E-contents

BUILDING MATERIALS AND CONSTRUCTION-III

CEMENT & LIME

AGGREGATES & MORTAR

CEMENT

TIMBER

GLASS

CEMENT

CEMENT

Introduction

- Popular as building material.
- Material with adhesive & cohesive properties.
- To bind the fine & coarse aggregate together
- To fill voids in between fine & coarse aggregate particle form a compact mass.

COMPOSITION OF CEMENT

Calcium Oxide (CaO)	= 60 – 65%
Silica (SiO_2)	= 20 – 25%
Aluminum Oxide	= 4 - 8%
Ferrous Oxide	= 2 – 4 %
Magnesium Oxide	= 1 – 3 %

Types of Cement

Depending upon our requirements i.e. using it at a suitable place, we use different types of cement.

- Rapid Hardening or High early strength Cement
- Quick setting Cement
- High Alumina Cement
- Portland Slag Cement
- Low Heat Cement
- Air Entraining Cement
- White Cement
- Coloured Cement
- Portland Pozzolona Cement

CEMENT

PORTLAND CEMENT

Made by mixing substances containing **Calcium Carbonate** such as chalk / limestone,

with substances containing **silica , alumina and iron oxide** such as clay/ shale.

•Clay/shale:

SiO_2	Silica (silicon oxide)	abbreviated S
$Fe_2 0_3$	Ferrite (iron oxide)	abbreviated F
$Al_2 0_3$	Alumina (aluminium oxide)	abbreviated A

•Limestone/chalk

$CaC0_3$	Calcium carbonate	abbreviated C

•then the mixture heated and became clinker.

•Clinker then grounded to powder.

•The hardening Portland cement is a chemical process during which heat is evolved.

Rapid Hardening Cement

This type cement gets the strength faster than OPC, However its Initial and Final setting is same as those of OPC. It contains more of Tri-Calcium Silicate and is more finely grounded. It gives out more Heat while setting so it is as such unsuitable for massive concrete. It is Used for the Structures which are Subjected to loads early e.g. Roads, Bridges.

Quick Setting cement

It sets faster than the Ordinary Portland Cement. Its Initial Setting Time is 5 minutes and the Final Setting Time is not more 30 minutes. It is required for making concrete that is required to set early as for lying under water or in running water. Initial setting being very little there is always the danger of concrete having undergone its initial setting. Thus this type of cement is used in more special cases.

- **High Alumina Cement**

  It is manufactured by the burning of bauxite ore and lime stone in correct proportions and at high temperature. The resulting product is then ground finely. It develops Strength Rapidly. It is of black colour and resists well the attack of chemicals especially of sulphates and sea water. Its ultimate strength is much higher than OPC. Its initial setting takes more than 2 hours and the final set takes place immediately thereafter. Most of the heat it gives in the first 10 hrs as a result it can be conveniently used in freezing temperatures. At ordinary temperature it is used in thin layers.

- **Portland Slag Cement**

  It is obtained by mixing clinker, gypsum and granulated slag in a proper proportion. The Properties of this cement is very similar to that of OPC which are as under. It has lesser heat of hydration and has better resistance of soils, sulphates of alkali metals, alumina and iron. It has better resistance to acidic water. This type of cement is mostly used in Marine Works.

- **Low Heat Cement**

  The Heat Generated by cement while setting may cause the structure to crack in case of concrete. This Heat generation is controlled by keeping the percentage of Tri-Calcium Silicate and that of Tri-Calcium Aluminate low. Its initial setting and Final setting times are nearly the same as those of OPC. It is not very suitable for Ordinary structures because the use of cement will delayed time of drying. It will also need more curing.

- **Air Entraining Cement**

  It is the OPC mixed with some air entraining agents. The common air entraining agents are oils, fats and fatty acids etc. These materials have the property of entraining air in the form of fine air bubbles. The bubbles render the concrete to become more plastic, workable and more resistant to freezing. However because of air entrainment the strength of concrete reduces and as such the quantity of air so entrained should not exceed 5%.

- **White Cement**

  It is the cement of pure white colour and having same properties as those of Ordinary Portland Cement. Greyish colour of cement is due to iron oxide (FeO). White cement is manufactured from chalk and clay free from Iron Oxide. Oil fuel and not the coal is used for the burning of this cement.It is much more costly than ordinary cement.

- **Coloured Cement**

  Various coloured cement are prepared when required in special cases. Suitable pigments are added with OPC to get red or brown cement but for other colours 5 – 10% of desired pigments are grounded with white cement. Pigments used should be chemically inert and also durable so as they must not fade due to the effect of lights sun or weather.

- **Portland Pozzolona Cement**

  Portland Pozzolona cement is produced by grinding together Portland cement and Pozzolona. This cement has properties similar to those of OPC and can therefore be used for all general purpose. Portland Pozzolona cement produces less heat of hydration and offers greater resistance to attack of aggressive water or sulphates bearing than OPC. Portland Pozzolona cement are particularly used in marine works. It takes a little longer to gain strength. Ultimate Strength of this cement is more than OPC

TEST OF CEMENT

- Consistency test
- Compressive strength test
- Tensile strength test

Consistency Test

- It is used to determine the % of water required for preparing cement pastes for other tests
- Procedure:

1. Take 300g cement, add 30% or 90g of water
2. Mix water and cement on a non-porous surface. Mixing should be done.

- Fill the mould of Vicat apparatus.

- The interval between the addition of water to the commencement of filling the moulds is known as the *time of gauging*.

- Among the factors affect the setting time are:
- a) Fineness of cement
- b) Chemical composition
  c) Amount of water
- Gypsum added to clinker to retard setting and prevent flash set.
- Flash set is defined as the rapid development of permanent rigidity of the cement paste along with high heat.
- False set is the rapid development of rigidity without the evolution of heat .

COMPRESSIVE STRENGTH

- Mortar of cement & sand is prepared, 1:3.
- Water is added, water cement ratio 0.4:1
- It is placed in moulds & form cubes of sides 70.6 or 76 mm.
- The cement required is 185 or 235g
- Compacted in vibrating machine in 2 min.
- Moulds placed in damp cabin for 24 hrs
- Specimens are removed & placed in water for curing.

- It is tested in compressive testing machine after 3 and 7 days.
- Every side is calculated and average is taken.

- For 3 days: > 115 kg/cm^2 or 11.5 N/mm^2
- for 7 days: > 175 kg/cm^2 or 17.5 N/mm^2

TENSILE STRENGTH

- Procedure:

1. Mortar is prepared cement(1) : Sand (3)
2. Water is added 8%
3. Mortar is placed in briquette moulds

Physical properties

- Feel smooth when touched or rubbed in between fingers.
- *If felt rough, indicates adulteration with sand.*
- If hand is inserted in cement bag, hand feels cool and not warm.
- If it immersed in water, it should sink and should not float
- A paste of cement feel sticky
- *If it contains clay & silt as adulterant, it give earthy smell.*

TYPES OF CEMENT PROCESSES

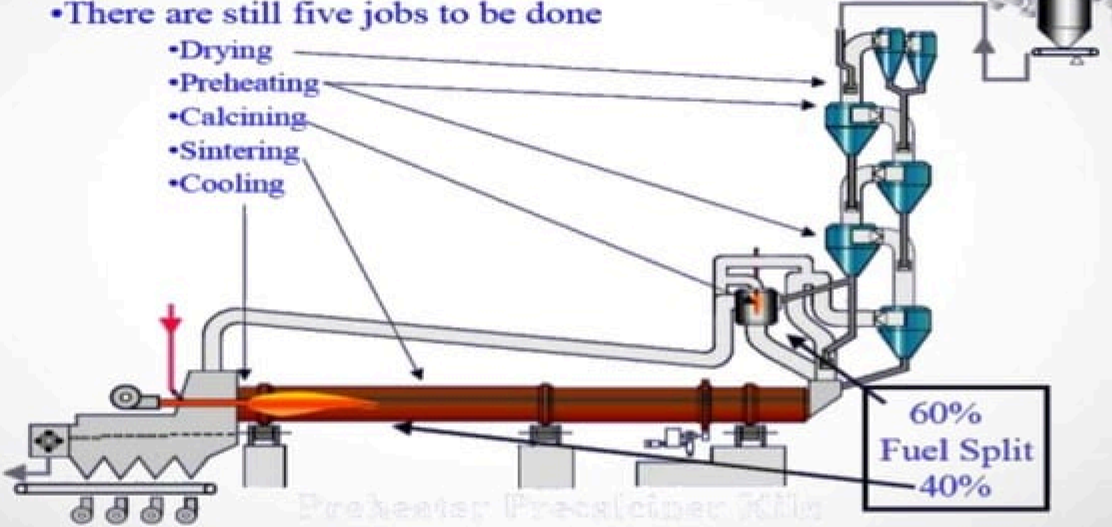
- Wet Process.
- Dry Process – 74% of cement produced.
- Preheater / Precalciner Process.

The Wet Cement Kiln

- The kiln is a continuous stream process vessel in which feed and fuel are held in dynamic balance
- 5 distinct process functions are performed in the kiln:
  - Dry
  - Preheat
  - Calcine
  - Sinter
  - Cool

Dry Process Preheater/Precalciner System

- There are still five jobs to be done
  - Drying
  - Preheating
  - Calcining
  - Sintering
  - Cooling



LIME

LIMESTONE ROCKS

LIMESTONE CHALK

PRODUCTION

- Excavation
- Crushing
- Grinding

Limestone

- Calcination → Quicklime
- Pulverize quicklime
- Mix with water under pressure → Slaked Lime
- Drying of Slaked Lime
- Pulverizing
- Marketing in bags.

CALCINATION

- $CaCO_3 \longrightarrow CaO + CO_2$ (> 900°C)

"quick lime"

	atomic weight (g/mol)
Ca	40.078
O	15.999
C	12.011

- Calcination is carried out in kilns:
  - Intermittent
  - Continuous
  - Rotary
  - Reactor

DIFFRENT TYPES OF LIME KILN

INTERMITTANT KILN

CONTINOUS KILN

USE OF LIME

- IT IS USED IN POLLUTION CONTROL, IN GAS SCRUBBERS TO DESULFURIZE WASTE GASES AND TO TREAT MANY LIQUID INFLUENTS.
- IN MORTAR AND PLASTER TO INCREASE THE RATE OF HARDENING AS WELL AS TO IMPROVE ADHESION.
- IT IS ALSO USED IN WATER AND SEWAGE TREATMENT TO REDUCE ACIDITY TO SOFTEN.
- IN AGRICULTURE TO REMOVE ACIDIC SOILS.
- IN PAPER MAKING TO DISSOLVE LIGNIN, AS A COAGULANT.

AGGREGATES

General introduction

Aggregates are the important constituents in concrete. They give body to the concrete, reduce shrinkage and effect economy.

Earlier aggregates were considered as chemically inert materials but now it has been recognized that some of aggregates are chemically active and also that certain aggregates exhibit chemical bond and at the interface of aggregate and paste.

The aggregate are occupy 70-80 percent of volume of the concrete. Their impact on various characteristics and properties of concrete is undoubtedly considerable.

I. Classification

- According to weight

i. Normal weight agg.

ii. Light weight agg.

iii. Heavy weight agg.

- According to size

i. Coarse aggregate.

ii. Fine Aggregate.

Natural Aggregate
Sand, Gravel, Crushed rock such as Granite, Quartzite, Basalt, Sand stone

Artificial Aggregate
Brocken Brick, Air cooled slag, Sintered fly ash, Bloated clay

ii. Source

- Almost all natural aggregate materials originate from bed rock.
- There are three kinds of rocks, Igneous, Sedimentary and Metamorphic.
- Igneous rocks : Most igneous rocks make highly satisfactory concrete agg.. Because they are normally hard, tough, and dense.
- The igneous rocks have massive structure, entirely crystalline or wholly glassy or in combination in between, depending upon the rate at which they were cooled during formation.

- The igneous rock as a class are the most chemically active concrete aggregate and show a tendency to react with the alkalis in cement
- **<u>Sedimentary Rock</u>** Igneous rock or metamorphic rocks are subjected to weathering agencies such as sun, rain and wind. These weathering agencies decompose, fragmentize, transport and deposit the particles of rock, deep beneath the ocean bed where they are cementing materials could be carbonated together by some of the cementing materials.

- The cementing materials could be carbonaceous, siliceous or argillaceous in nature. Due to static pressure of water and becomes compact sedimentary rock layer.

- The quality of aggregates derived from sedimentary rocks will vary in quantity depending upon the cementing material and the pressure under which these rocks are originally compacted. Some siliceous sand stones have proved to be good concrete aggregate. Similarly, the limestone also can yield good concrete aggregate.

- **Metamorphic Rocks** :Both igneous rocks and sedimentary rocks may be subjected to high temperature and pressure which causes metamorphism which changes the structure and texture of rocks. Metamorphic rocks show foliated structure. The thickness of this foliation may vary from a few centimeters to many meters.

size

- The largest maximum size of aggregate practicable to handle under a given set of conditions should be used. Perhaps, 80 mm size is the maximum size that could be conveniently used for concrete making.

- Using the largest possible maximum size will result in

(i) reduction of the cement content (ii) reduction in water requirement (iii) reduction of drying shrinkage. However, the maximum size of aggregate that can be used in any given condition may be limited by the following conditions

(i) Thickness of section; (ii) Spacing of reinforcement; (iii) Clear cover; (iv) Mixing, handling and placing techniques.

- Generally, the maximum size of aggregate should be as large as possible within the limits specified, but in any case not greater than one-fourth of the minimum thickness of the member.

- For heavily reinforced concrete member the nominal maximum size of aggregate should usually be restricted to 5 mm less than the minimum clear distance between the main bars or 5 mm less than the minimum cover to the reinforcement, whichever is smaller. But from various other practical considerations, for reinforced concrete work, aggregates having a maximum size of 20 mm are generally considered satisfactory.

- Aggregates are divided into two categories from the consideration of size (i) Coarse aggregate and (ii) Fine aggregate. The size of aggregate bigger than 4.75 mm is considered as coarse aggregate and aggregate whose size is 4.75 mm and less is considered as fine aggregate

SHAPE

- The shape of aggregates is an important characteristic since it affects the workability of concrete. It is difficult to really measure the shape of irregular body like concrete aggregate which are derived from various rocks. Not only the characteristic of the parent rock, but also the type of crusher used will influence the shape of aggregates.

- EX:- The rocks available round about Pune region are found to yield slightly flaky aggregates, whereas, good granite rock as found in Bangalore will yield cubical aggregate.

- The shape of the aggregate is very much influenced by the type of crusher and the reduction ratio i.e., the ratio of size of material fed into crusher to the size of the finished product

- As a consequence of these tendencies, schists, slates and shales commonly produce flaky forms, whereas, granite, basalt and quartzite usually yield more or less equidimensional particles. Similarly, quartzite which does not possess cleavage planes produces cubical shape aggregates.

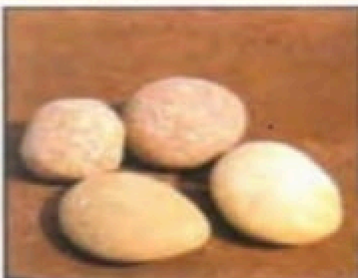
- From the standpoint of economy in cement requirement for a given water/cement ratio, rounded aggregates are preferable to angular aggregates. On the other hand, the additional cement required for angular aggregate is offset to some extent by the higher strengths and sometimes by greater durability as a result of the interlocking texture of the hardened concrete and higher bond characteristic between aggregate and cement paste.

- Flat particles in concrete aggregates will have particularly objectionable influence on the workability, cement requirement, strength and durability. In general, excessively flaky aggregate makes very poor concrete.

- Classification of particles on the basis of shape of the aggregate is shown in Table.

Table 3.1 Shape of Particle

Classification	*Description*	*Examples*
Rounded	Fully water worn or completely shaped by attrition	River or seashore gravels; desert, seashore and wind-blown sands
Irregular or Partly rounded	Naturally irregular or partly shaped by attrition, having rounded edges	Pit sands and gravels; land or dug flints; cuboid rock
Angular	Possessing well-defined edges formed at the intersection of roughly planar faces	Crushed rocks of all types; talus; screes
Flaky	Material, usually angular, of which the thickness is small relative to the width and/or length	Laminated rocks



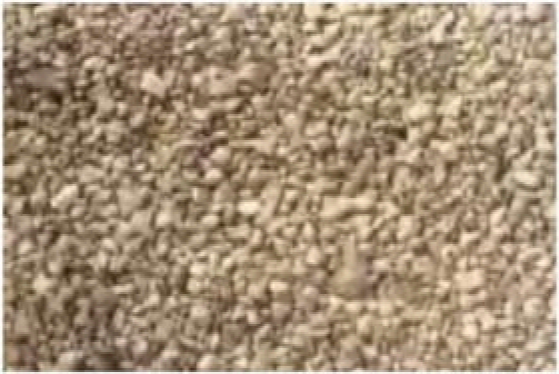
Round (spherical) concrete aggregate.

Flaky concrete aggregate.

Crushed concrete aggregate.

Poorly shapped crushed aggregate. It will make poor concrete.

Barmac crushed 20 mm cubical aggregate. It will make good concrete.



Good aggregate resulted from Barmac crusher.

20 mm crushed angular aggregates not so good for concrete.

Courtesy : Durocrete Pune

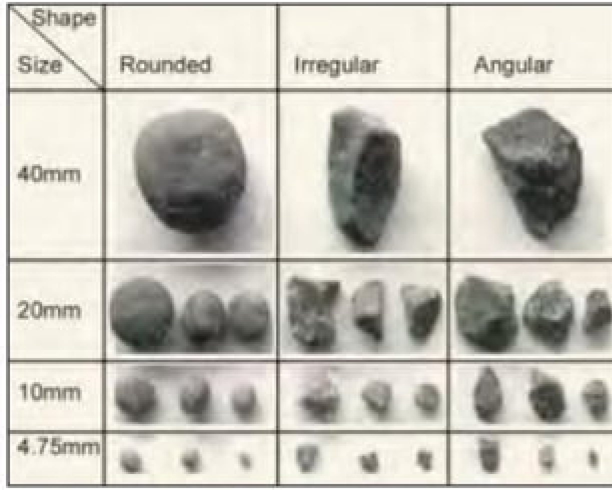
Quality of Agg.. checking

- A quantity of single sized aggregate is filled into metal cylinder of three litre capacity. The aggregates are compacted in a standard manner and the percentage of void is found out.
- The void can be found out by knowing the specific gravity of aggregate and bulk density or by pouring water to the cylinder to bring the level of water up to the brim.
- If the void is 33 per cent the angularity of such aggregate is considered zero. If the void is 44 per cent the angularity number of such aggregate is considered 11.
- In other words, if the angularity number is zero, the solid volume of the aggregate is 67 per cent and if angularity number is 11 the solid volume of the aggregate is 56 per cent.
- The normal aggregates which are suitable for making the concrete may have angularity number anything from zero to 11. Angularity number zero represents the most practicable rounded aggregates and the angularity number 11 indicates the most angular aggregates that could be tolerated for making concrete not so unduly harsh and uneconomical

- Murdock suggested a different method for expressing the shape of aggregate by a parameter called Angularity Index 'f_A'

Angularity Index $f_A = \frac{3f_H}{20} + 10$

Where f_H is the angularity number



Shape and size of aggregates

Courtesy : Ambuja Cement

The angular aggregates are superior to rounded aggregates from the following two points of view:

- (a) Angular aggregates exhibit a better interlocking effect in concrete, which property makes it superior in concrete used for roads and pavements.
- (b) The total surface area of rough textured angular aggregate is more than smooth rounded aggregate for the given volume. By having greater surface area, the angular aggregate may show higher bond strength than rounded aggregates.
- For water/cement ratio below 0.4 the use of crushed aggregate has resulted in strength up to 38 per cent higher than the rounded aggregate. With an increase in water/cement ratio the influence of roughness of surface of the aggregate gets reduced.
- A water/cement ratio of 0.65, no difference in strength of concrete made with angular aggregate or rounded aggregate has been observed.

TEXTURE

- Surface texture is the property, the measure of which depends upon the relative degree to which particle surfaces are polished or dull, smooth or rough. Surface texture depends on hardness, grain size, pore structure, structure of the rock, and the degree to which forces acting on the particle surface have smoothed or roughend it. Hard, dense.
- As surface smoothness increases, contact area decreases, hence a highly polished particle will have less bonding area with the matrix than a rough particle of the same volume.
- Rough textured aggregate develops higher bond strength in tension than smooth textured aggregate. The beneficial effects of surface texture of aggregate on flexural strength can be seen from Table.

Table 3.2. Influence of Texture on Strength[3.3]

Per cent of Particles		Water/Cement Ratio	Strength 28 days MPa	
Smooth	Rough		Flexural	Compressive
100	0	0.54	4.3	34.8
50	50	0.57	4.6	32.1
0	100	0.60	4.8	29.5

Surface texture characteristics of the aggregate as classified in IS: 383: 1970 is shown below

Table 3.3. Surface Characteristics of Aggregate

Group	Surface Texture	Examples
1.	Glassy	Black flint
2.	Smooth	Chert; slate; marble; some rhyolite
3.	Granular	Sandstone: oolites
4.	Crystalline	Fine : Basalt; trachyte; medium : Dolerite; granophyre; granulite; microgranite; some limestones; many dolomites. Coarse : Gabbro; gneiss; granite; granodiorite; syenite
5.	Honeycombed and porous	Scoria; Pumice, trass.

STRENGTH

- When we talk of strength we do not imply the strength of the parent rock from which the aggregates are produced, because the strength of the rock does not exactly represent the strength of the aggregate in concrete.
- Since concrete is an assemblage of individual pieces of aggregate bound together by cementing material, its properties are based primarily on the quality of the cement paste. This strength is dependent also on the bond between the cement paste and the aggregate.
- If either the strength of the paste or the bond between the paste and aggregate is low, a concrete of poor quality will be obtained irrespective of the strength of the rock or aggregate. But when cement paste of good quality is provided and its bond with the aggregate is satisfactory, then the mechanical properties of the rock or aggregate will influence the strength of concrete

TEST CONDUCTED BY FINDING THE STRENGTH OF AGGREGATE

Aggregate Crushing Value:

Aggregate Crushing Value Apparatus.

- Strength of rock is found out by making a test specimen of cylindrical shape of size 25 mm diameter and 25 mm height. This cylinder is subjected to compressive stress.
- Different rock samples are found to give different compressive strength varying from a minimum of about 45 MPa to a maximum of 545 MPa.
- This test is known as aggregate crushing value test. Aggregate crushing value gives a relative measure of the resistance of an aggregate sample to crushing under gradually applied compressive load.
- This test is made on single sized aggregate passing 12.5 mm and retained on 10 mm sieve. The aggregate is placed in a cylindrical Mould and a load of 40 ton is applied through a plunger.
- The material crushed to finer than 2.36 mm is separated and expressed as a percentage of the original weight taken in the Mould.
- This percentage is referred as aggregate crushing value. The crushing value of aggregate is restricted to 30 per cent for concrete used for roads and pavements and 45 per cent may be permitted for other structures

- **Aggregate Impact Value:**

Aggregate Impact Value Apparatus.

- With respect to concrete aggregates, toughness is usually considered the resistance of the material to failure by impact.
- Several attempts to develop a method of test for aggregates impact value have been made. The most successful is the one in which a sample of standard aggregate kept in a Mould is subjected to fifteen blows of a metal hammer of weight 14 Kgs falling from a height of 38 cm.
- The quantity of finer material (passing through 2.36 mm) resulting from pounding will indicate the toughness of the sample of aggregate. The ratio of the weight of the fines (finer than 2.36 mm size) formed, to the weight of the total sample taken is expressed as a percentage.
- This is known as aggregate impact value IS 283-1970 specifies that aggregate impact value shall not exceed 45 per cent by weight for aggregate used for concrete other than wearing surface and 30 per cent by weight, for concrete for wearing surfaces, such as run ways, roads and pavements

Aggregate Abrasion Value :

- Apart from testing aggregate with respect to its crushing value, impact resistance, testing the aggregate with respect to its resistance to wear is an important test for aggregate to be used for road constructions, ware house floors and pavement construction. Three tests are in common use to test aggregate for its abrasion resistance.

  (i) Deval attrition test

  (ii) Dorry abrasion test

  (iii) Los Angels test

- **Deval Attrition Test:** In the Deval attrition test, particles of known weight are subjected to wear in an iron cylinder rotated 10000 times at certain speed.
- The proportion of material crushed finer than 1.7 mm size is expressed as a percentage of the original material taken.
- This percentage is taken as the attrition value of the aggregate.
- This test has been covered by IS 2386 (Part IV) – 1963.

Los Angeles Abrasion Testing Machine.

Los Angeles Test :

- Los Angeles test was developed to overcome some of the defects found in Deval test.
- Los Angeles test is characterized by the quickness with which a sample of aggregate may be tested.
- The applicability of the method to all types of commonly used aggregate makes this method popular
- The test involves taking specified quantity of standard size material along with specified number of abrasive charge in a standard cylinder and revolving if for certain specified revolutions..
- The particles smaller than 1.7 mm size is separated out. The loss in weight expressed as percentage of the original weight taken gives the abrasion value of the aggregate.
- The abrasion value should not be more than 30 per cent for wearing surfaces and not more than 50 per cent for concrete other than wearing surface
- The below table gives average values of crushing strength of rocks, aggregate crushing value, abrasion value, impact value and attrition value for different rock groups

Table 3.4. Average Test Values For Rocks of Different Groups

Rock Group	Crushing Strength MPa	Aggregate crushing value	Abrasion value	Impact value	Attrition value		Specific gravity
					Dry	Wet	
Basalt	207	12	17.6	16	3.3	5.5	2.85
Flint	214	17	19.2	17	3.1	2.5	2.55
Gabbro	204	-	18.7	19	2.5	3.2	2.95
Granite	193	20	18.7	13	2.9	3.2	2.69
Gritstone	229	12	18.1	15	3.0	5.3	2.67
Hornfels	354	11	18.8	17	2.7	3.8	2.88
Limestone	171	24	16.5	9	4.3	7.8	2.69
Porphyry	239	12	19.0	20	2.6	2.6	2.66
Quartizite	339	16	18.9	16	2.5	3.0	2.62
Schist	254	-	18.7	13	3.7	4.3	2.76

Bulk Density

- The bulk density or unit weight of an aggregate gives valuable information's regarding the shape and grading of the aggregate
- For given specific gravity of angular aggregates show a lower bulk density. The bulk density of aggregate is measured by filling a container of known volume in a standard manner and weighing it.
- The bulk density depends on the particle size distribution and shape of the particles. One of the early methods of mix design make use of this parameter bulk density in proportioning of concrete mix.
- The higher the bulk density, the lower is the void content to be filled by sand and cement. The sample which gives the minimum voids or the one which gives maximum bulk density is taken as the right sample of aggregate for making economical mix

- For determination of bulk density the aggregates are filled in the container and then they are compacted in a standard manner. The weight of the aggregate gives the bulk density calculated in kg/liter or kg/m^3.
- Knowing the specific gravity of the aggregate in saturated and surface-dry condition, the void ratio can also be calculated.

$$\text{Percentage voids} = \frac{\underline{Gs - } \gamma \times 10}{G_s}$$

- where Gs = specific gravity of the aggregate and γ = bulk density in kg/litre

Specific Gravity

- Specific gravity of aggregates is made use of in design calculations of concrete mixes.
- With the specific gravity of each constituent known, its weight can be converted into solid volume and hence a theoretical yield of concrete per unit volume can be calculated.
- Average specific gravity of the rocks vary from 2.6 to 2.8

Absorption and Moisture Content:

- Some of the aggregates are porous and absorptive. Porosity and absorption of aggregate will affect the water/cement ratio and hence the workability of concrete.
- The porosity of aggregate will also affect the durability of concrete when the concrete is subjected to freezing and thawing and also when the concrete is subjected to chemically aggressive liquids.
- The water absorption of aggregate is determined by measuring the increase in weight of an oven dry sample when immersed in water for 24 hours.
- The ratio of the increase in weight to the weight of the dry sample expressed as percentage is known as absorption of aggregate.

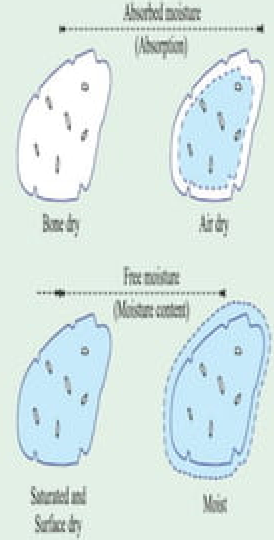
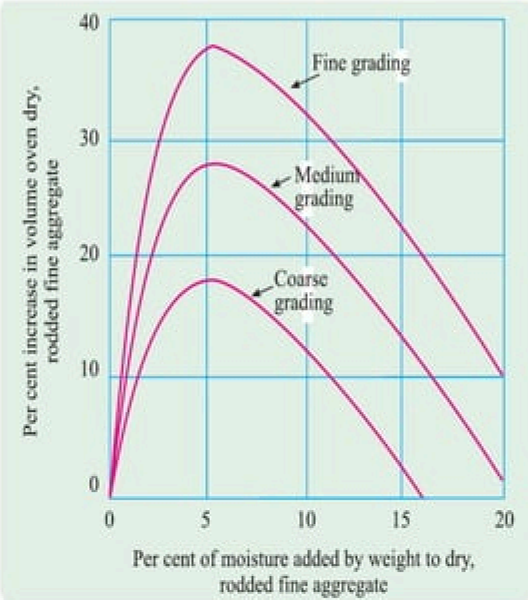


Fig. 3.1. Diagrammatic representation of Moisture in Aggregate.

Bulking of Aggregates

- The free moisture content in fine aggregate results in bulking of volume. Bulking phenomenon can be explained as follows:
- Free moisture forms a film around each particle. This film of moisture exerts what is known as surface tension which keeps the neighbouring particles away from it.
- Similarly, the force exerted by surface tension keeps every particle away from each other. Therefore, no point contact is possible between the particles. This causes bulking of the volume.
- The extent of surface tension and consequently how far the adjacent particles are kept away will depend upon the percentage of moisture content and the particle size of the fine aggregate



- It is interesting to note that the bulking increases with the increase in moisture content up to a certain limit and beyond that the further increase in the moisture content results in the decrease in the volume and at a moisture content representing saturation point.
- The fine aggregate shows no bulking. It can be seen from Fig. That fine sand bulks more and coarse sand bulks less.
- From this it follows that the coarse aggregate also bulks but the bulking is so little that it is always neglected. Extremely fine sand and particularly the manufactured fine aggregate bulks as much as about 40 per cent.

Deleterious Substance in Aggregate

- The concrete aggregates should be free from impurities and deletrious substances which are likely to interfere with the process of hydration, prevention of effective bond between the aggregates and matrix. The impurities sometimes reduce the durability of the aggregate.
- Generally, the fine aggregate obtained from natural sources is likely to contain organic impurities in the form of silt and clay. The manufactured fine aggregate does not normally contain organic materials. But it may contain excess of fine crushed stone dust. Coarse aggregate stacked in the open and unused for long time may contain moss and mud in the lower level of the stack.

- Sand is normally dredged from river beds and streams in the dry season when the river bed is dry or when there is not much flow in the river. Under such situation along with the sand, decayed vegetable matter, humus, organic matter and other impurities are likely to settle down.
- But if sand is dredged when there is a good flow of water from very deep bed, the organic matters are likely to get washed away at the time of dredging.
- The organic matters will interfere with the setting action of cement and also interfere with the bond characteristics with the aggregates. The presence of moss or algae will also result in entrainment of air in the concrete which reduces its strength.
- To ascertain whether a sample of fine aggregate contains permissible quantity of organic impurities or not, a simple test known as colorimetric test is made.

- The sample of sand is mixed with a liquid containing 3 per cent solution of sodium hydroxide in water. It is kept for 24 hours and the colour developed is compared with a standard colour card. If the colour of the sample is darker than the standard colour card, it is inferred that the content of the organic impurities in the sand is more than the permissible limit. In that case either the sand is rejected or is used after washing.
- Sometimes excessive silt and clay contained in the fine or coarse aggregate may result in increased shrinkage or increased permeability in addition to poor bond characteristics. The excessive silt and clay may also necessitate greater water requirements for given workability.
- The limits of deleterious materials as given in IS 383-1970 are shown in Table 3.5.

Table 3.5. Limits of Deleterious Materials (IS: 383-1970)

Sr. No.	*Deleterious substances*	*Method of test*	*Fine aggregate percentage by weight, max*		*Coarse aggregate percentage by weight, max*	
			uncrushed	*crushed*	*uncrushed*	*crushed*
(1)	(2)	(3)	(4)	(5)	(6)	(7)
(*i*)	Coal and lignite	IS:2386 (Part II)-1963	1.00	1.00	1.00	1.00
(*ii*)	Clay lumps	IS:2386 (Part II)-1963	1.00	1.00	1.00	1.00
(*iii*)	Materials finer than 75-micron IS Sieve	IS:2386 (Part I)-1963	3.00	15.00	3.00	3.00
(*iv*)	Soft fragments	IS:2386 (Part II)-1963	-	-	3.00	-
(*v*)	Shale	IS:2386 (Part II)-1963	1.00	-	-	-
(*vi*)	Total of percentages of all deleterious materials (except mica) including Sr. No. (*i*) to (*v*) for col. 4, 6 and 7 and Sr. No. (*i*) and (*ii*) for col. 5 only	-	5.00	2.00	5.00	5.00

Soundness of Aggregate

- Soundness refers to the ability of aggregate to resist excessive changes in volume as a result of changes in physical conditions.
- These physical conditions that affect the soundness of aggregate are the freezing the thawing, variation in temperature, alternate wetting and drying under normal conditions and wetting and drying in salt water.
- Aggregates which are porous, weak and containing any undesirable extraneous matters undergo excessive volume change when subjected to the above conditions. Aggregates which undergo more than the specified amount of volume change is said to be unsound aggregates. If concrete is liable to be exposed to the action of frost, the coarse and fine aggregate which are going to be used should be subjected to soundness test.

Alkali Aggregate Reaction

gate reaction. Alkali silicate g
ned under favourable conditi

- For a long time aggregates have been considered as inert materials but later on, particularly, after 1940's it was clearly brought out that the aggregates are not fully inert. Some of the aggregates contain reactive silica, which reacts with alkalies present in cement i.e., sodium oxide and potassium oxide.
- In the United States of America it was found for the first time that many failures of concrete structures like pavement, piers and sea walls could be attributed to the alkali-aggregate reaction.

- The reaction starts with attack on the reactive siliceous minerals in the aggregate by the alkaline hydroxide derived from the alkalies in cement. As a result, the alkali silicate gels of unlimited swelling type are formed.

- Tis swelling results in disruption of concrete with the spreading of pattern cracks and eventual failure of concrete structures. The rate of deterioration may be slow or fast depending upon the conditions. There were cases where concrete has become unserviceable in about a year's time.

- In India, the basalt rocks occurring in the Deccan plateau, Madhya Pradesh, Kathiawar, Hyderabad, Punchal Hill (Jammu and Kashmir), Bengal and Bihar should be viewed with caution.

- **Factors Promoting the Alkali-Aggregate Reaction**

(i) Reactive type of aggregate (ii) High alkali content in cement;
(iii) Availability of moisture (iv) Optimum temperature conditions.

- **Control of Alkali-Aggregate Reaction**

From the foregoing discussion it is apparent that alkali-aggregate reaction can be controlled by the following methods:

(i) Selection of non-reactive aggregates;
(ii) By the use of low alkali cement
(iii) By the use of corrective admixtures such as pozzolanas;
(iv) By controlling the void space in concrete;
(v) By controlling moisture condition and temperature.

Thermal Properties

Rock and aggregate possesses three thermal properties which are significant in establishing the quality of aggregate for concrete constructions. They are:

(i) Coefficient of expansion; (ii) Specific heat; (iii) Thermal conductivity.

- Specific heat and conductivity are found to be important only in mass concrete construction where rigorous control of temperature is necessary.

- These properties are of consequence in case of light weight concrete used for insulation purpose.

- An average value of the linear thermal coefficient of expansion of concrete may be taken as 9.9 x 10–6 per °C, but the range may be from about 5.8 x 10–6 per °C to 14 x 10–6 per °C depending upon the type and quantities of the aggregates

- The mix proportions and other factors. The range of coefficient of thermal expansion for hydrated cement paste may vary from 10.8 x 10–6 Per °C to 16.2 x 10–6 per °C. Similarly, for mortar it may range from7.9 x 10–6 per °C to 12.6 x 10–6 per °C.

Sieve Analysis

Set of Sieves assembled for conducting Sieve analysis.

- This is the name given to the operation of dividing a sample of aggregate into various fractions each consisting of particles of the same size. The sieve analysis is conducted to determine the particle size distribution in a sample of aggregate, which we call gradation.
- The aggregates used for making concrete are normally of the maximum size 80 mm, 40 mm, 20 mm, 10 mm, 4.75 mm, 2.36 mm, 600 micron, 300micron and 150 micron
- The aggregate fraction from 80 mm to 4.75 mm are termed as coarse aggregate and those fraction from 4.75 mm to 150 micron are termed as fine aggregate.

- Grading pattern of a sample of C.A. or F.A. is assessed by sieving a sample successively through all the sieves mounted one over the other in order of size, with larger sieve on the top.

- The material retained on each sieve after shaking, represents the fraction of aggregate coarser than the sieve in question and finer than the sieve above.

- Sieving can be done either manually or mechanically.
- In the manual operation the sieve is shaken giving movements in all possible direction to give chance to all particles for passing through the sieve. Operation should be continued till such time that almost no particle is passing through.
- Mechanical devices are actually designed to give motion in all possible direction, and as such, it is more systematic and efficient than hand sieving.

For assessing the gradation by sieve analysis, the quantity of materials to be taken on the sieve is given Table

Table 3.8. Minimum weight of sample for Sieve Analysis (IS: 2386 (Part I) – 1963)

Maximum size present in substantial proportions	*Minimum weight of sample to be taken for sieving*
mm	kg
63	50
50	35
40 or 31.5	15
25	5
20 or 16	2
12.5	1
10	0.5
6.3	0.2
4.75	0.2
2.36	0.1

- From the sieve analysis the particle size distribution in a sample of aggregate is found out. In this connection a term known as “Fineness Modulus” (F.M.) is being used. F.M. is a ready index of coarseness or fineness of the material.

The following limits may be taken as guidance:

- Fine sand : Fineness Modulus : 2.2 - 2.6
- Medium sand : F.M. : 2.6 - 2.9
- Coarse sand : F.M. : 2.9 - 3.2

- A sand having a fineness modulus more than 3.2 will be unsuitable for making satisfactory concrete.

Table 3.9. The typical Example of the Sieve Analysis

IS Sieve Size	Coarse Aggregate				Fine Aggregate			
	Weight retained weight kg	Cumulative weight retained kg	Cumulative percentage retained	Cumulative percentage passing	Weight retained gm	Cumulative weight retained gm	Cumulative percentage weight retained	Comulative percentage passing
80 mm	0	0	0	100	-	-	-	-
40 mm	0	0	0	100	-	-	-	-
20 mm	6	6	40	60	-	-	-	-
10 mm	5	11	73.3	26.7	0	0	0	100
4.75 mm	4.0	15.00	100	00	10	10	2	98
2.36 mm	-	-	100	00	50	60	12	88
1.18 mm	-	-	100	00	50	110	22	78
600 micron	-	-	100	00	95	205	41	59
300 micron	-	-	100	00	175	380	76	24
150 micron	-	-	100	00	85	465	93	7
lower than 150 micron	-	-	-	00	35	500	-	-
Total	15 kg		713.3		500 gm	—	246	

$$F.M. = \frac{713.3}{100} = 7.133 \qquad F.M. = \frac{246}{100} = 2.46$$

Standard Grading Curve

- The grading patterns of aggregate can be shown in tables or charts. Expressing grading limits by means of a chart gives a good pictorial view.

- The grading should be such that it could give a reasonable workability with minimum segregation. Segregation is very important in the production of good concrete.

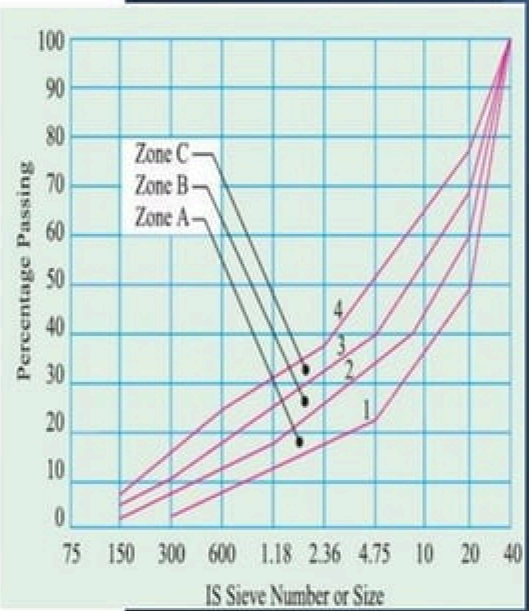
- The comparison of grading pattern of a number of samples can be made at one glance. For this reason, often grading of aggregates is shown by means of grading curves.

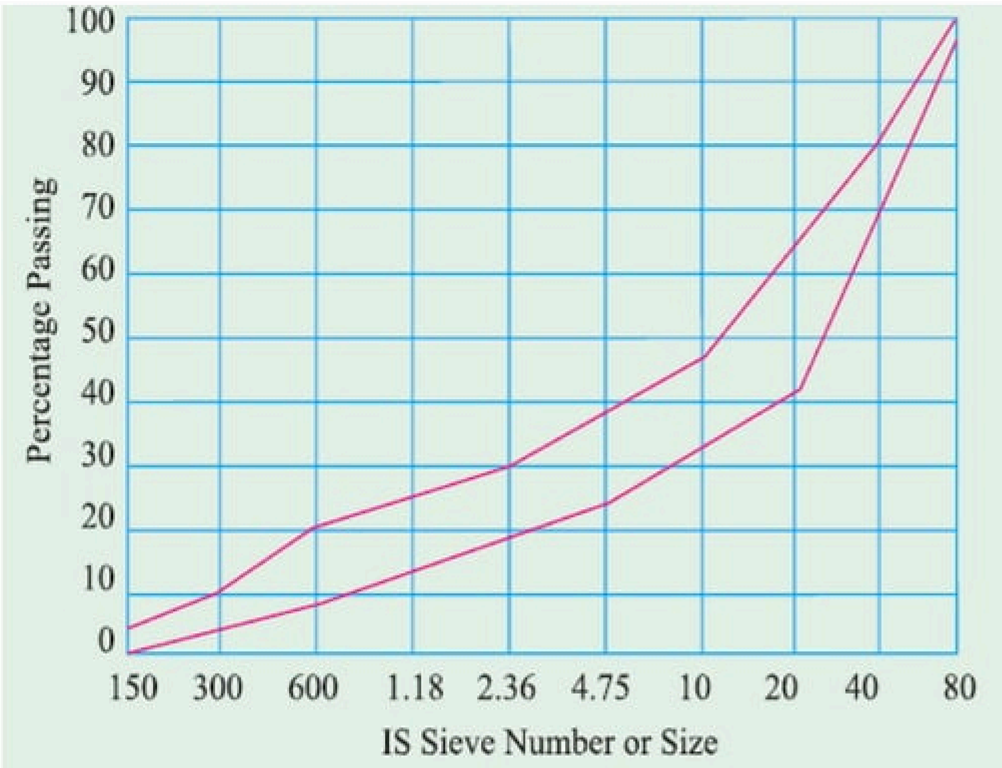
- On the basis of large number of experiments in connection with bringing out mix design procedure, Road Research Laboratory has prepared a set of type grading curve for all-in aggregates graded down from 20 mm and 40 mm. They are shown in figure.

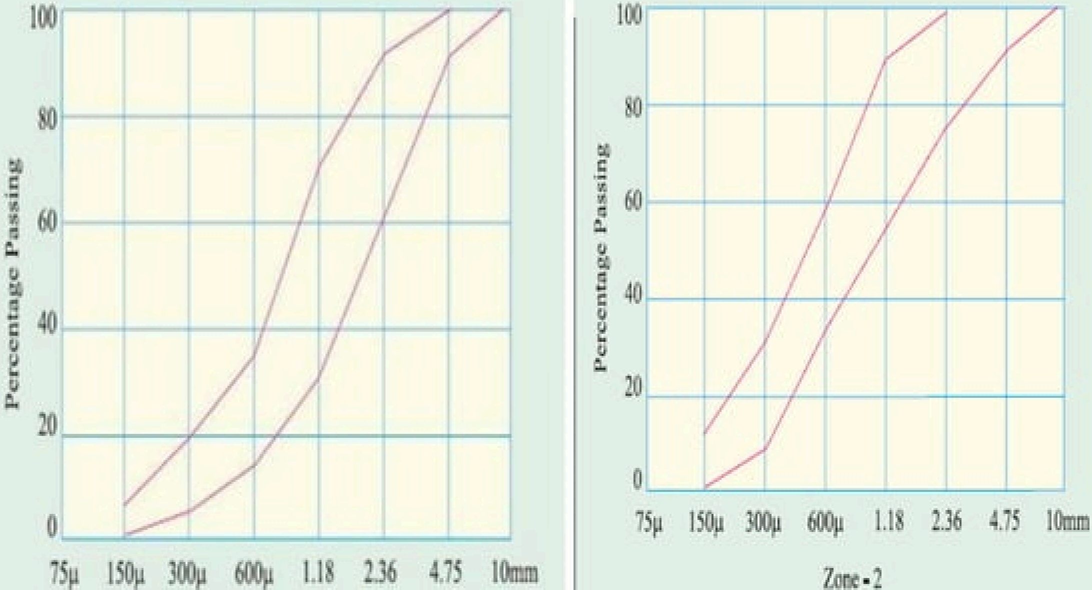
- Four curves are shown for each maximum size of aggregate except 80 mm size. From values of percentage passing it can be seen that the lowest curve i.e., curve No. 1 is the coarsest grading and curve No. 4 at the top represents the finest grading.

- Between the curves No. 1 to 4 there are three zones: A, B, C. In practice the coarse and fine aggregates are supplied separately.

- Knowing their gradation it will be possible to mix them up to get type grading conforming to any one of the four grading curves.




Percentage Passing
100
90
80
70
60
50
40
30
20
10
0
150
300
600
1.18
2.36
4.75
10
20
40
80
IS Sieve Number or Size



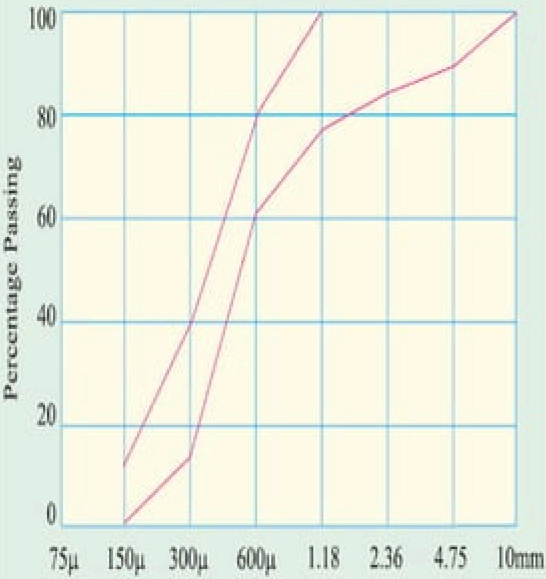
Zone - 1

(a)

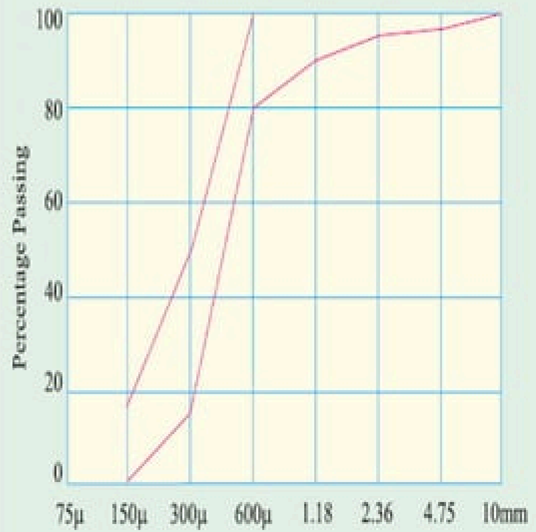
Zone - 2

(b)

Fig. 3.8. Grading limits for sand in zones 1 and 2 of I.S. : 383-1970. (Contd.)



Zone - 3



Zone - 4

(*d*)

In case of gradings lying partly in one zone and partly in another, there is likely hood of segregation if too many intermediate sizes are missing.

If on the other hand there is an excess of middle sized aggregate, the mix will be harsh and difficult to compact with hand and possibly even by vibration.

Therefore it is preferable to use aggregate with grading similar to type rather than totally dissimilar ones.

Grading of Fine Aggregates:

- Grading curves of the four zones of fine sand of table 4.3 as per I.S. 386 Part-I 1963 are shown in Fig a, b, c, d

- The grading curve of any fine aggregate falling wholly within the limits of any one A tolerance of total amount of 5% on certain sieves is permitted, but the aggregate should not be finer than the exact limits of the finest grading or coarser than the coarsest grading. In case of crushed stone 20% is allowed to pass the 150 micron test sieve in all zones.

- Sand (fine aggregate) falling into any zone can be generally used in concrete, although under some circumstances the suitability of a given sand may depend on the grading and shape of the coarse aggregate.

Table 4.23. Ratio of fine and coarse aggregate

S. No.	Maximum size of coarse aggregate in mm	Coarse/fine aggregate ratio for sand of zone			
		1	2	3	4
1.	10.0	1:1	1:1.5	1:2	1:3.0
2.	19.0	1:1.5	1:2	1:3	1:3.5
3.	38.0	1:2	1:3	1:3.5	—

Click to add text

- It is recommended that fine aggregate conforming to Grading Zone IV should not be used in reinforced concrete unless tests have been made to ascertain the suitability of proposed mix proportions.

- On the other hand the coarse sand of zone I produces a harsh mix and a high content of sand may be necessary for higher workability. This sand is more suitable for rich mixes or for use in concrete of low workability.

Grading of Coarse Aggregate

- The requirements of I.S. 383-1970 for the grading of coarse aggregate are reproduced in Table 4.2 and for all in aggregate in Table 4.24.

- The actual grading requirements depend to some extent on the shape and surface characteristics of the particles

Table 4.24. Grading for all in aggregate

S. No.	*I.S. sieve designation*	*Percentage passing for all in aggregate of*	
		40 mm nominal size	*20 mm nominal size*
1.	80 mm	100	—
2.	40 mm	95 – 100	100
3.	20 mm	45 – 75	95 – 100
4.	4.75 mm	25 – 45	30 – 50
5.	600 micron	8 – 30	10 – 35
6.	150 micron	0 – 6	0 – 6

Fig. 4.20 to 4.21. Curve 4.22 shows the grading limits for all in aggregates.

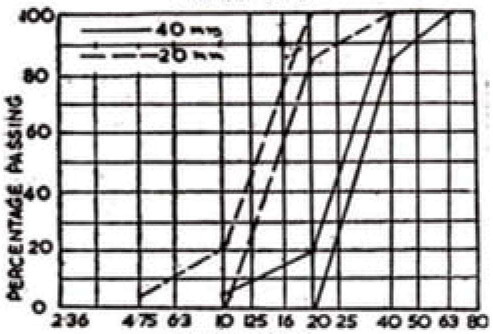


Fig. 4.20. Grading limit for coarse aggregate 40 mm and 20 mm single size

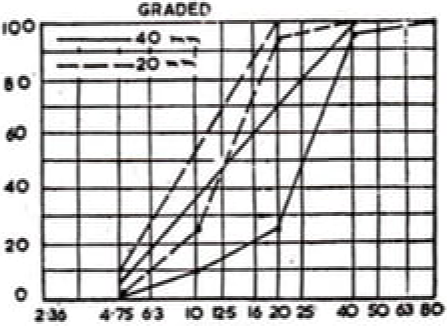


Fig. 4.21. Grading limits for coarse aggregate 40 mm and 20 mm graded

Oversize and Undersize

- Strict adherence to size limits of aggregate is not possible. Breakage during handling will produce some undersize material and wear of screen in the quarry or at the crusher will result in oversize particles being present.

- As per I.S. 383-1970, the limit for oversize is permitted between 5% to 15%. However no aggregate must be retained on a sieve one size larger than the nominal maximum size.

- The allowable limit of undersize material is 5 to 10%. For fine aggregate a total departure of 5% from zone limits is allowed, but not beyond the coarser limit of zone I or finer limit of zone IV

MORTAR

MORTAR

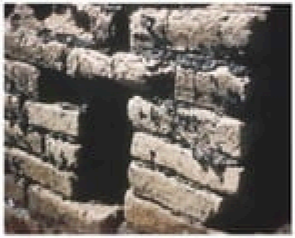
Mortar is a workable paste used to bind construction blocks together and fill the gaps between them. Modern mortars are typically made from a mixture of sand, a binder such as cement or lime, and water. Mortar may be used to bind masonry blocks of stone, brick, cinder blocks, etc. It becomes hard when it sets, resulting in a rigid aggregate structure.

ANCIENT MORTAR

The first mortars were made of mud and clay. Because of a lack of stone and an abundance of clay, Babylonian constructions were of baked brick, using lime or pitch for mortar.

According to Roman Ghirshman, the first evidence of humans using a form of mortar was at the Mehroarh of Baluchistan in Pakistan, built of sun-dried bricks in 6500 BCE. The ancient Harappa city in Pakistan was built in about 2600 BCE with kiln-fired bricks and a mortar of gypsum. Gypsum cement was "*light grey and contained sand, clay, traces of calcium carbonate, and a high percentage of lime*" was used in the construction of wells, drains and on the exteriors of important looking buildings.

Bitumen mortar was also used at a lower-frequency, including in the Great Bath at Mohenjo-daro.



Bitumen mortar

Historically, building with concrete and mortar next appeared in Greece. The excavation of the underground aqueduct of Megara revealed that a reservoir was coated with a pozzolanic mortar 12 mm thick. This aqueduct dates back to c. 500 BCE. Pozzolanic mortar is a lime based mortar, but is made with an additive of volcanic ash that allows it to be hardened underwater; thus it is known as hydraulic cement. The Greeks obtained the volcanic ash from the Greek islands Thira and Nisiros, or from the then Greek colony of Dicaearchia (Pozzuoli) near Naples, Italy.

Pozzolanic mortar

Later, the Romans used a mortar without pozzolana using crushed terra cotta, introducing aluminum oxide and silicon dioxide into the mix. It was not as strong as pozzolanic mortar, but because it was denser, it better resisted penetration by water.

Slaked lime

Around AD 500, sticky rice soup was mixed with slaked lime to make an inorganic–organic composite mortar that had more strength and water resistance than lime mortar.

TYPE OF MORTARS

POLYMER CEMENT MORTAR (PCM) are the materials which are made by partially replacing the cement hydrate binders of conventional cement mortar with polymers. The polymeric admixtures include latexes or emulsions, redispersible polymer powders, water-soluble polymers, liquid resins and monomers. It has low permeability, and it reduces the incidence of drying shrinkage cracking, mainly designed for repairing concrete structures.

PORTLAND CEMENT MORTAR

Known as cement mortar is created by mixing Ordinary Portland Cement (OPC), hydrated lime, and aggregate (or sand) with water.

It was invented in 1794 by Joseph Aspdin, largely as a result of various scientific efforts to develop stronger mortars than existed at the time.

The main popularity reasons for Portland cement are setting hard and quickly, allowing a faster pace of construction, and requires fewer skilled workers.

Laying bricks with Portland cement mortar

As a general rule, **Portland cement should not be used for the repair or repointing** of older buildings constructed in lime mortar, which require the flexibility, softness and breathability of lime if they are to function correctly. One of five standard types of mortar (available as a dry premixed product) are generally used for both new construction and repair. The ratio of cement, lime, and sand included in each mortar type produces different strengths of mortar. The formulations for each type are specified by the ASTM standards organization.

LIME MORTAR

is considered breathable in that it will allow moisture to freely move through it and evaporate from its surface. In old buildings with walls that shift over time, there are often cracks which allow rain water into the structure. The lime mortar allows this moisture to escape through evaporation and keeps the wall dry. Re-pointing or rendering an old wall with cement mortar stops this evaporation and can cause problems associated with moisture behind the cement.

POZZOLANA MORTAR

is a fine, sandy volcanic ash, originally discovered and dug in Italy at Pozzuoli in the region around Mount Vesuvius, but later at a number of other sites. The ancient Roman architect Vitruvius speaks of four types of pozzolana. It is found in all the volcanic areas of Italy in various colors: black, white, grey and red. Finely ground and mixed with lime it acts like Portland cement and makes a strong mortar that will also set under water.

FIRESTOP MORTAR

are mortars most typically used to firestop large openings in walls and floors required to have a fire-resistance rating. They are passive fire protection items.

Firestop mortar is usually a combination of powder mixed with water, forming a cementatious stone which dries hard.

It is sometimes mixed with lightweight aggregates, such asperlite or vermiculite.

Cable tray cross barrier firestop test, full scale wall

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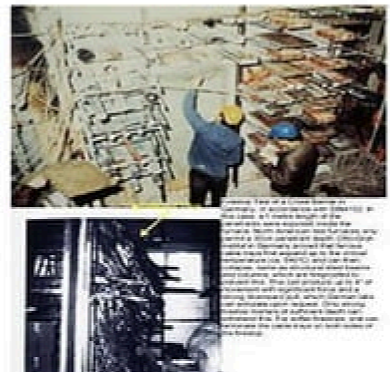


Cable tray cross barrier firestop test, full scale wall

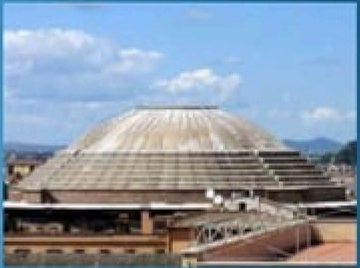
CONCRETE

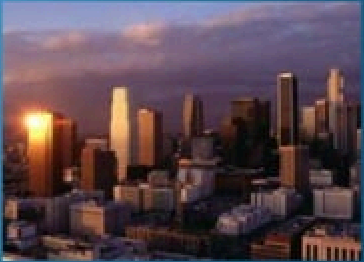
Introduction

- Concrete is mainly composed of Portland cement, Aggregate(Filler), Water and chemical Admixtures.

  Concrete = Filler + Binder

- Concrete is versatile construction material.
- The name concrete comes from the Latin word "Concretus" (meaning compact or condensed).
- Concrete solidifies and hardens after mixing with water and placement due to a chemical process known as hydration.
- The water reacts with the cement, which bonds the other components together, eventually creating a stone-like material.





Contd.

Portland Cement

Coarse Aggregate

Fine Aggregate

Admixtures

Types Of Concrete

- Based on Weight, Concrete can be classified into Four Categories:
  - Ultra-Light Weight Concrete (1200 Kg/m^3)
  - Light Weight Concrete (<1800 Kg/m^3)
  - Normal Weight Concrete (2400 Kg/m^3)
  - Heavy Weight Concrete (>3200 Kg/m^3)

- Based on Strength, Concrete can also be classified into Four Categories:
  - Low-strength concrete < 20 MPa compressive strength
  - Moderate-strength concrete 20 -50 MPa compressive strength
  - High-strength concrete 50 - 200 MPa compressive strength
  - Ultra high-strength concrete > 200 MPa compressive strength

Contd.

- Beside this there are various type of Concrete for different applications that are created by changing the proportions of the main ingredients.

- Regular Concrete
- Ready-Mix Concrete
- Green Concrete
- High-Performance Concrete
- Ultra-High Performance Concrete
- Rapid Strength Concrete
- Shrinkage Compensating Concrete
- Fibre-Reinforced Concrete
- Asphalt Concrete
- Polymer Concrete
- Gypsum Concrete

Factors affecting Concrete Strength

- Water/Cement Ratio
- Age and Curing Condition
- Aggregates
- Admixtures

Advantages of Concrete

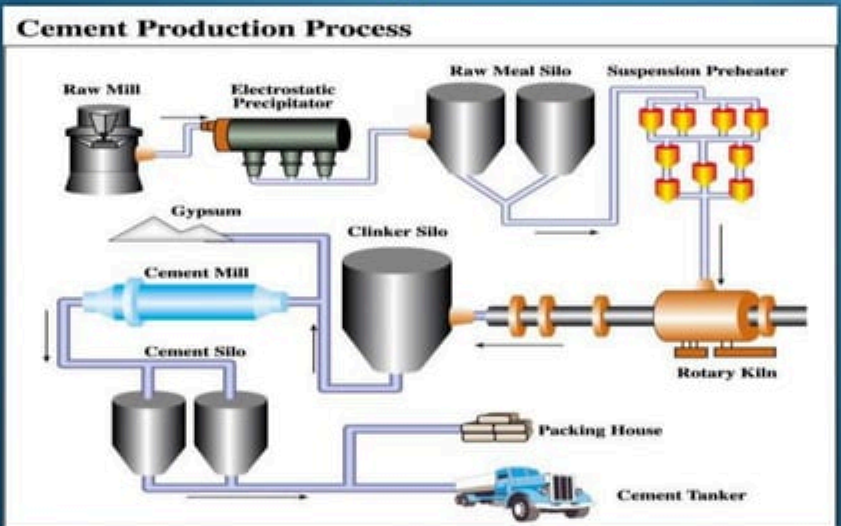
- More Economical
- Ability to be cast
- More Energy Efficient
- Excellent Resistance to Water
- High Temperature Resistance
- Fire Resistance
- Aesthetic Properties
- Ability to Consume waste
- Ability to work with reinforcing Steel

Types of Portland Cement

- **ASTM C 150**, Standard Specifications for Portland Cement:
  - **Type I**: General purpose. For use when the special properties specified for any other types are not required.
  - **Type II**: For general use, more specially when moderate sulphate resistance or moderate heat of hydration is desired.
  - **Type III**: For use when high early strength is desired. (limit the C3A content of the cement to maximum 15%)
  - **Type IV**: For use when low heat of hydration is desired.
  - **Type V**: For use when high sulfate resistance is desired. (Maximum limit of 5% on C3A)

Cement Manufacturing Process

- Process Flow Diagram:



Admixtures

- Admixtures are ingredients other than portland cement, water, and aggregates.
- Admixtures are added to the concrete mixture immediately before or during mixing.
- The use of admixtures in concrete is now widespread due to many benefits-
- ✓ It reduces the amount of water requirement in Concrete.
- ✓ It control the setting behavior of Concrete.
- ✓ It also improves the workability, durability & strength of the Concrete.

Summary

- Concrete is a composite material and highly versatile construction material, well suited for many structural applications.
- It is a mixture of Portland cement, water, aggregates, and in some cases, admixtures.
- Strength, durability, and many other factors depend on the relative amounts and properties of the individual components.
- Different types of concrete are there. But nowadays Ready-mix concrete becomes popular due to many advantages.
- The strength of the concrete highly dependent on water and water-cement ratio and also the curing condition, type of aggregate and type of admixtures used.

TIMBER

INTRODUCTION

TIMBER/LUMBER is a type of wood and which means TO BUILD.

Suitable for building and which is applied to the trees measuring not less than 600mm circumference of its trunk.

SUSTAINABLE BUILDING WITH TIMBER TO REDUCE THE BUILDING SECTOR'S ENVIRONMENTAL IMPACT

- Timber offer good prospects for cost-effective improvement

- Both massive and lightweight designs and construction methods with timber-core buildings provide good insulation.

- Has low thermal conductivity.

- Methods and recommendations for moisture-resistant timber building technology are therefore particularly important development areas.

•Growing trees remove Carbon-di-oxide from the atmosphere-the oxygen is released and the Carbon is sequestered within the timber.

•50% the weight is inside the carbon.

•An entire solid superstructure has an extremely beneficial “Coal” when aiming for low carbon/zero carbon buildings.

MATERIAL	CARBON RELEASED(kg/m3)	CARBON STORED(kg/m3)
TIMBER	15	50
ALUMINIUM	22000	0
STEEL	5320	0
CONCRETE	1200	0

However, just how effective are these alternative materials, especially in regards to their overall environmental impact. Each type of building material has a different ‘embodied energy’. ‘Embodied energy’ is the amount of energy used to fabricate particular building materials, and is calculated in MJ/m2 (Mega Joule per Meters Squared).

A good product should hav the following capabilities:

- Forest utilization
- **The generation of by-products**
- **Disposal of waste**
- **Resource depletion**
- **Global Warming**
- **Landfill**
- **Ozone hole extension**
- **Eutrophication (the growth of water based life forms)**
- **Synthesis of compounds responsible for acid rain**

This is made then the environmental impacts of a product must be assessed during *all stages of the life cycle of the building material.*
Therefore, a 'cradle to grave' approach is used to assess the life long impacts of the materials use.

TIMBER PROVES IT ALL!!

Timber should be the preferred building
product on environmental grounds across the
life of the
various building products. To demonstrate the
difference between wood and other building
products
it is essential to take into account thermal
utilisation of wood waste. Therefore it is
critical that the
Renewable Energy Regulations support the
use of wood waste as an effective and
efficient bioenergy
resource.

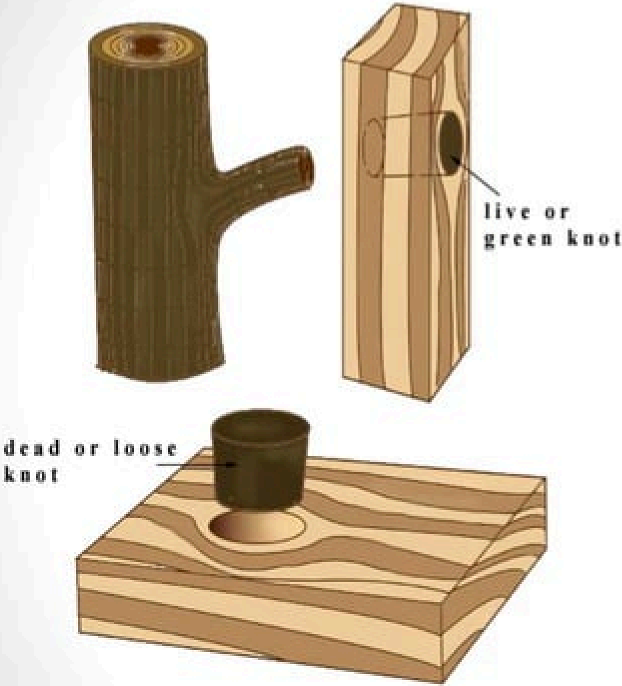
ULTIMATE BENEFITS OF TIMBER :

- Renewable
- Low in production energy
- Good insulator of heat and electricity
- Readily available
- Easy to work

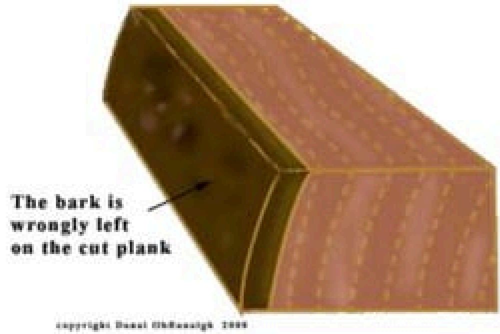
DEFECTS IN TIMBER

Waney edges:
Edges or corners of sections of timber that encroach into the area of the bark.
Shakes
Longitudinal splits in a log or or piece of timber. Often caused by hasty or poor seasoning.
Cross Grain
Grain in timber that does not lie in straight lines but it changes it's slope in relation to the plank.
Knot
A hard cross grain mass of wood that is formed in the trunk of a tree where a branch grows. They can weaken the timber or disfigure the surface.
Twist
The tendency in timber for the edges to move out of parallel
Cupping
The tendency in some sections of timber to dry out in a curved shape following the lines of the growth rings.

Knots



Waney edge



USES

Hadimba Temple, Manali

In zones with cold climates and earthquake prone areas, structures are entirely constructed out of timber. These buildings have a distinct architecture and all structural elements are made of timber.

Timber is frequently used in the frames of doors and windows.
Type of Wood used:
Shorea robusta
Vernacular name:

Source: KAASHTHA Timber Traders, Surat

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USES

Source: Extension to EED, SVNIT

Timber as a cast and support for concrete casting of ;

Beams

Columns

Slabs

Foundation

While Bamboo is used for scaffolding in Asian countries, Timber is occasionally used in scaffolds as platforms and in shoring

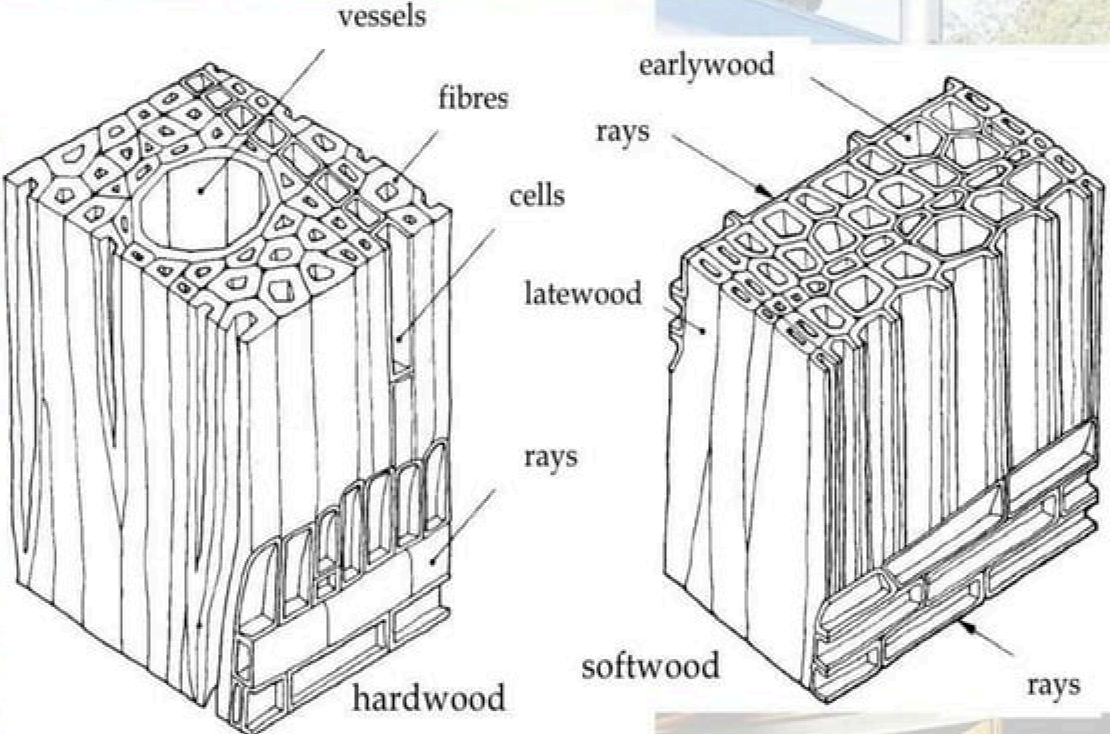
Source: Extension to EED, SVNIT

Plantations

In plantations trees are specifically planted and nurtured for timber production.

Harvesting timber

Timber is cellular!



Durability issues

- Timber has natural durability to some hazards. This can be due to the chemicals stored in the wood structure, or in some cases it may be due to the wood structure itself.

700 year old grain store, France

GLASS

Types of Glass Used for Glazing

- Glass plays an essential role in the facade. A facade is a special type of wall. It separates inside from outside. Glass is a uniform material, a solidified liquid. By its property of transparency it opens up our buildings to the outside world. In modern architecture there is tendency to open up our buildings by using very large facades that are as transparent as possible.
- In the external wall, glass can be used as a curtain wall or structural glazing.
- Glass is not essentially transparent. They are available in several opacities and various textures and finishes.

COMPOSITION OF GLASS

Glass is made from the following raw materials: Sand; soda-ash; limestone; dolomite; feldspar; sodium sulphate. These substances are themselves compounds of various elements and a chemical analysis shows that flat glass is made up from the following materials, used in various proportions:

Silica (S_2O_2)	71.0 to 78.0%
Alumina (Al_2O_3)	0.5 to 1.5%
Iron oxide (Fe_2O_3)	0.05 to 0.15%
Calcium oxide (CaO)	5.0 to 10.0%
Magnesium oxide (MgO)	2.0 to 5.0%
Sodium oxide (Na_2O)	13.0 to 16.0%
Potassium oxide (K_2O)	0.0 to 1.0%
Sulphur trioxide (SO_3)	0.0 to 0.5%

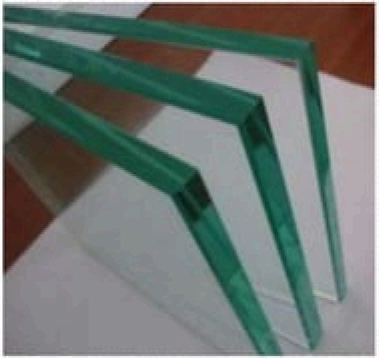
➢ BASIC TYPES OF GLASS

- float glass
- sheet glass
- patterned glass
- wired glass

➢ MODIFIED VARIETIES OF GLASS

- Reflective glass
- Insulating glass
- Safety glass
- – Laminated safety glass
- –Toughened safety glass
- Glass bricks
- Tinted glass, etc…

FLOAT GLASS



- Most widely used type of glass
- Monolithic and highly transparent
- Produced by flowing molten glass
- over a bath of molten tin and
- slowly cooling .
- Has uniform thickness, flatness
- and excellent optical quality.
- Manufactured in two main varieties, i.e.; clear and tinted.
- Used in mirrors, windows, curtain walls and doors.
- float glass can be toughened, a process that creates safety glass out of annealed glass.
- Available in thicknesses 2-19 mm
- Can be coloured during manufacturing.

SHEET GLASS

- There are three different kind of sheet glasses:
- – Annealed flat glass
- – Processed flat glass
- – Misc. glass
- Actual color green (or sometimes blue).
- **Sizes available:**
  2mm, 3mm, 4mm, 5mm,
  6mm, 8mm, 10mm, 12mm, 15mm and 19mm.
- Uses: windows, shelves, large size doors and table tops

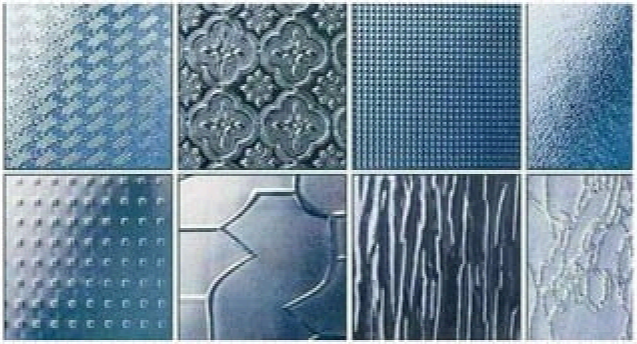
➢ PRIZE

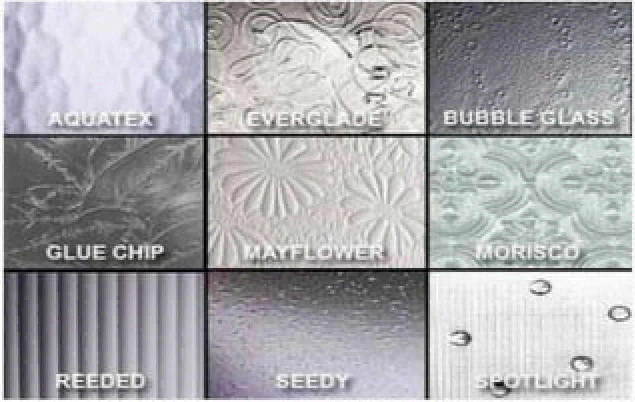
Thickness	Cost
4-6mm	Rs 53/sqm
8-12mm	Rs 63/sqm

PATTERNED GLASS

- Sometimes referred to as "figured" or "rolled" glass.
- Has a pattern or texture impressed on one or both sides in the process of rolling.
- This glass surface has a patterned decorative design which provide translucency and some degrees of obscurity.
- Patterns are classified as decorative or glazing i.e., used primarily for their functional properties.
- Uses: decorative glazing of windows, bathroom partitions, door.
- Is difficult to clean as dust settles between the crevices
- Thickness: 4mm, 6mm,
- Sizes: 2140 x 1280 mm, 2140 x 1320 mm respectively.

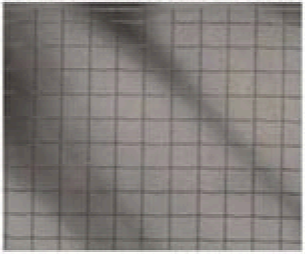
PATTERNED GLASS

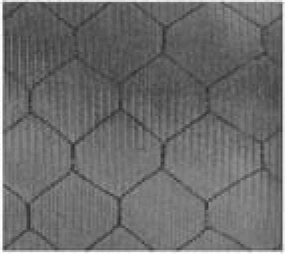




WIRED GLASS

- Fine twisted hexagonal wire netting or mesh inserted during the process of rolling.
- May be patterned, smooth rolled or ground and polished.
- Used primarily in fire rated windows, doors, skylights and applications requiring a safety glazing material.
- When broken, loose pieces of glass are held by the wire netting.
- Georgian wire mesh, 13mm provided.
- Thickness: 5 to 7 mm.
- Size: 3300 x 1830 mm.





REFLECTIVE GLASS

- Coating of a metal compound applied on one surface by chemical deposition.
- Reflects light and solar heat
- May be applied on any type of glass and thickness upto half an inch
- Uses: principally used in curtain wall glazing and structural glazing, train windows(AC compartments), doors and windows of commercial buildings, partitions and internal wall cladding.
- Disadvantages: Causes light pollution and is hazardous to traffic.

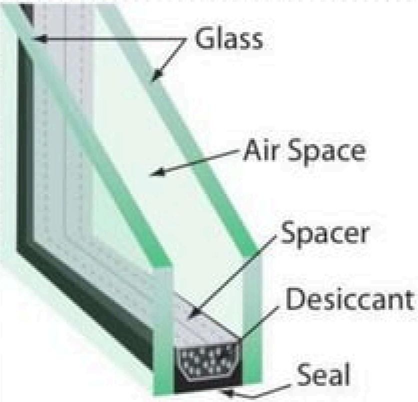
Thickness	Cost
4-6mm	Rs 53/sqm
8-12mm	Rs 63/sqm

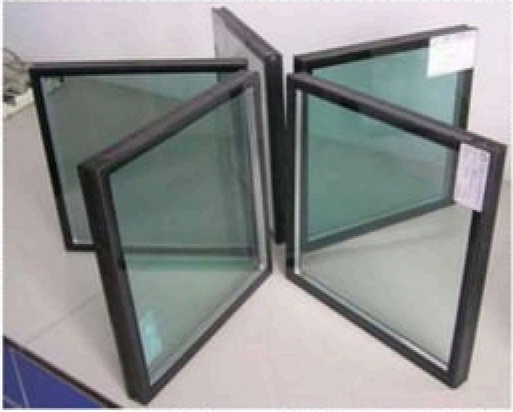
REFLECTIVE GLASS

INSULATING GLASS

- Factory assembled unit consisting of two or more panes of glass separated by air spaces.
- Moisture proof
- The periphery of the air spaces is hermetically sealed.
- There are two types of such sealed units:
- – Organic seal type: Two or more panes of glass separated by air spaces sealed at their edges with an organic seal.
- – Glass edge type: Two sheets of clear single strength or double strength glass fused together at their edges enclosing a nominal 3/16 inches air space. This type of glass is not produced with multiple air spaces.

INSULATING GLASS



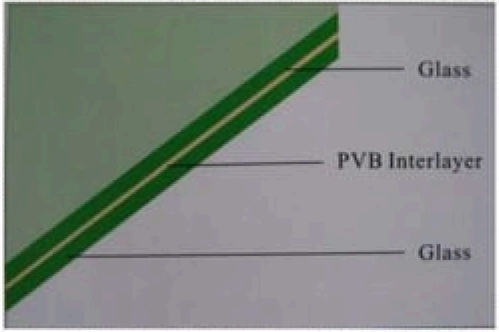


SAFETY GLASS

- Developed basically for vehicular purposes where safety from fracture of glass is a major concern.
- Requirement of uninterrupted vision rules out the use of wired glass.
- Is of two types-

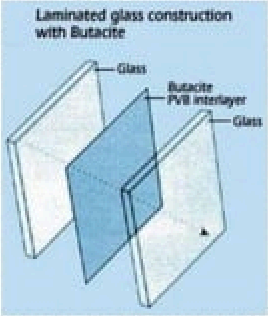
  Laminated safety glass

  Toughened safety glass



➢ LAMINATED SAFETY GLASS

- Made in the form of a sandwich consisting of an interlayer of transparent plastic material such as celluloid between two sheets of plate or sheet glass.
- Celluloid placed between sheets already coated with gelatin and specially prepared enamel.
- Adhesion achieved by applying considerable heat and pressure.
- When one or both sheets of this composite material are broken the glass adheres to the inter layer so that there is no danger from the flying fragments

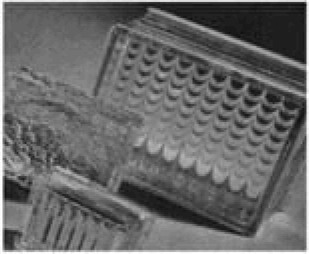


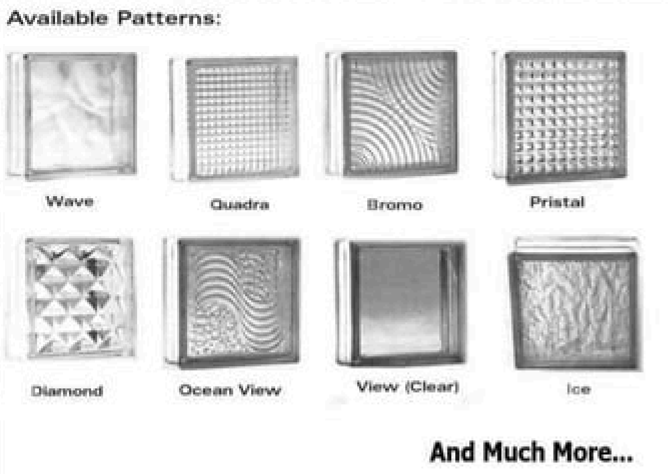
➢ TOUGHENED SAFETY GLASS

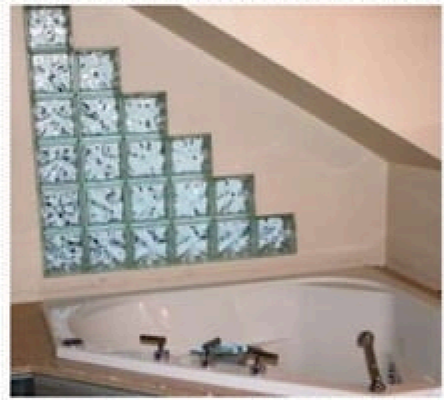
- Pieces of sheet or plate glass suspended in electric furnace until soft and suddenly cooled by blowing air on both sides.
- Fragments have no cutting edge.
- Toughened glass withstands a dead load more than four times that of ordinary glass.
- Additional compressive stresses in the surfaces makes the glass stronger.
- Can safely accommodate high tensile forces due to the pre-stress.
- Fracture can occur once the pre-stress has been exceeded.

GLASS BRICKS

- These are hollow glass units or blocks of glass shaped to work as bricks
- Joined with the help of silicon sealants to obtain seamless finish
- The two outer, exposed surfaces may be smooth or textured.
- Glass blocks can be coloured and have decorated surfaces.
- Walls of glass blocks meeting fire resistance are also possible.
- Found in Indonesian, Sri Lankan, Chinese, USA, German varieties
- Srilankan and Indonesian
  varieties: Rs 80 per piece
  European clear: Rs 350/pc
  European coloured: Rs 450/pc
  Chinese clear: Rs 52/pc
  Chinese coloured: Rs 152/pc




Available Patterns:
Wave
Quadra
Bromo
Pristal
Diamond
Ocean View
View (Clear)
Ice
And Much More...



TINTED GLASS

- Manufactured by adding a dye at the molten glass stage
- Used to minimize solar heat gain and glare while it also absorbs heat.
- Available in grey, bronze, green, blue and blue/green
- Allows for increased control of comfort and energy usage

Sizes available:

Grey and Bronze	-	4mm, 5mm, 6mm,8mm,and 10mm
Blue	-	6mm
Green	-	5mm, 6mm, and 10mm
Blue/Green	-	6mm and 10mm

Thickness	Rate/sq ft (Rs.)
3mm	22
4mm	30
5mm	35
6mm	38
8mm	70
10mm	90

THE MAJOR COMPANIES INVOLVED IN GLASS MANUFACTURING:-

- Saint-gobain
- Asahi India
- Goldplus group
- Allied glasses
- Float glass India ltd.