancy foundation:

It’s the foundation for heavy building with limited area and with poor soil for upper layers that need to deep excavation to reach required bearing capacity of subsoil.

9- Pier foundation:

Pier foundation consists of one, two or more piers with different shape of cross sectional area like square, circular, rectangular…etc.

Pier foundation with large section made with opening across the water to decrease the weight and cost.

Pier foundation can be use when it is impossible to use raft or pile foundation and when the area of the base of the pier is enough to distribute the loads on the subsoil.

1. انشاء المباني – آرتين ليفون – زهير ساكو
2. The construction of building , Part 1&4, by BARRY

Foundations (Cont.)

10- Piles:

This is an element of construction placed in the ground either vertically or slightly inclined to:

1. Increase the load carrying capacity of the soil.
2. Support the layer of subsoil subject to side force
3. Compact the subsoil

The reasons for use piles as foundations are:

1. When the soil is poor and cannot carry the load with other types of foundation
2. When the soil is clay and has seasonal shrinkage and swell according to the moisture content and ground water movement
3. When the structure construct above water like water intake
4. When we cannot excavate deep because of the existing building foundation close to new building
5. When we need to equilibrium to tensile or lateral forces then the piles called (anchor piles) when it is vertical and (batter piles) when it is with slope
6. For earthquake region
7. When ground water not deep from natural ground level
8. When it need to support existing building foundation by used jacked piles
9. When it need to support side pressure like soil or water by used sheet piles

Classification of piles:

Piles can be classified according to:

1. The method it transmit load to subsoil, then it classified to:
   a. Friction pile: These are designed to transmit the loads by the frictional force existing between the sides of the pile and the ground.
   b. Bearing pile: These are transmitting the super-imposed load to stronger strata below.
   c. Combine work pile: These are transmitting the loads by the frictional force and carry stronger strata below. Most of the piles designed like this type.
2. Material used:
   a. Wooden piles: Usually timber trees are used as piles after bark and the branches are removed.

Chemical preservation or mechanical protection is commonly provided as a treatment of wooden piles.

Advantages of wooden piles:

i. They are less expensive as most of the timber available can be used after suitable treatment.
ii. They can be made in longer lengths by joining the individual pieces easily.
iii. Cutting of these piles is very easy.
iv. They can be driven quickly and with lighter machinery.

Disadvantages:

i. They deteriorate by the action of water or insects.
ii. They have a lesser load bearing capacity.
iii. Whenever long piles are to be driven, it if necessary to join a number of small individual units and this entails lot of joining work and the cost is high.

b. Concrete piles: Concrete piles can be broadly classified into two types:
   i. Precast concrete piles: These are cast at a suitable place, cured and afterwards driven like a timber piles.
   ii. Cast-in-situ piles: These are cast at the place where they have to rest finally. They may have a casting which also remains intact.

Precast concrete piles: Precast concrete piles are commonly of square section with chamfered corners. Other shapes, e.g. octagonal types are also available. Octagonal type has a better appearance and steel reinforcement can also be placed in it easily. Whenever these piles are to be driven through hard soils, cast iron or mild steel shoes are used at the end which is driven into the soil. Generally for normal work 1:2:4 mix is used whereas for heavy loads and for driven through harder soils 1:1½:3 mix is employed.

Precast concrete piles are constructed without taper but have pointed lower ends. Whenever tapering is desired, it should not exceed 2cm per meter length of the pile. The reinforcement consists of longitudinal bars with spiral at the top and bottom ends and suitable ties in between.

Cast-in-situ piles: A Cast-in-situ pile is a concrete pile built in its permanent location within a hole made for this purpose. The various types of cast-in-situ piles are:

i. Simplex pile: A hollow cylinder steel pipe is driven into the ground to the required depth. A cast iron or steel base is placed under the pipe to displace the soil. The reinforcement is placed into the pipe, if needed. Concrete is poured to the depth about one meter into this pipe. After pouring concrete, the enclosing pipe is withdrawn to some extent. Concrete is again poured into the pipe and the pipe is withdrawn. As the casting is pulled out, the hole gets filled with concrete which act as a pile.

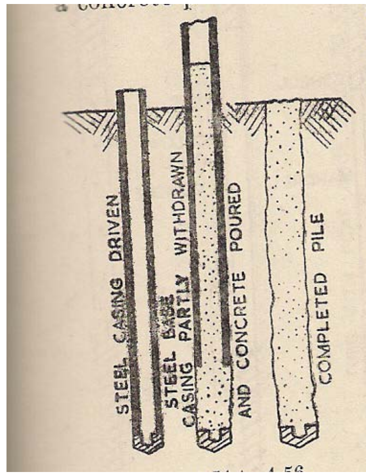


Fig.3-15 Casting of simplex pile

ii. Pedestal pile: The first step in the construction of this type of pile is to drive a casing and a core into the ground. The core is removed and concrete is placed to some depth inside the casing. The core is again placed and casing is pulled up by about meter while the pressure is being exerted on the concrete with the core. The concrete is rammed so as to form pedestal. The core is removed and concrete poured into casing. Finally, as the concrete get filled, the casing is withdrawn.

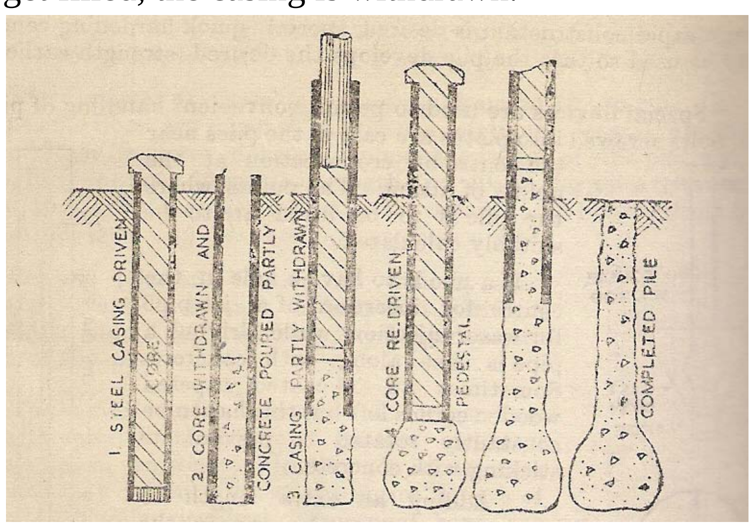


Fig.3-16 Pedestal piles

iii. Raymond pile: A thin sheet steel tapered shell is driven into the soil with a steel mandrill inside. The mandrill is removed and suitable reinforcement placed, if necessary. The shell is filled with concrete.

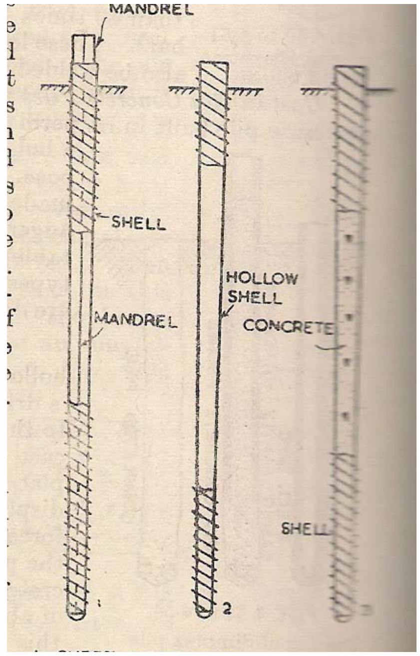


Fig.3-17 Raymond pile

iv. Mac Arthur case pile: This is formed by driving into the ground a heavy steel casing in which a core is inserted. The core is removed and a corrugated steel sheet is introduced. The shell is filled with concrete and casing is withdrawn.

v. Vibro piles: Vibro piles are formed by driving a steel tube fitted with a C.I. shoe into the ground. The tube is filled with concrete and is extracted by a succession of upward pulling and downward tamping blows. The pile thus gets enlarged every time and fits in the surrounding soil securely.

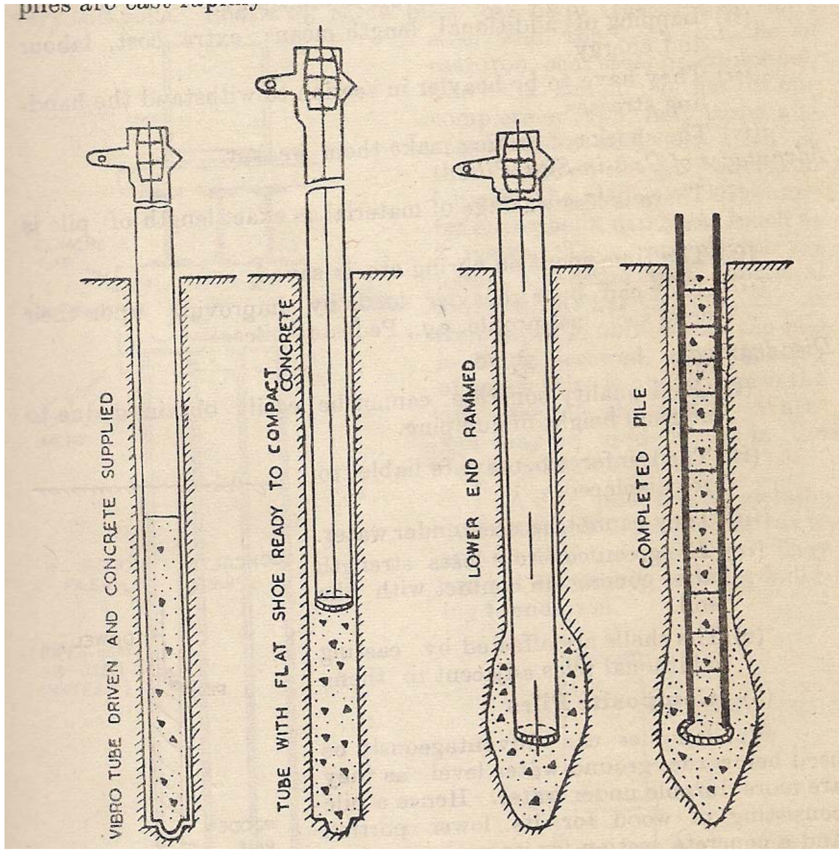


Fig.3-18 Vibro pile

Advantages of precast concrete piles:

i. Best concrete can be prepared by proper workmanship. Any defect can immediately repair.
ii. The reinforcement remains in proper position and does not get displaced.
iii. The concrete has only to withstand loads after complete curing has taken place.
iv. They can be cast before hand and a quick driving progress can be ensured.
v. They are more convenient through wet conditions.
vi. They are more suitable when a part of their length is to remain exposed.
vii. They are not affected by any other additional forces which act on them while adjacent piles are driven.

Disadvantages of precast concrete piles:

i. They are heavy and difficult to transport.
ii. Lapping of additional length means extra cost, labor and energy.
iii. They have to be heavier in section to withstand the hand ling stresses.
iv. The shocks of driving make them weaker.

Advantages of cast- in- situ piles:

i. There is less wastage of material as exact length of pile is cast.

ii. The time spent on curing etc. is saved.

iii. They can bear heavier loads by improving upon their cross sectional profile, e.g. Pedestal piles

Disadvantages of cast- in- situ piles:

i. Good quality concrete cannot be easily obtained due to unusual height of dumping.

ii. The reinforcement is liable to get displaced.

iii. They cannot use under water.

iv. The green concrete loses strength after coming in contact with the soil.

v. The shells are affected by casting additional piles adjacent to them.

c. Steel Piles: Steel pile may be of I-section or hollow pipe. Because of a small sectional area, steel piles are easy to drive. The pipes are driven with open ends. Compressed air may be used to drive out the soil within the pipe and thus facilitate driving. These pipes are filled with concrete. Steel piles are mostly used as bearing piles because of their less available surface area to take the loads by frictional forces.

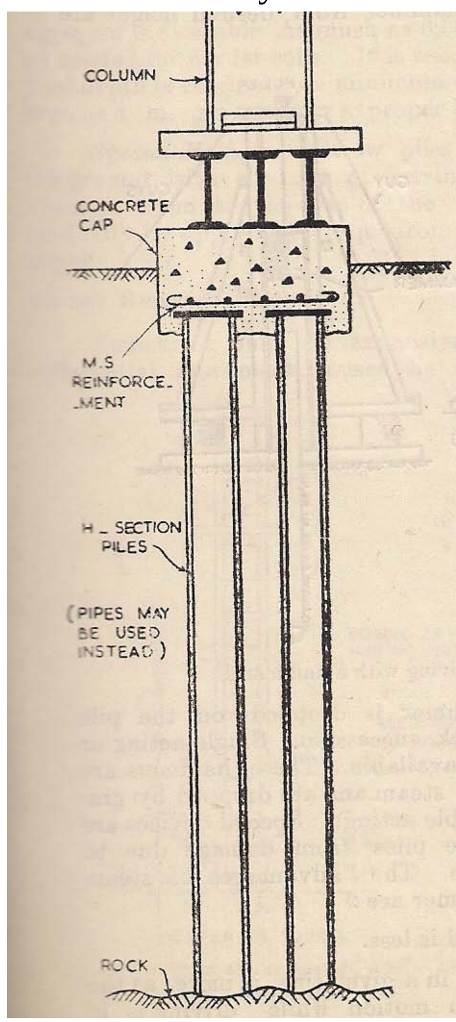


Fig.3-19 Steel H-pile

Another form of steel pile is the screw pile which is used in very soft soils. Shafts of screw piles can be of cast iron or mild steel.

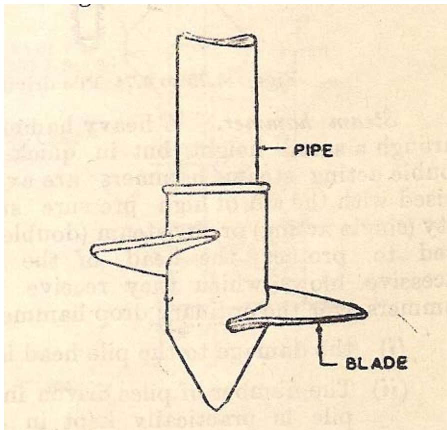


Fig.3-20 Screw pile

Reference:

Building construction , S.K. SHARMA

Concrete works

The concrete contains blocks of natural stone is made by mixing cement, sand, gravel and water. That the active substance in the mixture is the cement which binds physically and chemically with water and solidifies.

Components of concrete:

1. Cement: Portland cement is manufactured from limestone and clay which are ground together with water to form slurry. This is then dried and burnt at high temperature after which it is ground to a fine powder. Main types of cement are:

   i. Ordinary Portland cement
   ii. Rapid hardening cement
   iii. Sulphate-resisting cement
   iv. Extra rapid-hardening cement
   v. Ultra low-heat cement
   vi. Water repellent cement
   vii. Hydrophobic cement
   viii. High alumina cement
   ix. Pozzolana cement

2. Aggregates: The type and quality of aggregates, which make up the bulk of concrete, vary according to the purpose. The size, shape, grain, density and grading of aggregate all affect the workability of the concrete. They also affect its strength. Aggregate used in concrete classified to fine and coarse aggregate.
3. Water: Mixing water should be clean and free from acids, vegetable or deleterious matter. Normally it should be fit for drinking.
4. Admixtures: They are used in concrete to get especial properties.

Storing concrete materials:

The storage arrangements for cement and aggregate depend on the scope of the work but the followings precautions are essential.

Cement: where possible cement should be stored in a weatherproof shed and kept quite dry. The shed should preferably without windows and with the door on the leeward side to prevent draughts and rain penetration. The floor should be made of either strong boards and joists raised clear of the ground, or of blanks laid on a dry concrete slab above ground level. All cement should be stored for the shortest possible time.

Aggregate: These should always be kept in a clean condition and should not become contaminated with undesirable substances. Aggregate on medium- to large scale building sites are usually stored in bins. The floor of the bins are made of weak concrete and drained or laid to falls. The barriers or walls are built of stout planks, sleepers or concrete blocks. Aggregates are stored in adjoining bins but with dividing walls that high enough to cope with the highest stockpile without overspilling.

Layout of storage: Aggregate bins, mixers, cement sheds and water supply should be arranged to permit good access to materials, and the easy transport of concrete from the mixer to the delivery point.

Batching of concrete:

This operation is concerned with the measurement of dry materials for making concrete which may be mixed either by hand or machine. Manual mixing is fairly common with small builders. To get the correct proportion of materials a gauge box is used. This is still made in the traditional one cubic foot size for convenient handling, but the size can also be worked out to suit a 50 kg bag of cement. Thus, for a 1:2:4 nominal mix, using a bag as a measure, the box would be 0.071 m^3 in coarse aggregate (0.14m^3), one box of fine aggregate (0.071m^3) to one bag of cement (0.036m^3). Often gauge boxes are made bottomless to facilitate handling.

When sand or fine aggregate is damp it tends to swell or bulk and proportions should be adjusted daily to allow for this. The bulking factor varies but generally it is about 25 per cent in damp conditions. Very dry or very wet (saturated) sand does not bulk at all.

Mixing: Three methods of specifying mixes are recognized in building regulations. These are:

1. Designed mix: They refer to high grade or special work and will not be dealt with at this stage.
2. Standard mixes: also called prescribed mixes are specified by giving the dry weights of aggregates.
3. Nominal mixes are those specified by volume and used for small-to medium-scale work.

Mixing:

Hand mixing is used where only small quantities of concrete are needed. It should be carried out on a clean hard surface or platform to prevent soil contamination. The cement, sand and coarse aggregate must be thoroughly mixed before water added. The amount of water must given a good workable mix but the slump should not normally exceed 50mm. Water should be added from a watering can through a rose and mixing continued with shovels or hoes until a uniform colure is obtained. Hand mixing must only be used for non-structural concrete.

Concrete mixers are in wide use today even in for jobbing or maintenance work. For small-scale concreting, gauge boxes with bottoms are filled and tipped into the mixer drum as it revolves, the boxes being counted as they are tipped in. larger mixers have loading skips at ground level which are loaded with dry materials as required, then lifted mechanically and tipped into the drum and water is added as necessary. Bottomless gauge boxes placed in the skip can be used for measuring in this case. Some machines, termed weigh batchers, have dials which record the weight of these measured materials. This is done before the mixing starts thus eliminating any further need for boxes throughout the day. Measured materials should be weighed and dials reset daily.

Reference:

Construction technology, R.L.Fullerton

Concrete works (cont.)

Transport of concrete:

Concrete transported by different equipments, but it shall satisfy the followings:

1. Avoid the segregation of concrete components
2. Prevent concrete to contamination with any other materials
3. Transport and laid the concrete in short time before initial setting
4. Equivalent between transport quantity with production
5. Economy factor

Lay of concrete and compaction:

The concrete should lie in the forms and sometimes without forms as for footings and compacted by many ways. Any way may be use to compact concrete shall satisfy the followings:

1. Homogeneous of concrete without segregation
2. Get the required shape and good surface
3. Product concrete with less content of voids and more dense
4. Laid and compact the concrete in short time before initial setting
5. Good bonding with old concrete
6. Satisfy the required properties of concrete

To satisfy the above points, the followings points must be take in care:

1. Laid the concrete within 30 minutes from the time of add water in cold weather and 20 minutes from the time of add water in hot weather
2. Be careful in laid of concrete without any vibrating in forms and avoid to stock the concrete in one place
3. Avoid to threw the concrete from 1.5 meter because it due to segregate the concrete components, so openings may be done in columns and walls and chutes used with 1:3 slope to carry concrete
4. For walls, horizontal layers according to the required thickness with 1.5 meter in cold weather and 1 meter in hot weather and be careful to avoid initial setting and pressure in fresh concrete.
5. Don’t cast in rain day
6. Be careful in laid of concrete in slop surface and cast start from down to up without forms for low slope and with temporary form for high slope
7. For columns and walls, prefer to decrease w/c ratio for upper layers
8. For slabs supported in columns and walls, cast cannot start before 3 hours of casting of columns and walls

Why we compact concrete with good efficiency?

We compact concrete with good efficiency, so we can:

1. Decrease w/c ratio and it means more strength and low shrinkage
2. Can compact the concrete with high thickness
3. More dense of concrete and low voids and it means good quality and low permeability of concrete
4. More penetration of concrete between bars and good shape
5. Ability to use mixes with low workability and this mean high strength
6. Decrease the time to remove side forms and this is very important for production of tiles and blocks

Finish of concrete:

The surface of concrete must be finished with the required level and as the required texture.

Curing of concrete:

Traditional processes for curing are:

1. Spreading with water
2. Submerged in water
3. Covered with wet soil or sand
4. Covered with plastic sheets
5. Covered with wet clothes
6. Paint with chemical materials
7. Steam curing

Concrete works in hot weather:

Hot weather has negative affect during concrete works and this affect be more negative if there is wind during concrete works.

The suggest problems are:

1. More water required to get required workability
2. High rate of reduce workability with time
3. Difficult to control air entrained in fresh concrete
4. Reduce the time of initial setting
5. Difficult to transport, lie and curing of concrete
6. Increase of plastic shrinkage
7. Increase of dimensional change for solid concrete
8. Increase the ability to crack
9. Reduce the final strength of concrete
10. Decrease the durability of concrete

11. Increase of permeability of concrete
12. Decrease the bond between steel bars and concrete
13. Increase the ability of corrosion of steel

Many processes have to taken to avoid the above points and these include:

1. Raw materials:

a. Mixing water: Chilled water must be used or artificial ice. The use of artificial ice with 50% instead of mix water reduces 11°C.
b. Cement: Avoid new grinding cement in concrete works
c. Admixtures: Use of retarders type B or super plasticizers type D according to ASTM C494-71
d. Aggregate: Store the aggregate in shadow place and spread the coarse aggregate with water

2. Mix of raw material and concrete:

Rearrange the feeding of raw materials in the mixer to avoid crystallization of cement when it contact with water.

It is important to decrease the time of mix to decrease the temperature of mixing and also it is important to paint the mixer with white color and spread it with water

3. Transport of concrete:

It is important to decrease the time of transportation

4. Laid and compact of concrete:

In additional to normal process for laid and compact of concrete, it is important to follow these processes:

a. Be sure to be able to cast in continuous way without any stop
b. It is important to make shadow to decrease the temperature of forms and bars
c. Be accurate in indicate the positions of joints
d. Prefer to shadow all equipments by wet clothes
e. It is better to start concrete after mid day
f. Avoid cold joints

Reference:

آرتين ليفون و زهير ساكو، انشاء المباني، 1981

Brick Works

Introduction:

The bricks of the oldest building materials known to and used by humans. As are used clay in primitive buildings, and clay are cut and dried in a lump and potteries. The man used bricks to the availability of clay material in nature and ease of manufacture and used in construction.

Classification of Bricks:

Bricks can be classified by different methods:

1. According to the raw materials:
   a. Clay bricks
   b. Sand lime bricks
   c. Concrete bricks
   d. Glass bricks
2. According to the shape:
   a. Solid
   b. Perforate
   c. Hollow
   d. Cellular
   e. Bricks with openings

Brick works:

They are the art to put the bricks in mortar to make homogeneous block join brick together called wall which carry the loads uniformly and get good texture.

Work bricks expressions:

1. Frog: It is a hole in one of the working sides of brick or both for several purposes such as reducing the weight of brick, its lock binding material and assist them in keeping and handling of brick as shown in Fig. 5-1

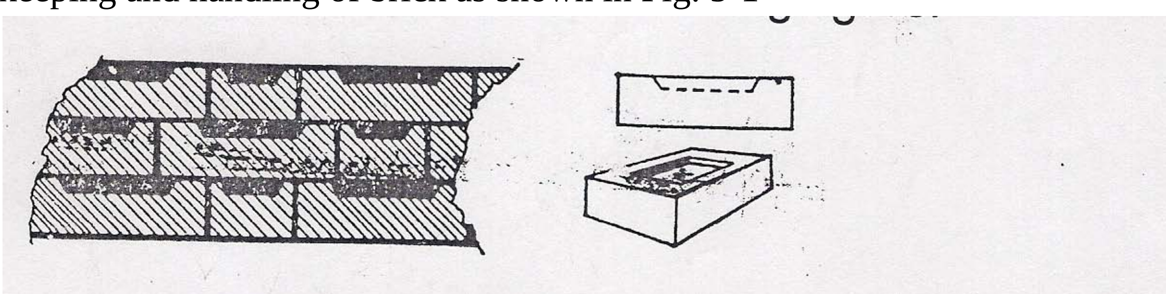


Fig. 5-1 Frog of bricks

2. Course: is a raw of bricks sandwiched between two horizontal joints. The high of course is the same thickness of brick as shown in Fig. 5-2

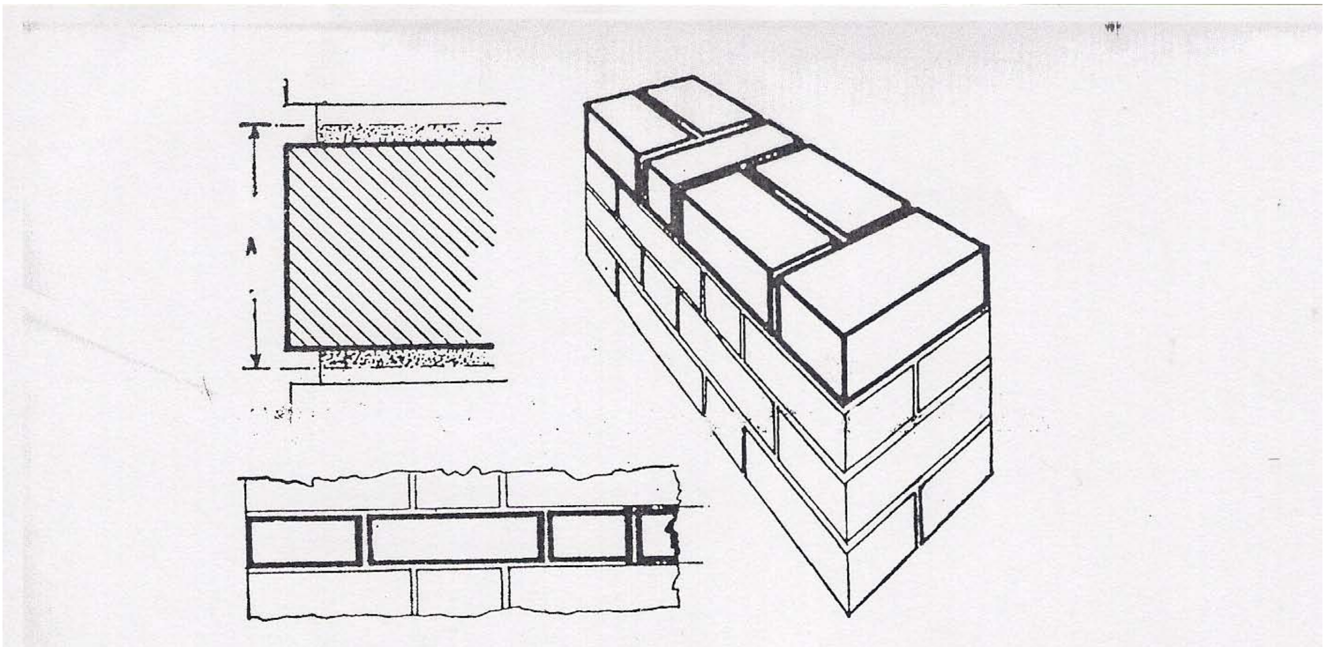


Fig. 5-2 Course of bricks

3. Bed joint: is a horizontal joint between two courses of bricks and is perpendicular to the pressure (Fig. 5-3).
4. Perpendicular joint: is a joint which is perpendicular in the face of the wall (Fig.5-3).

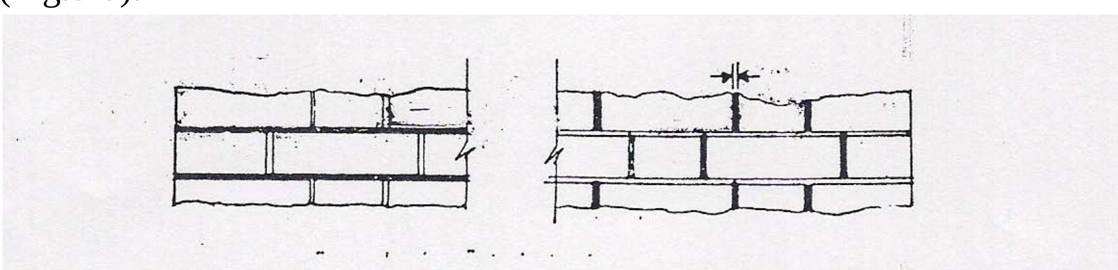


Fig. 5-3 Bed and perpendicular joints

5. Stratified on length: a term called to a brick set in construction so that the length of 24cm in parallel to the face of the wall.
6. Header: This term is called to a brick set in construction so that the length of 12cm in parallel to the face of the wall.
7. Stratified on thickness: This term is called a brick set in the building so that it is very thick (7cm) parallel to the face of the wall.

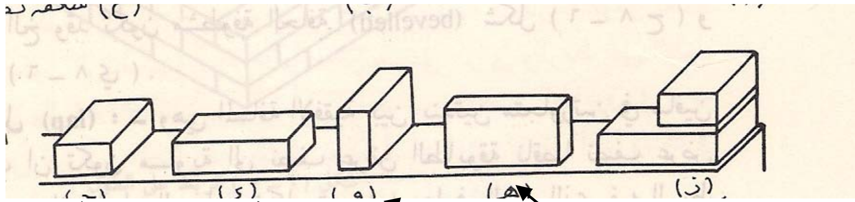


Fig. 5-4 Type of bricks sets

8. Bat type: It is part of the brick and usually called by the portion size to total size of brick , for example, is said to total a quarter or a third or half.
9. Closer: It is part of the brick cut along the length and has different type, for example, queen closer, king closer, beveled closer and mitered closer.
10. Lap: is the horizontal distance between adjacent perpendicular joints in one layer of brick. These must be equal to a quarter of the length of the brick in the good link quality.

Reference:

آرتين ليفون و زهير ساكو، انشاء المباني، 1981

Brick Works

Introduction:

The bricks of the oldest building materials known to and used by humans. As are used clay in primitive buildings, and clay are cut and dried in a lump and potteries. The man used bricks to the availability of clay material in nature and ease of manufacture and used in construction.

Classification of Bricks:

Bricks can be classified by different methods:

1. According to the raw materials:
   a. Clay bricks
   b. Sand lime bricks
   c. Concrete bricks
   d. Glass bricks
2. According to the shape:
   a. Solid
   b. Perforate
   c. Hollow
   d. Cellular
   e. Bricks with openings

Brick works:

They are the art to put the bricks in mortar to make homogeneous block join brick together called wall which carry the loads uniformly and get good texture.

Work bricks expressions:

1. Frog: It is a hole in one of the working sides of brick or both for several purposes such as reducing the weight of brick, its lock binding material and assist them in keeping and handling of brick as shown in Fig. 5-1

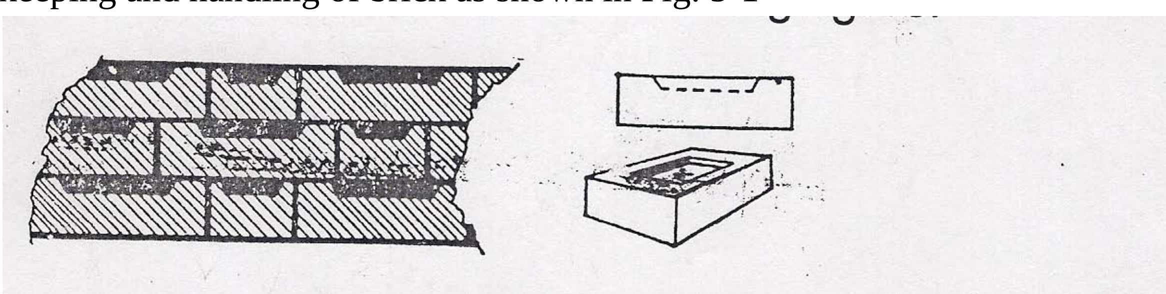


Fig. 5-1 Frog of bricks

2. Course: is a raw of bricks sandwiched between two horizontal joints. The high of course is the same thickness of brick as shown in Fig. 5-2

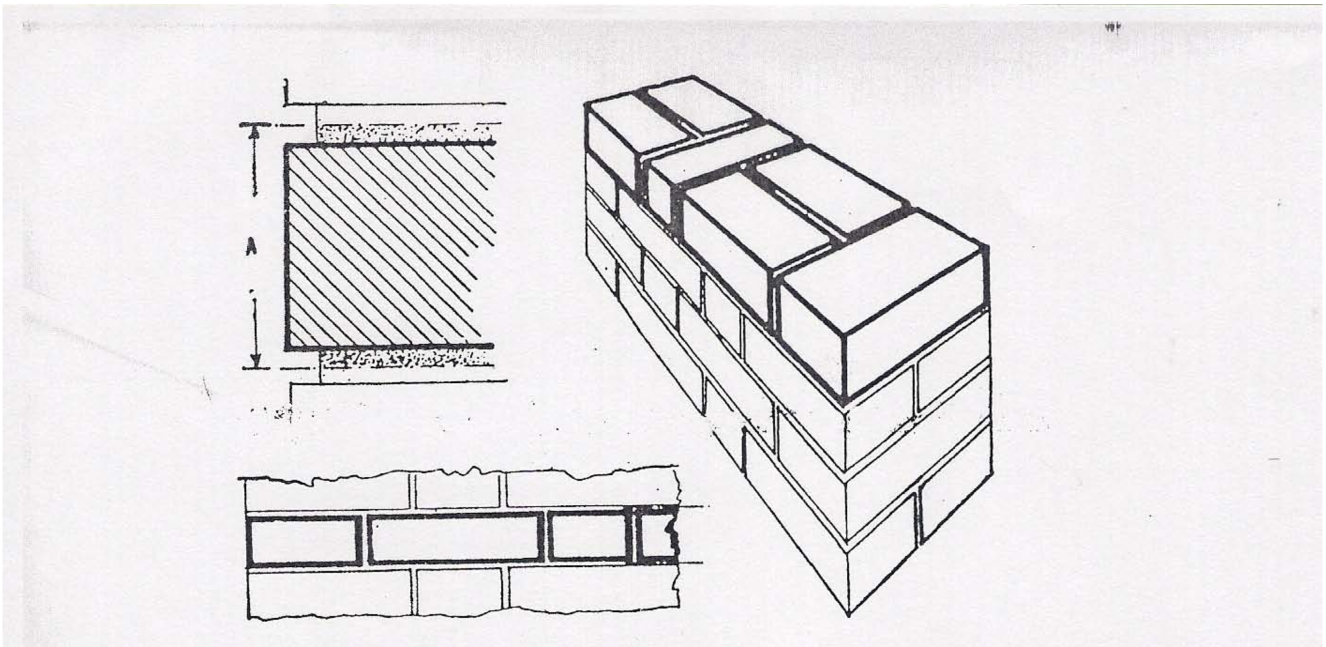


Fig. 5-2 Course of bricks

3. Bed joint: is a horizontal joint between two courses of bricks and is perpendicular to the pressure (Fig. 5-3).
4. Perpendicular joint: is a joint which is perpendicular in the face of the wall (Fig.5-3).

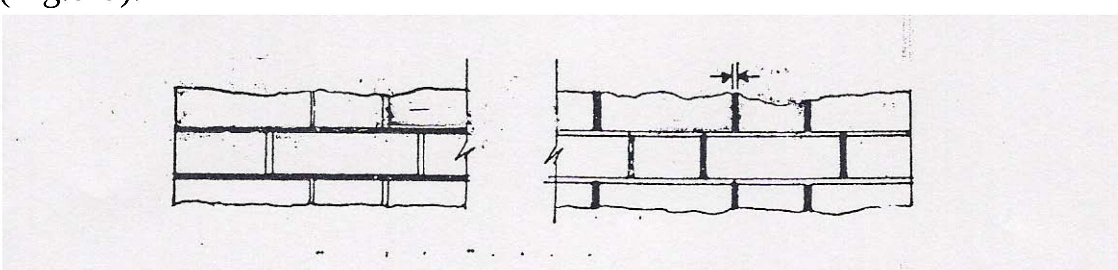


Fig. 5-3 Bed and perpendicular joints

5. Stratified on length: a term called to a brick set in construction so that the length of 24cm in parallel to the face of the wall.
6. Header: This term is called to a brick set in construction so that the length of 12cm in parallel to the face of the wall.
7. Stratified on thickness: This term is called a brick set in the building so that it is very thick (7cm) parallel to the face of the wall.

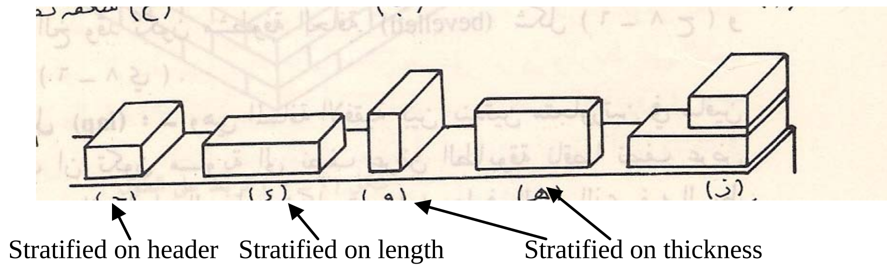


Fig. 5-4 Type of bricks sets

8. Bat type: It is part of the brick and usually called by the portion size to total size of brick , for example, is said to total a quarter or a third or half.
9. Closer: It is part of the brick cut along the length and has different type, for example, queen closer, king closer, beveled closer and mitered closer.
10. Lap: is the horizontal distance between adjacent perpendicular joints in one layer of brick. These must be equal to a quarter of the length of the brick in the good link quality.

Reference:

آرتين ليفون و زهير ساكو، انشاء المباني، 1981

Brick Works (cont.)

Building in bricks:

Building in brick by using mortar of cement and sand or gypsum paste. When a mortar cement and sand used, bricks must be soaked with water before use to achieve:

1. To insure that the brick not adsorption the water in mortar which is necessary for it.
2. To lift the dust stuck to the face of bricks to increase cohesion between the brick and mortar.
3. To decrease the soluble salts inside the bricks.

When bricks used in construction it should be noted, that:

1. The horizontal surface of the brick level
2. The face of the brick straight and straightening the outer face of the building
3. Faceted and staff placed vertically for the built and will be set by means of plumb line
4. Fill the joints (horizontal and vertical) between the bricks by mortar material.

Factors affecting the stability of brick building:

1. Vertical loads
2. Binding is not good enough, which makes the wall subjected to failures when downloading any weight
3. The side pushing.

Properties of bricks:

Hardness: This is somewhat vague term very commonly used to description of bricks. By general agreement it is recognized that the brick which is to have a moderately good compressive strength, reasonable resistance to saturation by rain water and sufficient resistance to the disruptive action of frost should be hard burned. A method of testing for hardness is to hold the brick in one hand and give it a light tap with a hammer. The sound cause by the blow should be a dull ringing tone thud.

Compressive strength; This is only property of bricks which can be determined accurately.

Absorption: A wall built of very hard bricks which absorb little water may well be more readily penetrated by rain water than one built of bricks which absorb a lot of water. This is because rain will more easily penetrate a small crack in the mortar between bricks if the bricks are dense than if the bricks around the mortar are absorptive.

Frost resistance: A very few failures of brickwork due to the disruptive action of frost have been reported during the last years. The few failures reported were in exposed parapet, walls chimney stacks, where bricks suffer most rain saturation and there is a likelihood of damage by frost. Parapet walls, chimney stacks and garden walls should be built of sound, hard burned bricks protected with coping, capping and damp proof courses.

Efflorescence: Clay bricks contain soluble salts that migrate, in solution in water, to the surface of brickwork as water evaporates to the outside air. These salts will be collect on the face of brickwork as efflorescence of white crystals that appear in irregular, usually patches.

Brick walls classification:

Brick walls may be classified according to:

1. Construction design:
   a. Bearing walls: which are built to transfer loads to the soil as in the light building like houses, schools and others. These walls constructed for buildings with one or two floors and rarely three floors. Its thickness variables between 24-36 cm.
   b. Non bearing walls: built to bear its weight only. It is divided the internal space in light buildings as well as heavy buildings. They should be of thickness 24cm for external one and 12 cm for internal one and in some cases the thickness 7cm.
   c. Retaining walls: design to resist lateral forces of the output of the dust materials as water in dams and other hydraulic structures. Short wall is one type of retaining walls which has a little height less than 1m to support the fill soil, which is used in walkways around the buildings and gardens.
2. Density design:
   a. Solid walls: This constructed without any voids between bricks.
   b. Hollow or cavity walls: This constructed with hollow according to the desire to improve one of the followings:
      i. Thermal isolation by leave the hollow or fill it with isolated material
      ii. Bearing capacity by fill the hollow with reinforcement concrete

   Or to allow the engineer to use the hollow as service duct

Bond of bricks:

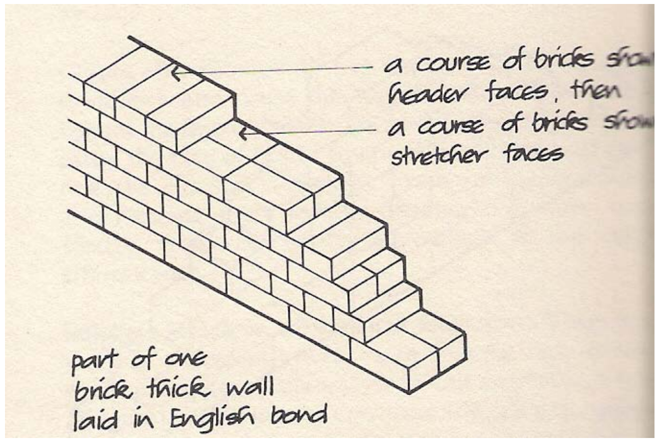
It is a building block in the organization so that they not be joints in the successive layers one above other and be more what can be the joint space. For good bond taking into account the following rules:

1. Brick placed on a regular basis in the construction and with joints of equal width.
2. Use less of what can break the bricks

3. The vertical joints in the frequent layers on the straight line and is perpendicular to the surface of the wall
4. Use brick of equal dimensions in order to achieve uniformity in construction

Bonding the bricks in the building in several types, including:

a. English bond: bricks are placed in this type so that the face of the building including the brick on the length and on its head in the following layer and as shown in the following in Fig. 5-5.



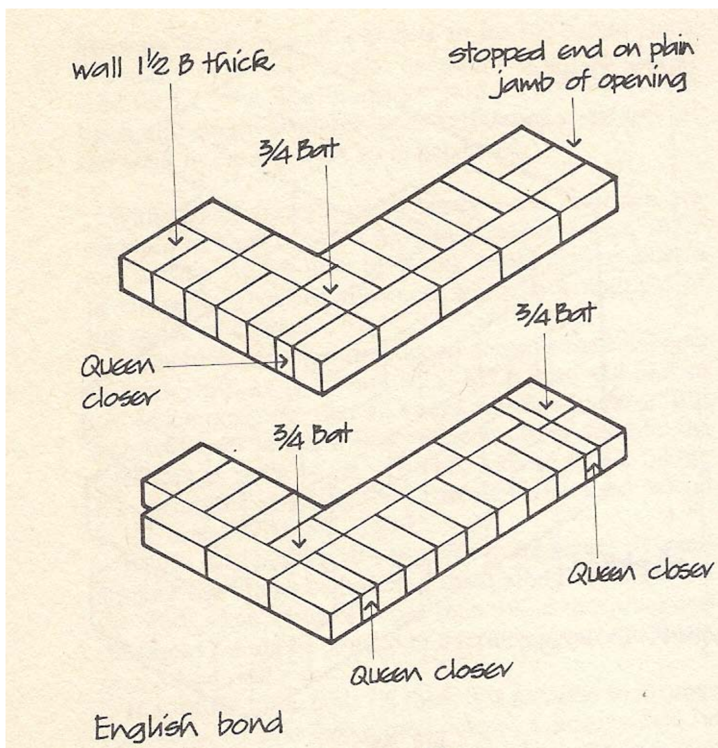


Fig. 5-5 English bond

b. German double bond (Flemish double bond): to be developed so that the bricks in the layer one brick on the length and the other on the head thus, as in Fig. 5-6.

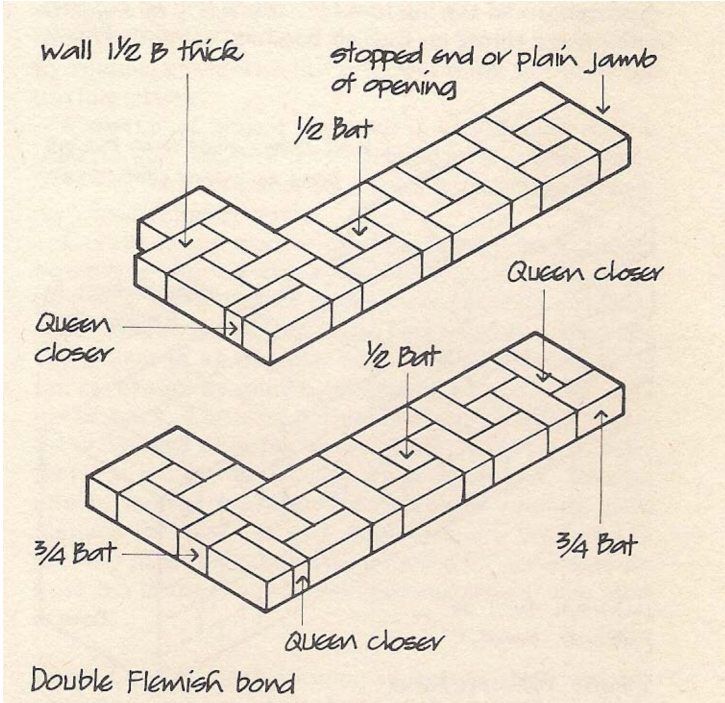


Fig. 5-6 Double Flemish bond

That this type of bond is the weakest bond comparing with the first type, and so should be used to break bricks in addition to the used of bricks to put on its length more than the first type. But this kind has the appearance of better than the English bond, also is economist because of the possibility of using broken bricks resulting from the transportation.

c. German single bond (Flemish single bond) : In this type the bricks putted so that the external face is of German bond and internal bond of English bond type where the wall of this type have strongly English bind and German beauty linkage as in Fig. 5-7.

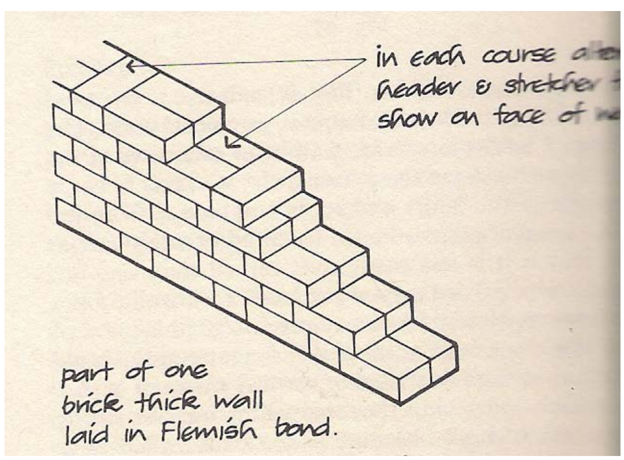


Fig. 5-7 Single Flemish bond

d. Bond on the length (Stretcher bond): This type is used in the non bearing walls with thickness 12cm with every laid on the bed with every brick showing a stretcher or long face as shown in Fig. 5-8.

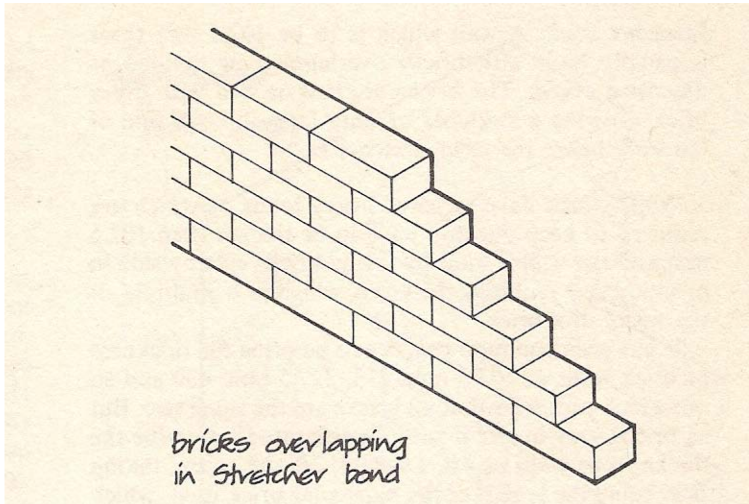


Fig. 5-8 Bond on the length

e. Bond on the head(Stretcher bond): This type is used in the non bearing walls with thickness 24cm with every laid on the bed with every brick showing a stretcher or head face as shown in Fig. 5-9.

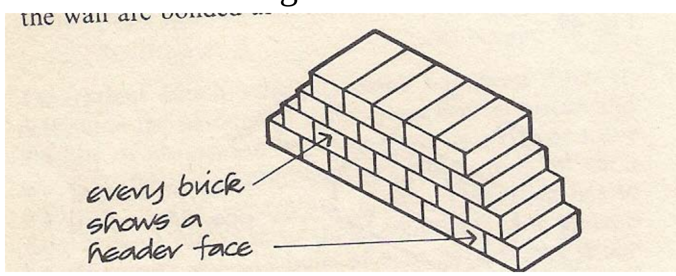


Fig. 5-9 Bond on the head

f. Raking bond: walls which are very thick have fewer stretchers in them and hence their longitudinal stiffness gets decreased. This defect is overcome by the use of raking courses at certain intervals along the height of the wall say, after sixth or eighth course (Fig. 5-10).

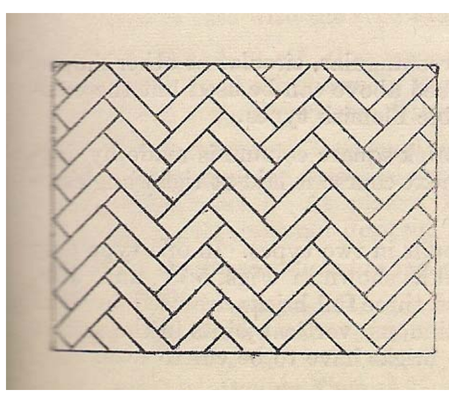


Fig. 5-10 Raking bond

Joints in the face of the building bricks (jointing):

The finishing in the face of construction joints of the brick walls that cover rising any other work in some ways set out below in order to obtain the strength in construction, landscape and good resistance to atmospheric changes:

a. Flush or flush joint: This is the simplest type of joint and when ribbed give a good finish. It used with English bond. This is filling the intervals between the bricks with mortar of cement and sand, then raise the excess mortar and wiping the face with a rough cloth.
b. Struck or weathered: This joint permits water to drop off from the face of brickwork. The works of this type done by filling the horizontal joints and clicking on the mortar along upper edge of the joint to an angle of about 60°. The appearance of this joint is not satisfactory if ordinary bricks are used because unevenness in the edges of the bricks is visible.
c. Recessed joint: This joint is made with jointing tool; the thickness of the rubber attached in front of the tool is being to the joint. Rubber attachment is used as it adjusts itself to the irregularity of the brick edge. This tool is used after any projecting mortar has been removed. The brick should be carefully selected and should have uniform thickness. This joint is at least 1cm in thickness. This is satisfactory in face-work for good textured bricks and good quality of mortar.
d. Keyed or curved recessed (Concave joint): This type similar to the first type, but it works a hole of a semi-circle along the separation in the center of it by rule with the end of the form of hemisphere.
e. V-joints: It is similar to flush but during construction, hole made as triangle. This is used to give an appearance of narrow joints. The finishing should be done before the mortar sets.
f. Projecting joints: Mortar is left projecting from the joints. This type of joint affords a rough surface which can be helpful in keying the plaster which is applied later on.

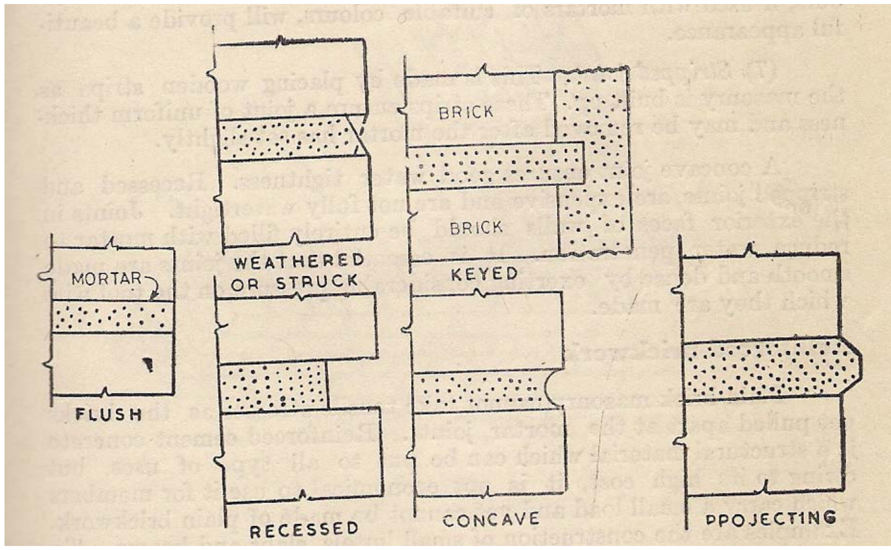


Fig. 5-11 Various types of jointing

Reference:

1. BARRY, The construction of building, vol. 1&4
2. S.K.SHARMA, Building construction

Stone masonry (cont.)

Joints in stone masonry:

The joints in stone masonry may be classified under the following three heads:

a. Strengthening joints
b. Lengthening joints
c. Mortar joints

a. Strengthening joints:

b. Strengthening joints, in stone masonry, are of two types, namely (a) joggle joints and (b) ramp joints. The former type is suitable for taking care of sliding of the abutting surfaces, whereas the latter type is suitable for prevention of separation or opening out of the joints.

Joggle joints can be in the form of tongue and groove, table and slate or metal or cement joggles. These joints are suitable to prevent sliding between vertical butt joints (e.g. landing of stone stair), horizontal sliding of stones, and lateral movement of stones in copings respectively. Dowels are also used for resisting lateral movements.

Cramps may be metallic or stone such as slate. Coverings of copings, cornices and projecting string courses are the situations where cramps can be used to resist the parting of stones. Lead plugs can also be used for this purpose.

Details of strengthening joints are given below:

1. Table or bed joggle joints: The projection of one stone fits into the depression of adjacent stone. This prevents the movement of the stones along the jointing plane.
2. Tongued and grooved: In this also the projection of one stone fits in the corresponding groove in the adjacent stone. This is also called joggled joint.
3. Slate or metal joggled joint: In this, a piece of metal or slate is placed in between the corresponding groove of the adjacent stone.
4. Dowel joint: Wherever stone is liable to be displaced, then a dowel is introduced to connect them. These dowels may be of slate, gun metal, brass, bronze, etc. They are set in cement mortar.
5. Cramped joint: The cramp is a piece of metal about 2 to 5 cm wide, 6 to 12 mm thick and 20 to 40 cm long with ends turned down. They may be set in depressions in the top of the stone or set beneath the stones with their ends upward. They should be protected by pouring molten lead around them. These cramps can be also made of slate or other stone.
6. Plug joints: This is an alternative to the use of cramps and consists of depression below the top surface dovetailed in plan. The stones are jointed in the usual way and this depression is filled with cement or lead.

Reference:

1. BARRY, The construction of building, vol. 2
2. S.K.SHARMA, Building construction

Stone masonry

Stone masonry is used for the construction of walls, columns, lintels, arches, beams, etc., of a building. Stones are abundantly available in nature and when cut and dressed to proper shapes, they provide an economical material for the construction of various parts of building.

Materials used for stone masonry:

The materials used for masonry are stone and mortar.

The natural stones used in building can be classified to their origin as:

1. Igneous: The igneous stone principally used in building is granite, which was formed from the fusion of minerals under great heat below the earth's surface many thousands of years ago.
2. Sedimentary: It was formed gradually over thousands of years from particle of calcium carbonate or sand deposited by settlement in bodies of water. Gradually layer upon layer of particles of lime or sand settled into depression in the earth's surface and in course of time these layers of lime or sand particles became compacted by the water or earth above them.
3. Metamorphic: Those that have been changed from igneous or sedimentary stone or from earth into metamorphic stone by pressure, or heat, or both in the earth's crust. Example are marble which was formed from limestone and slate and shale formed from clay.

The common types of stones available are:

1. Granite: It consists of grains of quartz in combination with felspar and mica. These are the hardest types of stones and difficult to work with. They are available in various colors ranging from white to green. These are used for the construction of steps, walls, sills and as facing over other masonry.
2. Sandstone: They are made of quartz cemented by a matrix of silica. They also contain mica, felspar and oxides of iron. The colors of sandstones are due to the presence other minerals in them. They can be worked easily to take any ornamental shape. Their texture being coarse, they give a good appearance when used along with brick masonry. Colored sandstones are used in the face work of building to give architectural treatment. They are used for walls, columns, facing, steps, flooring, etc.
3. Limestone: These are calcareous rocks and consist of carbonate of lime. They are available in various colors and easy to work with. They are used for walls, floors, steps, etc.

4. Marbles: They are like limestone, are calcareous rocks and consist and consist of carbonate of lime. They are very useful material for flooring and monumental structures. Marble are available in various colors and can very good polish.
5. Slates: These are available in hilly areas and are metamorphic rocks. Generally they have a black color. Slates can be split in thin sheets along their bedding planes. They mostly used for roofing work.

The properties of stones:

The proprieties of stones which are important for stone masonry are strength and durability. Economy and appearance are additional requirements. The main considerations for durability are the lasting qualities of the stone itself and the locality where it is to be used. Porous stones are unsuitable for areas prone to heavy rainfall and frost. Stones, e.g. marbles having low porosity and low coefficients of expansion and contraction should be used in areas subjected to large variations in rainfall and temperatures.

Generally lime and cement mortars are used for stone masonry. Their function is to provide a workable matrix and ultimately a hard building material, which renders masonry into a monolithic unit.

Cutting and dressing of stones:

Stones found in nature, have to be quarried from their thick beds. After quarrying large pieces of stones, it is essential to break them into smaller sizes so that they can be used in a building. They are also dressed into suitable shapes and polished to give a smooth surface, if desired. Various types of finishes and the methods of dressing and cutting the stones to get the desired surfaces are described below:

1. Scrabbling: Irregular edges of the stones are broken off and the stone is shaped somewhat.
2. Hammer dressed: Large raised portions of the stones are cut and the stone is made somewhat flat but rough due to hammer marks.
3. Boasted or droved finish: The stone is cut to a little level face and is finished by means of a boaster.
4. Tooled finish: In this case the chisel marks are continuous and parallel throughout the width of stone.
5. Furrowed finish: In this case about 1 cm vertical or horizontal grooves are sunk with a chisel having its end shaped as a hollow semi-circle.
6. Reticulated finish: In this type of work, irregular shaped sinking is made within the center portion of the stone having a 2 cm wide margin on its sides.

7. Vermiculated finish: The sinking is of the reticulated type except that they are more curved and give a worm eaten type of appearance.
8. Combed or dragged finish: This type of finish is done on soft stones. A comb is driven over the surface of this stone to remove all elevating portions.
9. Punched finish: Depressions are formed on the rough surface with a punch.
10. Picked finish: This type of finish is obtained by dressing stones with a point and the depressions are smaller than the above type.
11. Chisel drafted margins: They give a better appearance and help in getting uniform joints.
12. Moulded finish: Mouldings of various types can be worked on the stones to improve their appearance.
13. Rubbed finish: The surfaces of the stones are rubbed get a smoother surface finish.
14. Polished finish: Stones which can take polish, e.g., granites, marbles, lime-stones are first rubbed to a smooth surface and then polished by using rubber and pad, sand and water, pumice, and putty powder.
15. Sand Blasting: This is done to imprint letterings and designs on the surface of granites.

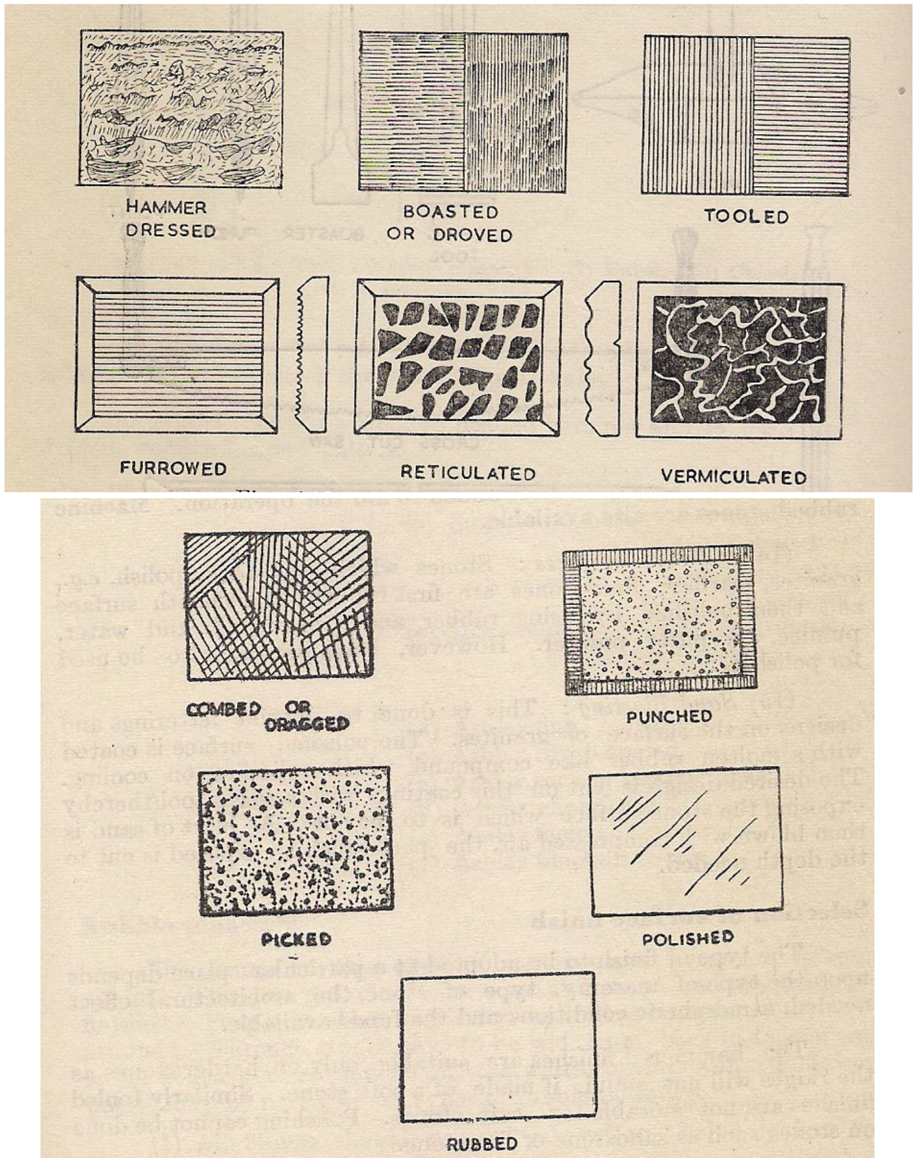


Fig. 6-1 Finishes for stone work

Types of stone masonry:

Masonry can be classified according to the thickness of joints, continuity of courses and finish of face.

Broadly speaking there are two types of stone masonry, namely:

1. Rubble masonry: This consists of blocks of stones either undressed or roughly dressed and having wider joints.
   a. Random rubble:
      i. Uncoursed
      ii. Coursed

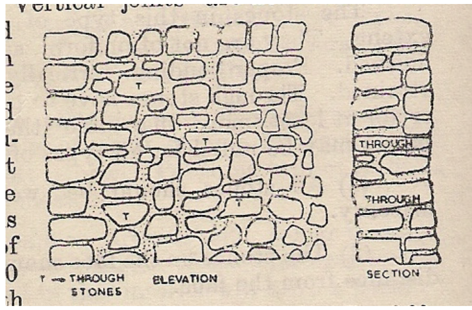


Fig. 6-2 Random rubble uncoursed

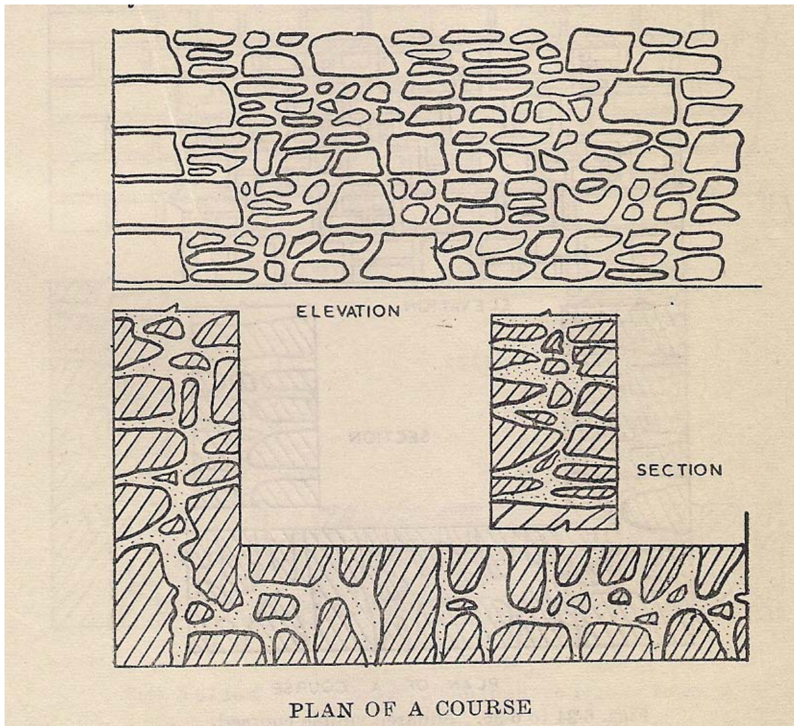


Fig. 6-3 Random rubble coursed

b. Squared rubble
   i. Uncoursed
   ii. Coursed
   iii. Built to regular courses

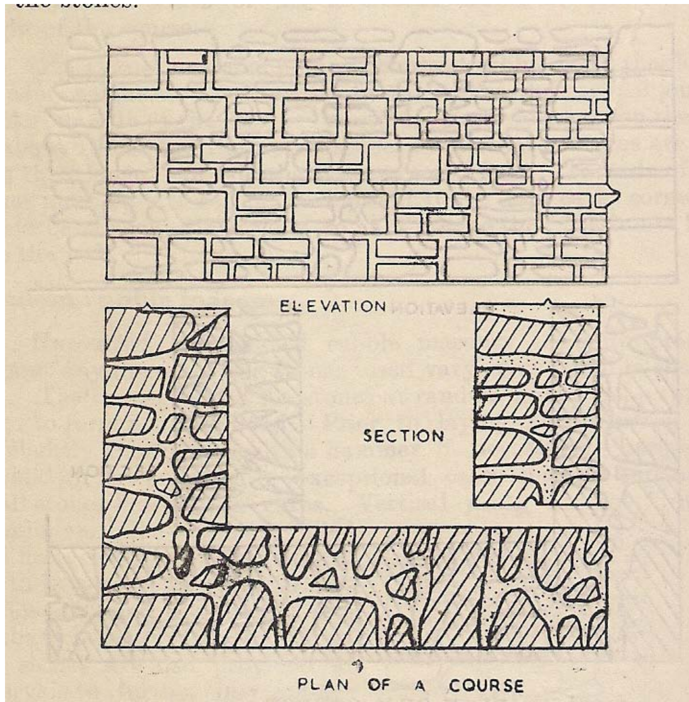


Fig. 6-4 Square rubble course

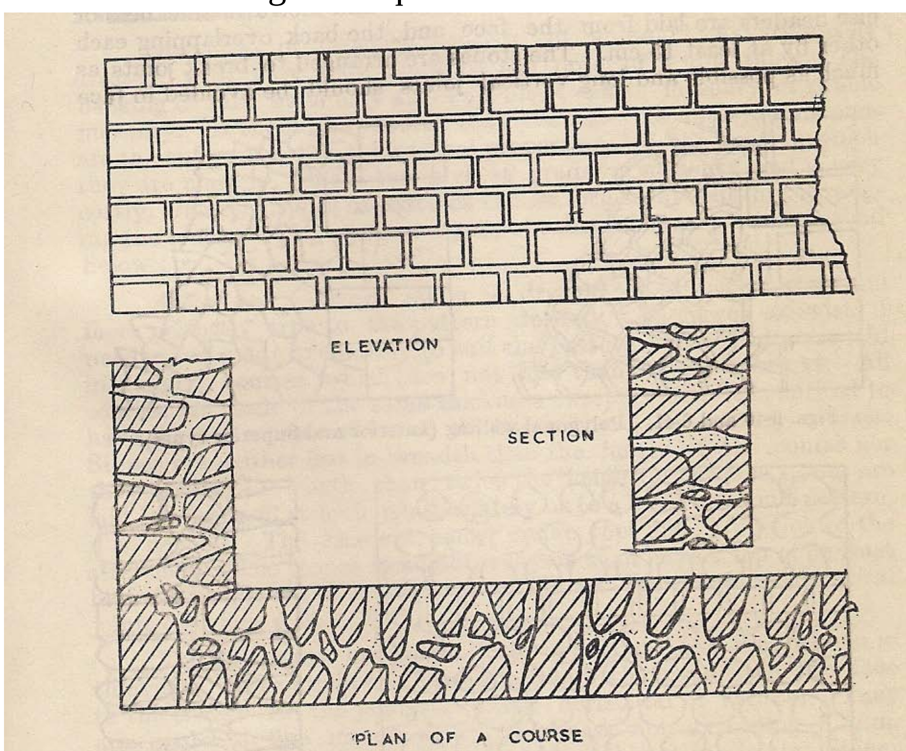


Fig. 6-5 Square rubble Built to regular courses

2. Ashlar masonry: This built of stones carefully dressed and has narrow joints.

General principles to be followed in the construction of stone masonry:

1. The stone used shall be hard, durable and tough. All stones should be laid on its natural bed.
2. The pressure acting on the stones should not act parallel to the bedding planes. This will try to split the stones. Sometimes stones used in corbels are laid with pressure acting parallel to bedding planes.
3. The bond stones and headers should not be of dumb-bell shape.
4. Large flat stones should be laid under the ends of girders, roof trusses, etc.
5. In all slopping retaining walls, the beds of the stones and the plan of the courses should be at right angles to the slope.
6. All laid fine dressed stone work should be protected against damage during further construction by means of wooden boxes.
7. Jambs for door and window openings should be made of quoins which are equal in height to the course. They should be in breadth equal to at least 1½ times the height of the course and their length should be at least twice the height.
8. All the surfaces should be kept wet while the work is in progress and also till the mortar has set.
9. Double scaffolding will be used wherever it is difficult to fit in the stones later on.
10. All the portions of the masonry should be raised uniformly. Wherever this is not possible, the stone work built earlier should be raked (stepped) so that the new work can be bonded well with the old.
11. Sufficient through stones should be used and they should form ¼th of the area in elevation.
12. The hearting of the masonry should be properly packed with mortar and chips, if necessary, to avoid any hollows or very thick mortar joints.
13. Vertical faces of the masonry walls should be checked with a plumb rule and the battered faces should be tested with wooden template corresponding to the batter and a plumb rule to ensure a constant batter.
14. The stones used in the masonry should be wetted before use to avoid moisture being sucked from the mortar.
15. Masonry should not be allowed to take tension.

Reference:

1. BARRY, The construction of building, vol. 2
2. S.K.SHARMA, Building construction