UNIT – I

STONES, BRICKS AND TILES

1.1 INTRODUCTION:

Building materials have an important role to play in this modern age of technology. Although their most important use is in construction activities, no field of engineering is conceivable without their use. Also, the building materials industry is an important contributor in our national economy as its output governs both the rate and the quality of construction work. There are certain general factors which affect the choice of materials for a particular scheme. Perhaps the most important of these is the climatic background.

Due to the great diversity in the usage of buildings and installations and the various processes of production, a great variety of requirements are placed upon building materials calling for a very wide range of their properties: strength at low and high temperatures, resistance to ordinary water and sea water, acids and alkalis etc. Also, materials for interior decoration of residential and public buildings, gardens and parks, etc. should be, by their very purpose, pleasant to the eye, durable and strong. Specific properties of building materials serve as a basis for subdividing them into separate groups. For example, mineral binding materials are subdivided into air and hydraulic-setting varieties. The principal properties of building materials predetermine their applications. Only a comprehensive knowledge of the properties of materials allows a rational choice of materials for specific service conditions.

1.2 Physical Properties:

Density

Density is the mass of a unit volume of homogeneous material denoted by:

$$\rho = M/V \text{ g/cm3}$$

where M = mass (g)
V = volume (cm3)
Density of some building materials is as follows:

Material	Density (g/cm3)
Brick	2.5–2.8
Granite	2.6–2.9
Portland cement	2.9–3.1
Wood	1.5–1.6
Steel	7.8–7.9

Bulk Density: It is the mass of a unit volume of material in its natural state (with pores and voids) calculated as $\rho_b = M/V$ kg/m^3

where M = mass of specimen (kg), V = volume of specimen in its natural state (m3) For most materials, bulk density is less than density but for liquids and materials like glass and dense stone materials, these parameters are practically the same. Properties like strength and heat conductivity are greatly affected by their bulk density. Bulk densities of some of the building materials are as follows:

Material	**Bulk density (kg/m3)**
Brick	1600–1800
Granite	2500–2700
Sand	1450–1650
Pinewood	500–600
Steel	7850

Specific Weight : It is also known as the unit weight) is the weight per unit volume of material,

$\Upsilon = \rho . g$

Where

Υ = specific weight (kN/m^3)

ρ = density of the material (kg/m)

g = gravity (m/s^2)

Specific weight can be used in civil engineering to determine the weight of a structure designed to carry certain loads while remaining intact and remaining within limits regarding deformation. It is also used in fluid dynamics as a property of the fluid (e.g., the specific weight

of water on Earth is 9.80 kN/m3 at 4°C).

Specific Gravity (G s)

The terms specific gravity, and less often specific weight, are also used for relative density. specific gravity (G s) of solid particles of a material is the ratio of weight/mass of a given volume of solids to the weight/mass of an equal volume of water at 4°C.

$$G_s = \frac{\gamma_s}{\gamma_w} = \frac{\rho_s}{\rho_w}$$

At 4° C γ_w = 1 g/cc or 9.8 kN/m^3

Porosity:

It is the degree to which volume of the material of the material is interspersed with pores. It is expressed as a ratio of the volume of pores to that of the specimen.

$$n = Vv/V.$$

Porosity is indicative of other major properties of material, such as bulk density, heat conductivity, durability, etc. Dense materials, which have low porosity, are used for constructions requiring high mechanical strength on other hand, walls of buildings are commonly built of materials, featuring considerable porosity. Following inter relationship exists between void ratio and the porosity.

Water Adsorption: It denotes the ability of the material to absorb and retain water. It is expressed

as percentage in weight or of the volume of dry material.

$$W_w = \frac{M_1 - M}{M} \times 100$$

$$W_v = \frac{M_1 - M}{V} \times 100$$

where M_1 = mass of saturated material (g)

M = mass of dry material (g)

V = volume of material including the pores (mm^3)

Water Permeability ; It is the capacity of a material to allow water to penetrate under pressure. Materials like glass, steel and bitumen are impervious.

Frost Resistance: It denotes the ability of a water-saturated material to endure repeated freezing and thawing with considerable decrease of mechanical strength. Under such conditions the water contained by the pores increases in volume even up to 9 per cent on freezing. Thus the walls of the pores experience considerable stresses and may even fail.

Heat: It is the ability of a material to conduct heat. It is influenced by nature of material, its structure, porosity, character of pores and mean temperature at which heat exchange

takes place. Materials with large size pores have high heat conductivity because the air inside the pores enhances heat transfer. Moist materials have a higher heat conductivity than drier ones. This property is of major concern for materials used in the walls of heated buildings since it will affect dwelling.

Chemical Resistance: It is the ability of a material to withstand the action of acids, alkalis, sea water and gases. Natural stone materials, e.g. limestone, marble and dolomite are eroded

even by weak acids, wood has low resistance to acids and alkalis, bitumen disintegrates under the action of alkali liquors.

Durability: *It is* the ability of a material to resist the combined effects of atmospheric and other factors.

1.3 Mechanical Properties:

The important mechanical properties considered for building materials are: strength, compressive, tensile, bending, impact, hardness, plasticity, elasticity and abrasion resistance. ***Strength:*** is the ability of the material to resist failure under the action of stresses caused by loads, the most common being compression, tension, bending and impact. The importance of studying the various strengths will be highlighted from the fact that materials such as stones and concrete have high compressive strength but a low (1/ 5 to 1/ 50) tensile, bending and impactstrengths.

Compressive Strength is found from tests on standard cylinders, prisms and cubes—smaller for homogeneous materials and larger for less homogeneous ones. Prisms and cylinders have lower resistance than cubes of the same cross-sectional area, on the other hand prisms with heights smaller than their sides have greater strength than cubes.

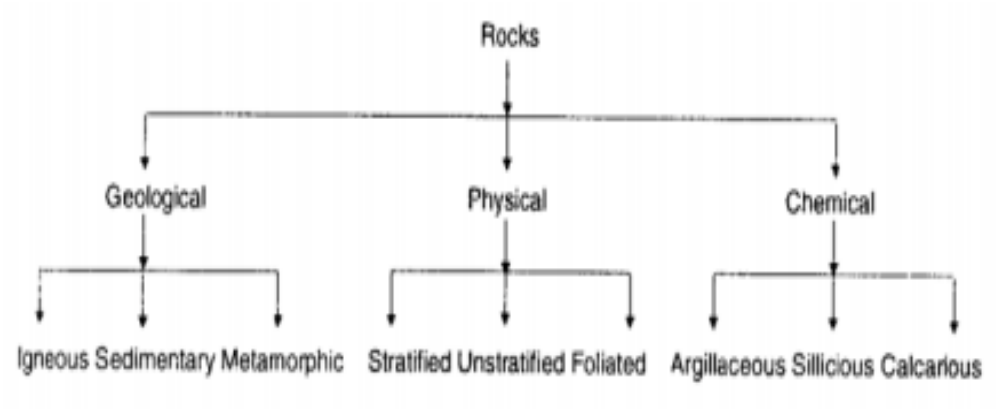
Hardness: is the ability of a material to resist penetration by a harder body. Mohs scale is used to find the hardness of materials. It is a list of ten minerals arranged in the order of increasing hardness. Hardness of metals and plastics is found by indentation of a steel ball.

Elasticity is the ability of a material to restore its initial form and dimensions after the load is removed. Within the limits of elasticity of solid bodies, the deformation is proportional to the stress. Ratio of unit stress to unit deformation is termed as modulus of elasticity. A large value of it represents a material with very small deformation.

Plasticity: is the ability of a material to change its shape under load without cracking and to retain this shape after the load is removed. Some of the examples of plastic materials are steel, copper and hot bitumen.

1.4 Classification of Stones:

The rocks may be classified on the basis of their geological formation, physical characteristics
and chemical composition as shown in Fig.



Igneous Rocks:

It also known as primary, unstratified or eruptive rocks are of volcanic origin and are formed as a result of solidification of molten mass lying below or above the earth's surface. The inner layers of the earth are at a very high temperature causing the masses of silicates to melt. This molten mass called magma is forced up as volcanic eruptions and spreads over the surface of earth where it solidifies forming basalt and trap. These are known as effusive rocks.

Sedimentary Rock:

These are also known as aqueous or stratified rocks. The various weathering agencies, e.g. rain, sun, air, frost, etc. break up the surface of earth. Rain water carries down these broken pieces to the rivers. As the rivers descend down to the plains, the velocity decreases gradually and the sediments (disintegrated rock pieces, sand, silt, clay, debris, etc.) in the water settle.

Metamorphic Rock:

These are formed from igneous or sedimentary rocks as a result of the action of the earth movements, temperature changes, liquid pressures, etc. The resultant mass may have a foliated structure, e.g. slate, gneiss, schist and phyallite or non-foliated structure, e.g. marble, quartzite and serpentine.

Based on physical Characteristics:

The rocks may be classified as stratified, unstratified and foliated.

Stratified Rocks: show distinct layers along which the rocks can be split. The examples are sandstone, limestone, shale, slate, marble, etc.

Unstratified Rocks: do not show any stratification and cannot be easily split into thin layers. The examples of such rocks are granite, basalt, trap, etc.

Foliated Rocks: it have a tendency to split up only in a definite direction. Most of the metamorphic rocks have a foliated structure, except for quartzite and marble which have granulose structure.

Based on Chemical Characteristics:

The rocks may be classified as argillaceous, silicious and calcarious.

Argillaceous Rocks: The principal constituent is clay (Al2O3). The rocks are hard and brittle, e.g. slate, laterite, etc.

Silicious Rocks: The principal constituent is silica (SiO2), i.e. sand. The rocks are very hard and durable, e.g. granite, basalt, trap, quartzite, gneiss, syenite, etc.

Calcareous: The principal constituent is lime, e.g. limestone, marble, dolomite, etc.

QUARRYING OF STONES:

The only operation involved in the production of natural stone is the quarrying process. The open part of the natural rock from which useful stone is obtained is known as quarry. While selecting a quarry site, the points to be borne in mind are availability of sufficient quantity of the stone of desired quality, proper transportation facilities, cheap local labour, problems associated with drainage of rain water, location of important and permanent structures in the vicinity and site for dumping refuse.

METHODS OF QUARRYING

Rocks suitable for the manufacture of stone materials are called useful minerals and the operations involved in obtaining minerals are called mining. In the process of mining, voids formed are called excavations, and the mined deposits are the quarries. The purpose of quarrying is to obtain stones for various engineering purposes. A knowledge of various quarrying methods is essential but does not make one very much more competent to choose or specify a stone for building work. Depending upon the nature and surface of rocks and the purpose for which stones are needed, quarrying is done by excavating, wedging, heating or blasting.

Excavation : Stones buried in earth or under loose overburden are excavated with pick axes, crow bars, chisels, hammers, etc.

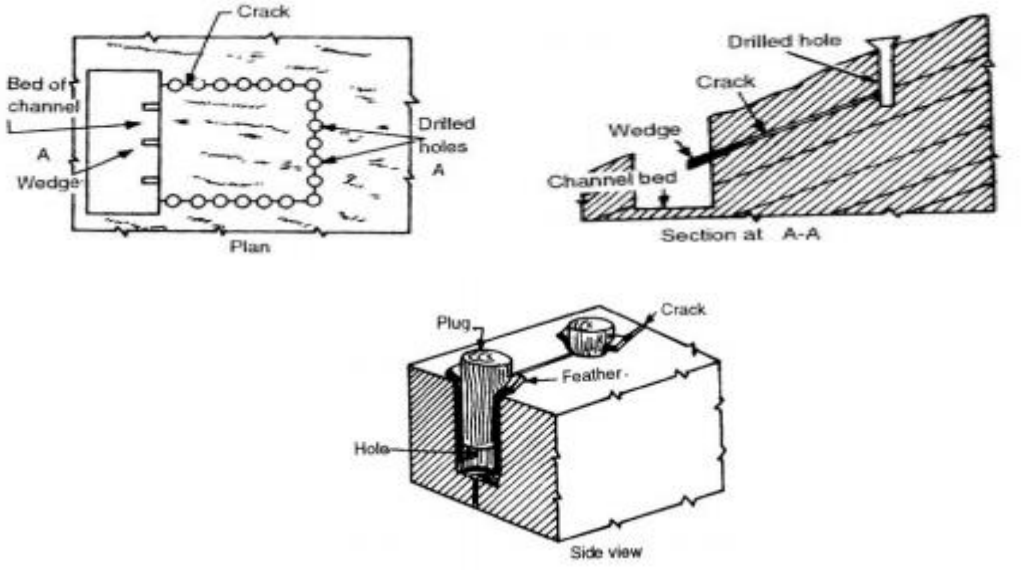
Wedging: This method of quarrying is suitable for costly, soft and stratified rocks such as sandstone, limestone, laterite, marble and slate. About 10–15 cm deep holes, at around 10 cm spacing, are made vertically in the rock. Steel pins and wedges or plugs (conical wedges) and feathers (flat wedges) as shown in Fig are inserted in them. The latter arrangement of plugs and feather is better. These plugs are then struck simultaneously with sledge hammer. The rock slab splits along the lines of least resistance through holes. In case of soft rocks, dry

wooden pegs are hammered in the holes and water is poured over them. The pegs being wet swell and exert pressure causing the rocks to crack along the line of holes. Then, the wedges are placed on the plane of cleavage (the joint of two layers) on the exposed face of rock and are hammered. The slab is completely detached and taken out with the help of crow bars and rollers. In this method, the wastage is minimum and the slabs of required size and shape can be quarried.

Heating: It is most suitable for quarrying small, thin and regular blocks of stones from rocks, such as granite and gneiss. A heap of fuel is piled and fired on the surface of rock in small area. The two consecutive layers of the rock separate because of uneven expansion of the two layers. The loosened rock portions are broken into pieces of desired size and are removed with the help of pick-axes and crow-bars. Stone blocks so obtained are very suitable for coarse rubble masonry. Sometimes, intermediate layers are to be separated from the top and bottom layers. In such a case, the intermediate layer is heated electrically and the expansion separates it from the other two.

Blasting: Explosives such as blasting powder, blasting cotton, dynamite and cordite are used. The operations involved are boring, charging, tamping and firing.

Boring: Holes are drilled or bored in the rock to be dislodged. For vertical holes, jumper is used whereas for inclined or horizontal holes, boring bars are used. One person holds the jumper exactly in the place where hole is to be made. The other person strikes it up and down and rotates it simultaneously. Water is poured in the hole regularly during the operation to soften the rock and facilitate drilling. The muddy paste generated in the process is removed from holes by scrapping. For hard rocks, machine drilling is employed instead of hand drilling.



Charging: The holes are dried completely and the required amount of charge is placed in the holes. For drying the holes, rag is tied in the scrapper and is moved in the hole from where it absorbs the moisture, if any. In case it is found that water is oozing into the hole, water tightness is ensured inside the hole.

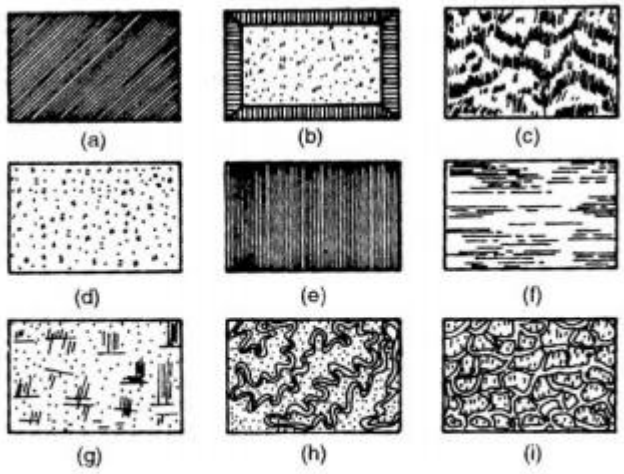
Tamping: After placing the charge in the hole, a greased priming needle, projecting a little outside the hole, is placed in the hole which is then filled up with damp clay or stone dust in layers tamped sufficiently with a braced tamping rod. The priming needle should be kept on rotating while tamping is going on. This is done so that the needle remains loose in the hole. The priming needle is then taken out and 60 to 75 per cent of space created by withdrawal of needle is filled with gun powder. A Bickford fuse, a small rope of cotton coated with tar, is placed just touching the needle. The other end of the fuse is kept of sufficient length so that the person igniting it can move away to a safe place. Blasting powder and cordite are ignited by means of a fuse, whereas gun cotton and dynamite are exploded by detonation.

Precaution in Blasting: Accidents may take place during blasting. Following are some of the points which should be taken note of:

1. Blasting should not be carried out in late evening or early morning hours. The blasting hours should be made public and a siren should warn the workmen and nearby public timely to retire to a safe distance.
2. The danger zone, an area of about 200 m radius, should be marked with red flags.
3. First aid should be available.
4. The number of charges fired, the number of charges exploded and the misfires should be recorded.
5. Explosives should be stored and handled carefully.
6. Detonators and explosives should not be kept together.
7. Cartridges should be handled with rubber or polythene gloves.
8. A maximum of 10 bore holes are exploded at a time and that also successively and not simultaneously.

Dressing of Stones:

A quarried stone has rough surfaces, which are dressed to obtain a definite and regular shape. Dressing of stones is done immediately after quarrying and before seasoning to achieve less weight for transportation. Dressing of stone provides pleasing appearance, proper bedding with good mortar joints, special shapes for arches, copings, pillars, etc. The various types of dressed stones are shown in Fig



(a) Stroked
(b) Punched
(c) Rock faced
(d) Sparrow picked
(e) Tooled
(f) Sawn
(g) Combed
(h) Vermiculated
(i) Reticulated

Composition of Good Bricks Earth:

For the preparation of bricks, clay or other suitable earth is moulded to the desired shape after subjecting it to several processes. After drying, it should not shrink and no crack should develop. The clay used for brick making consists mainly of silica and alumina mixed in such a proportion that the clay becomes plastic when water is added to it. It also consists of small proportions of lime, iron, manganese, sulphur, etc. The proportions of various ingredients are as follows:

Silica	50–60%	
Alumina	20–30%	
Lime	10%	
Magnesia	< 1%	Less than 20%
Ferric oxide	< 7%	
Alkalis	< 10%	
Carbon dioxide		Very small percentage
Sulphur trioxide		
Water		

Various methods of manufacturing of bricks:

Fly Ash: A waste material available in large quantities from thermal power plants can be added to alluvial, red, black, marine clays, etc. The fly ash contains amorphous glassy material, mullite, haematite, magnetite, etc. and shows a chemical composition similar to brick earths.

These silicates also help towards strength development in clay bodies on firing, when mixed in optimum proportion depending on the physio-chemical and plastic properties of soils to be used for brick making. The proportion of fly ash mixed as an additive to the brick earth

should be optimum to reduce drying shrinkage, check drying losses and to develop strength on firing without bloating or black coring in fired product. The crystallites present in the fly ash should comply with the resultant high temperature phases in the finished product. ***Sandy Loam*** Addition of sandy loam is often found effective in controlling the drying behaviour

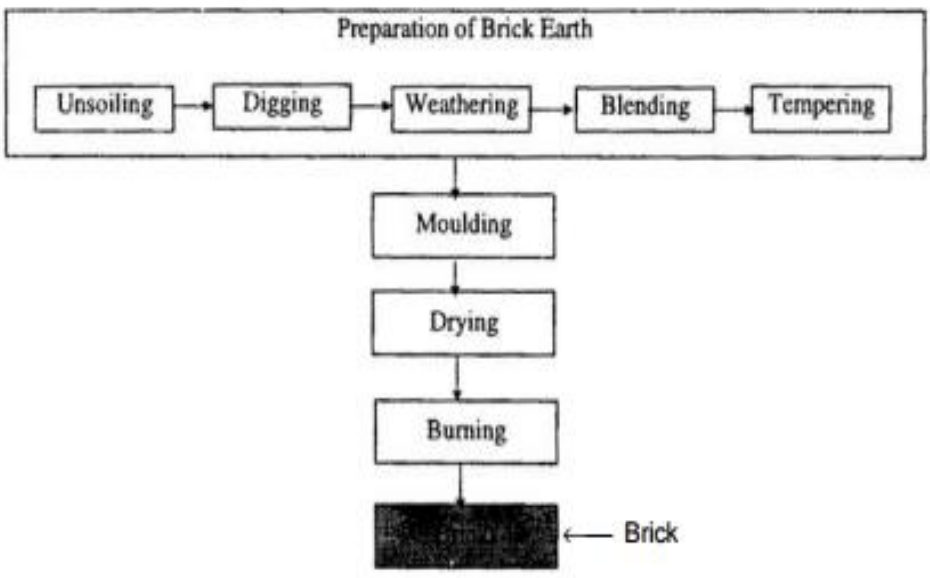
of highly plastic soil mass containing expanding group of clay minerals. Sandy loam should preferably have a mechanical composition as specified below. The material should, however, meet the other requirement as well.

Clay	(< 2 micron)	8–10%
Silt	(2–20 micron)	30–50%
Sand	(> 20 micron)	40–60%

Rice Husk Ash: The ash should preferably have unburnt carbon content in the range of 3–5% and should be free from extraneous material. It can be used with plastic black red soils showing excessive shrinkage.

Basalt Stone Dust: Basalt stone occurs underneath the black cotton soil and its dust is a waste product available in large quantity from basalt stone crushing units. The finer fraction from basalt stone units is mixed with soil mass to modify the shaping, drying and firing behaviour of bricks. The dust recommended for use as an additive with brick earth should be fine (passing 1 mm sieve), free from coarse materials or mica flakes and should be of non-calcitic or dolomitic origin.

The operations involved in the manufacture of clay bricks are represented diagrammatically in Fig.



PREPARATION OF BRICK:

It consists of the following operations.

Unsoiling: The soil used for making building bricks should be processed so as to be free of gravel, coarse sand (practical size more than 2 mm), lime and kankar particles, organic matter, etc. About 20 cm of the top layer of the earth, normally containing stones, pebbles, gravel, roots, etc., is removed after clearing the trees and vegetation.

Digging: After removing the top layer of the earth, proportions of additives such as fly ash, sandy loam, rice husk ash, stone dust, etc. should be spread over the plane ground surface on volume basis. The soil mass is then manually excavated, puddled, watered and left over for weathering and subsequent processing. The digging operation should be done before rains.

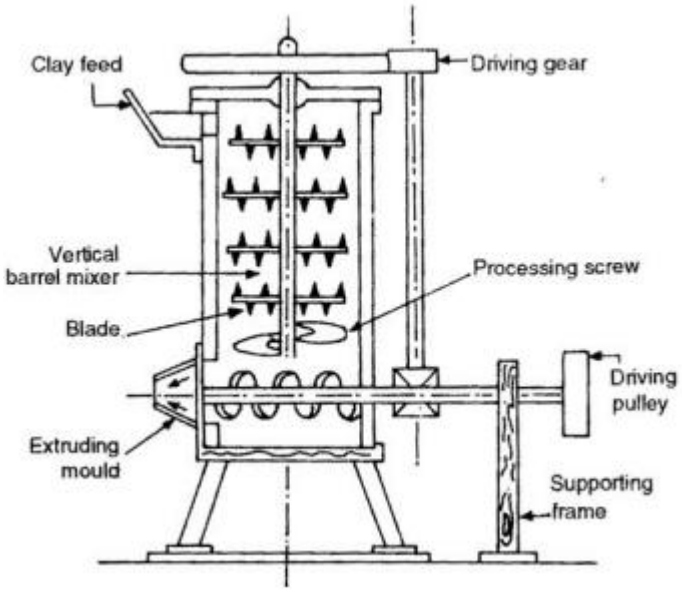
Weathering*:* Stones, gravels, pebbles, roots, etc. are removed from the dug earth and the soil is heaped on level ground in layers of 60–120 cm. The soil is left in heaps and exposed to weather for at least one month in cases where such weathering is considered necessary for the soil. This is done to develop homogeneity in the mass of soil, particularly if they are from different sources, and also to eliminate the impurities which get oxidized.

Blending: The earth is then mixed with sandy-earth and calcareous-earth in suitable proportions to modify the composition of soil. Moderate amount of water is mixed so as to obtain the right consistency for moulding. The mass is then mixed uniformly with spades. Addition of water to the soil at the dumps is necessary for the easy mixing and workability, but the addition of water should be controlled in such a way that it may not create a problem in moulding and drying. Excessive moisture content may effect the size and shape of the finished brick.

Tempering: Tempering consists of kneading the earth with feet so as to make the mass stiff and plastics (by plasticity, we mean the property which wet clay has of being permanently deformed without cracking). It should preferably be carried out by storing the soil in a cool place in layers of about 30 cm thickness for not less than 36 hours. This will ensure homogeneity in the mass of clay for subsequent processing.

For manufacturing good brick, tempering is done in pug mills and the operation is called pugging. Pug mill consists of a conical iron tube as shown in Fig. The mill is sunk 60 cm into the earth. A vertical shaft, with a number of horizontal arms fitted with knives, is provided at the centre of the tube. This central shaft is rotated with the help of bullocks yoked at the end of long arms. However, steam, diesel or electric power may be used for this purpose. Blended earth along with required water, is fed into the pug mill from the top. The knives cut through

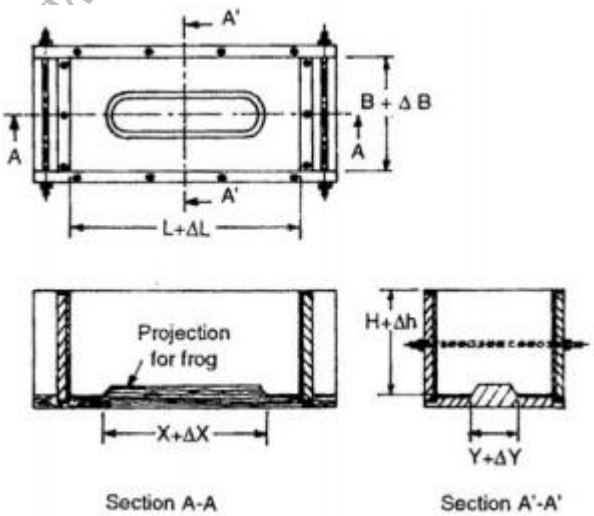
the clay and break all the clods or lump-clays when the shaft rotates. The thoroughly pugged clay is then taken out from opening provided in the side near the bottom. The yield from a pug mill is about 1500 bricks.



Moulding:

It is a process of giving a required shape to the brick from the prepared brick earth. Moulding may be carried out by hand or by machines. The process of moulding of bricks may be the soft-mud (hand moulding), the stiff-mud (machine moulding) or the dry press process (moulding using maximum 10 per cent water and forming bricks at higher pressures). Fire-brick is made by the soft mud process. Roofing, floor and wall tiles are made by dry-press method. However, the stiff-mud process is used for making all the structural clay products.

Hand Moulding: A typical mould is shown in Fig Hand moulding is further classified as ground moulding and table moulding.

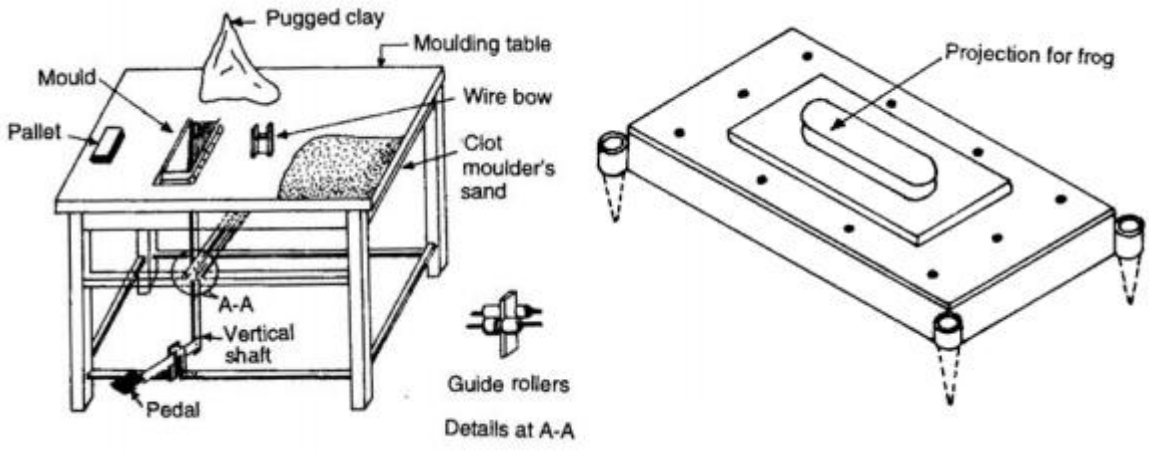


Ground Moulding: In this process, the ground is levelled and sand is sprinkled on it. The moulded bricks are left on the ground for drying. Such bricks do not have frog and the lower brick surface becomes too rough. To overcome these defects, moulding blocks or boards are used at the base of the mould. The process consists of shaping in hands a lump of well pugged

earth, slightly more than that of the brick volume. It is then rolled into the sand and with a jerk

it is dashed into the mould. The moulder then gives blows with his fists and presses the earth properly in the corners of the mould with his thumb. The surplus clay on the top surface is removed with a sharp edge metal plate called strike or with a thin wire stretched over the mould. After this the mould is given a gentle slope and is lifted leaving the brick on the ground to dry.

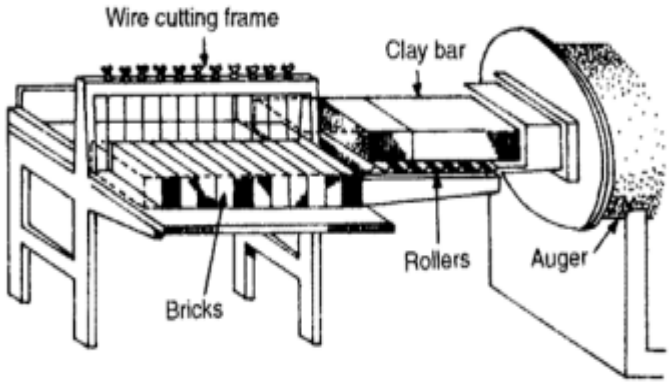
Table Moulding: The bricks are moulded on stock boards nailed on the moulding table. Stock boards have the projection for forming the frog. The process of filling clay in the mould is the same as explained above. After this, a thin board called pallet is placed over the mould. The mould containing the brick is then smartly lifted off the stock board and inverted so that the moulded clay along with the mould rests on the pallet. The mould is then removed as explained before and the brick is carried to the drying site.



Machine Moulding: *It can* be done by either of the following processes:

Plastic Method: The pugged, stiffer clay is forced through a rectangular opening of brick size by means of an auger. Clay comes out of the opening in the form of a bar. The bricks are cut

from the bar by a frame consisting of several wires at a distance of brick size as shown in Fig. This is a quick and economical process.



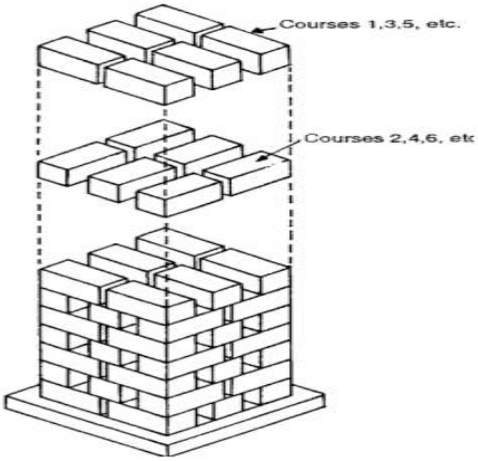
Dry – Press Method: The moist, powdered clay is fed into the mould on a mechanically operated press, where it is subjected to high pressure and the clay in the mould takes the shape of bricks. Such pressed bricks are more dense, smooth and uniform than ordinary bricks. These are burnt carefully as they are likely to crack.

Drying:

Green bricks contain about 7–30% moisture depending upon the method of manufacture. The object of drying is to remove the moisture to control the shrinkage and save fuel and time during burning. The drying shrinkage is dependent upon pore spaces within the clay and the mixing water. The addition of sand or ground burnt clay reduces shrinkage, increases porosity and facilities drying. The moisture content is brought down to about 3 per cent under exposed conditions within three to four days. Thus, the strength of the green bricks is increased and the bricks can be handled safely.

Clay products can be dried in open air driers or in artificial driers. The artificial driers are of two types,the hot floor drier and the tunnel drier. In the former, heat is applied by a furnace placed at one end of the drier or by exhaust steam from the engine used to furnish power and is used for fire bricks, clay pipes and terracotta. Tunnel driers are heated by fuels underneath, by steam pipes, or by hot air from cooling kilns. They are more economical than floor driers. In artificial driers, temperature rarely exceeds 120°C.The time varies from one to three days. In developing countries, bricks are normally dried in natural open air driers.

They are stacked on raised ground and are protected from bad weather and direct sunlight. A gap of about 1.0 m is left in the adjacent layers of the stacks so as to allow free movement for the workers.

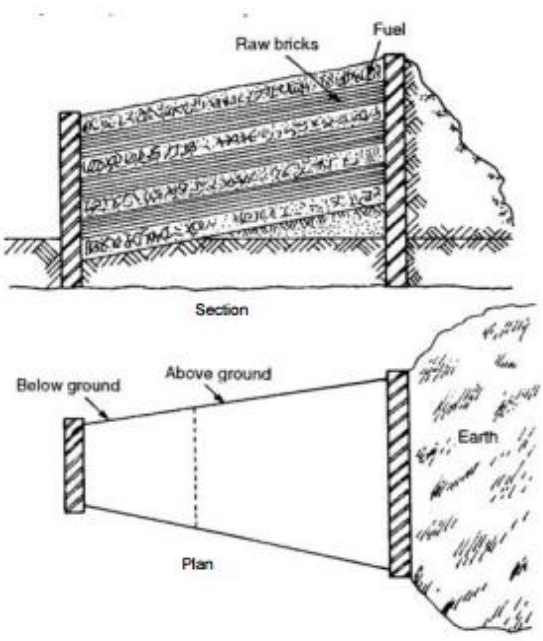


Burning of Bricks:

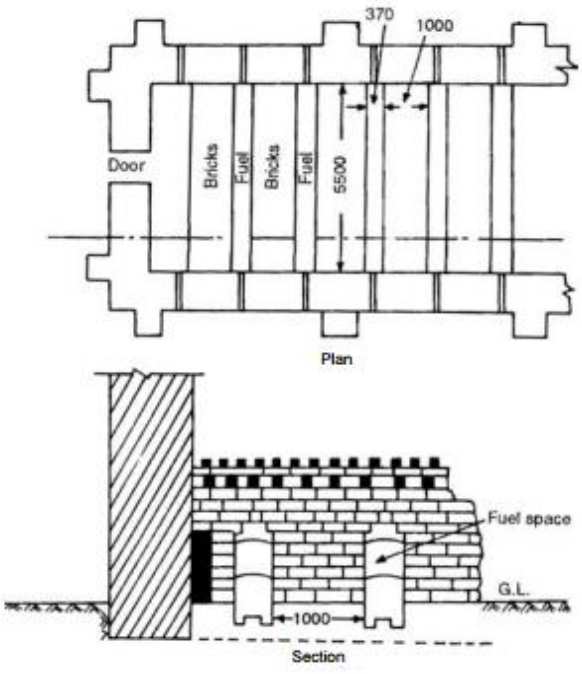
Kiln Burning: The kiln used for burning bricks may be underground, e.g. Bull's trench kiln or overground, e.g. Hoffman's kiln. These may be rectangular, circular or oval in shape. When the process of burning bricks is continuous, the kiln is known as continuous kiln, e.g. Bull's trench and Hoffman's kilns. On the other hand if the process of burning bricks is discontinuous, the kiln is known as intermittent kiln.

Intermittent Kiln: The example of this type of an over ground, rectangular kiln is shown in Fig.

After loading the kiln, it is fired, cooled and unloaded and then the next loading is done. Since the walls and sides get cooled during reloading and are to be heated again during next firing, there is wastage of fuel.



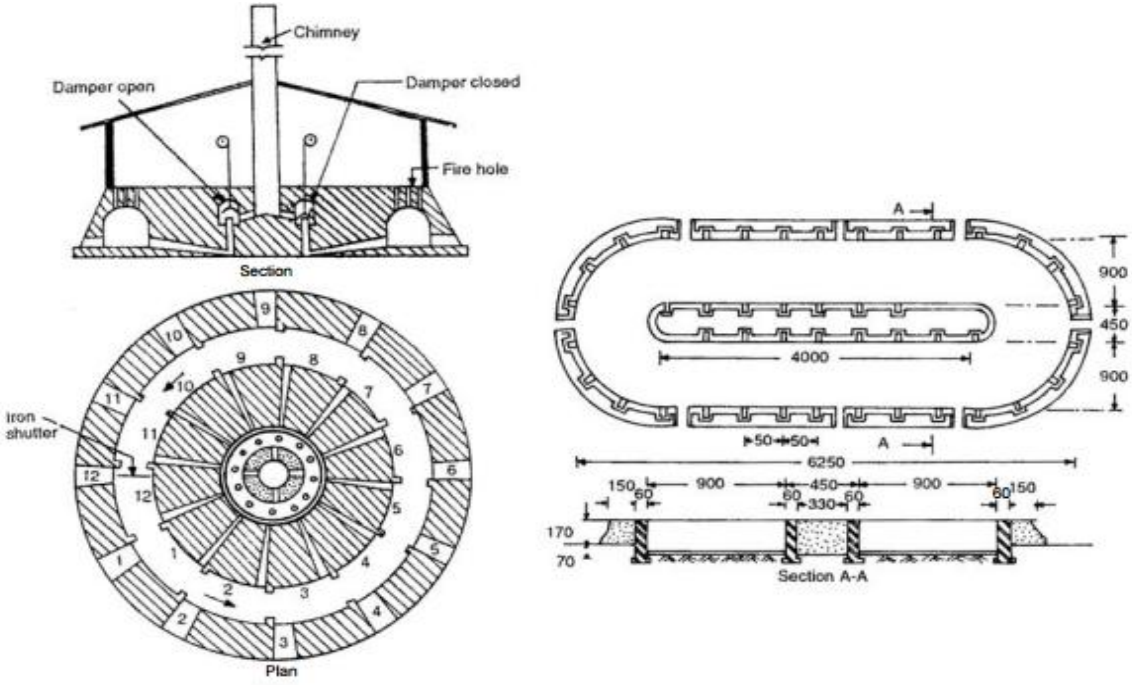
Clamp or Pazawah



Intermittent Kiln

Continuous Kiln: The examples of continuous kiln are Hoffman's kiln and Bull's trench kiln. In a continuous kiln, bricks are stacked in various chambers wherein the bricks undergo different treatments at the same time. When the bricks in one of the chambers is fired, the bricks in the next set of chambers are dried and preheated while bricks in the other

set of chambers are loaded and in the last are cooled.



CHARACTERISTICS OF GOOD TILES:

1. It should be free from any cracks, bends.
2. It should be regular shape and size.
3. It should be sound, hard & durable.
4. It should be well burnt.
5. It should be fit in properly, when placed in position.
6. It should possess uniform colour.

Manufacturing Methods of tiles:

There are four methods of Manufacturing methods of tiles:

Preparation of clay:

The selected clay is taken, such clay is then pressed and converted into fine powder in pug mills. The tiles of superior quality, a large quantity of pure water is added to the powdered clay and it is well mixed in a tank. The coarse heavy particles settle at the bottom of tank.

Moulding:

The clay is placed in moulds which represent the shape in which the tile is to be formed.

Drying:

The tiles, as they came out of moulds, are placed flat one above the other in suitable number. After about 2 days, the edges and under surfaces are cleaned. They are stacked on edge under a shade to dry for about two days (or) so.

Burning:

The tiles are then burnt in kilns. A typical kiln known as the Sialkot kiln, for accommodating about 30000 to 40000 tile.

Types of tiles:

There are two types:

1. Common tiles
2. Encaustic tiles

Common Tiles:

These tiles have different shapes and sizes. They are mainly used for paving, flooring and roofing.

Types of common tiles:

(A). Drain Tiles: These tiles are laid in the water logged areas.

(B). Floor (or) Paving tiles: The floor tiles should be hard and compact so that they can resisit water and tear in a better way.

(C). Roof Tiles: These tiles are used to serve as covering for pitched roof.

Different types of roof tiles:

1. Allahabad tiles
2. Corrugated tiles
3. Flat tiles
4. Manglore tiles
5. Flemish tiles
6. Guna tiles

Encaustic tiles:

These tiles are used for decorative purposes in floors, walls, ceilings and roofs.

An encaustic tile usually consists of the following three layers.

(a). Body: It is made of coarser clay.

(b). Face: It comprises of a 6 mm coat of finer clay and the colouring matter for making the ground of the pattern.

(c). Back: It is a thin coat of clay to prevent the tile from warping.

UNIT – II

MASONRY

Wood structure:

A tree can be divided into three portions, crown—composed of branches and leaves, trunk, and roots. The trunk accounts for about 80 per cent of the total bulk of wood. Figure 4.1 shows the structure of well grown timber from trunk of the exogenous tree. The structure of timber visible to naked eye or at a small magnification is called macrostructure, and that apparent only at great magnifications, the micro structure. Macro structure of the timber can be studied by cutting the trunk in three directions .In the cross-sectional and radial ducts, the following main parts of a tree, e.g. bark, cambium, sap wood, heart wood and pith, become readily apparent. Each of the components has a specific function. The bark protects the wood against mechanical damage. Its inner layer, called bast conveys the nutrients from the crown downwards and stores them. The function of cambium is to grow wood cells on the inside and smaller bast cells on the outside. The sapwood assists in the life process of tree by storing up starch and conducting sap. The cells in the sap wood are active. The heart wood gives a strong and firm support to the tree. With the growth of tree, the cells in the inner older portion of trunk gradually become inactive and lifeless, but do not decay. This portion of the trunk is called heart wood. At the centre of the cross-section is the pith, a small area occupied by friable tissues consisting of thin walled, loosely connected cells called plinth.

In a felled tree, it easily crumbles and rots. In the cross-sectional direction, nutrients pass from bast to the heart through groups of cells running at right angles to the cambium layers and are referred to as medullary rays.

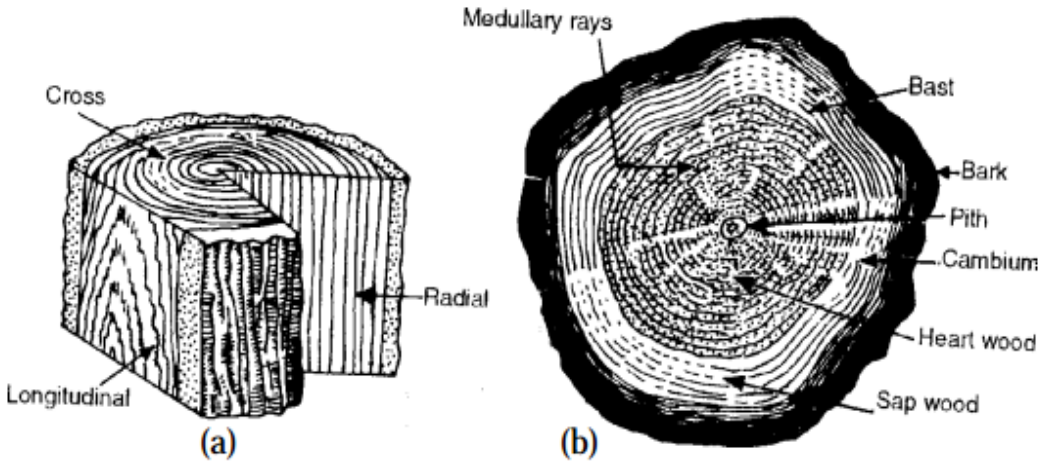


Fig. 4.1 Cross Section of a Tree

Properties of wood:

The principal characteristics of timber of concern are strength, durability and finished appearance.

1. Narrow annual rings, closer the rings greater is the strength.
2. Compact modularly rays.
3. Dark colour.
4. Uniform texture.
5. Sweet smell and a shining fresh cut surface.
6. When struck sonorous sound is produced.
7. Free from the defects in timber.
8. Heavy weight.
9. No woolliness at fresh cut surface.

Seasoning of timber:

Seasoning is the process of reducing the moisture content (drying) of timber in order to prevent the timber from possible fermentation and making it suitable for use. It can also be defined as the process of drying the wood to a moisture content approximately equal to the average humidity of the surroundings, where it is to be permanently fixed. Very rapid seasoning after removal of bark should be avoided since it causes case hardening and thus increases resistance to penetration of preservatives. Some of the objects of seasoning wood are as follows:

1. Reduce the shrinkage and warping after placement in structure.
2. Increase strength, durability and workability.
3. Reduce its tendency to split and decay.
4. Make it suitable for painting.
5. Reduce its weight

Classification of Timber:

The terms timber and wood are often used synonymously, but they have distinct meanings in the building industry. Wood is the hard, fibrous material that makes up the tree under the bark,

whereas timber may be defined as a wood which retains its natural physical structure and chemical composition and is suitable for various engineering works. Following is the classification of timber.

On basis of the positions:

Standing Timber: implies a living tree.

Rough Timber: forms a part of the felled tree.

Converted Timber (or) Lumber are logs of timber sawn into planks, posts, etc.

On basis of grading:

All grading specifications are clearly distinguished between structural or stress grading, and commercial or utility grading based on Indian Standard classification.

Structural Grading: also known as stress grading. However, there is a small distinction between the two. Structural grading refers to the principle by which the material is graded on the basis of visible defects which have known effects on the strength properties of the material. Stress grading refers to the principle by which the material is graded by consideration of maximum principle stresses to which it can be subjected. Structural grading is further divided as:

1. Grading based on known effects of defects and estimating accumulative value.
2. Machine grading.

Commercial Grading: also known as yard grading or utility grading refers to the principle by which the material is graded by consideration of usefulness of the material and price factors. Commercial grading is further divided in the following classes:

Grade A: This classification is based on dimensions and general appearance. The dimensions of lengths, widths and thicknesses of converted materials are measured. This system is prevalent is Kerala and Mysore.

Grade B: This classification is based on the best ultimate use of the material. Such a system is mostly in Andhra Pradesh and some parts of Tamil Nadu. Here, each grade is further divided into A, B and C classes to indicate occurrence of defects. Only two lengths are recognized, long (L) which is 5m and above, and short(S) that is under 5m. Each log is stamped such as BAL (Beam, A-class, long), PBS (Plank, B-class, short), etc. Some times another letter is also added indicating the species, e.g. T for teak.

Grade C: This classification is based on qualitative evaluation of defects and rough estimate of out-turn of utilizable material. It is prevalent in Madhya Pradesh.

Grade D: This classification is based on evaluation of units of defects and fixing the permissible number of standard volume of area or the material in each grade. This system is prevalent inBombay region and is increasingly adopted in Indian Standards and is recognized internationally.

On basis of Modulus of Elasticity:

The species of timber recommended for constructional purpose are classified as

Group A: Modulus of elasticity in bending above 12.5 kN/mm2

Group B: Modulus of elasticity in bending above 9.8 kN/mm2 and below 12.5 kN/mm2

Group C: Modulus of elasticity in bending above 5.6 kN/mm2 and below 9.8 kN/mm2 .

On basis of Availability:

According to availability, timber can be of three grades, namely X, Y and Z.

X—Most common, 1415 m3 or more per year

Y—Common, 355 m3 to 1415 m3 per year

Z—Less common, below 355 m3 per year

This is based upon the figures supplied by the forest departments.

On basis of Durability:

Test specimens of size 600 × 50 × 50 mm are buried in the ground to half their lengths. The condition of the specimen at various intervals of time is noted and from these observations their average life is calculated. Timbers are classified based upon such observations as of

High durability average life of 120 months and over.

Moderate Durability average life of less than 120 months but of 60 months or more.

Low Durability average life of less than 60 months.

On basis of Seasoning Characteristics:

Timbers are classified depending upon their behaviour to cracking and splitting during normalair-seasoning practice under three categories.

Highly Refractor (CLASS A)- are slow and difficult to season-free from defects.

Moderately Refractor (CLASS B) - may be seasoned free from surface defects, etc. if some protection is given against rapid drying.

Non Refractor y (Class C): These can be rapidly seasoned free from defects.

On basis of Treatability:

This classification is based upon the resistance offered by the heartwood of a species to preservatives under a working pressure of 1.05 N/mm2 as:

(a) Easily treatable.

(b) Treatable but complete preservation not easily obtained.

(c) Only partially treatable.

(d) Refractory to treatment.

(e) Very refractory to treatment, penetration of preservative being practically nil from the sides and ends.

DEFECTS IN TIMBER:

Defects can occur in timber at various stages, principally during the growing period and during the conversion and seasoning process. The defects in the wood are due to irregularities

in the character of grains. Defects affect the quality, reduce the quantity of useful wood, reduce the strength, spoil the appearance and favour its decay.

Defects due to abnormal growth:

Following are some of the important defects commonly found in wood due to abnormal growth or rupture of tissues due to natural forces.

Checks: is a longitudinal crack which is usually normal to the annual rings. These adversly affect the durability of timber because they readily admit moisture and air.

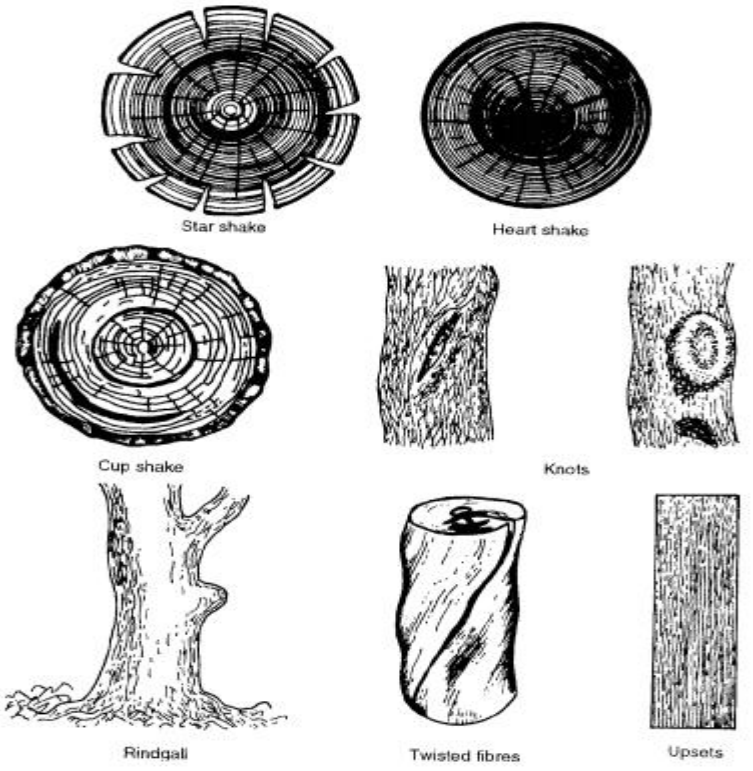
Shakes: are longitudinal separations in the wood between the annual rings. These lengthwise separations reduce the allowable shear strength without much effect on compressive and tensile values. The separations make the wood undesirable when appearance is important. Boths the shakes and checks if present near the neutral plane of a beam they may materially weaken its resistance to horizontal shear.

Heart Shake: occurs due to shrinkage of heart wood, when tree is over matured. Cracks start from pith and run towards sap wood. These are wider at centre and diminish outwards.

Cup Shake: appears as curved split which partly or wholly separates annual rings from one another. It is caused due to excessive frost action on the sap present in the tree, especially when

the tree is young.

Star Shake: are radial splits or cracks wide at circumference and diminishing towards the centre of the tree. This defect may arise from severe frost and fierce heat of sun. Star shakes appear as the wood dries below the fibre saturation point. It is a senous fault leading to separated log when sawn.



KNOTS: are bases of twigs or branches buried by cambial activity of the mother branch. The root of the branch is embedded in the stem, with the formation of annual rings at right angles to those of the stem. The knots interrupt the basic grain direction of the wood, resulting in a reduction of its strength. In addition these affect the appearance of the wood. A dead knot can be separated from the body of the wood, whereas live knot cannot be. Knots reduce the strength of the timber and affect workability and cleavability as fibres get curved. Knots are classified on the basis of size, form, quality and occurrence.

Size Pin knot (under 12 mm), small knot (12–20 mm), medium knot (20–40 mm) and large knot (over 40 mm).

Form: Round knot and spike knot (a round knot exposed by sawing lengthwise).

Quality Sound knot —as hard and solid as the surrounding wood, decayed knot—contains advanced decay and is softer than the surrounding wood, encased knot—the annual rings fail to grow into the fibres of the surrounding wood, tight knot—a knot so securely fastened that it holds its position in the finished product.

Occurrence Single knot—when wood fibres deflect around one knot, cluster knot—when wood fibres deflect about two or more knots as a unit and, branch knot—two or more knots radiating from a common centre.

End Spilts: are caused by greater evaporation of sap at the end grains of log and can be reduced by painting the exposed end grains with a water proof paint or capping the exposed end with hoop iron bandage.

Twisted Fibres: are caused by wind constantly turning the trunk of young tree in one direction.

Upsets: are caused by the crushing of fibres running transversely during the growth of the tree due to strong winds and unskilled felling consequently resulting in discontinuity of fibres.

Foxiness: is a sign of decay appearing in the form of yellow or red tinge or discolouration of over matured trees.

Rupture: is caused due to injury or impact.

Foundation:

Masonry

Masonry:-

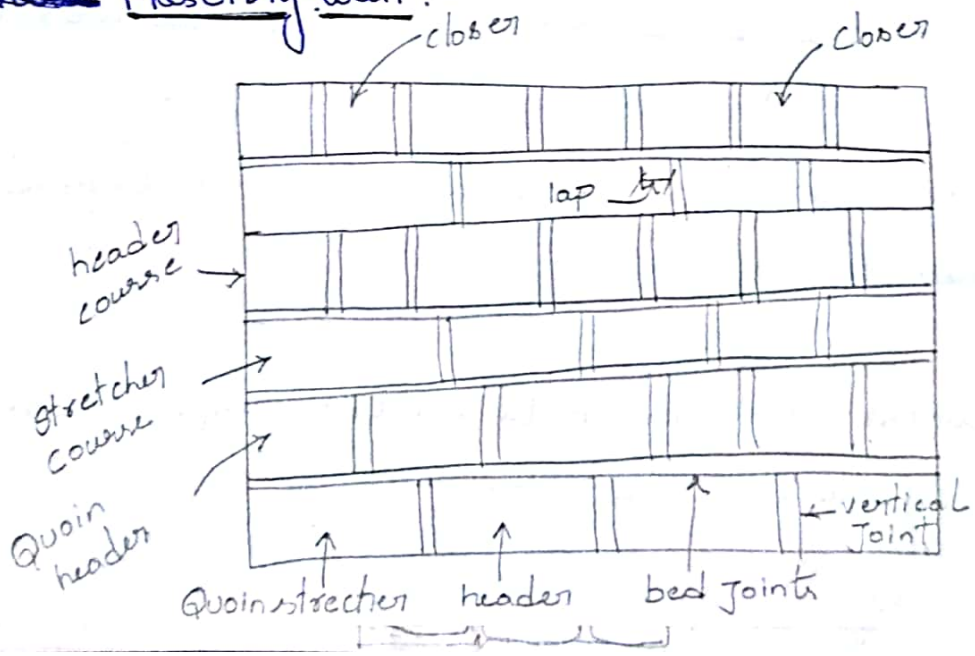
→ The Masonry is used to indicate the art of building the structure in either stones or bricks. The former type is called stone masonry and the latter type is called the brick masonry.

→ The masonry is used for the construction of foundations, walls, columns and other similar components of a structure.

Advantages:-

1. Affording architectural effect
2. Granting fire and weather protection
3. Providing acoustic and thermal insulation
4. Subdividing space,
5. supporting loads, etc.,

Masonry wall :-



Course:-

It is a horizontal layer of masonry units of a course will be equal to the height of the stone or Brick plus thickness of one mortar joint.

Header:-

It is a full stone unit or brick which is so laid that its length is perpendicular to the face of the wall.

Stretcher:-

It is a full stone unit or brick which is so laid that its length is along or parallel to the face of the wall.

Header course:-

A course of brick work showing only headers on the exposed face of the wall is known as header course

Stretcher course:-

A course of brick work showing only the stretchers on the exposed face of the wall is known as stretcher course.

closer:-

It is the portion of brick cut in such a manner that its one long face remains uncut.

Quoins:-

The exterior angle or corner of a wall is known as quoin.

Face:-

It is the surface of the wall exposed to the weather.

Back:-

The inner surface of the wall which is not exposed to weather is termed as back.

Lap:-

The horizontal distance between two perpendiculars in two successive course is called lap.

Masonry
- Stone Masonry
- Brick Masonry

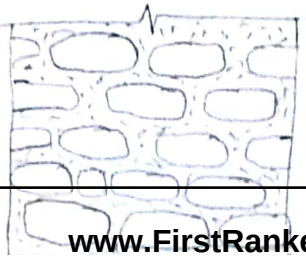
Classification of stone Masonry:-

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

Rubble Masonry:-

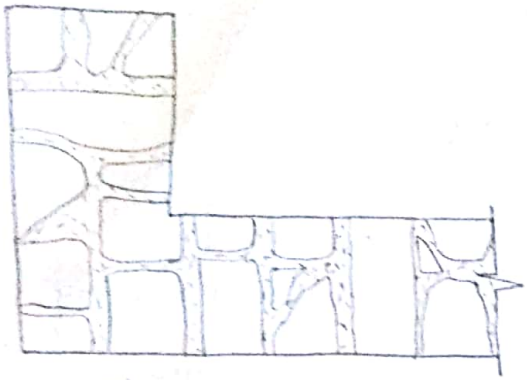
The stones, as obtained from quarry, are taken in use in the same form as they are broken and shaped in suitable sizes by means of hammer. The strength of rubble masonry mainly depends on three factors.

1. The quality of mortar.
2. The use of long through stones at frequent intervals, and
3. Proper filling of mortar between the spaces of stones

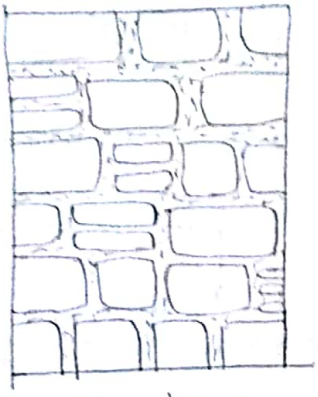


Coursed rubble masonry:-

The stones are sorted out before the work commences. The masonry work is 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 buildings etc.,



Plan



Elevation

Uncoursed rubble masonry:-

The courses are not maintained regularly. The larger stones are laid first and spaces between them are then filled up by means of spalls or snecks. The wall is brought to a level every 300mm to 500mm. This type of rubble masonry, being cheaper, is used for the construction of compound walls, godowns, garages, labour quarters etc.,

Random rubble masonry:-

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. This type of masonry is used for the construction of residential buildings, compound walls, godowns etc.,

Dry rubble masonry:-

This is just similar in construction to the coursed rubble masonry Except that no mortar is used in the joints. This type of construction is the cheapest, but it requires

Ashlar rough-tooled masonry:-

The face is made rough by means of tools A strip about 25 mm wide and made by means of a chisel, is provided around the perimeter of every stone exposed for view. The thickness of mortar joints does not exceed 6mm.

Ashlar rock or quarry faced masonry:-

A strip about 25 mm wide and made by means of a chisel, is provided around the perimeter of every stone exposed for view as in case of rough-tooled ashlar.

Ashlar chamfered masonry:-

The strip is provided ~~on~~ a and chamfered or bevelled at an angle of 45 degrees by means of chisel for a depth of about 25 mm. 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 b/w the rubble masonry and the ashlar masonry. 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, railway stations, temples, bridges, public buildings etc.,

more skill construction. It is extensively used for compound walls, pitching on bridge approaches, retaining walls etc.

Polygonal rubble masonry:-

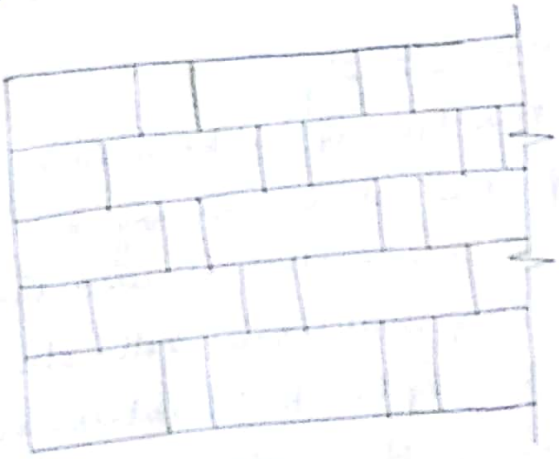
The stones are hammer-dressed and the stones selected for face work are dressed in an irregular polygonal shape. It is difficult to adjust them with regard to stability and appearance of the work as a whole.

Flint rubble masonry:-

The stones are extremely hard. But they are brittle and therefore they break easily. The face arrangement may be either coursed or uncoursed.

Ashlar masonry:-

The stone masonry in which properly cut in uniform size and dressed with fine finish stones are laid with a mortar of uniform thickness is called ashlar masonry.

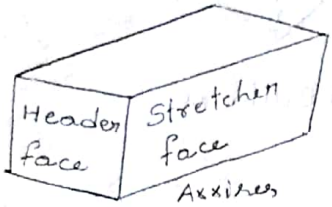


Ashlar fine masonry:-

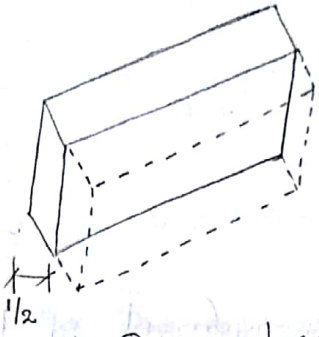
The stones are arranged in proper bond and the thickness of the mortar joints does not exceed 3mm. This type of construction gives perfectly smooth appearance, but it is costly in construction.

Brick Masonry

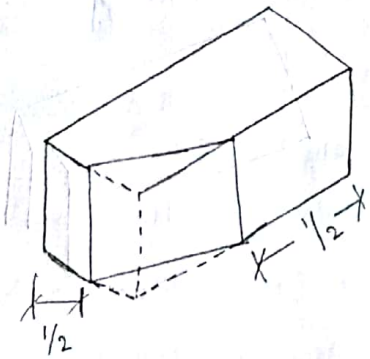
→ The bricks are obtained by moulding clay in regular rectangular blocks. These blocks are dried and then burnt to get Pucca bricks ready for use in masonry work. The construction carried out using bricks and mortar is known as brick masonry



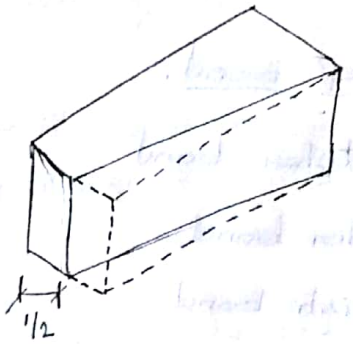
(a) Brick



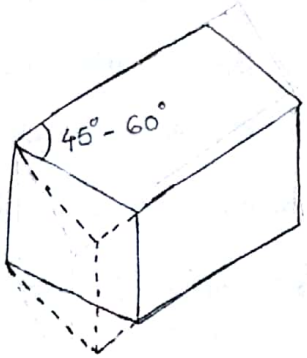
(b) Queen closer



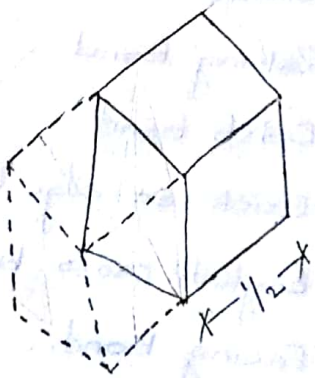
(c) King closer



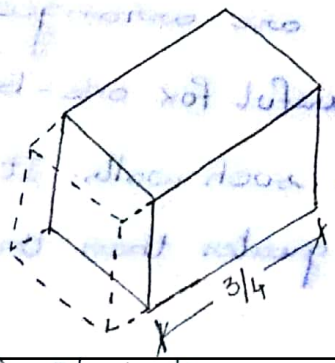
(d) Bevelled closer



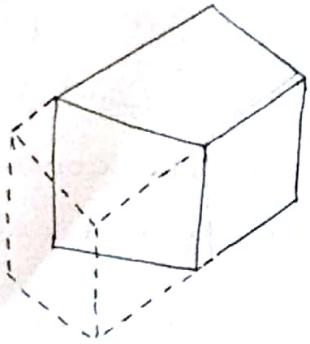
(e) Mitred closer



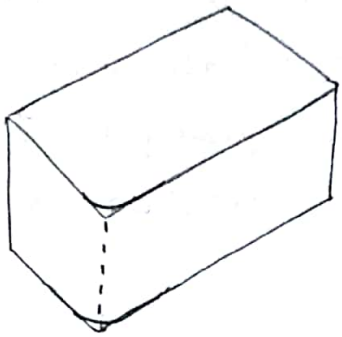
(f) Half brick



(G) 3/4 bat



(h) Bevelled bat



(i) Bullnose

Bonds:-

The arrangement of bricks in order to tie them together in a mass of brick work is called bonding.

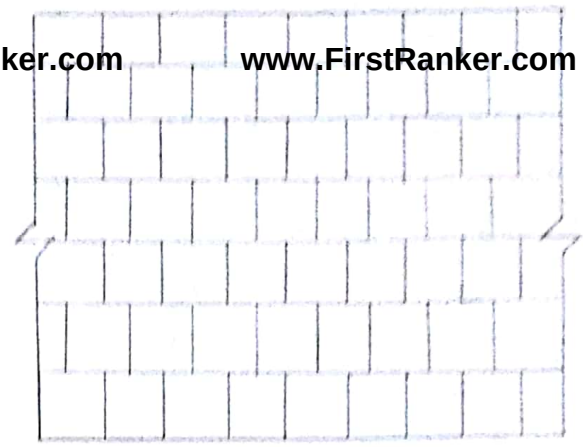
Types of bond:-

1. stretcher bond
2. Header bond
3. English bond
4. Flemish bond
5. Garden-wall bond
6. Raking bond
7. Dutch bond
8. Brick-on-edge bond
9. English cross bond
10. Facing bond.

1. stretcher bond:-

The bricks are arranged in the stretcher course The stretcher bond is useful for one-brick partition walls as there are no headers in such walls. It should not be used for walls having thicknesses greater than that of one-brick wall.

Stretcher bond



Header bond

2. Header bond:-

The bricks are arranged in header course. The overlap is usually kept equal to half the width of brick and it is achieved by using three-quarter brickbats in each alternate course as quoins. It is not suitable for load bearing walls.

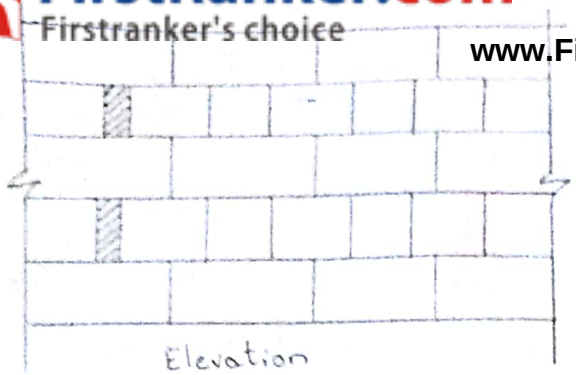
3. English bond:-

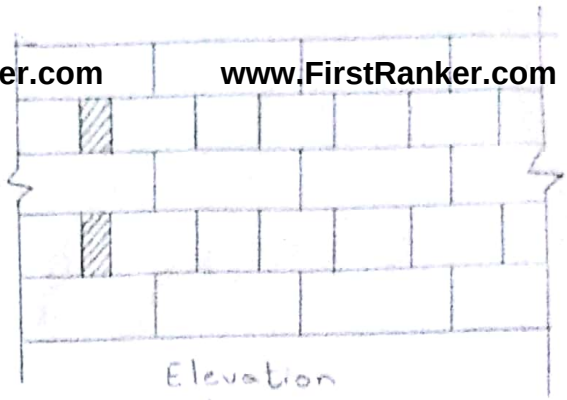
This type of bond is generally used in practice. It is considered as the strongest bond in brickwork. Following are the features of an English bond.

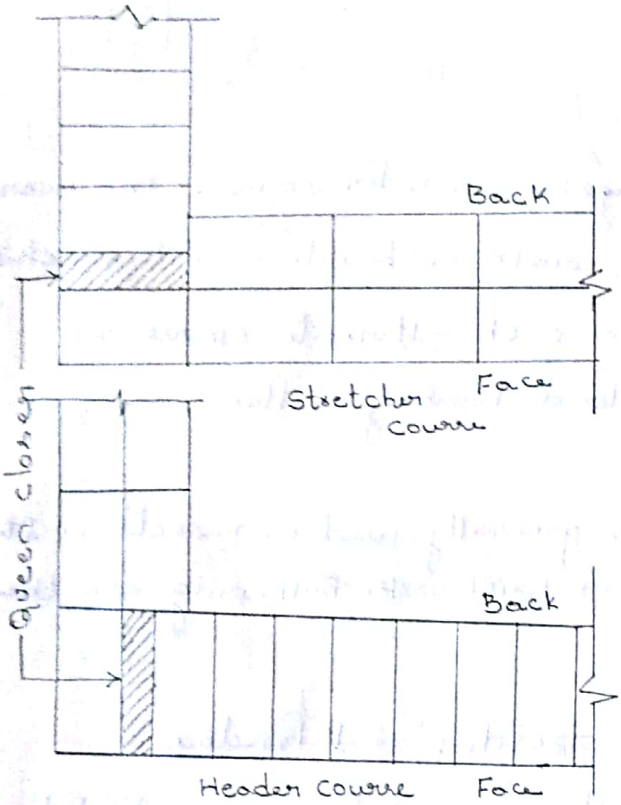
1. The alternate courses consist of stretcher and headers.
2. Each alternate header is centrally supported over a stretcher.
3. The bricks in the same course do not break joints with each other. The joints are straight.
4. The queen closers are not required in the stretcher courses.
5. In the stretcher course, the stretcher have a minimum lap of one-fourth of their length over the headers.

Figures are over-back.

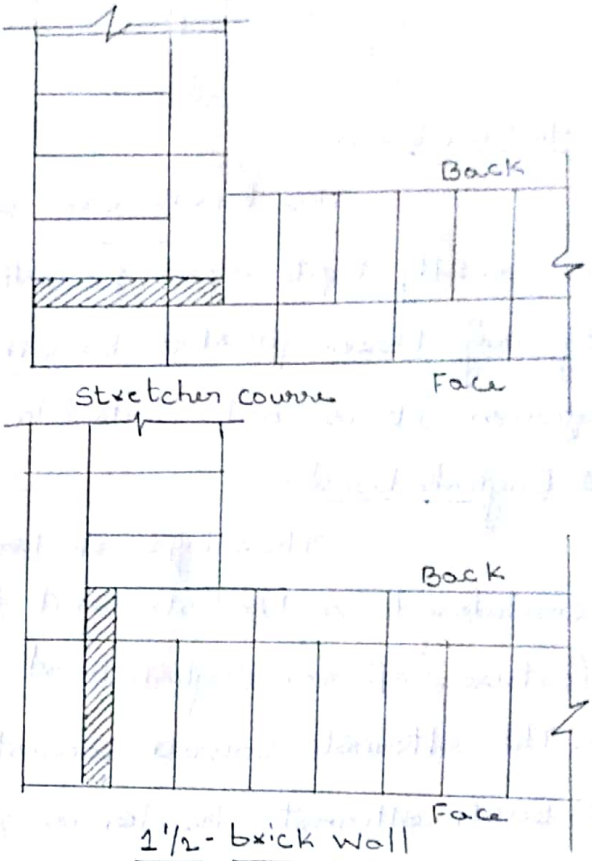
P.T.O



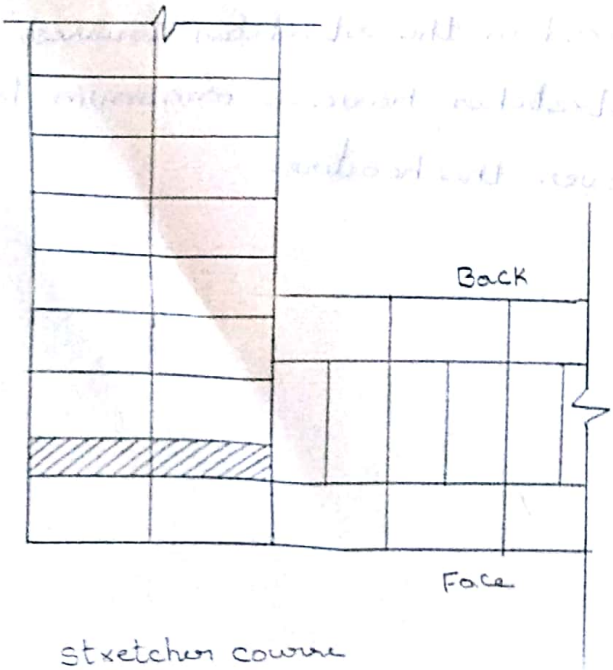


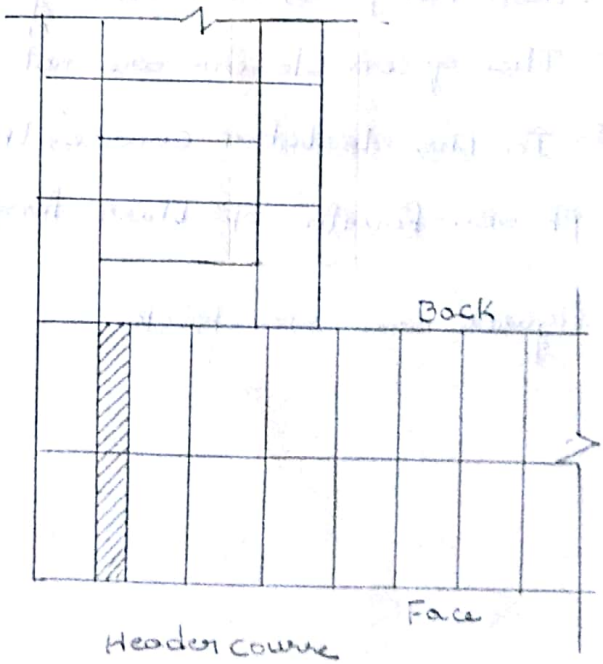


1- brick wall



1½- brick wall

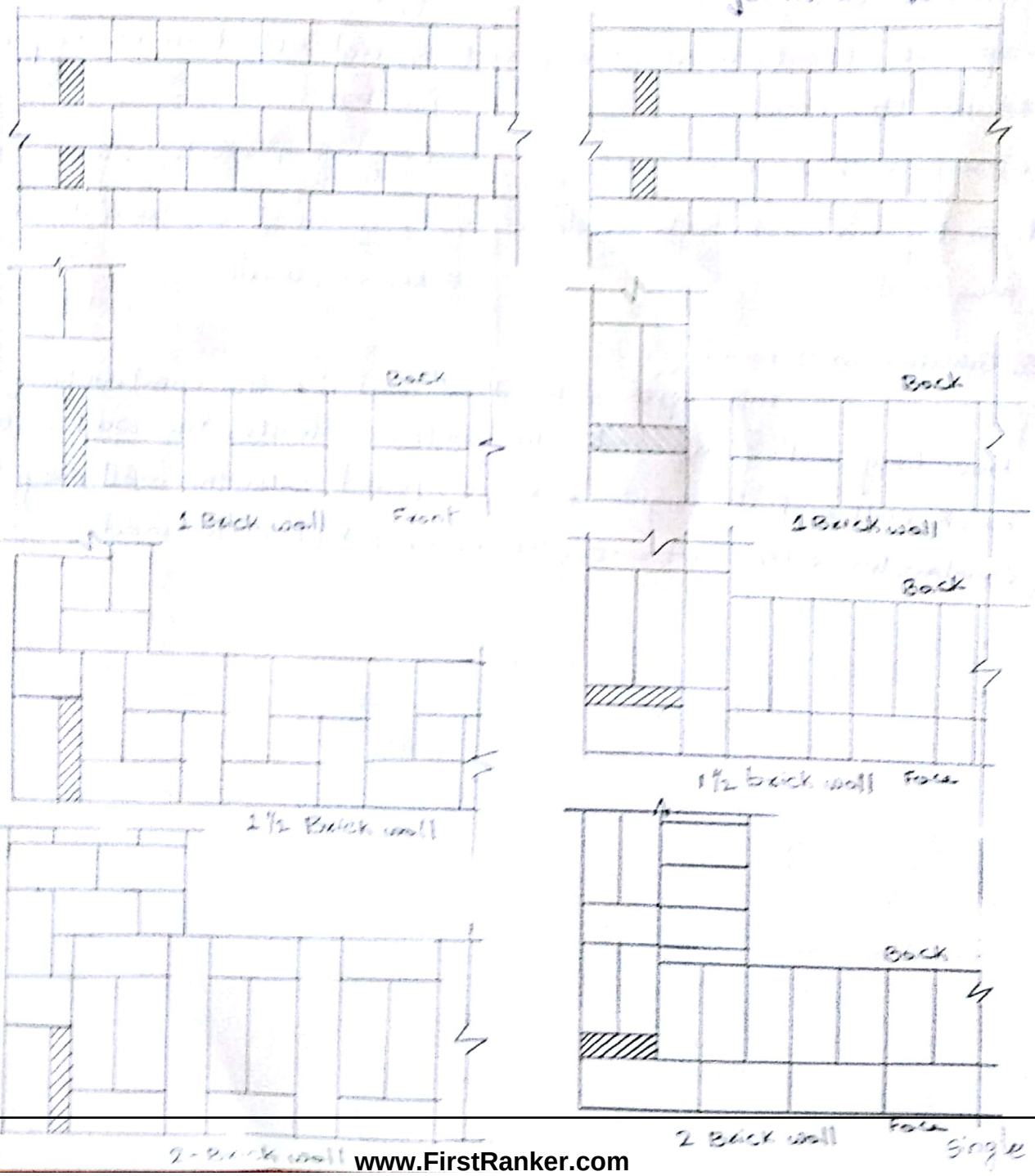




2- Brick wall

In this type of bond, the headers are distributed evenly and hence, it creates a better appearance than the English bond.

1. In every course, the headers and stretchers are placed alternatively.
2. Every header is centrally supported over a stretcher below it.
3. The Flemish bond may be divided into two groups.
   1. Double Flemish bond
   2. Single Flemish bond
4. In this bond, the short continuous vertical joints are formed.

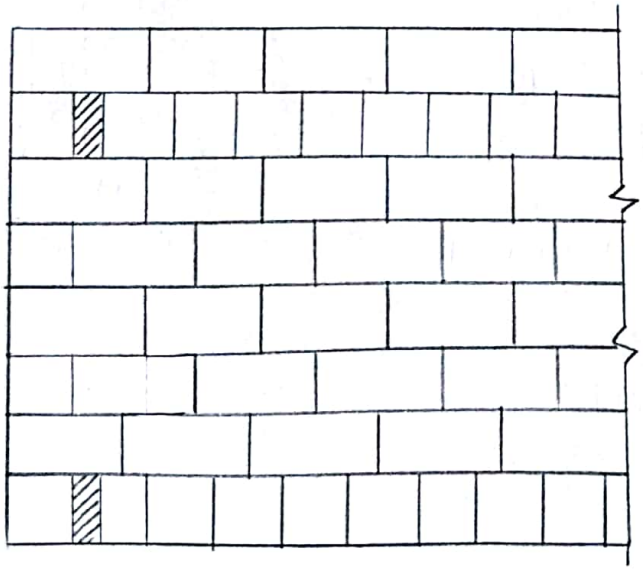


Comparison between English bond and Flemish bond:-

English bond	Flemish bond
1. Headers & stretchers are laid in alternate courses.	1. Header & stretcher are laid in alternately in each course.
2. Strongest of all types of bonds.	2. Comparitively less strong for walls more than 30 cm thick.
3. Provides rough appearance.	3. Provides good appearance.
4. Absence of vertical joints in the structure	4. Partly continous vertical joints appear in the structure
5. special attention is not requir-ed for this bond	5. Special attention is required for bond.
6. Progress of work is more	6. Progress of work is less
7. Costly, no bricks bats (or) Closer are used	7. Economical as brickbats or closer are used.

5. Garden-wall bond:-

This type of bond is used for the construction of the boundary walls, compound walls, garden walls etc., The wall is one-brick wall and its height does not exceed 2m. The wall may be constructed either in the English bond (or) Flemish bond.



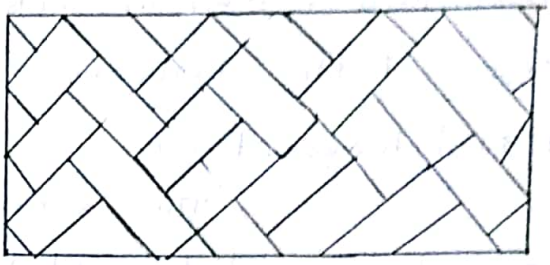
Garden-wall English bond

Zaking bond

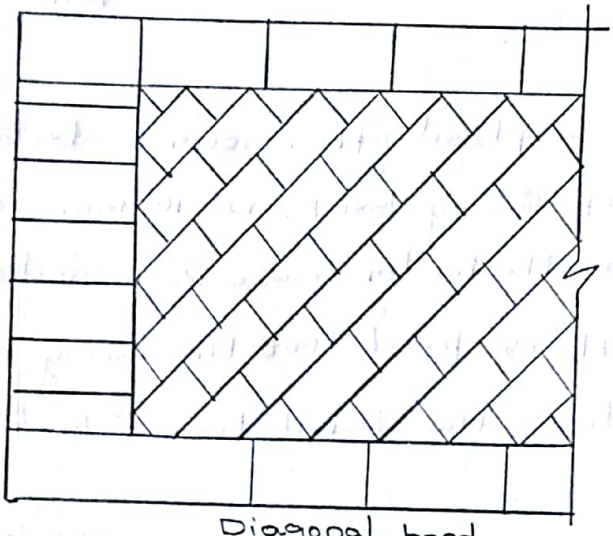
The filling of thicker walls is done by headers only, such walls become weak in the longitudnal direction. The zaking or inclined bonds are used in some cases as zemedial measures.

The 3 types of zaking bonds are

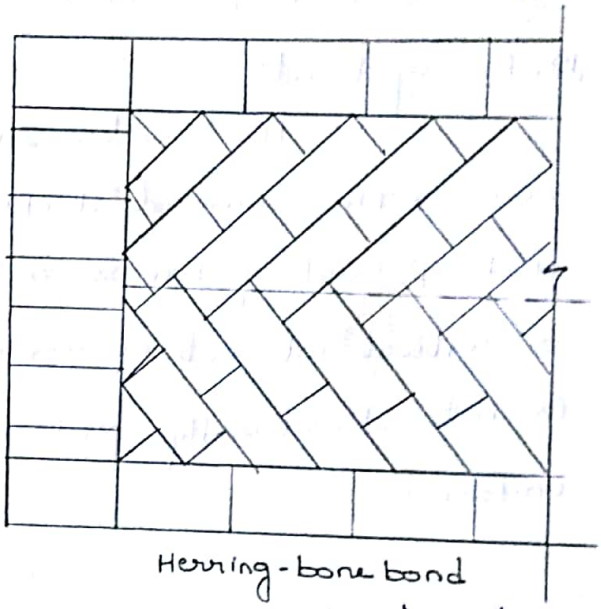
1. Diagonal bond
2. herring-bone bond
3. zig-zag bond.



zig-zag bond



Diagonal bond

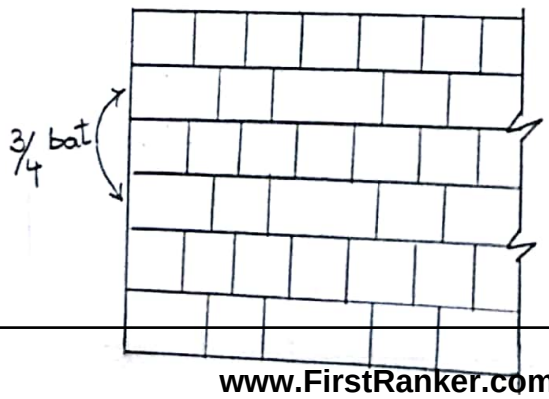


Herring-bone bond

Dutch bond:-

This is a modified form of the English bond and by this bond, the corner of the wall is strengthened. The elevation of a wall with Dutch bond is as follows.

1. The alternate courses are of headers and stretchers.
2. The quoin of a stretcher course is a three-quarter bat.
3. A header is introduced next to the three-quarter bat in every alternate stretcher course.



Dutch bond

8. Brick on edge bond:-

The bricks are laid on edge instead of bed. This bond is economical as it consumes less number of bricks and less quantity of mortar. The bricks are laid as headers and stretchers in alternate courses in such a way that the headers are laid on bed and the stretchers are laid on edge.

9. English cross bond:-

This is another modified form of the English bond and it is used to add beauty in the appearance of the wall. The elevation of a wall with English cross bond is as follows.

10, Facing bond:-

The header course is placed after several stretcher courses. The nominal thickness of facing bricks is 100mm and that of backing bricks is 80mm, the header course is provided at a vertical interval of 800mm. It is found that the facing bond is not structurally good and hence the distribution of load is not uniform.

UNIT – 3

LIME AND CEMENT

INTRODUCTION

Cement is broadly described as material having adhesive and cohesive property with capacity to bond the material like stone, bricks, building blocks etc.

Cement is a binder, a substance that sets and hardens independently, and can bind other materials together. Cements are inorganic material that shows the cementing properties of setting and hardening when mixed with water.

Cement is prepared from calcareous (Ca) material and argillaceous (Al + Si) material. Cement has property of setting and hardening under water by virtue of chemical reaction of hydrolysis and hydration. Therefore, cements are generally divided into two types hydraulic and non - hydraulic that is on the basis of their setting and hardening pattern.

Hydraulic cements harden because of hydration, chemical reactions that occur independently of the mixture's water content; they can harden even underwater or when constantly exposed to wet weather. The chemical reaction that results when the anhydrous cement powder is mixed with water produces hydrates that are not water - soluble. Non – hydraulic cements must be kept dry in order to retain their strength. Portland cement is example of hydraulic cement material while ordinary lime and gypsum plaster are consider as example of non - hydraulic cement.

Cement is used for structural construction like buildings, roads, bridges, dam etc. The most important use is the production of mortar and concrete the bonding of natural or artificial aggregates to form a strong building material that is durable in the face of normal environmental effects.

Both cement and concrete are different, because the term cement refers to the material used to bind the aggregate materials of concrete. Concrete is a combination of a cement and aggregate.

In the last couple of decades of eighteenth century, modern hydraulic cements began to be developed due to fulfil following requirement

- For finishing brick buildings in wet climates
- Development of strong concretes

- Hydraulic mortars for masonry construction of harbor works, etc., in contact with sea water

As the good quality building stone became expensive and construction of prestige buildings from the new industrial bricks, and to finish them with a stucco to imitate stone became the common practice. Hydraulic lime was favored for this, but the need for a fast set time encouraged the development of new cements.

James Parker developed cement from clay minerals and calcium carbonate and patented as Roman cement in 1796. It was made into a mortar with sand, set in 15 minutes. The success of "Roman Cement" led other manufacturers to develop competing products by burning artificial mixtures of clay and chalk.

In the first decade of nineteenth century,it was proved that the "hydraulicity" of the lime was directly related to the clay content of the limestone from which it was made first by John Smeaton and then by Louis Vicat . Vicat produce artificial cement by burning of chalk and clay into an intimate mixture in 1817. Also, James Frost produced "British cement" in a similar manner around the same time, and patented in 1822. At the same time Portland cement, was patented by Joseph Aspdinin 1824.

"Setting time" and "early strength" are important characteristics of cements. Hydraulic lime, "natural" cements, and "artificial" cements all rely upon their belite content for strength development. Belite develops strength slowly. Because they were burned at temperatures below 1250°C, they contained no alite, which is responsible for early strength in modern cements. In early 1840s the first cement to consistently contain alite was made by William , who is son of Joseph Aspdin. This was what we call today "modern" Portland cement. Vicat is responsible for establishing the chemical basis of these cements, and Johnson established the importance of sintering the mix in the kiln.

William Aspdin's innovation has high manufacturing costs but the product set reasonably slowly and developed strength quickly, thus opening up a market for use in concrete. The use of concrete in construction grew rapidly from 1850 onward, and was soon the dominant use for cements. Thus Portland cement began its predominant role.

But in the early 1930s it was discovered that, Portland cement had a faster setting time it was not durable especially for highways. These leads to development of some specialty cement based on the application and requirement of strength and setting time.

CLASSIFICATION

Based on source of cement

1.Natural cement

2. Artificial cement

1. Natural cement

Natural cement is obtained by burning and crushing of 20 - 40% clay, carbonate of lime and small amount of magnesium carbonate. It is brown in colour and best variety known as Roman cement. The natural cement resembles very costly element hydraulic lime and sets very quickly and strongly as compare to artificial cement. It finds very limited application

2. Artificial cement

Artificial cement is obtained by burning of calcareous mixture at very high temperature. Mixture of ingredients should be intimate and they should be in correct proportion. Calcined product is known as Clinker. A small quantity of gypsum added to clinker and pulverized to fine powder is known as cement or ordinary cement or normal setting cement. After setting, this cement closely a variety of sandstone which is found in abundance in Portland in UK. Therefore, it is also known as Portland cement.

Based on broad sense cement

1. Natural cement
2. Puzzolana cement
3. Slag cement
4. Portland cement

1. Natural cement

It is prepared from naturally occurring lime stone by heating it to a high temperature and subsequently pulverizing it. During heating both siliceous and calcareous material are oxidized and combined to give calcium silicates and calcium aluminates.

2.Puzzolana cement

It is the material which when mixed with lime without heating gives hydraulic cement. They mainly contains silicates of aluminum, iron and calcium natural Puzzolana which is found in deposits of volcanic ash consist of glassy material and simple mixing and grinding gives the cement. Similarly slaked lime also gives Puzzolana cement but they are the cement of ancie nt time and at present hardly used.

3. Slag cement

It is made by mixing blast furnace slag and hydrated lime. Furnace slag largely contains silicates of calcium and aluminum which is granulated by pouring it into cold water. Later it is dried and mixed with hydrated lime and the mixture is finally powdered to increase the rate of setting. Accelerator like clay, salt or caustic soda may be added.

4.Portland cement

It is refine powder of calcined product of clay and lime stone. It has controlled composition and therefore setting property. It is named after the paste of cement with water which resembled in colour and hardness to the Portland stone.

Based on the application, appearance and constituent of cement

1. Acid resistance cement
2. Blast furnace cement
3. Coloured cement
4. White cement
5. Rapid hardening cement
6. High alumina cement
7. Puzzolana cement
8. Hydrophobic cement
9. Expanding cement
10. Low heat cement
11. Quick setting cement
12. Sulfate resisting cement

1. Acid resistance cement:

It is composed of ¬Acid resistant aggregates like quartz ¬ Additives such as Na_2 SiF_6 ¬ Aqueous solution of sodium silicate or sodium glass Sodium fluorosilicate accelerates the hardening process of soluble glass and increase the resistance to acid. Soluble glass (water solution of sodium or potassium silicate) is used as binding material.

The cement has poor water resistance and fails when attacked by water or weak acids. By adding 0.5% linseed oil or 2% ceresit, its resistance to water is increased and cement is known as acid and water resistance cement.

It is used in acid resistant and heat resistant coatings or insulations in chemical industry.

2.Blast furnace cement

The cement is prepared from slag obtained from blast furnace. Slag is the waste product in manufacturing of pig iron and contains the basic elements of cement like alumina, lime and silica. Clinkers of cement are ground with 60 - 65% slag.

The properties are same as ordinary cement except less strength in early days. It requires longer curing periods.

3.Coloured cement

It can be obtained by intimately mixing mineral pigments of desired colour with ordinary cement. The amount of colouring material may vary from 5 to 10 %. If it exceeds 10%, the strength of cement is affected. Chromium oxide gives green colour, while cobalt impart s blue colour. Iron oxide in different proportions gives brown, red or yellow colour. Manganese dioxide is used to produce black or brown coloured cement.

Coloured cements are widely used for finishing of floors external surfaces, artificial marble, window sill slabs, textured panel faces, stair treads etc.

4. White cement

It is a variety of ordinary cement having white colour. It is prepared from colourless oxides of iron, manganese or chromium. For burning of this cement, oil fuel is used instead of coal. It should not set earlier than 30 minutes. It should be carefully transported and stored in closed containers only. It is more costly than ordinary cement because of specific requirements imposed upon the raw materials and the manufacturing process.

It is used for floor finish, plaster work ornamental work etc.

5.Rapid hardening cement

The cement is slightly costly than ordinary cement. Initial and final setting times of it are the same as those of ordinary cement. But it attains high strength in early days. due to following facts

- Very fine grinding
- Burning at high temperatures.
- Increased lime content in cement composition.

Advantage

- ✓ As it sets rapidly, construction work may be carried out speedily.
- ✓ Increased the frequency of use of formwork of concrete, due to possible earlier removal.
- ✓ Structural members constructed with this cement may be loaded earlier.
- ✓ Requires short period of cutting.

- ✓ It obtains strength in a short period. Compressive strength at the end of one day is about 115 kg/cm^2 and after 3 days is about 210 kg/cm. Similarly tensile strength at the end of one day is about 20 kg/cm^2 and that after 3 days is about 30 kg/cm^2.
- ✓ It is light in weight.
- ✓ Allows higher permissible stresses in the design. It therefore results in economic design.

6. High alumina cement

It is produced by grinding clinkers formed by calcining bauxite (ore of Aluminium) and lime. It is specified that total alumina content should not less than 32% and the ratio by weight of alumina to lime should be between 0.85 and 1.30.

Advantage

- ✓ Can with stand high temperatures.
- ✓ Initial setting time is more than 3 hours. Final setting time is about 5 hours. Therefore, it allows more time for mixing and placing operations.
- ✓ Evolves great heat during setting, hence, not affected by frost.
- ✓ Resists the action of acids in a better way.
- ✓ Sets quickly and it attains compressive strength of about 400 kg/cm^2 after 1day and that after 3 days is about 500 kg/cm^2.
- ✓ Its setting action mainly depends on the chemical reactions and hence, it is not necessary to grind it to fine powder.

Disadvantage

- ✓ Extreme care is to be taken to
- ✓ that it does not come in contact with even traces of lime or ordinary cement.It cannot be used in mass construction as it evolves great heat.
- ✓ It is costly.

Lime:

Lime used in the past as a constituent of masonry mortar; today cement has largely replaced it for this purpose.

- ✓ It is still used in the making of the finish or putty coat for interior plaster.
- ✓ Lime is obtained from LIMESTONE. Pure limestone is $CaCO_3$ (calcium carbonate).
- ✓ Impurities like MgCO3, Al2O3, SiO2, etc may be present.
- ✓ Limes classified as non- hydraulic or hydraulic. Non - hydraulic limes do not harden without air being present (e.g. under sea).

Production of Lime:

- ✓ Excavation of limestone
- ✓ Crushing
- ✓ Grading
- ✓ Calcination to obtain quicklime
- ✓ Pulverize (99% smaller than 0.15 mm)
- ✓ Mix with water under pressure
- ✓ Dry and pulverize to obtain hydrated lime
- ✓ Marketing.

PRACTICE OF CALCINATION

- ✓ Intermitten kiln (for small scale production)
- ✓ Continuous kiln
- ✓ Rotary kiln
- ✓ Reactor kiln

KILN=FURNACE

CLASSIFICATION OF QUICKLIMES:
According to Particle Size:

- ✓ Lump lime (10 - 30 cm lumps)
- ✓ Pebble lime (2 - 5 cm)
- ✓ Granular lime (0.5 cm)
- ✓ Crushed lime (crushed to a specified grading)
- ✓ Ground lime (passes 2 mm sieve or less than 2 mm)
- ✓ pulverized lime (less than 0.15 mm or passes 0.15 mm sieve

ACCORDING TO CHEMICAL COMPOSITION

- ✓ High - calcium lime : ($CaO \geq 90\%$) rich, fat, caustic lime.
- ✓ Calcium lime : $75 < CaO < 90\%$
- ✓ Magnesium lime : $MgO \geq 20\%$
- ✓ High magnesian (dolomitic) lime: $MgO > 25\%$.

ACCORDING TO USE:

- ✓ Mortar lime (used for stonework)
- ✓ Plaster lime.

High Calcium Lime (fat lime):

Produced by burning pure limestone, essentially calcium carbonate ($CaCO_3$) so as to drive off the carbon dioxide (CO_2) leaving calcium oxide or quicklime.

When water is added to quicklime considerable heat is evolved, there is considerable expansion. Resulting product is calcium hydroxide (Ca(OH)2).

Although they are unlikely to be present in hydrated lime, unslaked particles tend to slake and expand after lime has been used; causing localized popping of plaster or expansion of brickwork (unsound).

Hardening depends on combination with carbon dioxide (CO2) from the air (carbonation) with reformation of the original calcium carbonate (CaCO3)..

Because hardening is necessarily from the outside, the interior of a mass hardens more slowly, even where a mix includes sand, which makes access of air to the interior somewhat easier.

High calcium lime is used in mortars, rendering and plasters.

High calcium limes with formulas

Limestone: $CaCO_3$ (sometimes it is as $CaCO_3 + MgCO_3$).

Limestone under 900^0C gives calcium oxide + carbon dioxide. This procedure is performed in kilns.

Production of quicklime:

$$CaCO_3 \xrightarrow{900^oC} CaO + CO_2$$

Produced CaO is quicklime

Slaking of lime:

$$CaO + H_2O \longrightarrow Ca(OH)_2 \text{ (Hydrates (slaked) lime).}$$

HYDRATION (SLAKING)

$$CaO(\text{quicklime}) + H_2O \longrightarrow Ca(OH)_2 + \text{Heat}$$

Lime intended to be used in MORTAR is usually slaked in a box.

The mixture of quicklime and water is stirred until a thin paste has been formed. This paste is then placed in a hole (or barrel) in the ground and covered with 5 - 10 cm thick soil to protect it from the action of air. It's kept in there for SEASONING;

- 1 week for use in mortar
- 6 weeks for use in plaster (appearance important)

Seasoning provides homogenous mass and completion of chemical reactions. During slaking heat evolves and volume expands (2.5 - 3 times).

Hardening of lime:

$$Ca(OH)_2 + CO_2 \longrightarrow CaCO_3 + H_2O$$

Magnesium Lime:

These non - hydraulic limes are made from limestone, contain about 20% of magnesium oxide. They slake and evolve less heat than high - calcium limes. The magnesium limes are more plastic and develops a better ultimate strength.

High Magnesium Lime

The limestone of that kind contains more than 25% of magnesium oxide.

Hydraulic Lime:

- ✓ Hardens by an internal reaction of burning chalk or limestone.
- ✓ Like all other limes, they must be thoroughly slaked, excess water would lead to premature hardening and the exact amount of water required can only be determined by experience with the particular lime concerned.
- ✓ It has low strength. So cannot be used as structural material.
- ✓ Used for ornamental and architectural works.

UNIT-4

BUILDING COMPONENTS

LINTELS: A lintel is a horizontal member which is placed across the openings like doors, windows etc. in buildings. Lintels takes the load from the structure above it and provides support. Lintel is also a type beam, the width of which is equal to the width of wall, and the ends of which are built into the wall. These are very easy to construct as compared to arches.

Types of Lintels used in Building Construction

Timber Lintels

In olden days of construction, Timber lintels were mostly used. But now a days they are replaced by several modern techniques, however in hilly areas these are using. The main disadvantages with timber are more cost and less durable and vulnerable to fire.

If the length of opening is more, then lintel is provided by jointing multiple number of wooden pieces with the help of steel bolts which was shown in fig (a). In case of wider walls, lintel is composed of two wooden pieces kept at a distance with the help of packing pieces made of wood. Sometimes, timber lintels are strengthened by the provision of mild steel plates at their top and bottom, called as flitched lintels.

Stone Lintels

These are the most common types of lintels especially where stone is abundantly available. The thickness of these are most important factor of its design. These are also provided over the openings in brick walls. Stone lintels are provided in the form of either one single piece or more than one piece.

The depth of this type is kept equal to 10 cm / meter of span, with a minimum value of 15 cm. They are used up to spans of 2 meters. In the structure is subjected to vibratory loads, cracks are formed in the stone lintel because of its weak tensile nature. Hence caution is needed.

Brick Lintels

When the opening is less than 1m and lesser loads are acting, brick lintels are used. The depth of brick lintel varies from 10 cm to 20 cm, depending up on the span. Bricks with frogs are more suitable than normal bricks because frogs when filled with mortar gives more shear resistance of end joints. Such lintel is known as joggled brick lintel.

Reinforced Brick Lintels

If loads are heavy and span is greater than 1m, then reinforced brick lintels are useful. The depth of reinforced brick lintel should be equal to 10 cm or 15 cm or multiple of 10 cm. the bricks are so arranged that 2 to 3 cm wide space is left length wise between adjacent bricks for the insertion of mild steel bars as reinforcement. 1:3 cement mortar is used to fill up the gaps.

Vertical stirrups of 6 mm diameter are provided in every 3rd vertical joint. Main reinforcement is provided at the bottom consists 8 to 10 mm diameter bars, which are cranked up at the ends.

Steel Lintels

If the superimposed loads are heavy and openings are large then we can go for steel lintels. These lintels consist of channel sections or rolled steel joists. We can use one single section or in combinations depending up on the requirement.

When used singly, the steel joist is either embedded in concrete or cladded with stone facing to keep the width same as width of wall. When more than one units are placed side by side, they are kept in position by tube separators.

Reinforced Cement Concrete Lintels

At present, the lintels of R.C.C are widely used to span the openings for doors, windows, etc. in a structure because of their strength, rigidity, fire resistance, economy and ease in construction. R.C.C lintels are suitable for all the loads and for any span. The width of lintel is equal to width of wall. Depth of lintel is dependent of length of span and magnitude of loading.

ARCHES:

An arch is a curved **structure** that is usually made of stone, brick, concrete, or, more recently, steel. Its purpose is to support or strengthen a building. Most arches consist of **wedge**-shaped blocks. The top center stone, called the keystone, is the last block to be inserted.

Flat Arch

- For flat arch, the intrados is apparently flat and it acts as a base of equilateral triangle which was formed by the horizontal angle of 60^0 by skewbacks.
- Even though the intrados is flat but it is given that a slight rise of camber of about 10 to 15 mm per meter width of opening is allowed for small settlements.
- Extrados is also horizontal and flat. These flat arches are generally used for light loads, and for spans up to 1.5m.

Segmental Arch

- This is the basic type of arch used for buildings in which Centre of arch lies below the springing line.
- In segmental arch, the thrust Transferred in inclined direction to the abutment.

Semi-Circular Arch

The shape of arch curve looks like semi-circle and the thrust transferred to the abutments is perfectly vertical direction since skewback is horizontal. In this type of arch, the Centre lies exactly on the springing line.

Horse Shoe Arch

Horse Shoe Arch is in the shape of horse shoe which curves more than semi-circle. This is generally considered for architectural provisions.

Pointed Arch

The other name of pointed arch is Gothic arch. In this type of arch two arcs of circles are met at the apex hence triangle is formed. This may be either isosceles or equilateral.

Venetian Arch

Venetian arch is also pointed arch but its crown is deeper than springing's. It contains four Centre's, all located on the springing line.

Types of Arches based on number of Centers

Based on number of centers the arches are classified as:

One-centered Arches

Segmental, semi-circular, flat, horse-shoe arches and stilted arches are one centered arches. In some cases, perfectly circular arch is provided for circular windows which is called as bull's eye arch is also come under these category.

Two Centered Arches

Pointed or gothic or lancet arches are generally come under this type.

Three Centered Arches

Semi elliptical and Florentine arches are generally having three number of centers

Four Centered Arches

Venetian arch is a typical example for four-centered arch. Tudor arch is also having four centers.

Five centered arches

A good semi-elliptical shape arch contains five centers.

1. Stone Arches

Based on workmanship, these are sub divided into two types. They are,

Rubble arches

Rubble arches are very weak and used only for inferior work. These are used up to spans of 1m. These are made of rubble stones which are hammer dressed, roughly to shape and size and fixed in cement mortar. Sometimes these are also used as relieving arches up to a depth of 37.5cm, but these are constructed in one ring. If the depth is more, we can go for two rings in alternate course of headers and stretchers.

Ashlar Arches

In this type, the stones are cut to proper shape of voussoirs (a wedge-shaped or tapered stone used to construct an arch) and fully dressed, joined with cement mortar. Ashlar stones are also used to make flat arches.

Brick Arches

Brick arches are also subdivided into:

Rough brick arches

These are constructed with ordinary bricks without cutting to the shape voussoirs. The arch curve is provided by forming wedge shaped joints with greater thickness at extrados and smaller thickness at intrados. So, it looks unattractive. That's why it is not recommended for exposed brick works.

VAULTS:

Vault, in building construction, a structural member consisting of an arrangement of arches, usually forming a ceiling or roof. ... Medieval European builders developed a modification, the rib **vault**, a skeleton of arches or ribs on which the masonry could be laid.

- Dome.
- Pitched brick barrel **vault**.
- Barrel **vault**.
- Groin **vaults**.
- Rib **vault**.
- Fan **Vault**.
- Hyperbolic paraboloids.

TYPES OF Stairs

(a) Flier (b) Bull Nose (c) Round Ended (d) Splayed (e) Commode (f) Dancing (g) Winders Straight Staircase′ Turning Staircase′ (a)Quarter Turn (b)Half Turn (Dog-Legged & Open well Staircase) (c)Three-Quarter Turn Staircase (d)Bifurcated Staircase Continuous Staircase′ (a)Circular Staircase (b)Spiral Staircase (c)Helical Staircase

STRAIGHT STAIRCASE : If the space available for stair case is narrow and′ long, straight stairs may be provided. Such stairs are commonly used to give access to′ porch or as emergency exits to cinema halls. In this type all steps are in one direction.′ They may be provided in single flight or in two′ flights with landing between the two flights

DOG-LEGGED STAIRCASE It consists of two straight flights with 180° turn′ between the two. They are very commonly used to give access from′ floor to floor. Photograph shows the arrangement of steps in′ such stairs.

OPEN WELL OR NEWEL STAIRCASE It differs from dog legged stairs such that in this′ case there is 0.15 m to 1.0 m gap between the two adjacent flights.

GEOMETRICAL STAIRCASE This type of stair is similar to the open newel′ stair except that well formed between the two adjacent flights is curved. The hand rail provided is continuous.′

BIFURCATED STAIRCASE Apart from dog legged and open newel type′ turns, stairs may turn in various forms. They depend upon the available space for stairs.′ Quarter turned, half turned with few steps in between and bifurcated stairs are some of such turned stairs. Figure shows a bifurcated stair.

SPIRAL STAIRCASE These stairs are commonly used as emergency′ exits. It consists of a central post supporting a series of′ steps arranged in the form of a spiral. At the end of steps continuous hand rail is′ provided. Such stairs are provided where space available′ for stairs is very much limited. Figure shows a typical spiral stair. Cast iron,′ steel or R.C.C. is used for building these stairs.

5. Cement concrete floor:

The floors whose topping consists of cement concrete is called cement concrete floor or conglomerate floor. These floors consists of 2.5 cm to 5cm thick concrete layer laid over 10 cm thick base concrete and 10 cm thick clean sand over ground whose compaction and consolidation is done. These floors are commonly used these days.

Following are the advantages of concrete floors:

1. They are hard & Durable
2. Provide a smooth & non absorbent surface
3. They are more fire resistant
4. They provide more sanitary surface as they can be cleaned & washed easily.
5. They are economical as they require negligible maintenance cost
6. They can be finished with a pleasing appearance.

Types of cement concrete floors:

1. Non-Monolithic or bonded floor finish floor
2. Monolithic floor finish floor

Mosaic Floors: The floors having its topping consisting of mosaic tiles or small regular cubes, square or hexagons, embedded into a cementing mixture is known as Mosaic Floors Method of Construction: The earth is consolidated.¬ 10cm thick layer of clean sand is spread.¬ 10cm thick Lime Concrete (1:4:8) or Lean Cement Concrete (1:8:16) is¬ laid thus forming base concrete. Over this base course 5cm thick Lime Mortar or Cement Mortar or Lime ¬ and Surkhi

mortar (1:2) is laid. The mortar is laid in small area so that the mortar may not get dried¬ before finishing the wearing course. 3mm thick cementing mixture is spread.¬ The cementing mixture consists of one part of pozzolana, one part of¬ marble chips and two parts of slacked lime. After nearing 4 hours, patterns are formed on the top of the cementing¬ material. Now the tiles of regular shaped marble cubes are hammered in the¬ mortar along the outline of the pattern. The inner spaces are then filled with colored pieces of marble.¬ A roller 30cm in diameter and 50cm in length is passed gently over the¬ surface. Water is sprinkled to work up the mortar between the marble pieces.¬ The surface is then rubbed with pumice stone fixed to a wooden handle¬ about 1.5m long. The surface is then allowed to dry up for 2 weeks

Terrazzo is a composite material, poured in place or precast, which is used for floor and wall treatments. It consists of chips of marble, quartz, granite, glass, or other suitable material, poured with a cementitious binder (for chemical binding), polymeric(for physical binding), or a combination of both. Metal strips divide sections, or changes in color or material in a pattern. Additional chips may be sprinkled atop the mix before it sets. After it is cured it is ground and polished smooth or otherwisefinished to produce a uniformly textured surface.

The main advantages of terrazzo flooring are:

- **Aesthetic appeal:** terrazzo flooring is a great alternative to plain concrete flooring, as you get the same slick, quasi-industrial style but with added texture and interest that is more like a carpet – think of terrazzo as a concrete carpet, if you like! The point is, that if you like the minimal, or industrial look, but want to soften the hard edges, terrazzo is good for that.
- **Cutting edge cool:** terrazzo is only just coming up again as a cool flooring material, so if see yourself as a trend-setter, terrazzo may be for you.
- **Infinitely customizable:** terrazzo comes in a limitless range of colors, with a breadth of aggregate options and is easy to pour into custom designs, meaning you can create a really unique floor.
- **Versaility:** not only can you pour terrazzo into custom designs, but it can also be molded into panels for staircases, or into custom shapes such as bathtubs, sink, countertops and stone-like furniture.
- **Underfloor heating friendly:** terrazzo is a great choice in combination with radiant or hydronic underfloor heating systems, as it is very good at retaining heat.
- **Healthy:** properly sealed terrazzo is non-porous and resistant to microbes and mold, making it a very safe flooring surface.
- **Easy maintenance:** For me the ultimate advantage of terrazzo – you barely need to do anything other than sweep and mop from time to time.

- **Environmentally-friendly:** many terrazzo manufacturers use recycled materials to create the aggregate, particularly recycled glass, porcelain and metals.
- **Durable:** there's a reason terrazzo is used so much in commercial and institutional buildings – it's very, very durable. (The family of one of our Home Flooring Pros is from Greece and the terrazzo laid in her grandmother's house is over 60 years ago still looks great!

The main disadvantages of terrazzo flooring are:

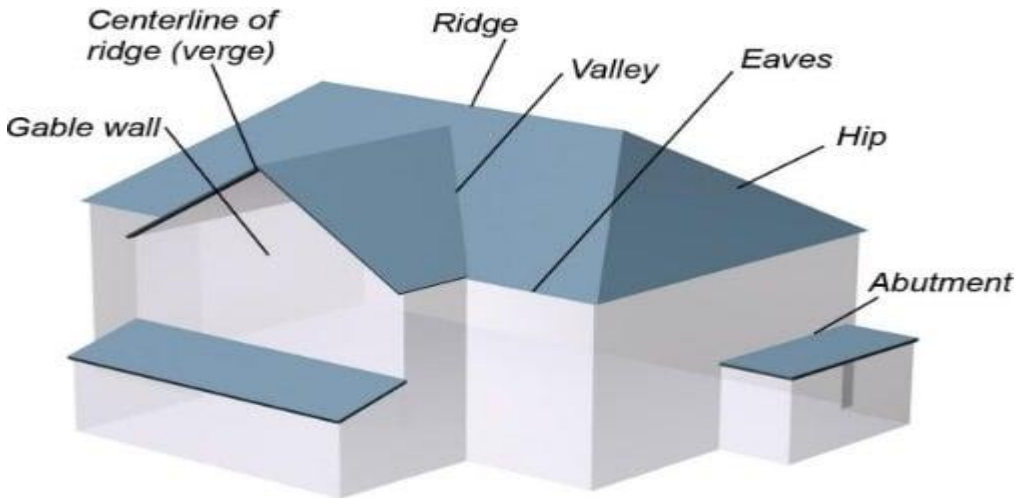
- **Beware of trends:** terrazzo may be "having a moment" right now in designer homes everywhere, but is this a trend that is going to last? Or is it a look that is just that bit too distinct? Not everyone will like this type of flooring, so I would steer clear of terrazzo if you are doing a fixer-upper for resale. Also, as contemporary terrazzo has a definite, minimalist vibe to it, be sure that you have the interior décor to match.
- **Cracks:** structurally, the main concern with terrazzo is that it can crack if not properly installed. Cracks can be dealt with, but not easily and not cheaply! Make sure you choose a pro installer and the right method for your project.
- **Cold and hard:** if you don't have underfloor heating, you may find that terrazzo flooring is pretty cold to walk on in winter; and as well as cold, some people don't care for the hardness underfoot that is inherent in a terrazzo floor.
- **Costs**: terrazzo flooring is generally speaking not a cheap option

Pitched roof

Pitched roof is a type of roof which is provided with some slope as structure covering. We know that the roofs are generally provided at top to cover and protect the structure from different weather conditions. Pitched roofs are generally used where rainfall is heavy. If buildings are constructed with some limited width, then also we can go for pitched roofs.

Components or Elements of Pitched Roofs

Following are the elements of pitched roofs:



1. Span

Span of roof is the clear distance between the two supports on which roof is positioned by some other elements.

2. Ridge

The apex of the angle which is developed at top by the inclined surfaces at the top of slope

Rise

The vertical distance or height of top of ridge from wall plate is called as rise.

4. Wall plates

Wall plates are provided at top of wall or supports. And these are generally made of wood and are used to fix the common rafters.

5. Pitch

Pitch is nothing but slope of roof with the horizontal plane and is calculated as the ration of rise to span.

6. Eaves

The bottom edge of sloped roof surface is called as eaves from which rain water is drops down during raining.

7. Hip

Hip is a place where two sloping surfaces meet, where exterior angle is more than 180°.

8. Hipped end

At the end of a roof sloped triangular surface is formed which is called as hipped end.

9. Valley

It is also a place where two sloping surfaces intersects but the exterior angle is less than 180

Flat roofs.

A **flat roof** is a **roof** which is almost level in contrast to the many types of sloped **roofs**. The slope of a**roof** is properly known as its pitch and **flat roofs** have up to approximately 10°. **Flat roofs** are an ancient form mostly used in arid climates and allow the **roof**space to be used as a living space or a living **roof**.

Advantages and Disadvantages of Flat Roofs:

Advantages • Cost One of the most significant benefits of a flat roof is that it is less expensive to install than a pitched roof. Rafters and engineered trusses must be installed to support a pitched roof, while a flat roof usually requires only basic support beams. As a result, less labour and materials are necessary, so you can save considerable money. • More Usable Space While a pitched roof can provide attic space that a flat roof cannot, the area is not usually suitable for use as a room. With a flat roof, you may opt to have your interior ceiling extended to the point where the roof begins, creating additional usable space in your home. In addition, you may have extra

support added to the flat roof so it can house a deck or patio, creating additional space for outdoor entertaining. Disadvantages • High Maintenance The major drawback to a flat roof is that it typically requires more maintenance than a pitched roof. Because it is not sloped, the roof does not drain naturally so water can easily accumulate. If water puddles on the surface, it can soak into the roof through its seams and cause structural damage. You must check your roof on a regular basis to ensure that it is free of water and clean up any debris that has settled on the roof as well so the drainage system does not become clogged. • Shorter Lifespan A flat roof typically does not last as long as a pitched roof. Its lifespan is affected by the maintenance measures that are taken, but -- depending on the material from which it is made -- a flat roof may have a lifespan as short as 10 years. Make sure that you address the issue of materials with your roofing professional to determine the most durable option for a flat roof. • Absorbs Heat All parts of a flat roof are continually exposed to the sun, so the roof absorbs heat all day long. In warmer climates, the heat absorption may cause your home to become uncomfortably warm. You may also have a problem in milder climates during hot summer months. However, in a cooler climate, you may find the additional heat provided by a flat roof to be beneficial, particularly during the winte

Lean to roof

A **lean-to** is a type of simple structure originally added to an existing building with the rafters "leaning" against another wall. Free standing lean-to structures are generally used as shelters. One traditional type of lean-to is known by its Finnish name *laavu*

A Finnish **laavu**, Swedish **gapskjul** or **slogbod**, or Norwegian **gapahuk** is also a traditional, ethnic lean-to, small building intended for temporary residence during hiking or fishing trips in the wilderness.

Laavus are commonly found in Finnish Lapland near popular fishing rivers and in national parks. In principle, a laavu is a simplified version of a wilderness hut. Like wilderness huts, laavus are not kept warm, and may not be reserved beforehand. Unlike wilderness huts, laavus lack doors or windows. A typical laavu is a wooden building, about 10 m² in area and 2 m high, consisting of a roof, floor, and three walls. The fourth wall is left permanently open.

A laavu is intended to only provide a safe place to sleep during fishing or hiking trips. Visitors are expected to bring their own sleeping bags, as there are no other sleeping facilities. Most laavus also have a place to hold a campfire in front of them, but the laavu is built such that a reasonable fire cannot provide warmth for the night.

A laavu can also be an improvised structure of the same fashion built out of available materials (branches with leaves or pine/fir needles intact or moss or pelts for the covering and sturdier stripped branches or young tree-trunks as the supporting structure) for temporary camp deep in the wilderness, even for a single overnight stay. This is the traditional meaning of the word. Traditionally a log fire was used, made such that it did not need surveillance during the night ("rakovalkea" in Finnish, "nying" in Swedish and Norwegian).

In the United States this same type of structure is commonly referred to as an "Adirondack". Many youth camps use such structures to provide an inexpensive shelter for campers that is sturdier, and more durable, than a textile tent.

A simple tarp shelter

Laavus made of tent cloth are also sold, meant for four or five people. They are lighter than tents and can be warmed by a camp fire. Some of the modern nylon laavus have a front wall that is pulled down for the night if fire is not to be kept.

Types of pitched roofs:

(i) Single roof

(ii) Double or purlin roof

(iii) Trussed roofs

(i) Single roof: In this type of roofs, common rafters are provided to each slope without any intermediate support. The following are the varieties of single roof.

a) Lean to roof

b) Couple roof

c) Couple close roof

d) Collar beam roof

a) **Lean to roof:** It is the simplest form of a pitched roof and it is known as pent roof or Aisle roof. In this type of roof, one wall is carried up sufficiently higher than the other to give necessary slope to the roof. A lean-to roof is generally used for sheds, out-houses attached to main buildings verandah etc. This is suitable for a maximum span of 2.40m as shown in fig 13.3.

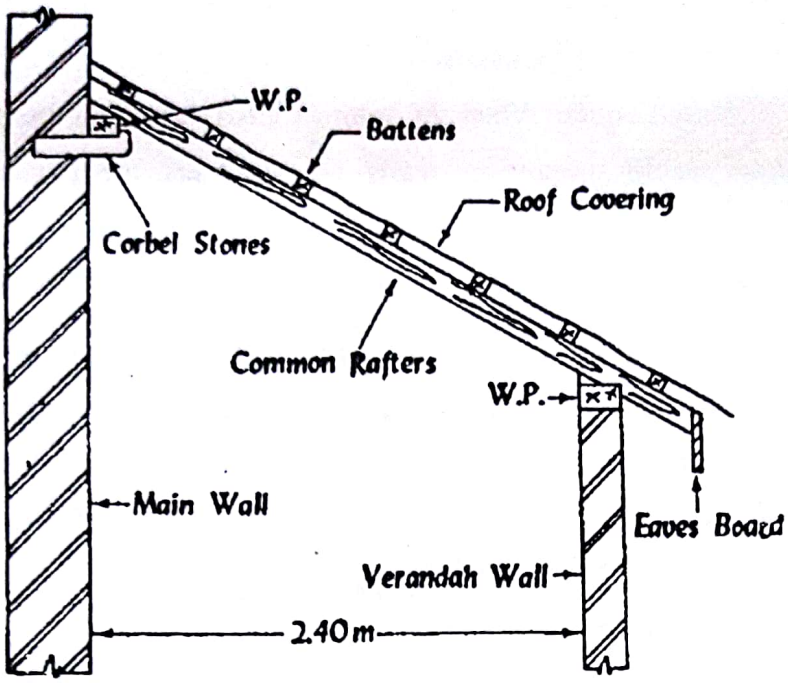


Fig 13.3 Lean-to roof

b) **Couple roof:** In this type of roof the common rafters slope upwards from the opposite walls and they meet on a ridge piece in the middle as shown in the fig 13.4. A couple roof is suitable for spans upto about 3.6m.

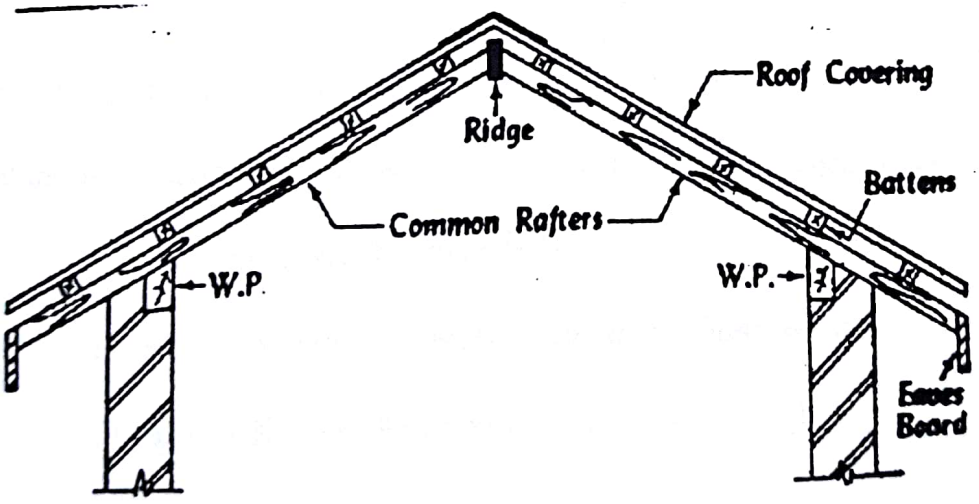


Fig 13.4 Couple roof

c) **Couple close roof:** This roof is just similar to couple roof except that the legs of the common rafters are connected by a tie beam as shown in the fig 13.5. The tie beam prevents the tendency of rafters to spread out and thus danger of overturning of the walls is avoided. This roof can be adopted economically upto the span of 4.2m.

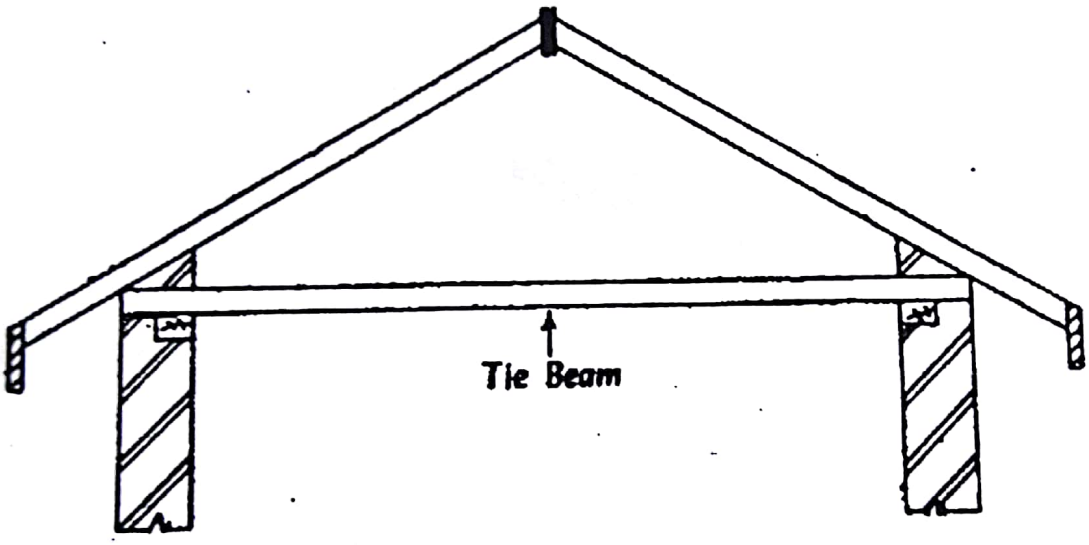


Fig 13.5 Couple close roof

d) **Collar beam roof:** The tie beam is raised and placed at a higher level as shown in fig 13.6 known as collar or collar beam. This beam roof is adopted to economise the space and to increase the height of a room. This roof can be adopted upto a maximum span of 4.8m.

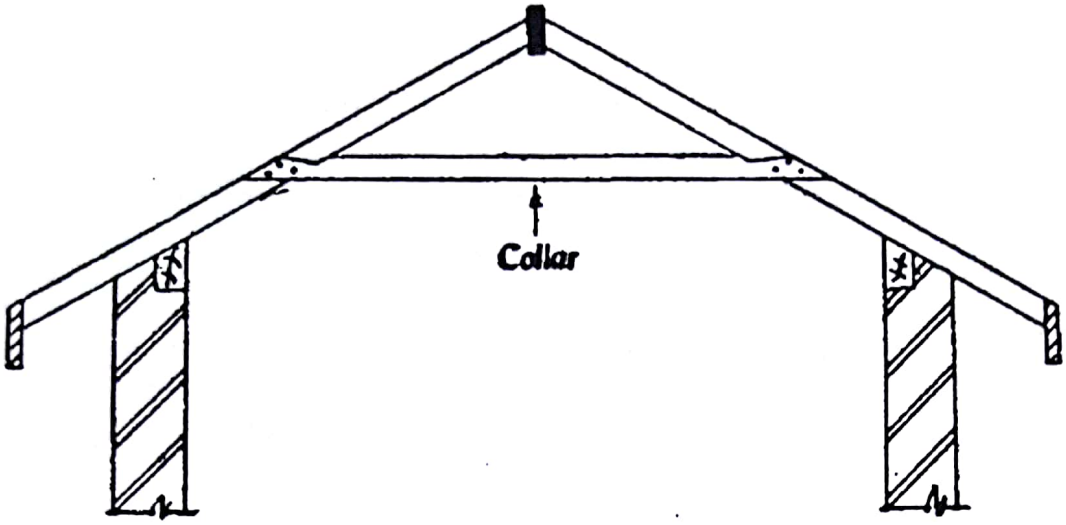


Fig 13.6 Collar beam roof

(i) **Double or purlin roofs:** When the span exceeds 2.4m, the necessary size for the rafters becomes uneconomical. Hence in order to reduce the size of rafters, intermediate supports called purlins are introduced under the rafters as shown in fig 13.7. This roof can be adopted economically upto 4.8m.

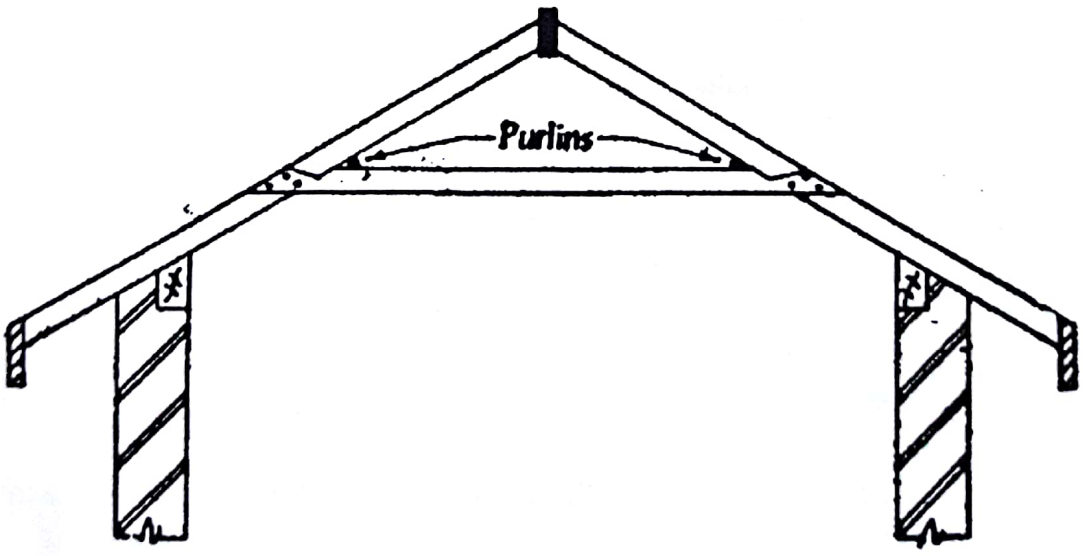


Fig 13.7 Double or Purlin roof

(ii) **Trussed roofs:** When the span exceeds 4.8m and when there are no inside supporting walls or partitions for purlins, framed structure known as trusses are on the roof, position of cross walls, span and material of the truss. The spacing is 3m for wooden trusses. Trusses carry the ridge piece and purlins on which the common rafters rest. Some of the usual forms of roof truss are given below.

a) King-post truss
b) Queen post truss
c) Mansard truss
d) Truncated truss
e) Bel-fast truss
f) Steel trusses
g) Composite trusses

a) **King post truss:** In this type of truss, the central post known as king-post forms support for the tie beam. The inclined members, known as structs, prevents the principal rafters from bending in the middle. A king-post truss suitable for roofs of span varying from 5 to 8 m as shown in fig 13.8.

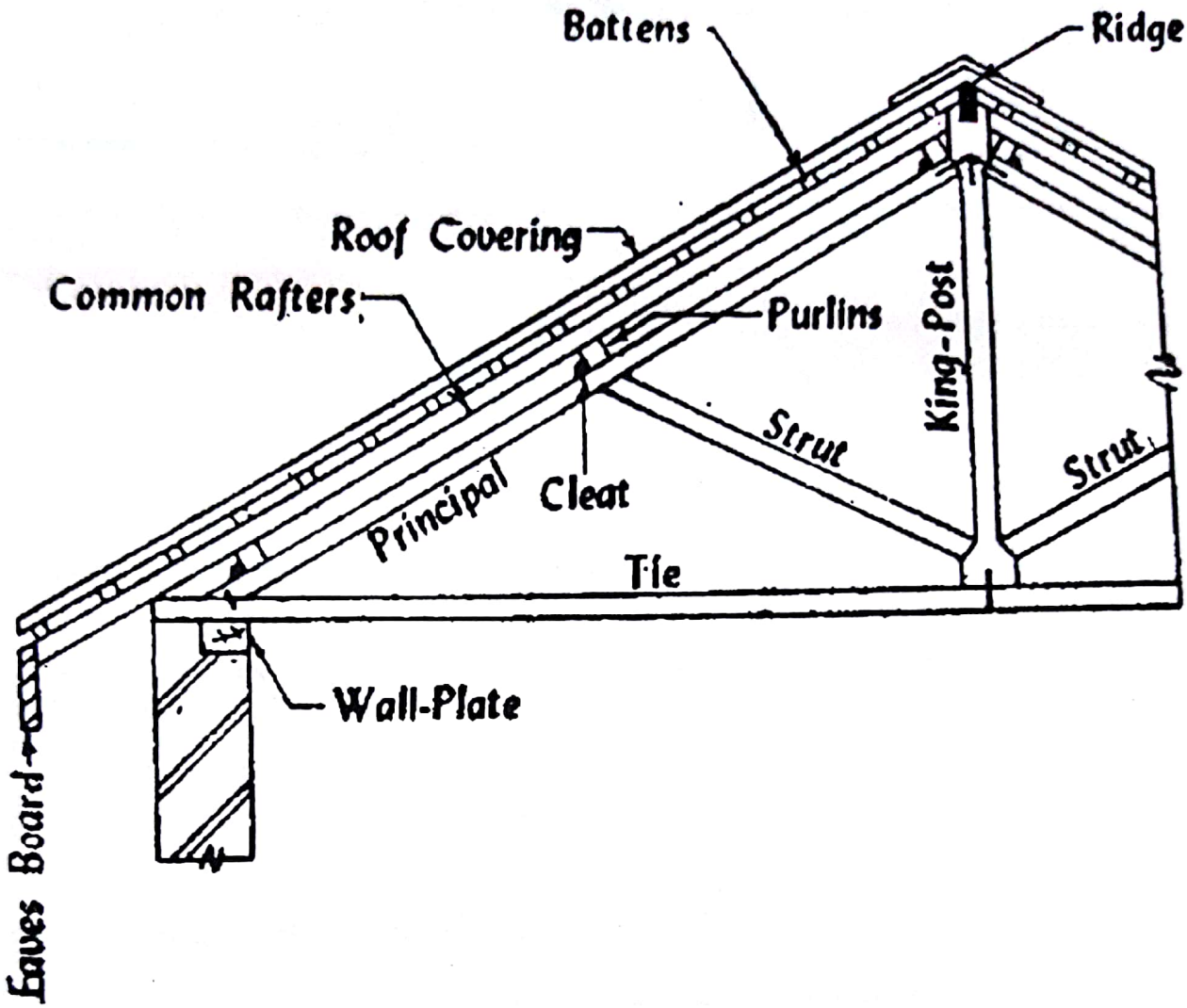


Fig 13.8 King post truss roof

b) **Queen post truss:** This truss is differ from a king-post truss in having two vertical members known as queen posts. The upper ends of the queen posts are kept in position by means of a horizontal member known as straining beam. Additional purlins are supported on the queen posts. A queen post truss is suitable for roof spans varying 8 to 12 m as shown in fig 13.9.

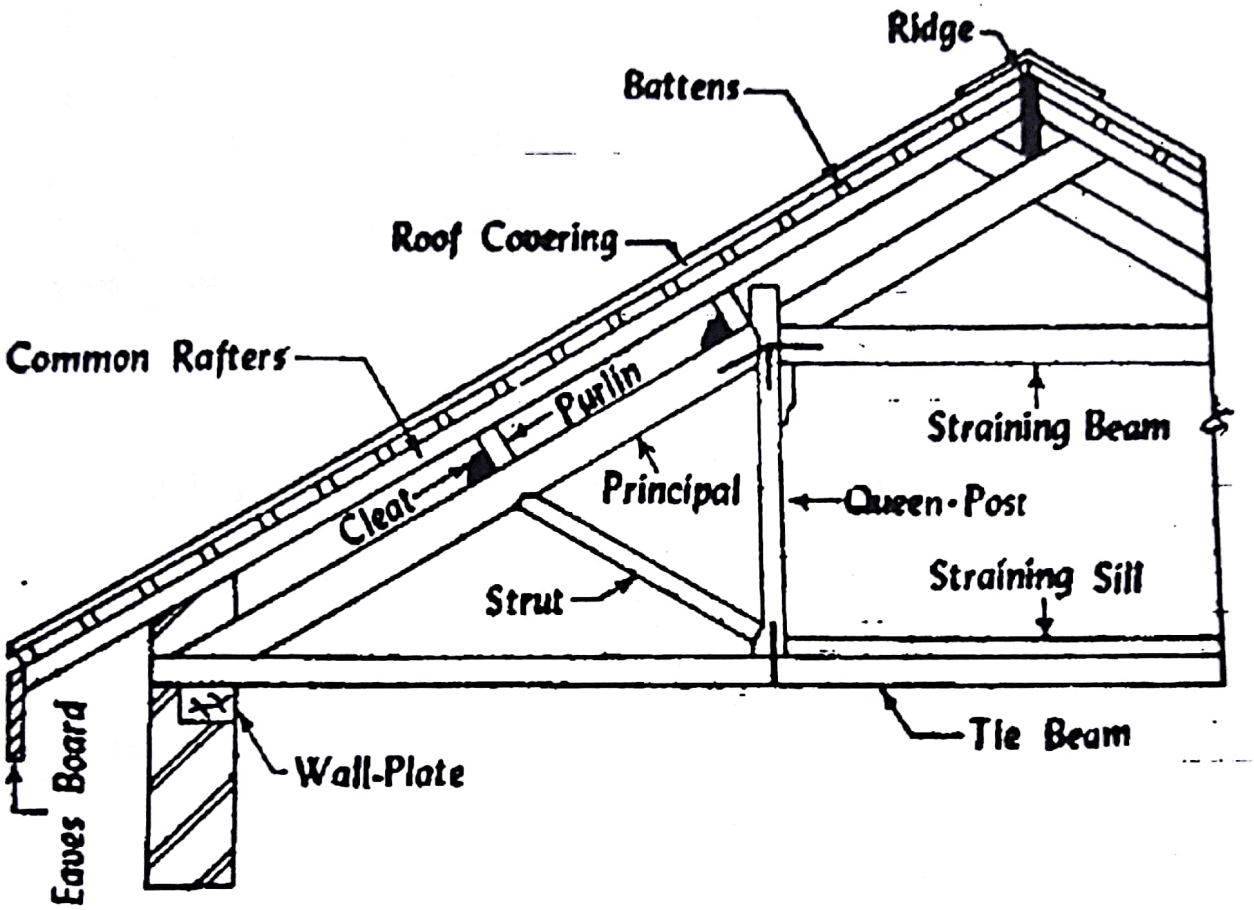


fig 13.9 Queen post truss

c) **Mansard truss:** this is a combination of king post and queen post trusses. Lower queen post & upper king post trusses. Use of mansard trusses results in the economy of space and room may be provided in the room as shown in the fig 13.10.

DAMP PROOF AND FIRE PROOF CONSTRUCTION

Damp prevention and fire protection are the chief requirements to ensure the safety of buildings against dampness and fire respectively. The sources, effects, techniques and methods of damp prevention, materials used for damp-proofing (D.P.C) damp-proofing treatments in buildings, treatment of dampness are discussed under damp proof chapter.

14.1 Sources of dampness(causes)

Dampness in building in generally due to one or more of the following causes

(i) Faulty design of structure

(ii) Faulty construction or poor workmanship

(iii) Use of poor materials in construction

These cause give rise to an easy access to moisture to enter the building from different points, such as rising of moisture from ground, rain penetration through walls, roofs and floors etc. The moisture entering the building from foundation and roofs, travels in different directions further under the effects of capillary action and gravity respectively. The entry of water and its movements, in different parts of the building are positively due to the one or more of the causes listed above.

14.2 Effects of dampness:

The various effects caused due to dampness in buildings mainly results in poor functional performance, ugly appearance and structural weakness of the buildings.

1. A damp building creates unhealthy living and working conditions for the occupants
2. Presence of damp condition causes efflorescence on building surfaces which ultimately results in the disintegration of bricks stones, tiles etc and hence reduction of strength
3. It may result in softening and crumbling of plaster
4. It may cause bleaching and flaking of the paint which results in the formation of coloured patches on the wall surfaces and ceilings
5. It may result in the corrosion of metals used in the construction of buildings
6. The materials used as floor coverings such as tiles are damaged because they lose adhesion with the floor bases
7. Timber when in contact with damp condition, gets deteriorated due to the effect of warping, buckling and rolling of timber
8. All the electrical fittings gets deteriorated, causing leakage of electric current with the potential danger of a short circuit
9. Dampness promotes the growth of termites and hence creates unhygienic conditions in buildings

10. Dampness when accompanied by the warmth and darkness, breeds the germs of tuberculosis, neuralgia, aute and chronis neumatism etc which some times result in fatal diseases

14.3 Techniques and methods of damp prevention:

The following are the precautions to be taken to prevent dampness in buildings, before applying the various techniques.

1. The site should be located on high ground and well drained soil to safe guard against foundation dampness
2. All the exposed walls should be of sufficient thickness to safeguard against rain protection (minimum 30cm)
3. Bricks of superior quality free from defects should be used
4. Good quality cement mortar (1:3) should be used to produce definite pattern and perfect bond in the building
5. Cornices and string courses should be provided to through rain water away from the walls
6. All the exposed surfaces like top of walls, compound walls etc should be covered with water proofing cement plaster
7. Cavity walls are more reliable than solid walls in preventing the dampness

Techniques:

1. Use of damp proof courses
2. Water proof or damp proof treatments
3. Cavity walls or hallow walls

4. Guniting or shot concrete or shotcrete
5. Pressure grouting or cementation

1. Use of damp-proof courses (D.P.C.)

These are layers or membranes of water repellent materials such as bituminuous felts, mastic asphalt, plastic sheets, cement concrete, mortar, metal sheets, stones etc which are interposed in the building structure at all locations wherever water entry is anticipated or suspected. The best location or position of D.P.C. in the case of building without basement lies at plinth level or structures without any plinth level, it should be laid at least 15cm above ground level. The damp proof course provided horizontally and vertically in floors, walls etc. In the case of basements, laying of D.P.C. is known as taking Fig 14.1 shows the D.P.C. treatment above ground level.

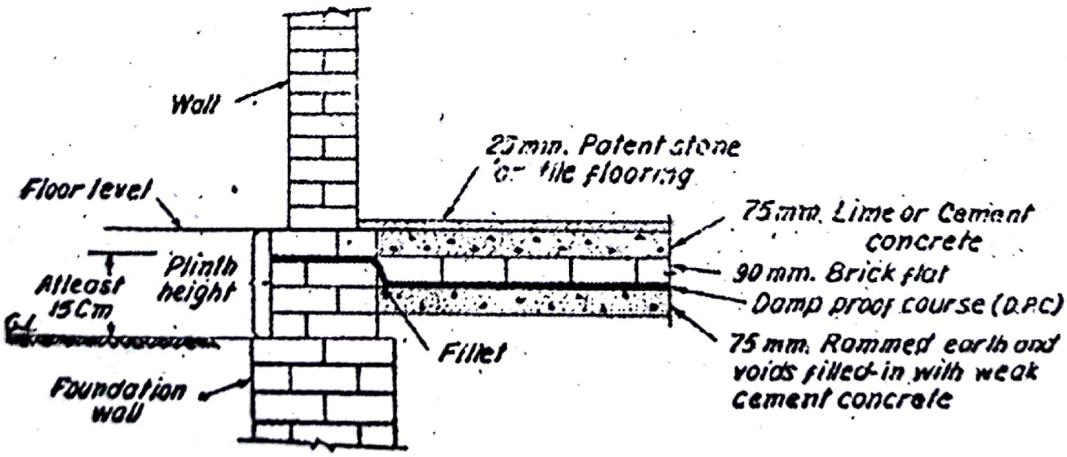


Fig 14.1 D.P.C. above ground level for new buildings

2. **Water proof surface treatments:** The surface treatment consists in filing up the pores of the material exposed to moisture by

providing a thin film of water repellent material over the surface (internal / external) . External treatment is effective in preventing dampness

Many surface treatments, like pointing, plastering, painting, distempering etc are given to the exposed surfaces and also to the internal surface . The most commonly used treatment to protect the walls against dampness is lime cement plaster (1:6) (1-cement, 6-lime) mix proportion. Generally employed as water proofing agent in surface treatments are sodium or potassium silicate. Aluminium or zinc sulphate, Barium Hydroxide and magnesium sulphate in alternate applications. Soft soap and alum also in alternate applications, unie and unseed oil; coal tar, bitumen, waxes and fats; resins and gums

Waxes and fats are not suitable in tropics as they melt with rise in temperatures

3. Integral damp-proofing treatments :

The integral treatment consists of adding certain compounds to the concrete or mortar during the process of mixing, which when used in construction acts as barriers to moisture penetration under different principles

i) **Compounds like chalk**, talc, fallers earth etc have mechanical action principle (i.e.,) they fill the pores present in the concrete or mortar and make them dense and water proof

ii) **Compounds like denser** and water proof sulphates, calcium chlorides etc work on chemical action principle (i.e.) they react chemically and fill the pores to act as water-resistant

iii) **The compounds like soaps,** petroleum, oils fatty acids compounds such as sterates of calcium, sodium ammonium etc work on the repulsion principle i.e., they are used as admixture in concrete to react with it and become water repellent

4. **Cavity walls or hallow walls:** A cavity wall consists of two parallel walls or leaves or skins of masonary separated by a continuous air space or cavity. The provision of continuous cavity in the wall per effectively prevent the transmission or percolation of dampness from outer walls or leaf to inner wall or leaf. The following are the advantages of cavity wall.

(i) As there is no contact between outer and inner walls of cavity wall, possibility of moisture penetration is reduced to a minimum.

(ii) A cavity wall prevents the transmission of heat through wall.

(iii) A cavity wall offer good insulation against sound.

(iv) The cavity wall tends to reduce the nuisance of efflorescence.

(v) The cavity wall also provides benefits such as economy, better comfort and hygienic conditions in buildings

The cavity wall construction and D.P.C. details for flat roofs is as shown in fig no 14.2

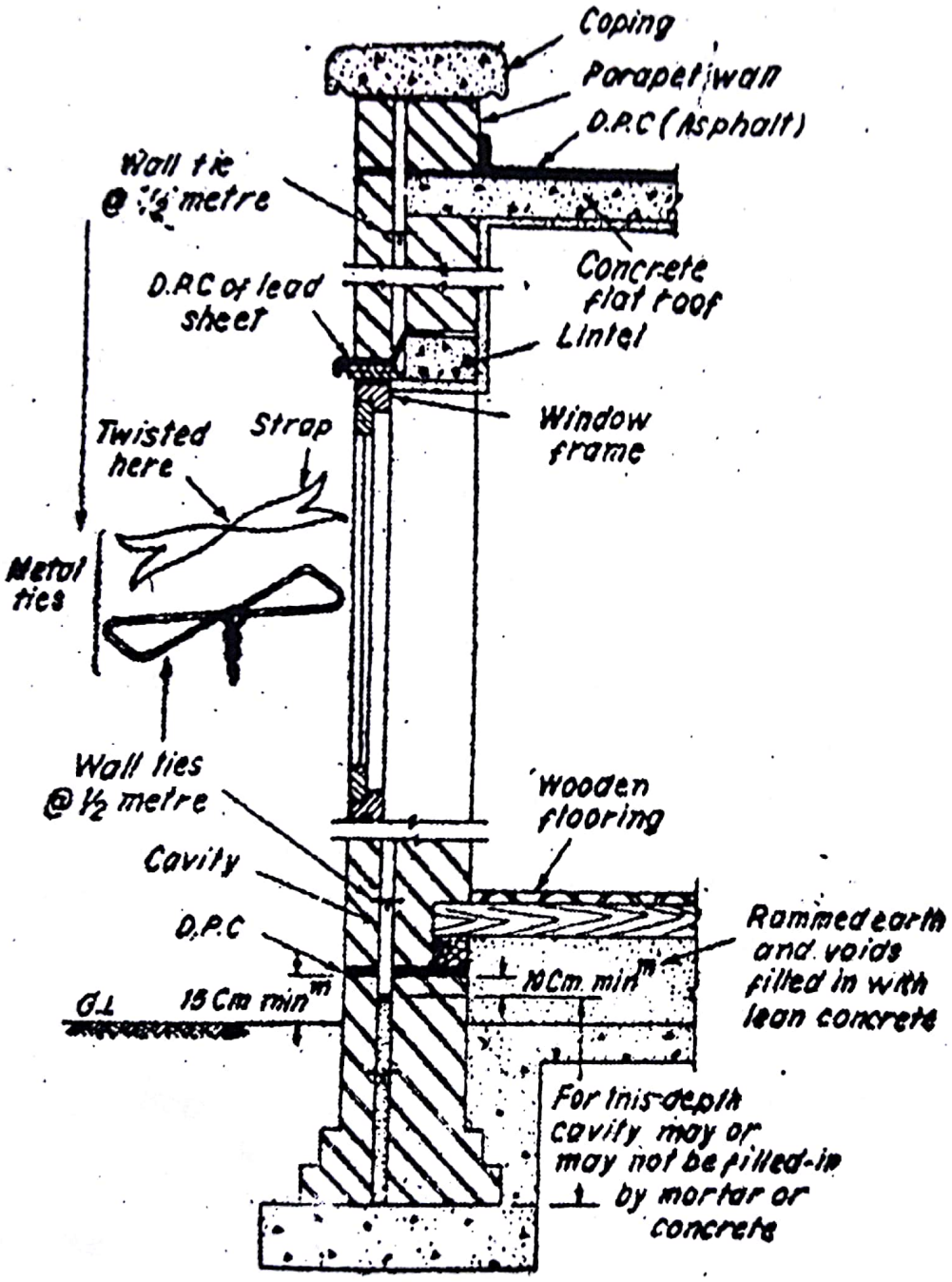


Fig 14.2 Cavity wall construction and D.P.C. details for flat roofs

5. **Guniting: (or shot concrete) :** The technique of guniting consists in forming an imperious layer of rich cement mortar (1:3) or fine aggregate mix for water proofing over the exposed concrete surface or over the pipes, cisterns etc for resisting the water pressure. By this technique, an impervious layer of high compressive strength (600 to 700 kg/cm^2) is obtained and hence this is also very useful for reconditioning or repairing old concrete works

6. **Pressure grouting or (cementation).** The mixture of cement, sand and water under pressure into the cracks, voids or fissures present in the structural component or the ground. In general, the foundations are given this treatment to avoid the moisture penetration. This technique also used for repairing structures, consolidating ground to improve bearing capacity, forming water cut-offs to prevent seepage etc.

Pointing:-

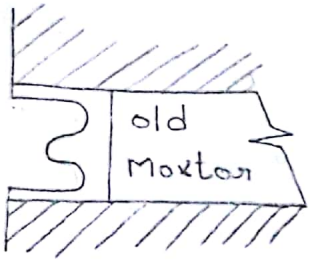
The term pointing is used to indicate the finishing of mortar joints either of stone masonry or brick masonry. The joints are about the depth of 20mm and then these spaces are filled up by suitable mortar in the desired shape.

Types of Pointing:-

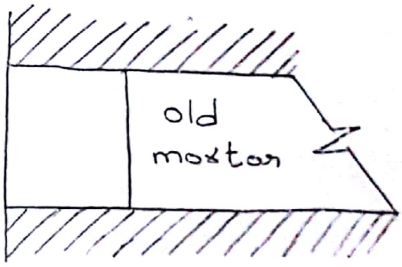
The pointing can be carried out in a number of shapes. The choice of a particular type will depend on the nature of masonry and the effect required.

1. Beaded Pointing:-

It is formed by a steel or iron rod with a concave edge. The beaded pointing is good in appearance. It is difficult to maintain as it can be easily damaged.



Beaded pointing



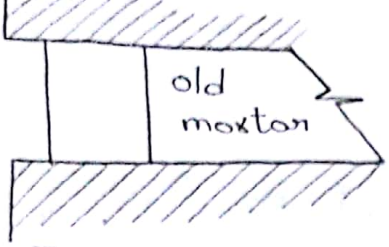
Flush pointing

2. Flush pointing:-

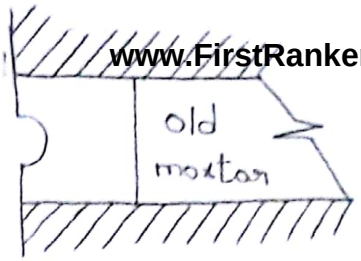
It is formed by removing the excess mortar from the joint. The joint is made flush with the face. This type of joint does not give good appearance. But it is durable as it does not provide any space for accumulation of dust, water etc., and it is extensively used.

3. Recessed Pointing:-

The face of the pointing is kept vertical and it is pressed inside the wall surface by a suitable tool to a depth of about 5mm or more. It gives very good appearance.



Recessed pointing



Rubbed pointing

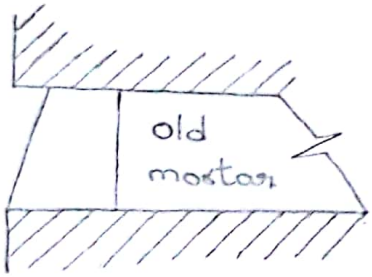
4. Rubbed or keyed or grooved pointing:-

A groove is formed at the centre of height by a pointer. This type of pointing gives better appearance and is generally adopted.

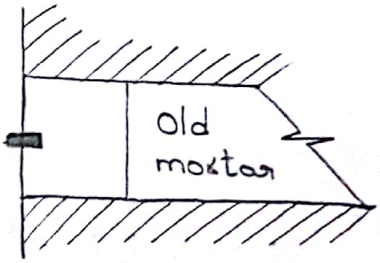
5. Struck Pointing:-

The face of pointing is kept inclined. The upper edge of joint is about 10mm inside the face of masonry.

If the lower edge of joint is kept inside the face of masonry, It is known as the overhand struck pointing.



Struck pointing

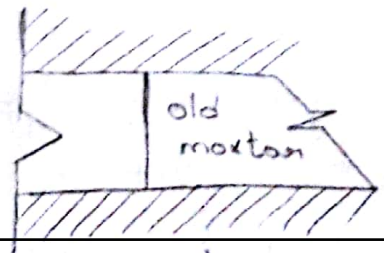


6. Tuck pointing:-

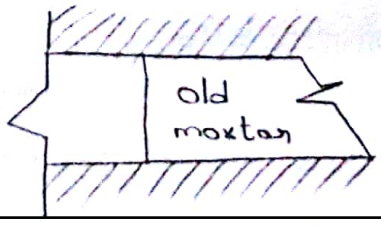
A groove is formed at the centre of joint. The width and depth of groove are respectively 5mm and 3mm.

7. Vee-pointing:-

It is formed in the mortar joint.



Vee-pointing



Weathered pointing

Weatherd pointing:

A projection in the form of a vee-shape.

Plastering:-

The term plastering is used to describe the thin plastic covering that is applied on the surfaces of walls and ceilings. The Plastering removes the unevenness of the surfaces and sometimes the Plastering is used to develop decorative effects.

Requirements:-

1. It should be cheap and economical.
2. It should be hard and durable.
3. It should be possible to apply it during all weather conditions.
4. It should possess good workability.
5. It should remain adhered during all variations of the climatic changes.

Mortar for plastering:-

The selection of type of mortar for plaster depends on various factors such as availability of binding materials, atmospheric conditions, durability required, finishing desired, location of the surface etc., There are mainly 3 types of mortar which can be used for the process of plastering.

1, Lime mortar
2, Cement mortar
3, Water proof mortar.

1, Lime mortar:-

The lime mortar consists of equal volumes of lime and sand. These two materials are carefully ground in a Mortar mill. The fat lime is used for plaster work because the fat lime contains 75% of CaO, and it combines with CO_2 of atmosphere and gives $CaCO_3$ quickly. Thus the lime sets quickly. but it is of

of strength so it can be only used for plastering works.

Cement Mortar:-

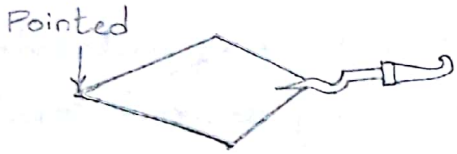
The cement mortar consists of one part of cement and four parts of clean, coarse and angular river sand by volume. There materials are mixed throughly in dry condition before water is added. This mixing is done on a watertight platform and motar of one cement bag is prepared at a time and this quantity of mortar is consumed within 30 mins after adding water.

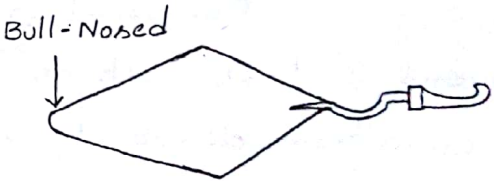
Water-proof mortar:-

This mortar is water-proof and it is prepared by mixing one part of cement, two parts of sand and pulverised alum at the rate of 120 N per m^3 of sand. In the water to be used 0.75 N of soft soap is dissolved per one litre of water and this soap water is then added to dry mix.

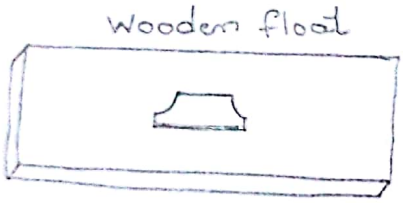
Tools for plastering:-

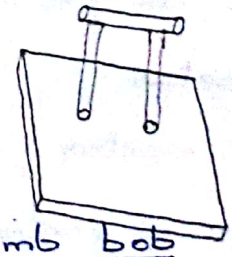
1. Gauging trowel:-



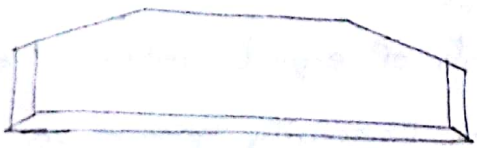


2. Float:-





3. Floating rule



4. Plumb bob

5. Miscellaneous tools:-

such as brushes, spirit level, set squares, straight edges etc, are also used for the plastering works.

External surface finishes:-

Depending upon the factors such as the desired appearance of the building, degree of maintenance, cost etc, the external walls of the building are finished with suitable materials. The common varieties are as follows:-

1. Sand-faced finish:-

→ The first coat of sand faced cement plaster is carried out in cement mortar of proportion 1:4 i.e, one part of cement and four parts of clean coarse and angular river sand by volume.

→ The thickness of first coat is less than 12mm and watered for atleast 7 days.

→ The thickness of second coat is 8mm.

→ The sponge is used in the second coat and it is applied when the second coat is wet and it is so worked that the density of sand grains appearing on the surface is Equal and uniform.

→ After completion of the second coat, the surface is kept well-watered atleast for 15 days.

2. Pebble-dash or dry-dash finish:-

The finishing coat is made of 12mm thick and clean pebbles of size varying from 10mm to 20mm are dashed against the surface so that they are held in position by the mortar already applied. The pebbles may be lightly pressed into the mortar with the help of wooden float.

WATER-BASED PAINTS

The majority of wall paint sold today is water-based, but oil-based paint remains popular for glossy woodwork, doors, and furniture, as well as demanding surfaces such as floors.

Be cautious when switching to a water-based paint if the surface has previously been coated with an oil-based product, as the new paint may not stick. In this situation, Sherwin-Williams recommends washing the surface and then roughening it all over with a medium to smooth grit sandpaper—making it clean, dry, and dull in order to prevent peeling of the new coat.

Advantages of water-based paints

- low VOCs (low levels of toxic emissions)
- easy cleanup with water
- quick drying
- an elastic, flexible finish resistant to cracking
- stable color over time, without yellowing

OIL-BASED PAINTS

For those instances when an oil-based paint would traditionally be preferable, but you desire a water-based product, a number of companies have introduced "waterborne enamels" or "waterborne alkyds." These paints look and behave much like oil-based options because they have good leveling qualities for a smooth finish.

Advantages of oil-based paints

- attractive gloss
- good "leveling" (brush strokes fill themselves in to create a smooth finish)
- hard, durable finish

PAINT FINISHES

Sheen options vary by manufacturer, but share some common characteristics.

As durability improves across all sheen levels with newer paints, many people are finding creative ways to mix and match them. "We've noticed that customers are becoming more experimental in their use of paint finish, to create real impact and texture within a scheme," says Farrow & Ball director Sarah Cole. "Try painting a stripe of full gloss on a matte wall in the same color to create a striking, textured look," she suggests.

Matte paint:

- is the least reflective sheen available
- has a velvety texture
- helps hides imperfections in walls and ceilings
- offers great depth of color
- is generally considered the standard sheen for walls
- can sometimes be difficult to clean

Eggshell and satin paint (satin is slightly glossier than eggshell):

- have some reflectivity
- offer improved durability
- are frequently used in demanding environments, like kitchens and bathrooms, where easy cleanup without a highly glossy finish is desired

Semi-gloss and gloss paint:

- are the most reflective sheens
- are highly durable and stand up to multiple cleanings
- are traditionally used on baseboards, moldings, and doors
- can make a statement, but also highlight imperfections

Sue Kim, color trend and forecast specialist at Valspar, recommends trying an accent wall with a gloss sheen, while painting the rest of a room matte. But at the end of the day, "It's all about how you want to set the atmosphere of your home," she says. "A matte sheen gives you a calm and serene feeling, because of that textural element." On the other end of the spectrum, gloss adds energy and excitement.

As for eggshell and satin, Kim likes to use them in smaller spaces with little natural light. "I always say that a satin finish is great in a powder room," she says. "It reflects the light to bring out the color."

FORM WORK (SHUTTERING)

Formwork is the term given to either temporary or permanent moulds into which concrete is poured till it get sufficient strength for self supporting.

The form work involves various materials such as timber (wood), plywood, steel, aluminium, combined wood–steel etc... used as moulds in civil structures, in which concrete is poured. The construction of form work involves considerable materials. The cost of form work may be upto 20 – 25 % of the cost of the structure in building works and even higher in bridges. In order to reduce this expenditure, it is necessary to design economical types of form work.

When the concrete reach a certain required strength, the form work is no longer needed and is removed. The operation of removing the form work is commonly known as Stripping. Similarly, when the components of form work are removed and then reused for other parts of the civil structure for several times are known as Panel forms.

FORMWORK MATERIALS:

Timber is the most common material used for form work. When the form work is to be used for small works only a few times, then timber proves to be more economical than steel or aluminium.

Advantages: Formwork material of timber is

- Easily available
- Formwork material can be made to desired shape
- Can be made to required size
- Easy to carry
- Economically viable and cheap
- Convenient for small works

Disadvantages:

- Possibility of warping, swelling and shrinkage of timber. However, those effects can be overcome by applying shuttering oil as coating. This coating prevents the material from adhering to concrete and hence the stripping (removing of formwork material) makes easier.

Steel/Aluminium formwork: If the formwork is desired to be re-used several times, then the use of steel or aluminium is preferred. Though the initial cost of steel is very high but for large works with many repetitions, the steel form work proves to be economical. In case of specific structures, such as round columns, curved surfaces, tunnels etc the use of steel form work should be made.

Steel form work has many advantages such as

- Can be used a number of times
- It provides ease stripping
- It ensures an even and smooth concrete surface.
- It is not liable to shrinkage/ swelling.

Requirements for a Form work: A good form work should satisfy the following requirements:

- The material of the formwork should be cheap and it should be suitable for re-use several times.
- It should be water proof so that it doesn't absorb water from concrete.
- Shrinkage and swelling of material should be minimum.

• It should be strong enough to withstand all loads coming on it such as dead load of concrete, live load of concrete during its pouring, compaction and curing of concrete.

• The surface of the form work material should be smooth and should afford easy stripping.

• All joints of the form work should be stiff so that lateral deformation under loads is minimized.

Indian Standards on form work (IS 456 – 2000)

General: The formwork shall confirm to the shape, dimensions etc as shown on the plans and so constructed as to remain the rigidity during the placing of the concrete and the form work shall be sufficiently tight to prevent loss of liquid from the concrete.

Cleaning and treatment of forms: All rubbish particularly chippings, saw dust shall be removed from the interior of the form work material before the concrete is placed.

Procedure to be adopted for removing the form work: All form work materials are to be removed without creating vibrations as would damage the reinforced concrete. Before the form work materials are removed, the concrete surface should be checked thoroughly.

Tolerances: Form work shall be so constructed that the internal dimensions are within the permissible tolerance specified by the designer.

SCAFFOLDING

The Scaffolding is a temporary frame work of timber or steel components having platforms at different levels, to enable the masons to work at different heights of a buildings. When the height of wall or column or other structure of a building exceeds about 1.5 mts (4'), temporary structures are used to support the platform over which the work men can sit and carry the activities. These temporary structures constructed are very close to the wall, is in the form of timber or steel frame work, commonly called scaffolding.

Scaffolding materials is needed for the repairs or even demolition of a building. In addition, surface finishing such as plastering, pointing, white washing or distempering of walls, columns etc at higher levels can also be carried out. The scaffolding should be stable and be strong enough to support work men and other construction material placed on the platform. The height of the scaffolding goes on increasing as the height of construction increases.

Components of Scaffolding:

Standards: These are the vertical members of the frame work supported on the ground or embedded into the ground.

Ledgers: These are horizontal members, running parallel to the wall,

Braces: These are diagonal members fixed on standards.

Putlogs: These are transverse members, placed at right angles to the wall with one end supported on ledgers and other end on the wall.

Transoms: These are those putlogs whose both ends are supported on ledgers.

Boardings: These are horizontal platform to support workmen and material and are supported on the putlogs.Various components or members of the scaffolding are secured by means of rope lashings, nails, bolts etc……

TYPES OF SCAFFOLDING:

• **Single / Bricklayer's / Putlog scaffolding**: It consists of a single row of standards (vertical members) which are driven into the ground. Standards are to be arranged parallel to the wall at distance of 1.20 mts. The standards are then connected to each other by ledgers (horizontal members placed at right angles. They are secured in position by rope lashings or cuplock materials. The put logs are fastened to ledgers by rope lashings. The cross braces are used for strengthening of the structure.

Double scaffolding/ Mason's Scaffolding: This type of scaffolding is stronger than the single scaffolding and is used in the constructions of stone work. The form work is similar to the single scaffolding except two rows of standards are used, one row close to the wall within 15 cm and the other at 1.2 to 1.5 m away from the face of the wall. The put logs are supported at both ends on ledgers. Sometimes, in addition to the diagonal braces, inclined supports called Racking shores are provided to prevent the slipping of scaffold away from the wall.

3. **Cantilever Scaffolding / Needle Scaffolding**: This type of scaffolding is needed under the following circumstances:

• Where it is not possible to fix the standards in to the ground

• Where the scaffolding is to be provided on the side of a busy street without obstructing the traffic on road.

• Where the scaffolding is required in case of tall buildings.

In this work, single scaffolding or double scaffolding components are supported by a series of cantilevers or needle beams (timber beams projecting from wall) passing through window openings or through holes in the wall.

4. **Suspended scaffolding**: This type of scaffolding is suitable for maintenance works such as painting, pointing, distempering etc. The working platform is suspended from the roofs by means of wire ropes or chains.. The mechanical arrangements are provided to raise or lower the platform to attain the optimum level for working.

• **Trestle scaffolding**: The working platform is supported on the top of mobile devices such as tripods, ladders etc mounted on wheels. Trestle scaffolding is suitable for minor repairs or painting work upto a maximum height of 5 mts from the supporting level.

• **Steel scaffolding/Centering**: It is practically similar to timber scaffolding except that wooden members are replaced by steel tubes and rope lashings are substituted by special couplings and set-screws at junctions. Though its initial cost is more but its salvage (The property so saved) value is higher.

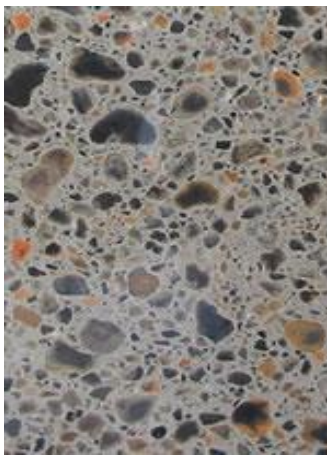
 Ladder Scaffolding / Patented scaffolding: The working platforms are supported on brackets (with inner row of standards) which can be adjusted at any suitable height. The various components of the scaffold are

CHAPTER 6

AGGREGATES




4. AGGREGATES



4.1 Introduction

- Aggregates occupy at least three quarters of vo of concrete.
- Quality is especially important.
- Cheaper than the cement, put into the mix as as possible.
- Higher volume stability and better durability th cement paste alone.

4.2 General Classification of Aggregates

a) According to Production Methods

- Natural Aggregates:
  - Taken from native deposits without any change in their natur during production except for crushing, grading or washing.
  - Example: sand, gravel, crushed stone, lime rock.

- By-Product Aggregates:
  - Comprise blast-furnace slags and cinders, fly ash, etc. Cinders residue of coal or wood after burning.

Processed Aggregates:

- Heat treated, expanded materials with lightwei characteristics.
- Example: Perlite, burnt clays, shales, processed ash.

Colored Aggregates:

- Glass, ceramics, manufactured marble for deco and architectural purposes.

b) According to Petrological Characteristics

- **Igneous Rocks:**

Solidification of molten lava forms igneous rocks.

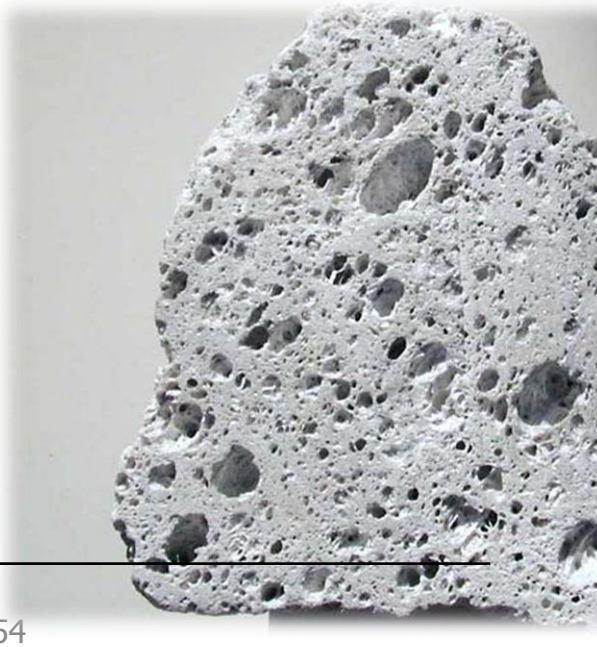
- Example: Quartz, granite, basalt, obsidian, pumice, tuff.

- **Sedimentary Rocks:**

Obtained by the deposition of weathered and transported pre existing rocks.

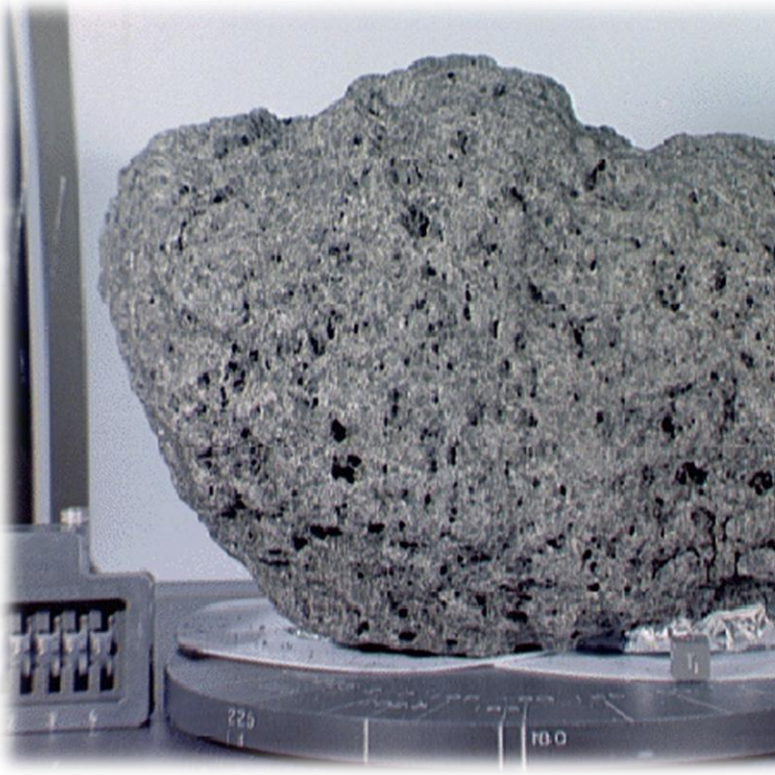
- Example: Sandstone, limestone, shale.
- IMPORTANT: If these are hard and dense, OK. If not, high absorption capacity gives unsatisfactory results.

Sedimentary Rocks



Formation of PUMICE

Basalt



- **Metamorphic Rocks:**

Formed at a depth under high heat and pressure the alterations of either igneous rocks or sedimentary rocks.

- Example: Marble, slate, schist.

- IMPORTANT: If hard and dense, OK.

If laminated, undesirable.

c) According to Particle Size

1) Fine Aggregate (sand):

Fine aggregate includes the particles that all passes throug
4.75 mm sieve and retain on 0.075 mm sieve.

2) Coarse Aggregate (gravel):

Coarse aggregate includes the particles that retain on 4.75 mm sieve.

Silt: sizes 0.002-0.075 mm

Clay: sizes smaller than 0.002 mm

d) According to Their Unit Weights:

1) Normal Weight Aggregates:

- Sand, gravel and crushed stone.
- Concrete produced by these aggregates:2160 to 2560 kg/m^3.

2) Light Weight Aggregates:

- Slag, slate and other light stones.
- Concrete produced by them: 240 to 1440 kg/m^3.
- This concrete is normally used for insulation purposes.

3) Heavy Weight Aggregates:

- Hemotite, barite magnetite, steel and iron punchings.
- Concrete produced by them: 2800 to 6400 kg/m^3.

4.4 Mechanical Properties of Aggrega

4.4.1 Bond of Aggregate

- Bond is the interlocking of the aggregate and the paste the roughness of the surface of the former.

- A rough surface, such as that of crushed particles, resu better bond; better bond is also usually obtained with s porous and mineralogically heterogeneous particles.

- No accepted test exists.

- Generally, when bond is good, a crushed concrete spec should contain some aggregate particles broken right t in addition to the more numerous ones pulled out from sockets.

4.4.2 Strength of Aggregate

- NOTE:

Comp. strength (concrete) < Comp. strength (aggregate)

- The crushing strength of aggregate cannot be tested with direct test. There are some indirect tests to inform us abo crushing strength of aggregate.
  - Test method: Crushing value test

Other Mechanical Properties of Aggregates:

a) Impact value: Impact value of aggregates measures the to of particles by impact.

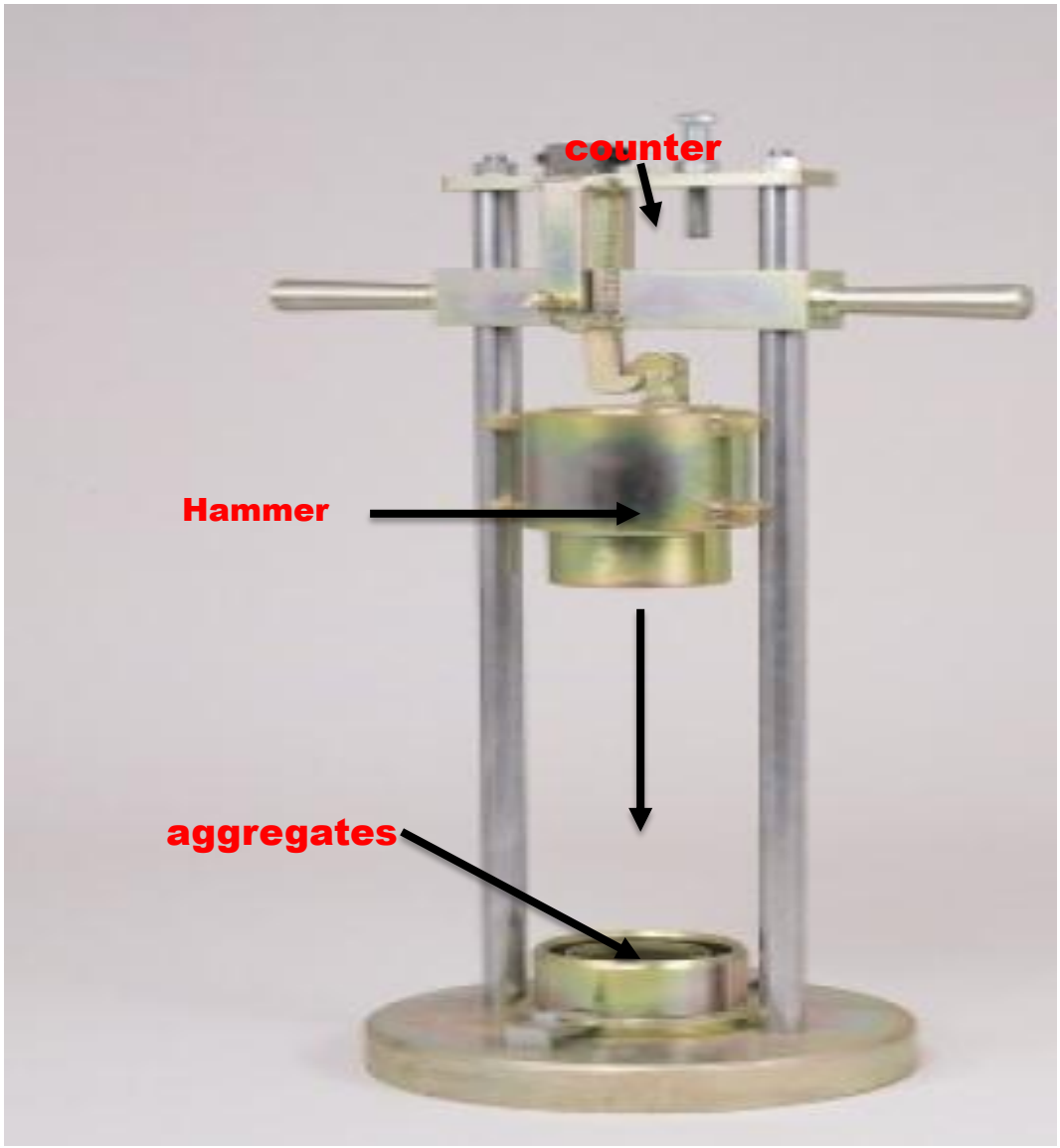
b) Abrasion: Abrasion of aggregates measures the resistanc aggregates against wearing.

- It is an important property of concrete in roads and in fl surfaces subjected to heavy traffic. The most frequently method is the Los Angeles Abrasion Test.

- ***Los Angeles Abrasion Test***: The aggregate of specified gr placed in a cylindrical drum, mounted horizontally. A cha steel balls is added and the drum is rotated a specified n revolutions. The tumbling and dropping of the aggregate balls result in abrasion and attrition of the aggregate. Th grading should be compared with the standard limitatio

Los Angeles Abrasion Test

Aggregate Impact Value Test



4.5 Physical Properties

4.5.1 Specific Gravity

- The specific gravity of an aggregate is a characteristic of the material, which needs to determined in making calculations of mix des of concrete.

4.5.2 Porosity and Absorption of Aggrega

- The porosity of aggregate, its permeability, and abso influence the bonding between aggregate and ceme paste, the resistance of concrete to freezing and tha and resistance to abrasion.

- When all the pores in the aggregate are full it is said saturated.
- If just the surface of aggregate is dry then it is said saturated-surface-dry.

- If the aggregate in saturated surface dry condition al to stand free in dry air, some water from pores will evaporate and it is said to be air dry condition. (See 4.1)

water absorption:

Determined by measuring the increase in weight
oven-dried sample when immersed in water, for 2
hours. (The surface water being removed).

The ratio of the increase in weight to the weight o
sample, expressed as a percentage is termed abso

- Water absorption = $W_{wet} - W_{dry}$

**At the time of setting of concrete the aggregate
saturated-surface-dry condition.**

Moisture Content of Aggregate

- Moisture content is the water in excess of t saturated surface dry state.
- Total water content of a moist aggregate is equal to the sum of absorption and moistu content.

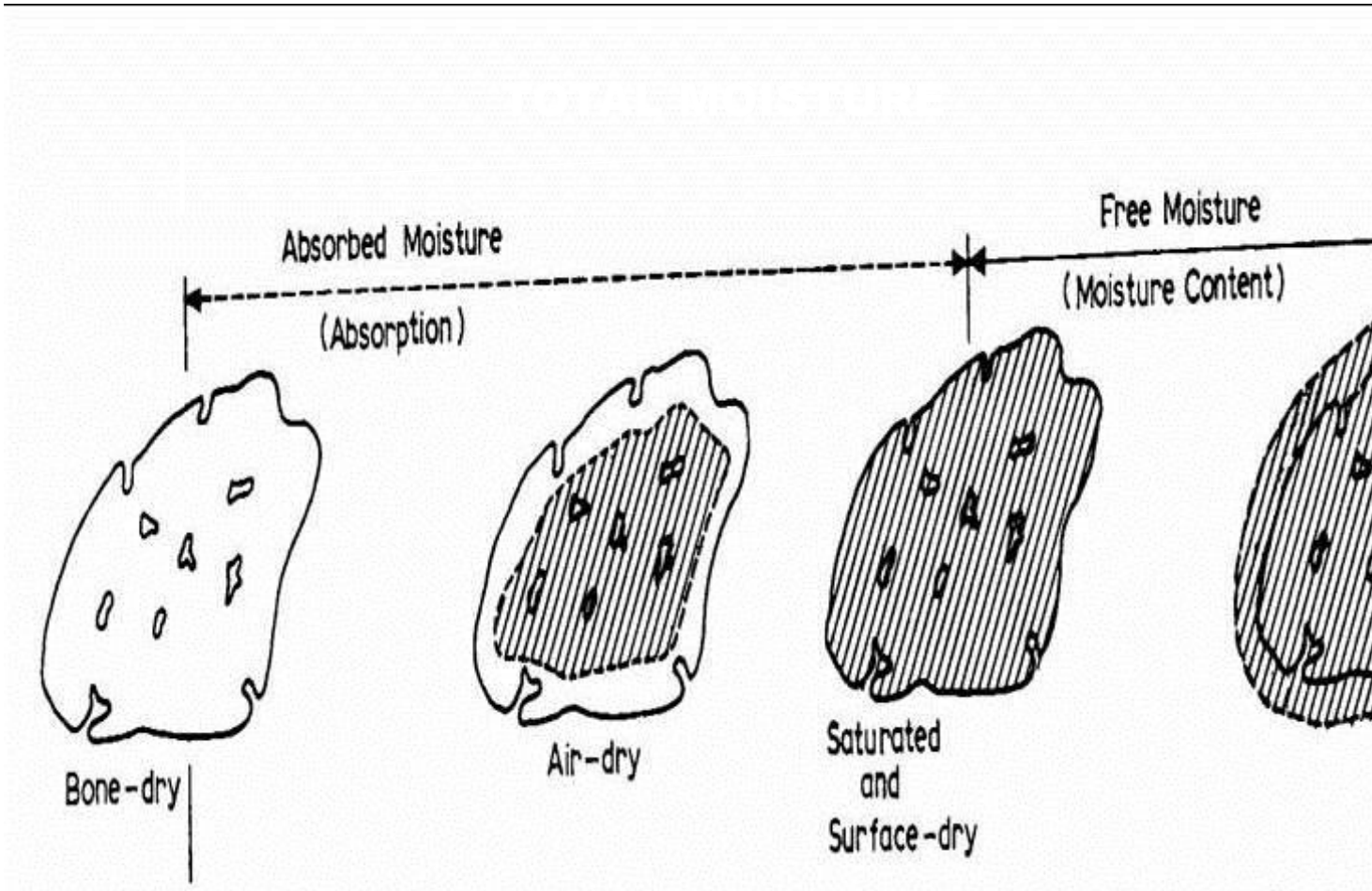
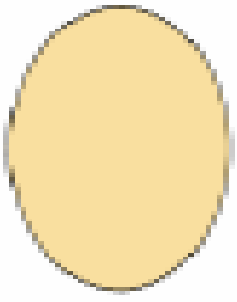
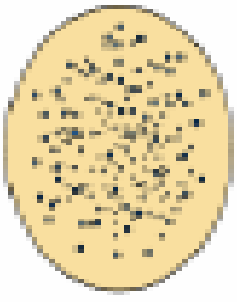


Figure 4.1 Different moisture conditions of aggregate

State	Oven dry	Air dry	Saturated, surface dry	Da
				
Total Moisture	None	Less than potential absorption	Equal to potential absorption	Gr a

Moisture conditions of aggregates

• 4.5.5 Deleterious Substances in Aggregates

a) Organic Impurities:

- Consists of products of decay of vegetable matter. The organic impu interfere with the process of hydration of cement. This affects the r gaining strength.

b) Clay and Other Fine Materials:

- Found as surface coatings which interfere with the bond between a and the cement paste. Affects the strength and durability of concre

Other types of fine material:

Silt and crusher dust.

Affect the bond between cement paste and aggregates.

- "BS EN 12620: Aggregates for Concrete" limits the content of all three not more than the follows:
  - 15% by weight in crushed sand
  - 3% by weight in natural or crushed gravel
  - 1% by weight in coarse aggregate.

c) Salt Contamination:

- Aggregates from the seashore contain salt and have to b washed with fresh water. The aggregate washed even wi sea water do not contain harmful quantities of salts.

- If salt is not removed;
  - It will absorb moisture from the air and cause efflorescence uns white deposits on the surface of the concrete.
  - A slight corrosion of reinforcement may also result, but this is n to progress to a dangerous degree, especially when the concrete good quality and adequate cover to reinforcement is provided.

d) Alkalinity of Aggregates:

- Reactive forms of silica such as opal may occur in so types of rocks, like siliceous limestone.
- The reaction takes place between the siliceous mine the aggregate and the alkaline hydroxides derived fr the alkalis (Na_2O, K_2O) in the cement.
- The resulting gel tends to increase in volume in a hu medium and causes cracking of concrete.
- In this case, it is recommended to *control the limit o alkalis in the cement*.

4.5.6 Soundness of Aggregate

This is the name given to the ability of aggrega
resist excessive changes in volume as a result c
changes of physical conditions.

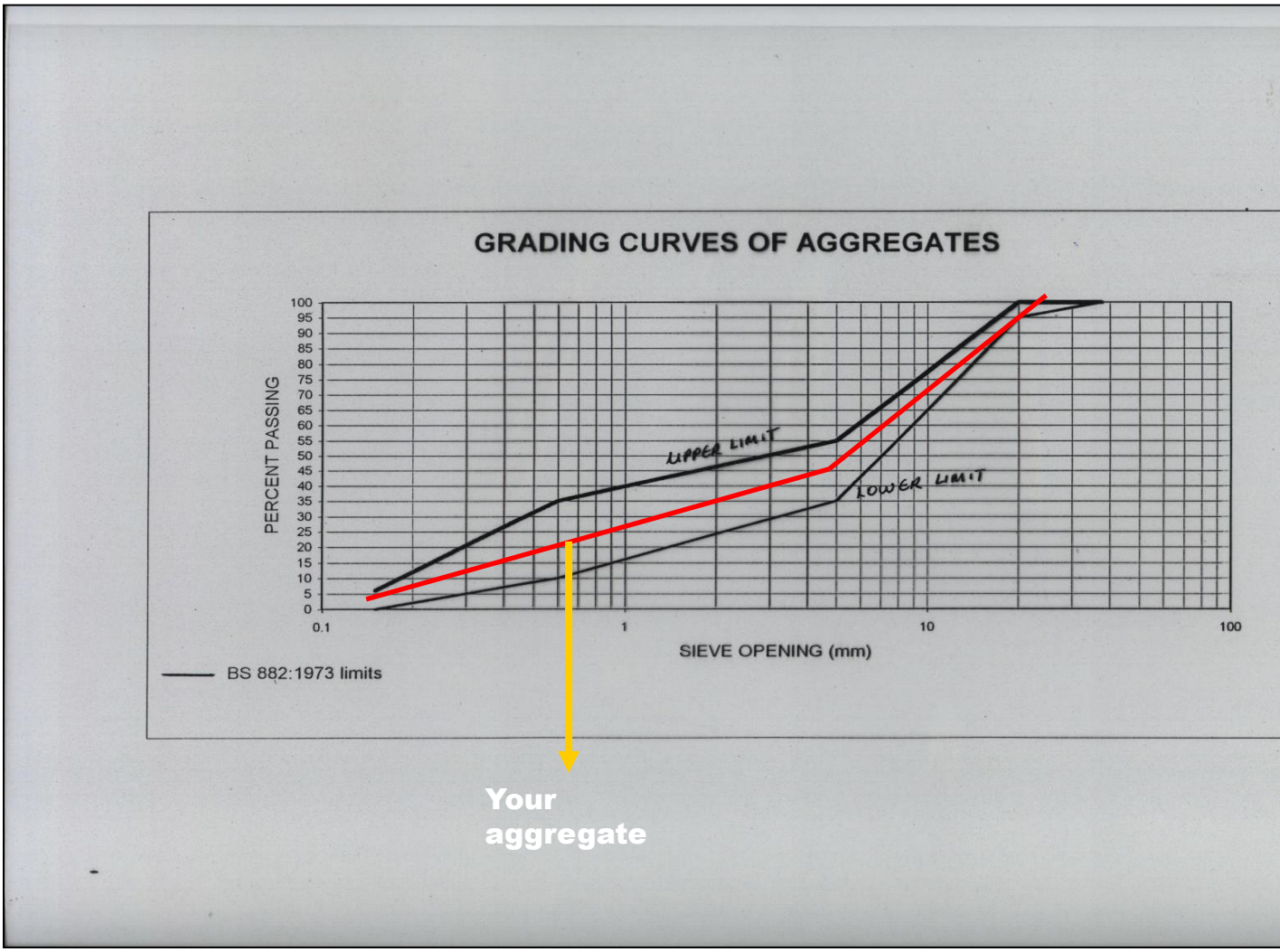
- Aggregate is said to be unsound when volume
changes, induced by the freezing and thawing
result in deterioration of the concrete.

4.5.7 Sieve Analysis

- Sieve analysis is the name of the operation of d
  sample of aggregate into fractions, each consist
  particles of the same size.

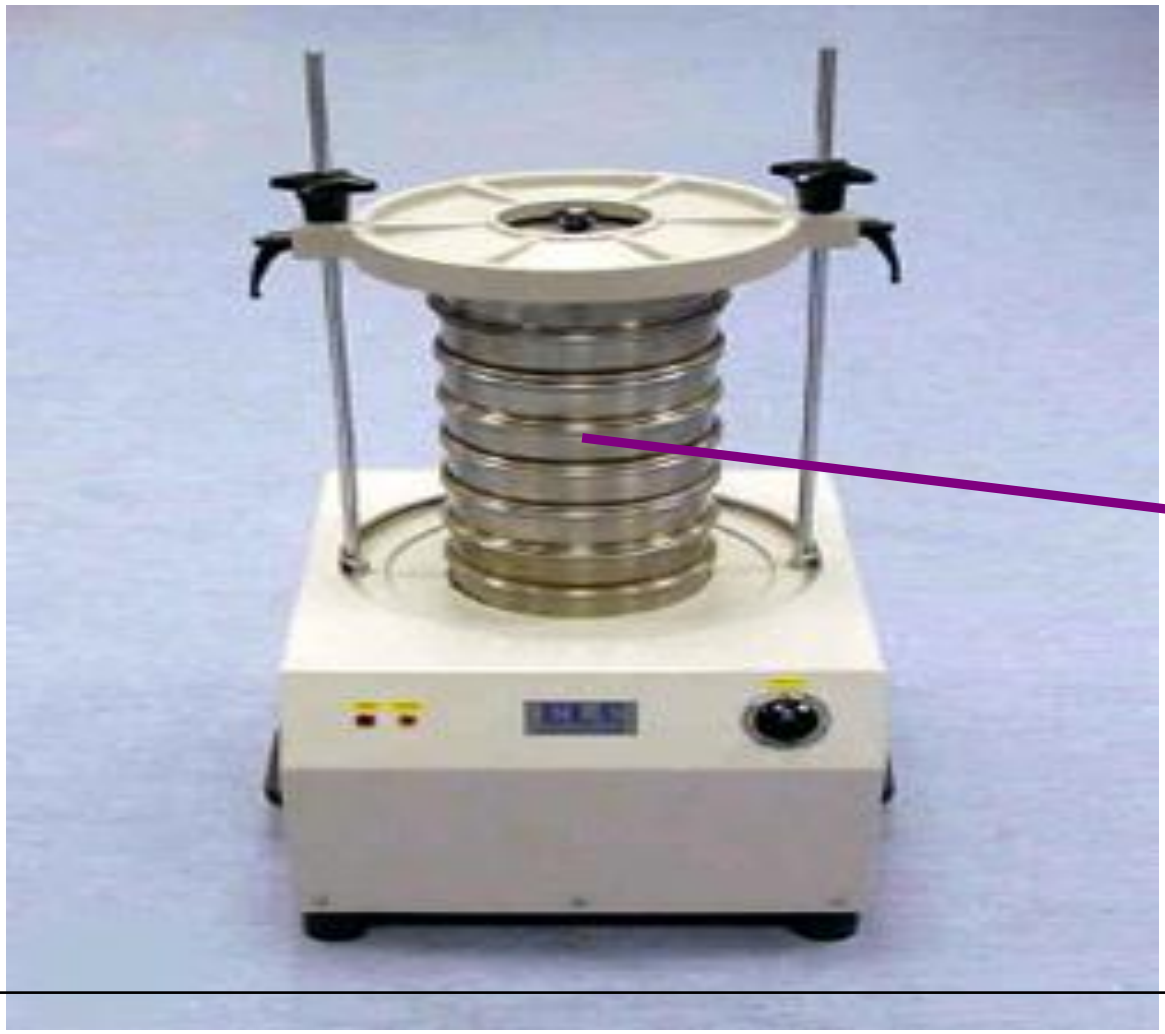
- In practice each fraction contains particles betw
  specific limits, these being the openings of stan
  test sieves.

Grading curves & standard limits of aggregates



Sieves

Sieve shaker



Pouring agregate from top of sieves.

Placing in sieve shaker

Sieve shaker

Measuring weight retained on each sieve

Table 4.3 Sieve designations

British standards (millimeters)	*American standards*	*Nominal openings (inches)*
75	3 in	3
37.5	1 ½	1.5
20	¾	0.75
12.5	½	0.5
6.3	¼	0.25
4.75	No 4	0.187
2.36	No 8	0.0937
1.18	No 16	0.0469
0.600	No 30	0.0234
0.300	No 50	0.0117
0.150	No 100	0.0059
0.075	No 200	0.0029

Table 4.4 The weight of reduced samples f sieving.

Nominal Size of Material (mm)	Minimum weight of sample to be taken for sieving (kg)
63	50
50	35
40	15
28	5
20	2
14	1
10	0.5
6 or 5 or 3	0.2
Less than 3	0.1

The results of a sieve analysis are best reported in tabular form as below:

(1) Sieve Sizes (mm)	(2) Weight Retained (gr)	(3) Percentage Retained	(4) Cumulative Percent Retained	(5) Cumulative Percent Passing

Column 1: Sieve sizes

Column 2: The weights retained on each sieve

Column 3: Percentage of retained weights on each sieve according to the total weight of the sample.

Column 4: Cumulative percentage retained starting from largest sieve to smallest one

Column 5: Cumulative percentage passing from each sieve. It is found by subtracting Column 4 values from 100.

4.5.8 Grading Curves

- Graphical representation (ordinates represent cumulative percentage passing and the abscis sieve opening plotted to a logarithmic scale)

- See at a glance whether the grading of a given sample conforms to that specified or is too coa too fine.

4.5.9 Fineness Modulus

- Fineness modulus is the sum of the cumulative percentage reta
  sieves of the standard test sieves.

  Fineness modulus (FM) = (Cum. percent retained ⁄ 100)

Standard test sieves are as follows:

Coarse aggregate:
75mm, 38mm, 20mm, 10mm

Fine aggregate:
4.75mm, 2.36mm, 1.18mm, 0.600mm, 0.300mm, 0.150mm

Limits for FM:

- Fine aggregate: 2.3-3.0
- Coarse aggregate: 5.5-8.0
- Combined aggregate: 4.0-7.0

Example on Sieve Analysis

Sieve size (mm)	Mass retained (Grams)	Percentage retained	Cumulative percentage retained	Cumulative percentage passing
10.00	0	0.0	0	100
5.00	6	2.0	2	98
2.36	31	10.1	12	88
1.18	30	9.8	22	78
0.600	59	19.2	41	59
0.300	107	34.9	76	24
0.150	53	17.3	93	7
<0.150	21	6.8	-	
			Total = 246	
	Total = 307		Fineness modulus = 2.46	

Fineness Modulus = Cum.% retained / 100 = (2+12+22+41+76+93) / 100 = 2.46

Problem on sieve analysis

1	2	3	4	5
BS sieve size (mm)	Weight retained (gr)	Percentage retained (%)	Cumulative percentage retained (%)	Cumulative percentage passing (%)
75	0	0	0	100
37.5	0	0	0	100
20	454			
10	227			
4.75	454			
2.36	227			
1.18	454			
0.6	454			
0.3	681			
0.15	1135			
Pan	454			
total				

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4.5.10 Grading Requirements

- The purpose of sieve analysis is to determine whether or not a particular grading is suitable. The related problem of grading is combining of fine and coarse aggregates so as to produce desi grading (See Table 4.5, 4.6).

The main factors governing the desired aggregate grading are:

1. the surface area of the aggregate, which determines the amou water necessary to wet all the solids
2. the relative volume occupied by the aggregate
3. the workability of the mix
4. the tendency to segregation.

4.5.10 Grading Requirements (cont'd

- The grading of aggregate is a major factor in the work a concrete mix.
- Grading affetcs characteristics of fresh concrete and h state: strength, shrinkage and durability.
- Ensure that the grading is kept constant during the co work; otherwise variable workability results and as th usually corrected at the mixer by a variation in the wa content, concrete of variable strength is obtained.

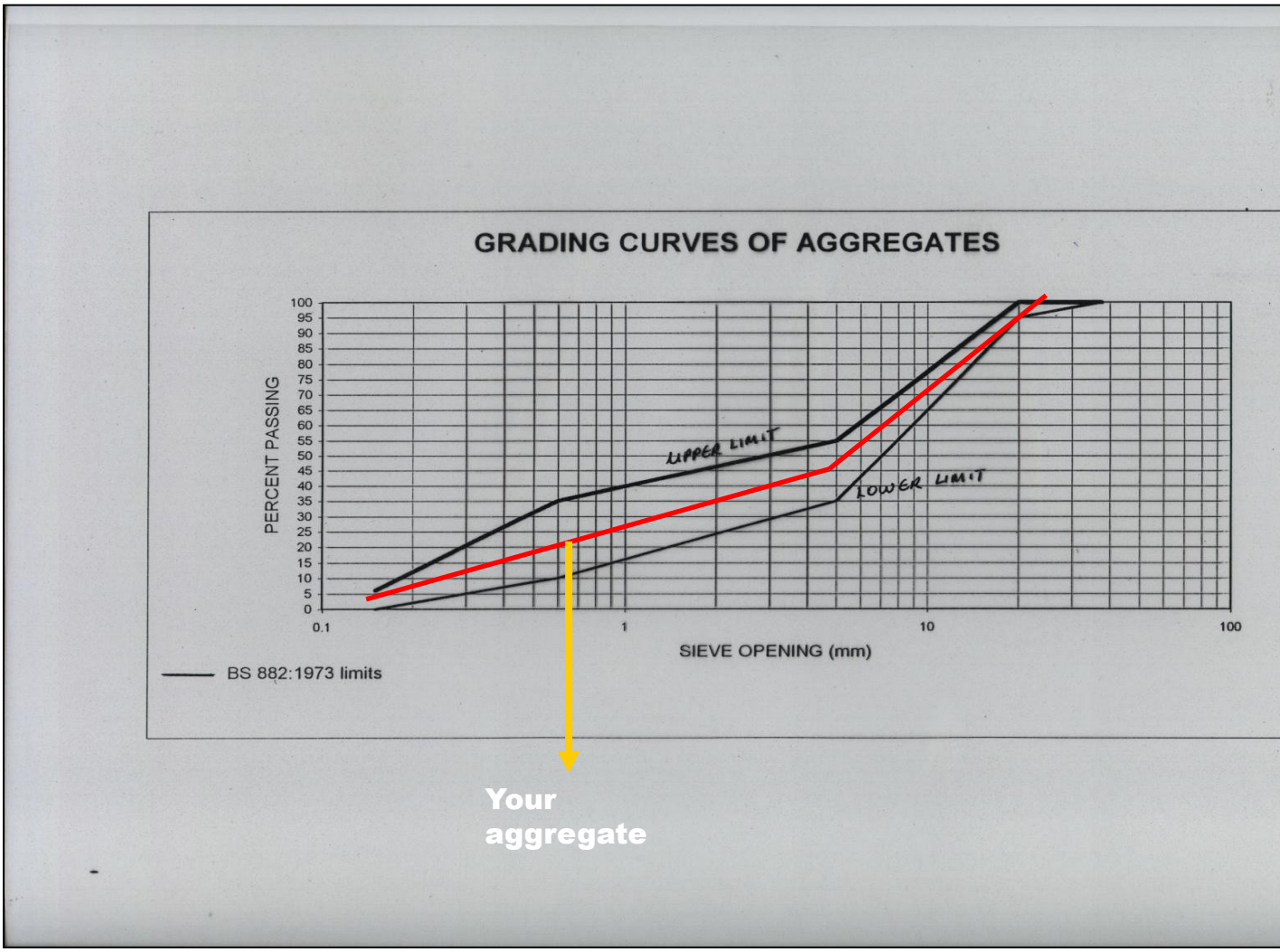
Table 4.5: ASTM C33/C 33M Grading Requirements for Fine Aggr

Sieve	Percent passing
9.5 mm	100
4.75 mm	95-100
2.36 mm	80-100
1.18 mm	50-85
600 µm	25-60
300 µm	5-30
150 µm	0-10

Table 4.6: ASTM C33/C 33M Grading Requirements for Coarse Aggregates

Size	Amounts finer than each laboratory sieve, mass percent											
mm	100	90	75	63	50	37.5	25	19	12.5	9.5	4.75	
90-37.5	100	90-100	...	25-60	...	0-15	...	0-5	...	...	...	
63-37.5	...	...	100	90-100	35-70	0-15	...	0-5	...	...	...	
50-25	...	...	...	100	90-100	35-70	0-15	...	0-5	...	...	
50-4.75	...	...	...	100	95-100	...	35-70	...	10-30	...	0-5	
37.5-19	...	...	...	...	100	90-100	20-55	0-15	...	0-5	...	
37.5-4.75	...	...	...	...	100	95-100	...	35-70	...	10-30	0-5	
25-12.5	...	...	...	...	...	100	90-100	20-55	0-10	0-5	...	
25-9.5	...	...	...	...	...	100	90-100	40-85	10-40	0-15	0-5	
25-4.95	...	...	...	...	...	100	95-100	...	25-60	...	0-10	
19-9.5	...	...	...	...	...	...	100	90-100	20-55	0-15	0-5	
19-4.75	...	...	...	...	...	...	100	90-100	...	20-55	0-10	
12.5-4.75	...	...	...	...	...	...	...	100	90-100	40-70	0-15	
9.5-2.36	...	...	...	...	...	...	...	...	100	85-100	10-30	
9.5-1.18	...	...	...	...	...	...	...	...	100	90-100	20-55	
4.75-1.18	...	...	...	...	...	...	...	...	...	100	85-100	

Grading Curves of Aggregates (grading requirement)



- Gap grading is a grading in which one or more intermediate size fractions are omitted. (see Fi 4.2).

- **Well Graded** means sizes within the entire ran in approximately equal amounts (friction at ma points, excellent interlocking, very few voids) (Figure 4.2).

- **Uniform gradation** means a large percentage
the particles are of approximately the same s
(poor interlocking, high percentage of voids,
friction at few points of contact) (see Figure 4

- **Combined gradation** means fine and coarse
aggregates are combined (friction at many po
good interlocking, few voids, economical).

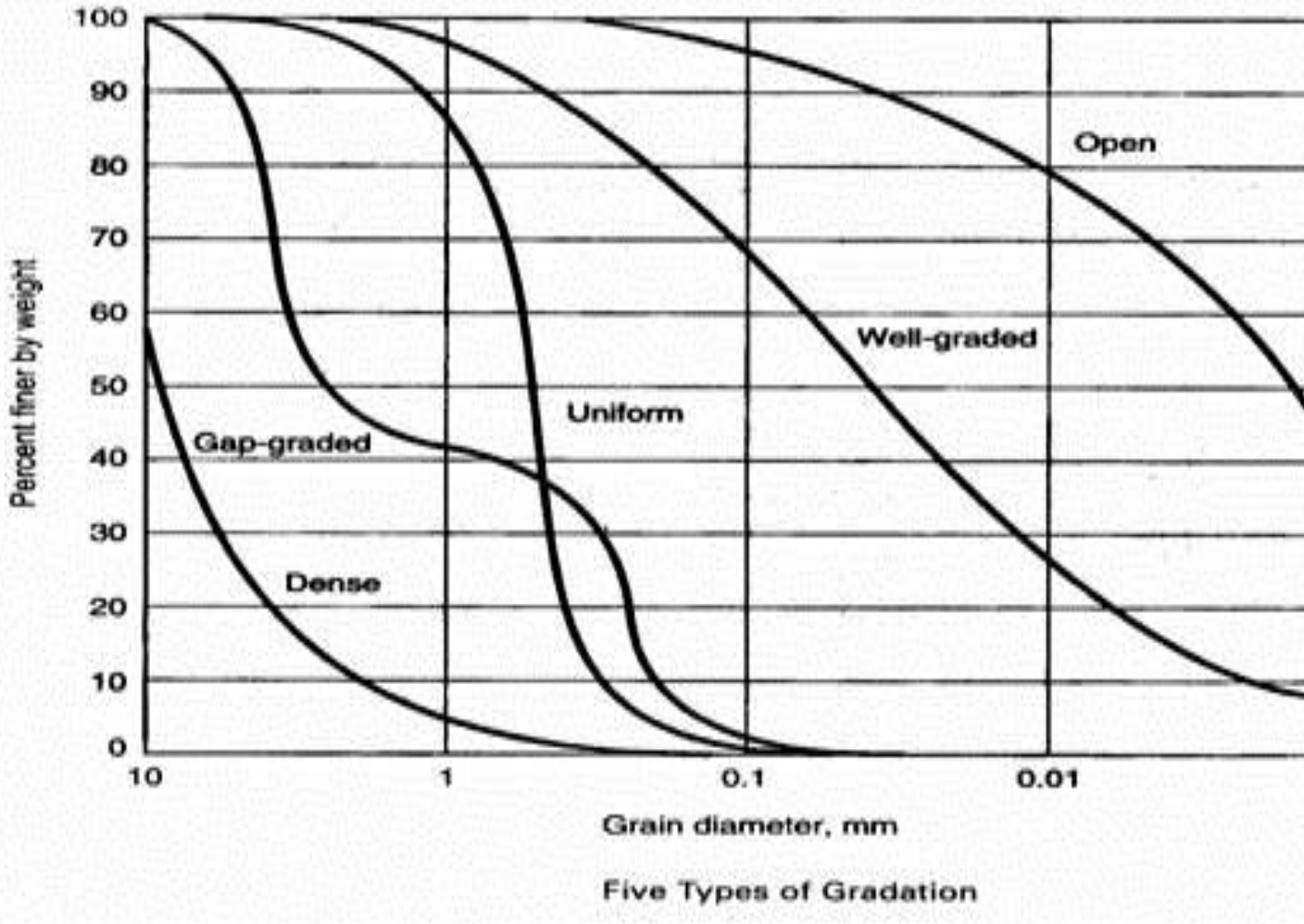
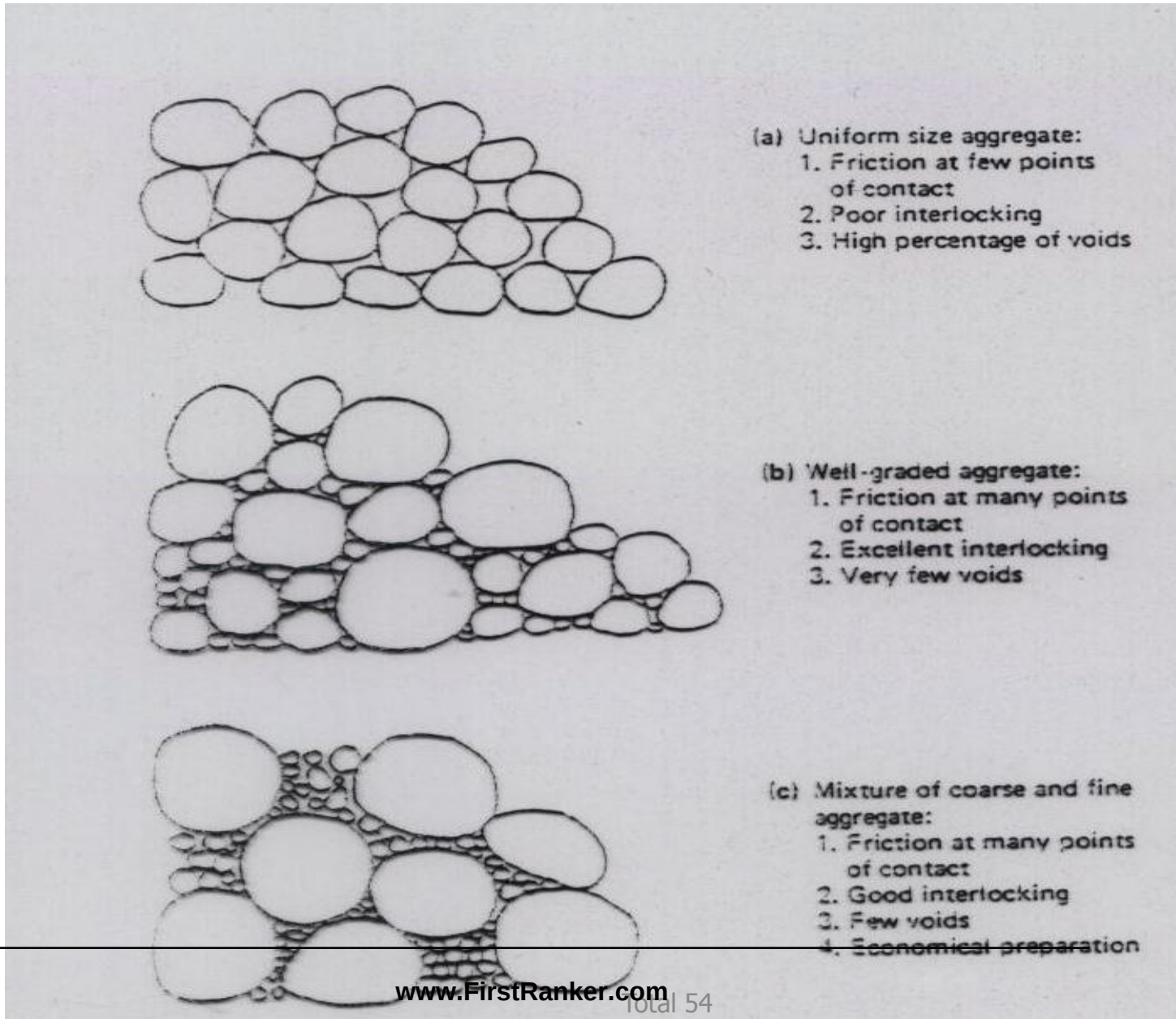
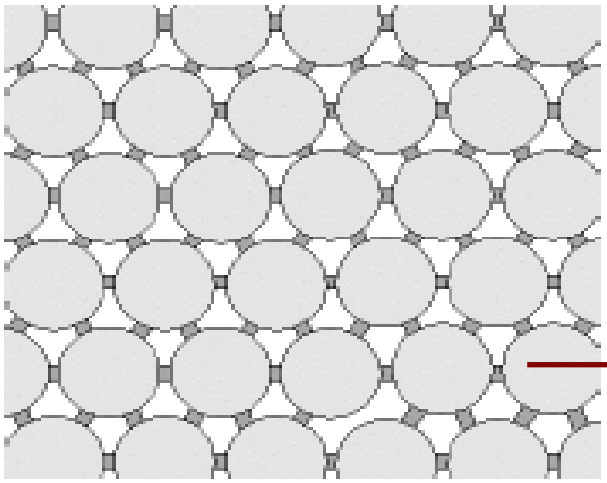


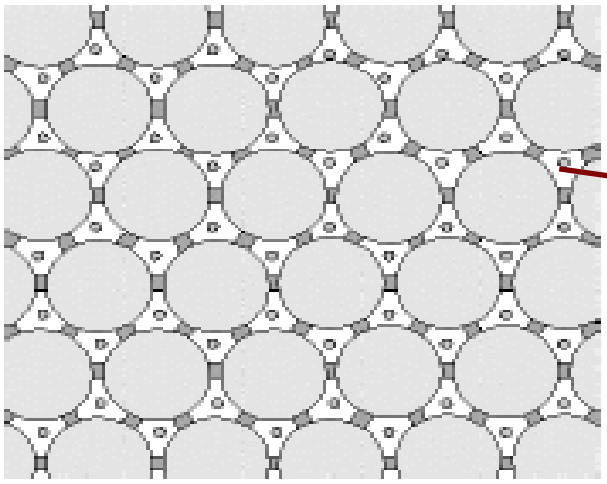
Figure 4.2 Grading of aggregates

Grading of aggregates





: Optimized cement paste content for binding the aggregates only in their contact point



: Due to filling the interstices with fine mortar there will be a higher compressive streng
but also a higher dry density