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BRICK

Defn:- A brick is an artificial kind of stone made of clay whose chief characteristics are plasticity when wet and stone like hardness after being heated to high temperature.

■ Factors that affect the quality of bricks :-

- chemical properties of clay used
- preparation of clay
- process of drying
- Different degrees of burning.

■ constituents of brick clay & their functions :-

constituents	Percentage	Functions
Silica	55	<ul style="list-style-type: none">- Prevents cracking, shrinking & warping.- Too much makes brick brittle & weak.
Alumina	30	<ul style="list-style-type: none">- Imparts plasticity to clay & density.- Too much causes brick crack & warp during drying & becomes very hard under the influence of heat.
Iron oxide	8	<ul style="list-style-type: none">- Makes the brick impermeable & durable qualities.- Gives the color to the brick.
Magnesia	5	<ul style="list-style-type: none">- Decreases shrinkage.- Gives yellow tint.

Lime	1	<ul style="list-style-type: none"> - Reduces shrinkage of bricks during drying. - Binds the particles of brick together by melting.
Alkalies & organic matters	1	<ul style="list-style-type: none"> - Small quantity assists in burning silicon bricks. - Too much causes brick porous.

■ Harmful constituents of brick clay:-

constituents	Harmful effects
Iron pyrites	<ul style="list-style-type: none"> - Cause crystallization & disintegration of bricks on burning.
Alkalines	<ul style="list-style-type: none"> - Cause the bricks to fuse, twist & warp during burning.
Stone particles	<ul style="list-style-type: none"> - Non uniformity of brick texture. - Make bricks porous & weak.
Vegetation & organic matter	<ul style="list-style-type: none"> - Porous & weak bricks
Lime	<ul style="list-style-type: none"> - Excess lime causes the brick to fuse too readily & the shape is lost. - Lime in form of limestone (CaCO_3) is converted into lime (CaO) & CO_2. On contact with water, lime gets hydrated & swells & causes the bricks to split & crumble to pieces.

■ Colour of bricks:- The colour of bricks mainly depends on its iron content. The colour ranges from light yellow to orange & red. The color gradually deepens to red and then purple as the iron content goes upto 8%. By adjusting the burning temp. red color due to iron oxide or black color due to manganese can be produced. Magnesia in presence of iron makes the brick yellow.

■ Manufacture of bricks:- Steps involved in the manufacture of bricks are given below

1) Selection of brick clay

2) Preparation of brick clay

3) Brick moulding

a) Machine moulding

b) Hand moulding

4) Brick drying

5) Brick burning

a) Clamp or Parawah burning

b) Kiln burning.

■ Selection of brick clay:- Brick clay should be free from harmful constituents. The sedimentary deposits of clay are generally quite suitable for the manufacture of bricks.

■ Preparation of brick clay:- Three steps are involved in the preparation of brick clay.

a) Weathering :- In this step selected brick clay is excavated before the rains & spread on the ground for sometime. This step has an important influence on the plasticity & strength of clay.

b) Blending :- In this step the quality of brick clay is improved (if there is any deficit of any important constituent ingredients) by adding sand, lime, alumina and magnesia.

c) Tempering :- In this step blended brick clay is cut, slashed and well worked with spade & is trodden which makes it soft. Water is gradually added when tempering is in progress. The clay is well tempered by kneading it under the feet of men & cattle into a stiff condition & thereby the clay is

made homogeneous having uniform consistency, so that it may possess the reqd plasticity for moulding for large scale manufacture of bricks.

A pug mill, consists of a conical vessel of wrought iron, $5\frac{1}{6}$ " high, partially ($2\frac{1}{4}$ ") buried underground is also used to temper the brick clay.

It is provided with a central revolving shaft to which are attached horizontal blades. To these horizontal blades, small vertical wedge shape steel knives are fixed. Feeding of clay and water is done through the top. The shaft is rotated either by bullocks (oxen) or by mechanical power. When tempering is completed the clay is forced out of an aperture at the base of the mill. (Fig. 3.1 PUG MILL, AII2-32)

■ Brick moulding :- moulds are rectangular boxes with top & bottom made of any various st hard wood, sometimes lined with iron or brass where accurate moulding is needed. Moulds are sometime made of iron or brass. The internal dimension of mould is about $\frac{1}{10}$ larger than the size of the burnt bricks.

There are two types of brick moulding

- Hand moulding

- Machine moulding

After placing the mould either on the smooth ground or on the table, the rolled up brick clay slightly long & thicker than the required brick is lifted over head & dashed with force into the mould pressed by hand very carefully & thoroughly so as to fill the mould completely. After removing excess earth from the top of the mould by strike, a thin piece of wood, known as pallet board, little larger than the size of the mould is placed on the top of the mould & the mould is lifted up & put upside down. The mould is then lifted leaving the wet brick on the pallet.

Brick drying :- Before burning the bricks are dried so that they are sufficiently hard to be handled & stocked in the burning kiln, without injury. The moulded bricks are dried by being placed on their edges for sometimes & then piled

in open order in long rows & stacks. This should be carried on a raised platform & the surrounding should be sanded to keep it dry in wet season. In case of machine made bricks, drying is performed by circulating hot air or gages around the bricks.

■ Brick burning:- When drying is complete, bricks are burnt to impart hardness and strength to bricks and to increase the density of bricks to make them less absorbent to water & thereby increasing durability. Bricks are burnt in clamps or kilns where the temp. is raised to about 1100°F . At a temp. of about 1200°F organic matter present in the bricks is oxidized & disappeared. When temp. is raised to about 2100°F , certain chemical changes take place in its constituents giving new properties to the bricks, increasing density, clarity and strength of the bricks. Fusible glass in a small quantity is produced by burning of alumina & sand grains. But when heated

greater quantity & the bricks are said to be vitrified. Vitrification softens the bricks and they begin to loose their shape.

Clamp and kiln burning: M.A. AII-2 - 36.
Details with figure and advantages & disadvantages

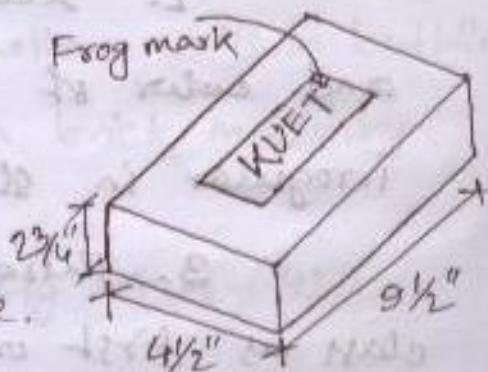
Characteristics of good bricks:-

- Uniform in color, size & shape.
- Sound & compact
- Free from cracks & other flaws such as air bubbles, stone nodules etc.
- Should not absorb more than $\frac{1}{6}$ of their own wt of water when immersed in water for 24 hrs.
- Compressive strength in the range of 5000-8000 psi
- Percentage of soluble salts (sulphates of Ca, Mg, Na, K) should not exceed 2.5%.
- Neither over-burnt nor underburnt.
- Low thermal conductivity
- Non-flammable & incombustible
- No change in volume when wetted.

■ Field tests of bricks:-

- Take a brick and try to mark on the surface by nail. If you can make it, it is not a good brick, but if not, it is hard & compact.
- Take a brick & strike it with another brick or a hammer. If it gives clear ringing or metallic sound, it is good brick, if not a bad one.
- Take two bricks & form a tee 'T' and drop from a height of 6' on a more or less solid surface. If they remain unbroken, they are good bricks.

■ Size of brick:- According to PWD (Public Works Department) specification standard size of brick is $9\frac{1}{2}'' \times 4\frac{1}{2}'' \times 2\frac{3}{4}''$. This size is most economical because when bricks are put in any construction with mortar the size becomes $10'' \times 5'' \times 3''$. The size of walls which are constructed by bricks in our country are $3'', 5'', 10'', 15'', 20'', 25'', 30''$ etc. So this size of bricks can be used safely without breakage.



■ Frog marks:- It is the identification marks of bricks. It is generally left on the face of the brick during the process of moulding to indicate the name of the manufacturer of the brick. This is done by fitting a fillet or projection on the corresponding face of the mould & usually on the lower surface.

■ Classification of bricks:-

1. First class bricks:- Uniform in color, size, thoroughly and evenly burnt, ring clearly when struck with a hammer or another brick, should be well shaped with even surfaces & without cracks or flaws of any kind, should not absorb more than $\frac{1}{6}$ of their own wt of water when immersed in water for 24 hrs.

2. Second class bricks:- possess the hardness and color of first class bricks but are slightly irregular in shape, size or rough on the surface.

3. Third class bricks:- Not well-burnt to the class as first or second but burnt sufficiently & of uniform shape & size for use in unimportant constructions.

4. First class bats:- Broken bricks of the same quality as first & second class bricks.

5. Second class bats:- Broken bricks of the same quality as third class bricks.

6. Jhama bricks:- Well burnt bricks but not quite so well shaped as pitched jhama bricks, must not be spongy and must be free from cinders & projecting lumps & lumes and of fairly good shape.

7. Pitched jhama bricks:- Uniformly vitrified throughout, but must be of good shape, heavy & of selected quality & must not be spongy.

8. Jhama bats:- Broken bricks of the classes as pitched jhama & jhama bricks.

④ Special bricks:-

- Perforated bricks used in building
- Hollow bricks used in hollow walls in building
- Checkered bricks used in brick masonry.
- Stable bricks
- Plinth bricks
- Jam bricks
- Klinker bricks

(Fig. Aiz-45)

■ Use of bricks:-

- Construction of walls of any size
- Construction of floors
- Construction of arches & cornices
- Making Khoa to use as aggregate in concrete.
- Manufacturing surki to be used in lime plaster & lime concrete.

Cement

Defn:- cement is a cementing or binding material in engg. constructions. It is very useful & superior to lime under the following circumstances -

- For construction of structures in wet places & under water.
- Where great strength & durability of structures are required.
- Where mortar or plaster has to set quick & attain its strength.
- Where hard surface is required for the protection of exposed surfaces of structures.
- For water tightness of structures.
- For decorative, ornamental & pointing works.

■ Types of cements:-

(a) Natural cement:-

- Obtained by burning & crushing to powder natural stones containing 25 to 40 percent of clay, the remainder being the carbonate of lime, sometimes mixed with carbonate of magnesia.
- Brown in color & sets very quickly when mixed with water.
- Not so strong as artificial cement.

b) Artificial cements:-

- The best variety is known as ordinary portland cement due to its resemblance in color & quantity to portland stone, which was first found & quarried in Dorset in Europe.

Composition of Portland cement:- Raw materials

for manufacturing of portland cement are of two types

1) Calcareous materials which are the compounds

of calcium & magnesium

2) Argillaceous materials which are mainly silica

alumina & oxides of iron.

Constituents of portland cement are of two types -

i) Mineral constituents

ii) Acid & Alkaline constituents.

Table → Mineral constituents of Portland cement

Mineral Constituents	Oxide Composition	Abbreviation	Percent
1) Tricalcium silicate	3CaO·SiO ₂	C ₃ S	45-55
2) Dicalcium silicate	2CaO·SiO ₂	C ₂ S	20-30
3) Tricalcium aluminate	3CaO·Al ₂ O ₃	C ₃ A	9-13
4) Tetracalcium Aluminoferrite	4CaO·Al ₂ O ₃ ·Fe ₂ O ₃	C ₄ AF	8-20
5) Calcium sulphate	CaSO ₄	-	2-6
6) Other Compounds	-	-	2-8

Table - Acid & alkaline constituents

Constituents	Range of Percentage	Composition
1) Calcium oxide	- CaO	60-67
2) Magnesium oxide	- MgO	0.1-0.4
3) Silica	- SiO ₂	17-25
4) Alumina	- Al ₂ O ₃	3-8
5) Iron oxide	- Fe ₂ O ₃	0.5-6
6) Sulphur Trioxide	- SO ₃	1-3
7) Potassium oxide	- K ₂ O	0.3-1
8) Sodium oxide	- Na ₂ O	1
9) Alkalines	-	0.4-1.3
10) Loss on ignition	-	1.5-2.0
11) Insoluble residue	-	0.3-0.5

Functions of various ingredients of cement :-

1. Lime (CaO), 63% :-

- Present in cement in the form of silicates & aluminaates of calcium.
- Deficiency reduces the strength of cement & causes it to set quickly.
- Excess makes cement unsound & causes it to expand & disintegrate.

2. Silica (SiO₂), 30% :-

- Present in the form of dicalcium & tricalcium silicate.
- Imparts strength to cement.

3. Alumina (Al_2O_3) :- exists & C_3A - also

- Imparts quick setting property to cement.

4. Magnesia (MgO) :-

- Excess reduces the strength of cement.

5. Iron oxide (Fe_2O_3) :-

- Imparts color to cement.

- Forms tricalcium aluminoferrite at a high temp
which imparts hardness & strength of cement.

6. Calcium sulphate (CaSO_4) :-

- Present in cement in the form of gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$)

- Retards the setting action of cement

7. Sulphur trioxide (SO_3) :-

- Excess causes cement to become unsound.

8. Alkalines :-

- Excess causes efflorescence.

■ Manufacture of cement:-

There are generally two processes namely

i) Wet process - (Ariz - 69)

ii) Dry process

A typical flow diagram based on wet process of manufacture cement is shown below -

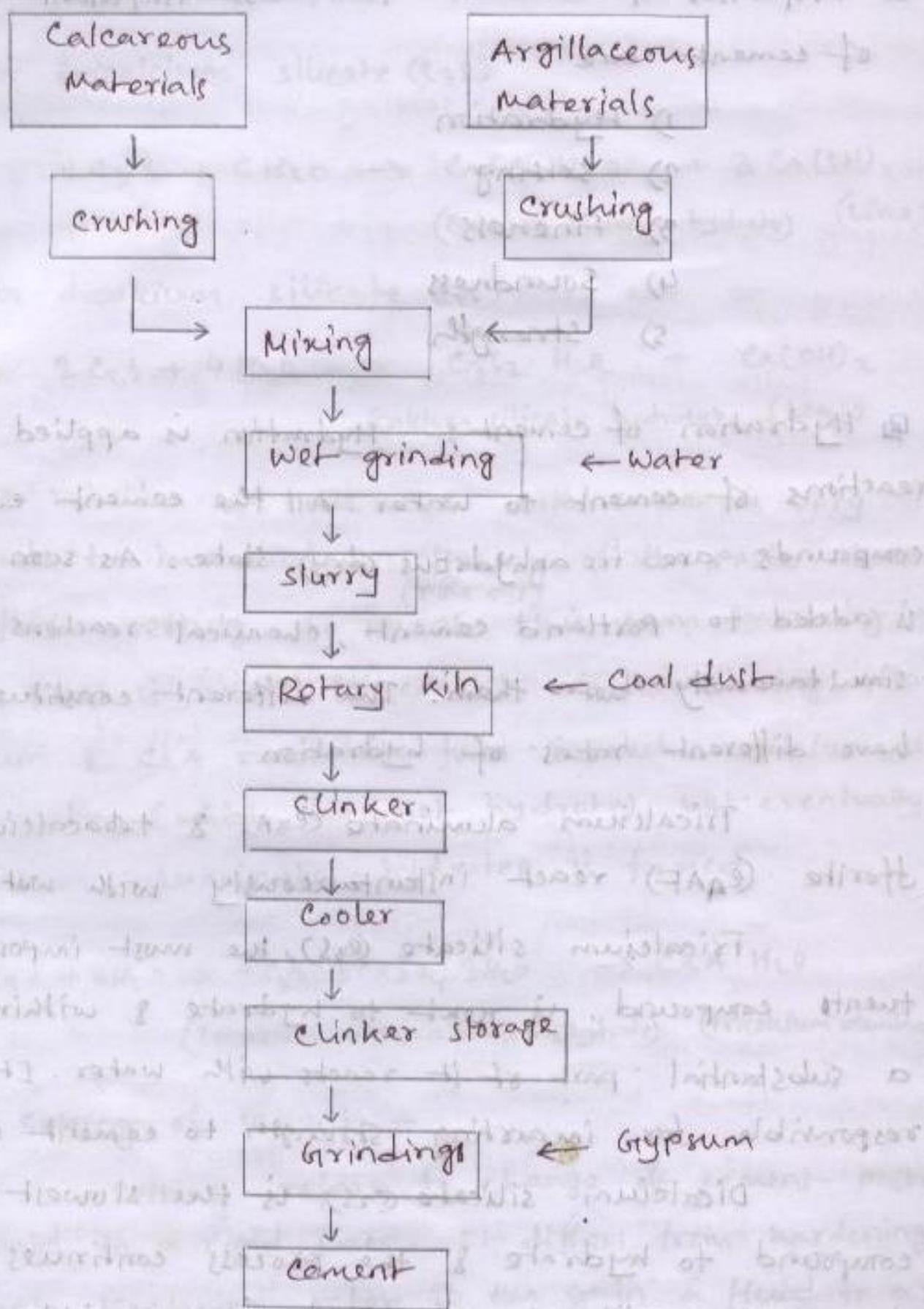


Fig. Flowchart showing manufacture of cement by wet process

Properties of cement:- The most important properties of cement are

- 1) Hydration
- 2) Setting
- 3) Fineness
- 4) Soundness
- 5) Strength

Hydration of cement :- Hydration is applied to all reactions of cement to water. All the cement constituent compounds are in anhydrous (dry) state. As soon as water is added to Portland cement, chemical reactions start simultaneously betw them. The different constituent compoun have different rates of hydration.

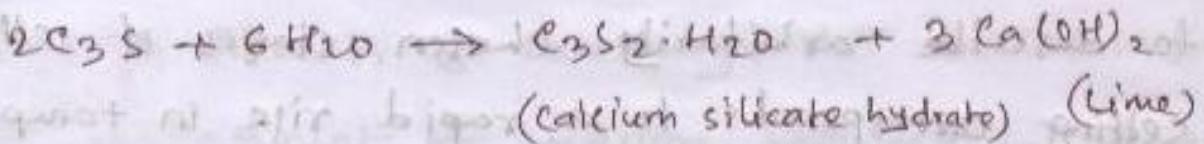
Tricalcium aluminate (C_3A) & tetracalcium aluminoferrite (C_4AF) react instantaneously with water.

Tricalcium silicate (C_3S), the most important constituents compound, is next to hydrate & within a week a substantial part of it reacts with water. It is mainly responsible for imparting strength to cement in early days.

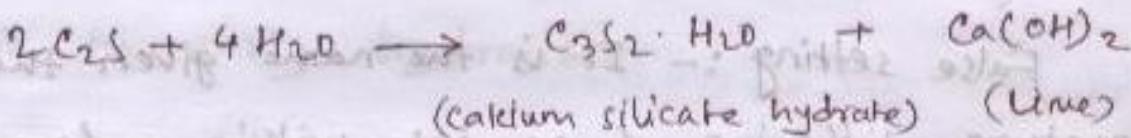
Dicalcium silicate (C_2S) is the slowest constituent compound to hydrate & the process continues for several days. This constituent compound is responsible for the progressive strength of cement.

Hydration reactions —

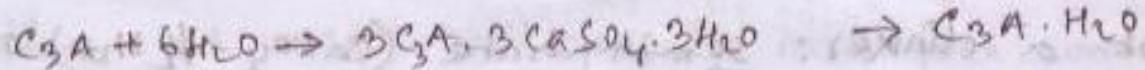
For tricalcium silicate (C_3S)



For dicalcium silicate (C_2S)



The reaction of true C_3A with water is very violent & leads to immediate stiffening of the paste, known as flash setting. To prevent this from happening, gypsum ($CaSO_4 \cdot 2H_2O$) is added to cement clinker during grinding. Gypsum & C_3A react to form insoluble calcium sulfo-aluminate (which does not hydrate) but eventually a tricalcium aluminate hydrate is formed.



(Tricalcium sulfo-aluminate hydrate) (Tricalcium aluminate hydrate)

■ Setting of cement:-

Setting refers to change of cement paste from a fluid to a rigid state. It differs from hardening of cement. Hardening refers to the gain of fluid to a rigid state or hardening refers to the gain of strength of a set

cement paste, although during setting the paste acquires some strength.

The term initial setting & final setting are used to describe arbitrarily chosen stages of setting. Initial setting corresponds to a rapid rise in temp and final setting to the peak temp.

False setting :- It is the name given the abnormal premature stiffening of cement within a few minutes of mixing with water. It differs from flash setting in that no appreciable heat is evolved, and the remixing the cement paste without addition of water further amount of water restores plasticity of the paste until it sets in the normal manner & without a loss of strength.

Some causes of false settings-

- dehydration of gypsum when interground with too hot a clinker: semihydrate ($\text{CaSO}_4 \cdot \frac{1}{2} \text{H}_2\text{O}$) or anhydrite (CaSO_4) are formed and when the cement is mixed with water these hydrate to form gypsum again. Thus setting takes place with a resulting stiffening of the paste.

- During storage, they may carbonate & alkali due carbonates react with calcium hydroxide, Ca(OH)_2 , liberated by the hydrolysis of C_3S to form calcium carbonate (CaCO_3). This precipitates & induces a rigidity of the paste.

■ Fineness of cement:-

The rate of hydration depends on the fineness of cement particles, and for a rapid development of strength, high fineness is necessary. An increase in fineness increases the amount of gypsum required for proper retardation as in a finer cement more C_3A is available for early hydration.

■ Soundness of cement:-

It is essential that a cement paste, once it has set, does not undergo a large change in volume. Such changes in volume may take place due to the delayed in hardened cement, namely free lime, magnesia & calcium sulphate.

If the raw materials fed into the kiln contain more lime (CaO) than that can combine with the acidic oxides, the excess will remain in a free condition. The free lime will hydrate very slowly in a subsequent stage and the mortar and concrete prepared with such cement is therefore liable to expand & crack after a few months or a year. Cements which exhibit this expansion are known as unsound.

A cement can be unsound due to the presence of magnesia (MgO), which reacts with water in a manner similar to quick lime (CaO). If gypsum is present in excess of the amount that can react with C_2A during setting, unsoundness in the form of a low expansion will result.

■ Strength of cement:-

There are several forms of strength of cement namely - a) Tensile strength, b) compressive strength, c) Flexural strength. Compressive strength is used in Bangladesh & elsewhere.

■ Testing of cement:-

1) Field test - shetty (concrete Technology)

2) Laboratory test

a) Test for fineness

b) Test for setting time: Initial & final

c) Test for soundness

d) Test for chemical composition

e) Test for strength : Compressive & Tensile.

LT:- Details from ARIZ-79.

Initial setting time is regarded as the time elapsed betn the moment that the water is added to the cement, to the time that the paste starts losing its plasticity.

Final setting time is the time betn the moment the water is added to the cement & the time when the paste has completely lost its plasticity & has attained sufficient stability to resist certain definite pressure.

□ Types of Portland Cement :- (A212-86)

Table - Main types of Portland cement.

English Description (B.S.I)	American (ASTM) Description
1. Ordinary Portland	Type I
2. Modified Portland	Type II
a) Air Entraining Portland	-
b) Expanding Portland	-
3. Rapid Hardening Portland	Type III
4. Quick setting Portland	-
5. Low Heat Portland	Type IV
6. Sulphate Resisting Portland	Type V
7. Blast Furnace	Type IS
8. Pozzolana Portland	Type IP
9. White Portland	-

Sand

Q Sieve analysis data of two different variety of sands one from sylhet & other from kustia are given below. wt. of each sample is 500 gm. calculate the amount of each variety of sand in a mix of 20 kg to obtain the combined fineness modulus of 2.50.

<u>Sieve</u>	<u>Sylhet sand, gm</u>	<u>Kustia sand, gm</u>
No. 4	21	3
No. 8	58	11
No. 16	105	35
No. 30	111	52
No. 50	115	262
No. 100	90	137

Soln: For sylhet sand For kustia sand

<u>Cumulative wt. Retained</u>	<u>% Cumulative wt. retained</u>	<u>Cumulative wt. retained</u>	<u>% cumulative wt. retained</u>
21	4.2	3	0.6
79	15.8	14	2.8
184	36.8	45	9.0
295	59.0	101	20.2
410	82.0	363	72.6
500	100.0	500	100.0
	297.8		206.0

$$FMs = \frac{297.8}{100} = 2.98 \quad FMK = \frac{206.0}{100} = 2.06 \quad \Delta Fcom = 2.50$$

Ratio of sylhet sand to be mixed with 1 of kustia sand is

$$R = \frac{Fs - Fcom}{Fcom - Fk} = \frac{2.98 - 2.50}{2.50 - 2.06} = 1.09$$

$$\text{Amount of sylhet sand} = \frac{20}{(1.09+1)} \times 1.09 = 10.43 \text{ kg}$$

$$\text{Amount of kustia sand} = 20 - 10.43 = 9.57 \text{ kg}$$

LIME

Defn:- Lime is a more or less impure calcium oxide (CaO) obtained by the calcination (heating) of shells, corals, limestones, Kankar and other substances composed of almost pure or impure calcium carbonate (CaCO_3). It acts as a binding or cementing material in engg. construction.

■ Uses of lime :- Lime is used for following purposes -

- white washing
- Lime punning
- Making mortar (lime mortar & surki mortar)
- Making concrete (lime concrete)
- Manufacturing cement.

■ Technical terms :-

- calcination - Heating of limestone to redness (1500°F) in air.
- Quick lime / caustic lime - Lime obtained immediately after calcination of limestone.
- Slaking - When water is poured on quick lime, it gives rise to heat due to certain chemical reactions & this process is termed as slaking of quick lime.
- Slaked lime - The substance left after slaking of quick lime.
- Hydraulicity - The property of lime to set under water.

■ Constituents of Limestones :-

Calcium oxide - principle constituents of limestone
- Acts as a binder.

Clay - small quantity retards slaking & large proportion arrests slaking.

- Causes setting of lime & renders it insoluble in water.

Silica & Alumina - Impart hydraulicity in lime.

Magnesium carbonate - slakes lime more slowly

- evolves less heat, expands less

- sets more slowly, but finally gains greater strength.

Sulphates - Retards the slaking action -

- Increases the rapidity of setting.

Alkaline & metallic oxides - Impart hydraulicity in lime.

Iron pyrites - Reduce the strength of lime.

■ Classification of lime :-

a) Fat lime or high calcium lime :-

- Obtained by the calcination of pure limestone, chalk & sea shells.

- Swells two to three times its volume when slaked.

- Nearly white & free from other substances to produce any major effect upon either slaking or setting action.

- Used for finishing coat in plastering, white washing & lime punning

b) Hydraulic Lime:-

- Obtained from kankar or clayey limestone
- Possesses the property of setting & hardening under water
- Not white because it contains impurities of clay & MgO
- Used for masonry in foundations & for thick walls.
- Used for mortar for masonry work in superstructure in buildings & plastering.

c) Natural cements:-

- These natural stones are the complicated compounds of calcium, aluminium & silica. After calcination the products exhibit a high value of hydraulicity.

Table : Composition of limestone for different types of limes .

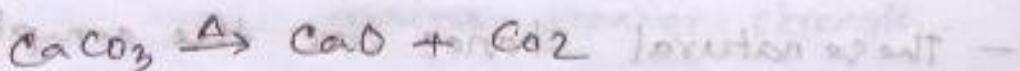
Principle Ingredients	Percentage composition Quality of lime stone		
	Fat lime	Hydraulic lime	Natural cement
Calcium oxide	96	45-65	30-35
Magnesium oxide	1-2	30-40	10-15
Aluminium oxide	Little or Nil	2-5	5-10
Silica	2	20-30	20-35
Iron oxide	Little or Nil	2-5	About 5
Other impurities	"	1-5	Upto 2

grid Tests on Limestone:-

** 1) Physical tests:- The sample of limestone showing a slightly earthy surface indicates the presence of clay & will be suitable for producing hydraulic lime while white color indicates pure limestone.

** 2) Chemical test:- The following tests are used for the limestone as chemical tests -

a) Heat test:- Weigh a piece of dry limestone. Heat it to redness in an open fire for about 6 hrs. The following reaction takes place



Allow the product to cool & weigh again. For every loss in wt. of 44 parts, there is 56 parts of lime by wt. clayey & silicious impurities require higher temp to drive out carbon-dioxide & this indicates the extent to which the lime is hydraulic.

b) Slaking test:- When water is added to quick lime, the following reaction takes place



During the process of hydration, heat is given out & the energy thus liberated is often enough to split it & to make it crumble to produce powder.

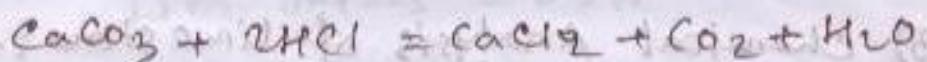
²⁷⁰⁵

A vigorous slaking indicates high calcium content

in the sample i.e., flat lime, while with hydraulic
limes, the slaking action is very slow. After the
addition of sufficient water if the sample sets under
water it is hydraulic lime, if not flat lime.

c) Acid test:- This test is carried out for two
purposes which are given below -

(i) To determine the presence of calcium carbonate
in a given sample of limestone :- Effervescence with
the liberation of carbon-dioxide & formation of calcium
chloride will cause when dilute hydrochloric acid is
added to the specimen. The reaction is as follows



Effervescence will be vigorous if the presence of
calcium carbonate content of the sample is very high
& thereby the residue will be less if the effervescence
is not vigorous, calcium carbonate content is less &
the residue will be more.

(ii) To determine the rough composition of limestone:-
Weigh dry powdered sample of limestone, let the wt.
be W gms. Put the powdered sample in a tumbler &

add dilute hydrochloric acid gradually. stir & add hydrochloric acid until effervescence ceases. strain the content through filter paper. carefully dry the residue on the filter paper & weigh it. let the wt. be w_1 gms. Then $(w - w_1)$ will be the wt. of calcium carbonate in the sample. To separate the clay from sand in the residue, stir up the residue with water. The sand being ^{heavier} will settle at the bottom, while the clay particles will be in suspension. Decant the water. Dry the sand & weigh it. Let the wt. be w_2 gms. Then $(w_1 - w_2)$ will be the wt. of clay.

* 3) Chemical Analysis of limestone:-

Hydraulic Index or Ratio

$$= \frac{\text{Silica} + \text{Alumina} + \text{Oxides of Iron}}{\text{Lime} + \text{Magnesia}}$$

Cementation Index

$$= \frac{2.8 \text{ Silica} + 1.1 \text{ Alumina} + 0.7 \text{ Oxides of Iron}}{\text{Lime} + 1.4 \text{ Magnesia}}$$

The hydraulicity of limestone is always expressed on the basis of hydraulic index & cementation index.

Table - Hydraulic values of different type of hydraulic lime

Quality of Lime	Hydraulic Index	Cementation Index
Foebly hydraulic lime	0.1 ~ 0.2	0.2 ~ 0.4
Moderately hydraulic lime	0.2 ~ 0.3	0.4 ~ 0.6
Eminently hydraulic lime	0.3 ~ 0.4	0.6 ~ 1.0

Example - The chemical analysis of limestone gave the following results.

calcium oxide = 70%

Alkalies and Silica = 20%

Aluminas = 6%

Magnesia = 1.5%

Iron oxides = 2.5%

Determine the hydraulic index & cementation index and also write what type of hydraulic lime it is?

Soln:

$$\text{Hydraulic Index} = \frac{20+6+2.5}{70+1.5} = 0.399$$

$$\text{Cementation Index} = \frac{2.8 \times 20 + 1.1 \times 6 + 0.7 \times 2.5}{70 + 1.4 \times 1.5} = 0.892$$

This is the eminently hydraulic lime.

■ Manufacture of Limes:- stages involved in the manufacture of the lime are

- Pre-Heating
- Calcination or Burning
- Hydration or Slaking

Pre-heating :- In this stage limestone is heated in a closed container at a temp. of about 600°F to remove moisture.

Calcination or Burning :- kiln burning is adopted in every country for calcination of limestone because it economizes fuel. Fuel used for calcination is generally coal, coal-dust or fire wood.

Fig. Modern continuous lime kiln - (AII-62)

Fig. shows that the central section of the continuous lime kiln is widened out to form the zone of calcination so as to accomodate the hot gases of combustion & to establish a continuous draught.

The feed consisting of limestones or kankas with coal is put at the mouth at first. An iron grating is provided at the bottom with holes to draw the calcined particles. The burnt limestones are collected for

further treatment of slaking or hydration.

At a temp of about 1500°F , limestone dissociates into calcium oxide & CO_2 . Limestone should not be heated beyond 1500°F , because at higher temp of about 2200°F , a series of complicated reactions will take place & these reactions are not desirable to have a good variety of lime.

Hydration or slaking :- Lime powder is obtained after the hydration of calcined particles. Hydration of lime is accompanied by chemical combination of calcium oxide with water to form calcium hydroxide, by evolution of heat capacity, by increase in volume.

■ Qualities of good lime:-

— Free from ashes, underburnt, particles & other impurities.

— Must pass through sieve No. 4.

■ Testing of lime:-

1) Adhesive strength test: Two standard sized bricks, placed flat in a cross-fashion one over the other are jointed with a $\frac{1}{2}$ " thick lime mortar (1:3). The two jointed bricks should be kept wet with the

help of gunny bag for 24 hrs. & then kept immersed in water for 7 days. The force required to separate them at the joint should not be less than 30 psi.

2) Tensile strength test:- A briquette is made with a lime mortar (1:3) & kept under water for 7 days. This is tested in the machine for tensile strength of lime. This should not be less than 45 psi after 7 days & 90 psi after 28 days.

3) compressive strength test:- with the help of lime mortar (1:3), 2" cubes are made & kept for 7 days in water. The cubes are then tested for compressive strength by machine. The comp. strength should not be less than 200 psi after 7 days & 450 psi after 28 days.

4) Soundness test:- The lime is mixed with necessary quantity of water to form paste. The paste is made into a small ball, 1" diameter by hand & then allowed to set under a wet cloth for 24 hrs. Then it is kept under water for a further period of 24 hrs. It is exposed to steam for 6 hrs. At the end of this period, the ball should not show any sign of cracking or warping.

AGGREGATE

Aggregates occupy 70-80% of the volume of concrete.

They give body to the concrete, reduce shrinkage & effect economy.

■ Classification:-

According to unit wt

1) Normal wt. aggregate

→ Natural (sand, Gravel, crushed rock such as graphite)

2) Light wt. aggregate

→ Artificial (Broken bricks)

3) Heavy wt. aggregate

According to size

1) Coarse aggregate ($> 4.75 \text{ mm } \Phi$)

2) Fine aggregate ($< 4.75 \text{ mm } \Phi$)

■ Source:- Almost all natural aggregate materials originate from bed rocks.

■ Size:- The largest maxm size of aggregate practicable to handle under a given set of conditions should be

used. 80 mm is the maxm size that could be conveniently used for concrete making. Using the largest possible maxm size will result in

- Reduction of the cement content

- Reduction in water requirement
- Reduction of drying shrinkage.

The max^m size of aggregate that can be used in any given condition may be limited to the followings-

1) Thickness of section 2) Spacing of reinforcement

3) Clear cover 4) Mixing, handling & placing techniques

■ Shape :- The shape of aggregate affects the workability of concrete. Classification of particles on the basis of the shape of the aggregate is shown in following table.

Classification	Description	Example
Rounded	Fully water worn	River or sea-shore Gravels
Irregular partly rounded	Naturally irregular having rounded edges	Pit sands & gravels
Angular	Possessing well-defined edges formed at the intersection of roughly planar faces	Crushed rock of all types
Flaky	Material usually angular, of which the thickness is small relative to the width &/or length.	Laminated rocks

■ Strength :- Since concrete is an assemblage of individual pieces of aggregate bounded together by cementing material, its properties are base primarily on the quality of the cement paste. This strength is dependent also on the bond betw the cement paste & the aggregate. If either the strength of the paste or the bond betw the paste & aggregate is low, a concern of poor quality will result irrespective of the strength of the rock or aggregate. But when cement paste of good quality is provided & its bond with the aggregates is satisfactory, then the mechanical properties of the rock will influence the strength of concrete. From the above it can be concluded that while strong aggregate cement paste makes strong concrete, for making strong concrete, strong aggregates are are an essential requirement.

■ Absorption & moisture content:- Some of the aggregates are porous & absorptive porosity & absorption affect the w/c ratio & hence the workability of concrete. The porosity of aggregate will also affect the durability of concrete when the concrete is subjected to freezing & thawing & also when the concrete is

subjected to chemically aggressive liquid.

In mix design calculation, the relative wt. of the aggregates are based on the condition that the aggregates are saturated & surface dry. But in practice, aggregates in such ideal condition is rarely met with.

The aggregate may have been exposed to rain or may have been washed in which case they may contain surface moisture or the aggregates may have exposed to the sun for a long time in which case they are absorptive. If aggregate are dry they absorb water from the mixing water thereby affect workability, & if the aggregates contain surface moisture, they contribute extra water to the mix & affect workability.

In making quality concrete, it is very essential that corrective measures should be taken both for absorption & free moisture so that the w/c ratio is kept exactly as per the design.

Absorbed moisture = Absorption ; Free moisture = Moisture content

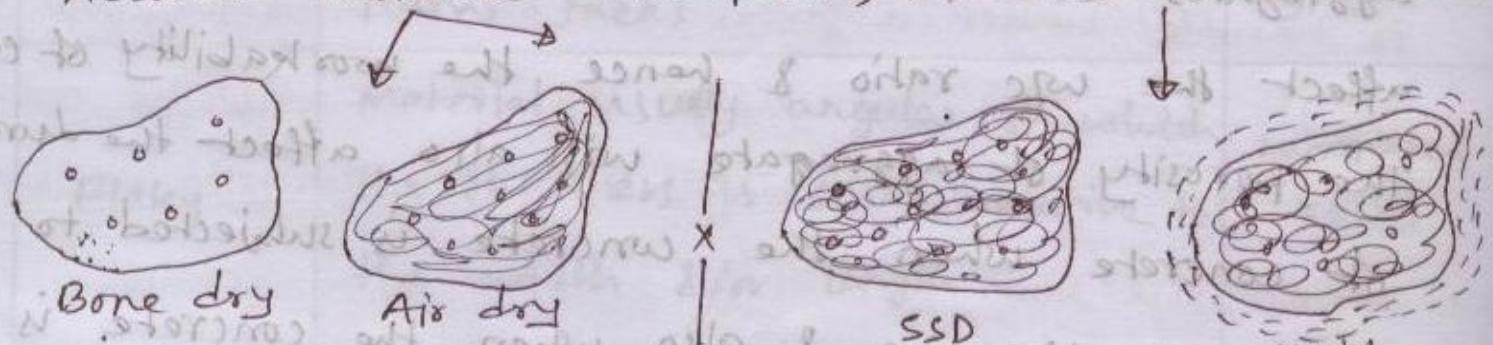


Fig. Diagrammatic representation of moisture in aggregate.

Adam
06/01/10

AGGREGATE

Aggregate — 75~80% in concrete

CLASSIFICATION

→ According to unit wt.

Aggregate

Normal wt. aggregate

Natural

Sand, gravel,
crushed stone,
rock such as
granite, quartzite,
Basalt, sandstone.

Artificial

Broken brick,
Air-cooled slag

Light wt. aggregate

(Expanded clay, shell,
slate etc)

1450-1750 kg/m³

Heavy wt. aggregate

(Magnetite Fe₃O₄,
Scrap iron etc)

3000-5700 kg/m³

→ According to size

Aggregate — [Coarse ($> 4.75 \text{ mm} \phi$)
Fine ($\leq 4.75 \text{ mm} \phi$)]

SOURCE

Natural - Sand

Artificial - Brick

SIZE

$\nexists 80 \text{ mm } \phi$

Max^m size of aggregate may be limited by

- I) Thickness of sect' $\nexists \frac{1}{4}$ th of the min^m thickness of the member
- II) Spacing of reinforcement
- III) Clear cover
- IV) Mixing, handling & placing techniques.



Rounded, irregular or partly rounded, Angular, Flaky.

SHAPE

Rounded (river or seashore gravels), irregular or partly rounded (pit sands & gravels, cuboid rock etc), Angular (crushed rocks of all types), Flaky (laminated rocks).

TEXTURE

Glossy, smooth, granular, crystalline, honeycombed porous.
(Blackflint) (slate) (Sandstone) (Basalt) (pumice, trass)

PROPERTIES

i) Strength

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 b/w the cement paste or the bond b/w the paste & the aggregate. If either the strength of the paste or the bond b/w the paste & 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 & its bond with the aggregate is satisfactory, then the mechanical properties of the rock or aggregate will influence the strength of concrete. It can be concluded that strong aggregate cannot make strong concrete, for making strong concrete, strong aggregate are an essential requirement.

ii) Thermal properties

- a) Co-efficient of expansion Avg. value 9.9×10^{-6} per °C
- b) Specific heat
- c) Thermal conductivity

Mechanical properties

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ମୁଦ୍ରଣ ଲେଖିବା

- Toughness
- Hardness
- Sp. gravity
- Bulk density
- Porosity & absorption of agg.
- Moisture content of agg.

Specific Gravity

Specific gravity of aggregate is made use of —

- in design calculations of concrete mixes.
- in calculating the compacting factor in connection with the workability measurement.

Avg. sp. gravity of rocks vary from $2.6 \sim 2.8$.

Bulk density

— The bulk density or unit wt. of an aggregate gives valuable informations regarding the shape & grading of the aggregate.

— Bulk density shows how densely the aggregate is packed when filled in a standard manner.

— Bulk density depends on the particle size distribution & shape of the particles.

— The method sample which gives the min^m voids or the one which gives max^m bulk density is taken as the right sample of aggregate for making economical mix.

$$\text{Percentage voids} = \frac{G_S - \gamma}{G_S} \times 100$$

$G_S \rightarrow$ sp. gravity of the aggregate
 $\gamma \rightarrow$ bulk density in kg/litre.

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ମୁଦ୍ରଣ ଲେଖିବା

ing of aggregate

Good grading implies that a sample of aggregate contains all standard fractions of aggregate in required proportion such that the sample contains min^m voids. A sample of the well graded aggregate containing min^m voids will require min^m paste to fill up the voids in the aggregate. Minimum paste will mean less quantity of cement & less quantity of water, which will further mean increased economy, higher strength, lower shrinkage & greater durability.

The advantages due to good grading of aggregates can also be viewed from other angle. If concrete is viewed as a two phase material, paste phase of aggregate fills of concrete. Paste is weaker than avg. aggregate in normal concrete with rare exceptions when very soft aggregates are used. The paste is more permeable than many of the mineral aggregates. It is the paste that is susceptible to chemicals. Paste is a weak link in a mass of concrete. The lesser the quantity of such weak matter achieved by having well graded aggregates.

on aggregates

• ग्रनिट एक्सीस्टेंस
पर्सनल मैट्टर्स

- Test for the determination of flakiness index & elongation index.
- Test for the determination of agg. crushing value.
- " " " " impact value
- " " " " abrasion "
- " " " " sp. gravity
- " " " " bulk-density & voids in agg.
- " " " " surface moisture in fine agg.
- Estimation of % of bulking off.
- Determination of organic impurities
- Determination of clay, fine silt, fine dust.
- Determination of potential reactivity
- " " soundness of aggregate

Aggregate Crushing Value

The 'aggregate crushing value' gives a relative measure of the resistance of an aggregate to crushing under a gradually applied compressive load. With aggregates of 'aggregate crushing value' 30 or higher, the result may be anomalous & in such cases the 'ten percent finer value' should be determined & used instead.

The standard aggregate crushing test is made on aggregate passing a 12.5mm I.S. sieve & retained on 10mm I.S. sieve. If reqd or if the standard size is not available, other sizes upto 25mm may be tested.

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पर्सनल मैट्टर्स

~~6.5 kg material consisting of aggregates passing 10.5 mm retained on 10mm sieve is taken. The aggregate in a~~ ~~sieve~~ ~~dry~~ condition is filled into the standard cylindrical measure in three layers approximately of equal depth. Each layer is tamped 25 times with the tamping rod & finally levelled off using the tamping rod as st. edge. The wt. of the sample contained in the cylinder measure is taken(A). The same wt. of the sample is taken for the subsequent repeat test.

The cylinder of the test apparatus with aggregate filled in a standard manner is put in position on the base-plate & the aggregate is carefully levelled & the plunger inserted horizontally on this surface.

Concrete: concrete is an artificial compound generally made by mixing lime, surki or cement mortar with some hard material such as broken stone, gravel, shingle, broken brick etc. The mortar used in concrete is called matrix or binder and the hard broken material is known as aggregate or filler.

Aggregate \rightarrow Fine aggregate
 \rightarrow coarse aggregate

Lime concrete = lime + aggregate + water
 Cement " = cement + " + "

Ingredients of concrete:

- 1) cement / lime
- 2) fine aggregate i.e; sand 0.75 mm to 4.75 mm
- 3) coarse aggregate i.e; brick khaa, stone-chips > 4.75 mm

Properties of concrete \rightarrow A.M. Neville (4th edn)

Classification of concrete:

- 1) Lime concrete
- 2) Gurki concrete
- 3) composite mortar ~~cement~~ concrete
- 4) cement concrete

28.02.08

Function of aggregates in concrete:

- 1) Aggregate gives volume to the concrete.
- 2) It makes concrete cheaper because aggregates are cheaper than cement.
- 3) Not only the economic reasons, it confirm considerable technical advantage on concrete, which has a higher volume stability and better durability than cement paste alone.

Function of water in cement:

Water serves the following 3 purposes:

- 1) To wet the surface of aggregate to develop adhesion, because the cement paste adheres quickly and ~~satisfactory~~ ^{stays} to the wet surface of the aggregate than to a dry surface.
- 2) To prepare a plastic mixture of the various ingredients and to impart workability to.

concrete to facilitate placing
the desired position and
3) Water is also needed for the hydration of
the cementing materials to set and harden
during the period of curing.

Advantage of concrete over other materials of construction: As some or All

Special terms:

Segregation: Must

def. coarse- effect
control.

Bleeding: must

03.03.08

Properties of concrete:

no air

why cube specimens gives greater value
than cylinder specimen from work

06.03.08

Impenetrability:

Sensory - don't touch skin (it's wet)

Workability:

Measurement of workability:

There are various types of test to measure workability of concrete -

- 1) slump test
- 2) compacting factor test
- 3) flow test
- 4) Kelly Ball test
- 5) Vee Bee ~~and~~ consistometer test.

① Slump test: Aim -

Fig. Measurement of workability by slump test

Assignment — next class

② write down the parameters on whose the properties of concrete depend.

10.03.08

Shrinkage of concrete:

Types of shrinkage: From book (~~Affiliation~~)
(defn and now)

Creep:

Factors affecting creep of concrete: only name

Chemical attack of concrete: ~~defn~~

Tri calcium aluminate \rightarrow C₃T

Leaching:

Sulphate attack:

~~reduced edge strength~~

Sea water attack:

Acid attack:

At high temperature in domestic sewage when sulphur components become reduced by aerobatic bacteria to H₂S. It is dissolved in moisture films on the exposed surface of the concrete and undergoes oxidation by aerobic bacteria finally producing sulphuric acid. The cement gradually dissolves and progressive deterioration of concrete takes place.

→ Various types of concrete:

① Precast concrete

② RCC

③ pre-stressed concrete

④ Light weight concrete

Concrete mix Design

Defn: Mix design can be defined as the process of selecting suitable ingredients of concrete and determining their relative proportions with the objective of producing concrete of certain minimum strength and other durability as economically as possible.

Various methods of proportioning:

- ① Arbitrary proportion
- ② Andes modulus method (FM)
- ③ Maximum density method
- ④ Surface area method
- ⑤ DRC (Indian Road Congress), 44 method
- ⑥ High strength concrete mix design
- ⑦ Mix design based on flexure strength
- ⑧ Road Note No. 4 (Grading curve method)
- ⑨ ACI committee 211 method
- ⑩ DOE method
- ⑪ Mix design for pumpable concrete
- ⑫ Mix design for pumpable concrete
- ⑬ Indian standard recommendation method IS 10262-82.

ACI Method:

Assumptions:

1) Type-I, Non-air entraining cement with a specific gravity of 3.15 is used.

- ③ The coarse and fine aggregates are of satisfactory quality, are graduated within limits.
- ④ The coarse aggregate has bulk dry specific gravity of 2.68 and an absorption of 0.5 percent.
- ⑤ The fine aggregate has a bulk dry specific gravity 2.64 and an absorption of 0.7 percent and fineness modulus of 2.80.

→ Steps for the mix design:

Step-1: choice of slump (Table-7.1)

Step-2: choice of max size of aggregate (Table-7.1)

Depend on the member size and spacing of reinforcement.

Step-3: Estimation of water content and air content. (Table-7.5)

Step-4: selection of water cement ratio (7.3, 7.4)

Step-5: determination of cement content.

Step-6: Calculation of amount of fine aggregate.

Step-7: Calculation of coarse aggregate.

Step-8: Adjusting for field condition.

17.03.08

Prob-7:5:1

[Art. 5.3, Page-41, K. Raju]

Concrete is required for casting the interior large columns in the ground floor of a multi-storyed buildings. Structural consideration specify a mean cylinder strength of 250 kg/cm^2 at 28 days. The coarse aggregate locally available is well graded having a maxm size of 40mm and a dry packed unit wt of 1600 kg/m^3 . Fineness modulus of sand available at site 2.8. Slump specified for the job = 80mm - 100mm. Specific gravities of cement, coarse and fine aggregates are 3.15, 2.68 and 2.64 respectively. Type of cement available at site ordinary portland (Type-I).

Soln:

Non-air entrained concrete is selected since the structure is not exposed to adverse adverse weather condition.

water/cement ratio = 0.62 (T-7.4)

Approximate mixing water for a slump of 80-100mm and maximum size of aggregate = 175 kg/m^3 (T-7.5)
The quantity of cement per unit meter = 282.06 kg .
volume of coarse aggregate per cubic meter of concrete = 0.72 (T-7.6)

Weight of coarse aggregate per cubic meter
of concrete = $1600 \times 0.72 = 1152 \text{ kg}$

	<u>kg</u>	<u>m^3</u>
1. Cement	282	$\frac{282}{3.15 \times 1000} = 0.090$
2. Water	175	$\frac{175}{1000} = 0.175$
3. Coarse aggregate	1152	$\frac{1152}{2.68 \times 1000} = 0.430$
4. Fine aggregate		0.010
4. Entrapped air(%)		<u>0.705 m^3</u>
5. Total volume of ingredients except sand		<u>0.295</u>
5. Fine aggregate		

Volume of dry sand = $1 - 0.705 = 0.295 \text{ m}^3$
Weight of dry sand = $0.295 \times 1000 \times 2.64 = 780 \text{ kg}$

Density of concrete = $\frac{282 + 175 + 1152 + 780}{0.090 + 0.175 + 0.430 + 0.295} = 2389 \text{ kg/m}^3$

Mix proportion by wt

cement	sand	coarse aggregate	water
282	780	1152	175
1	2.77	4.09	0.62

PA - 5%, CA - 1%]

④ Moisture content

20.03.08

Field adjustments:

If the coarse and fine aggregates are found to contain 1 and 5 percent of moisture respectively. The field mix quantities after adjusting for free water content are as given:

$$\text{Cement} = 282 \text{ kg}$$

$$\text{Water} = 175 - \frac{1152}{100} \times 1 - \frac{780}{100} \times 5 = 125 \text{ kg}$$

$$\text{Sand} = 780 + \frac{780}{100} \times 5 = 818 \text{ kg}$$

$$\text{Coarse aggregate} = 1152 + \frac{1152}{100} \times 1 = 1167 \text{ kg}$$

Conversion

$$1 \text{ MPa} = 10.25 \text{ kg/cm}^2 (10.20)$$

$$1 \text{ MPa} = 143 \text{ psi} (145.04)$$

$$1 \text{ kg/cm}^2 = 14.21 \text{ psi}$$

Assignment

Concrete is required for a portion of a structure that will be below ground level if a location where it will not be exposed to severe weathering or sulphate attack.

28 days required strength = 3500 psi = 246.07 kg/cm²

Required slump = 3 to 4 inch = 75 to 100 mm

Available size of coarse aggregate = 4" to ~~1.5"~~ 1.5" = 100 to 37.5 mm

Dry packed weight of coarse aggregate = 100 kg/m³ = 147 kg/m³

R.M of sand = 2.80

specific gravity of FA = 2.64
" " " C.A = 2.68

Type of cement used = ordinary Portland cement.

Field adjustment for 2% and 0.5% absorption of coarse and fine aggregates.

SHETTY - 205

Admixtures

Defn: To change or develop some special properties of cement or concrete some additives are added to the concrete. This additive is known as admixture. Unfortunately the use of plasticizers and superplasticizers have not become popular in Bangladesh.

- ▷ 90% of the concreting activities are in the hand of common builders or government departments who do not generally accept something new.
- ▷ Plasticizers were not manufactured in Bangladesh and they were to import hence costly.
- ▷ Lack of education and awareness of the benefits accorded by the use of plasticizers.

Admixtures used in concrete: As per report of the ACI committee 212, admixtures have been classified into three groups:-

- ▷ Plasticizers
- ▷ Super-plasticizers with retarders
- ▷ Retarders and retarding plasticizers

(The determination of the quantity of coarse aggregate in the mix is based on the assumption that the optimum ratio of the bulk volume of coarse aggregate to the total volume of concrete depends only on the maximum size of aggregate and on the grading of fine aggregate.) The shape factor of the aggregate is automatically taken into account in the determination of the bulk density. (The water cement ratio is selected based on strength and durability requirements.) Knowing the volumes of water, coarse aggregate and cement, the quantity of fine aggregate required is determined by the absolute volume method, allowing for the quantity of air entrained in the mix. The final proportions should be established by actual trial and necessary adjustments required for the field mixes.

7.2 DESIGN OF CONCRETE MIXES ACCORDING TO ACI 211.1-77

The procedure to be followed in designing a concrete mix is detailed below:

- Dependence upon the type of construction, the required slump and maximum size of aggregates are selected from Tables 7.1 and 7.2.
 - The type of exposure will help in deciding whether air entrained or non-entrained concrete is to be used and the recommendations contained in Table 7.3 are useful in this regard.
- TABLE 7.1 Recommended Slumps for various types of Construction**
- | Type of construction | Slump (mm) ^a | |
|---|-------------------------|------|
| | Max. | Min. |
| Reinforced foundation walls and footings | 175 | 50 |
| Plain footings, caissons, and sub-structure walls | 100 | 25 |
| Slabs, beams, and reinforced walls | 150 | 75 |
| Building columns | 150 | 75 |
| Pavements | 75 | 50 |
| Heavy mass construction | 75 | 25 |
- TABLE 7.2 Maximum sizes of aggregate recommended for various types of construction.**
- | Minimum dimension of section (mm) | Maximum size of aggregate (mm) | Reinforced walls, beams and columns | Un-reinforced walls | Heavily reinforced slabs | Lightly reinforced or un-reinforced slabs |
|-----------------------------------|--------------------------------|-------------------------------------|---------------------|--------------------------|---|
| 62.5-125 | 12.5-20 | 20 | 20-25 | 20-40 | 20-40 |
| 150-275 | 20-40 | 40 | 40-60 | 40-60 | 40-60 |
| 300-275 | 40-80 | 80 | 40-80 | 80 | 80 |
| 750 or more | 40-80 | 160 | 40-80 | 80-160 | 80-160 |

- The water/cement ratio is selected based on the durability criterion of durability and strength using tables 7.3 and 7.4. The minimum of the two values being adopted for the trial mix.
- The approximate mixing water required is selected from Table 7.5 for the desired workability and maximum size of aggregate.
- The cement content is calculated from the water content and the water/cement ratio required for durability or strength.
- The coarse aggregate content is estimated from Table 7.6 for the maximum size of aggregate and the fineness modulus of sand.
- The fine aggregate content is determined by subtracting the sum of the volumes of coarse aggregate, cement, water and air content from the unit volume of concrete.
- If the aggregates contain excessive moisture, suitable adjustments are made in the field mix proportions to account for the water in the aggregates.

7.3 MIX DESIGN PROCEDURE FOR NO-SLUMP CONCRETE ACCORDING TO ACI 211.3-75

The ACI standard recommended practice^b for selecting proportions for no-slung concrete of drier consistencies adopts the compacting factor^c, Vee-Bee^d, and the drop-table method developed by Thaallow^e, for the measurement of workability. A comparison of the consistency measurements obtained by these various methods are compiled in Table 7.7. It is important to note that concrete having a consistency in the range from 'extremely dry' to 'stiff' should be compacted by vibration. The sequential operations to be followed in selecting the mix proportions are detailed below:-

Adopted from Table 4 of the 1940 joint committee report on recommended practice and standard specifications for concrete and reinforced concrete.

^aWhen high frequency vibrators are used, the values given should be reduced by about one third.

TABLE 7.3 Maximum permissible/water cement ratios for different types of structures and degrees of exposure

Type of structures	Exposure conditions*					
	Severe wide range in temperature, or frequent alternations of freezing and thawing (air entrained concrete only)			Mild temperature rarely below freezing, or rainy, or mild.		
	In air	In fresh water	In sea water or in contact with sulphates [†]	In air	In fresh water	In sea water or in contact with sulphates [†]
Thin sections, such as railings, curbs, sills, ledges, ornamental or architectural concrete, reinforced piles, pipe and all sections with less than 25 mm concrete cover over reinforcing.	0.48	0.44 ^{**}	0.39**	0.53	0.48	0.39**
Moderate sections, such as retaining walls, abutments, piers, girders, beams.	0.53	0.48	0.44**	++	0.53	0.44**
Exterior portions of heavy (mass) sections.	0.57	0.48	0.44**	++	0.53	0.44**
Concrete deposited by tremie under water.	-	0.44	0.44	-	0.44	0.44
Concrete slabs laid on the ground.	0.53	-	-	++	-	-
Concrete protected from weather, interiors of buildings, concrete below ground.	--	-	-	--	-	-
Concrete which will later be protected by enclosure or backfill what may be exposed to freezing and thawing for several years before such protection is offered.	0.53	-	-	--	-	-

*Air entrained concrete should be used under all conditions involving severe exposure and may be used under mild exposure conditions to improve workability of the mixture.

[†]Soil or ground water containing sulphate concentrations of more than 3.2 per cent.

**When sulphate resisting cement is used, maximum water/cement ratio may be increased by 0.5 gal per bag.

^{††}Water/cement ratio should be selected on basis of strength workability requirements.

TABLE 7.4 Relationship between water/cement ratio and compressive strength of concrete

Cylinder compressive at 28 days (kg/cm ²)	Water/cement ratio by Weight
450	0.38
400	0.43
350	0.48
300	0.55
250	0.62
200	0.70
150	0.80

The procedure is the same as that followed in section 7.2 from (a) to (c).

- (d) The approximate mixing water required is selected from Table 7.8 to suit the maximum size of aggregate and the required consistency.
- (e) The quantity of cement required per cubic metre of concrete is determined from (c) and (d).

- (f) The coarse aggregate content is estimated from Table 7.6, for the maximum size of aggregate and the fineness modulus of sand.
- (g) For consistencies other than plastic, a multiplying factor is applied to the volume of coarse aggregate determined from (f). This factor depending on the consistency and size of aggregate is obtained from Table 7.9.

After this stage the procedure is the same as that outlined in (g) and (h) of section 7.2.

7.4 LIMITATIONS OF THE ACI METHOD

The ACI standard recommendations for selecting proportions of concrete having different consistencies are based on experimental investigations using well shaped aggregates within the range of generally accepted specifications. If the aggregates available at site depart from the standard gradings and have less favourable shape with an increased angularity number, suitable precautions are necessary to maintain the consistency of the mix by increasing the cement content. The water/cement ratio and strength relations of Table 7.4, are based on the use of ordinary Portland cement (Type I) in the mix. If rapid hardening Portland cement (Type III) is used, the corresponding strengths at 28 days will be higher for the same water/cement ratio. The strength, water/cement ratio curves of Fig. 5.1, are useful in this regard.

TABLE 7.5 Approximate mixing water (kg/m³) of concrete requirements for different slumps and maximum sizes of aggregates

Slump (cm)	10	12.5	20	25	30	40	50	70	150	Maximum sizes of aggregates (mm)										
										Non Air Entrained Concrete	Air Entrained Concrete	Amount of air entrained	Trapped air in concrete	Open air entrained concrete	Trained concrete	Concrete percent	ed Average cement	ed cement	ed cement	ed cement
2.5	205	200	185	180	160	155	145	135	125	125	120	—	—	—	—	—	—	—	—	—
3.5	180	175	165	160	145	140	135	125	115	115	110	105	100	95	90	85	80	75	70	65
5-10	200	190	180	175	160	155	150	140	130	130	125	120	115	110	105	100	95	90	85	80
8-10	225	215	200	195	180	170	165	155	140	140	135	130	125	120	115	110	105	100	95	90
15-10	240	230	210	205	185	170	160	150	140	140	135	130	125	120	115	110	105	100	95	90
15-18	215	205	190	185	170	165	155	145	135	135	130	125	120	115	110	105	100	95	90	85

After Entrained Concrete

Admixtures

Defn: To change or develop some special properties of cement or concrete some additives are added to the concrete. This additive is known as admixture.

Unfortunately the use of plasticizers and super plasticizers have not become popular in Bangladesh, because

- ▷ 90% of the concreting activities are in the hand of common builders or govt. departments who don't generally accept something new & risky.

- ▷ Plasticizers were not manufactured in BD and they were to import hence costly.
- ▷ Lack of education and awareness of the benefits accrued by the use of plasticizers.

◻ Admixtures used in concrete:

As per report of the ACI committee 212, admixtures have been classified into those groups-

1) Plasticizers

2) Superplasticizers
3) Retarders and accelerating plasticizers
4) Air-entraining admixtures -
means to reduce the number of air voids.

Admixtures

5) Air entraining admixtures

6) Workability admixtures

7) Damp-proofing & Water-proofing admixtures

8) Grouting admixtures

9) Bonding admixtures

10) Colouring admixtures

11) Accelerators

12) Plasticizers :- The basic products containing

of plasticizers are as follows -

a) Anionic surfactants such as lignosulphonates

and their modifications and derivatives, salts of sulphonates, hydrocarbons.

b) Nonionic surfactants such as polyglycol

esters, acid hydroxylated carboxylic acids

and their modifications and derivatives.

c) Other products such as carbohydrates etc.

Many research workers explained that one or more of the following mechanisms may take place simultaneously.

- Reduction of the surface tension of water

- Induced electrostatic repulsion b/w particles of cement

- Lubricating film between particles of cement
- Dispersion of cement grains releasing water trapped within cement floes.
- Inhibition of the surface hydration reaction of the cement particles leaving more water to fluidify the mix.

- Change in the morphology of the hydration products
- Induced steric hindrance preventing particle to particle contact to grow.

Let us consider the following -

Super plasticizers:- Sometimes it is called high range water reducers. The use of super plasticizers is practiced for production of flowing, self levelling, self compacting and for the production of high strength and high performance concrete.

Super plasticizers can produce -

- At the same w/c ratio which more workable concrete than plain ones.
- for the same workability, it permits the use of lower w/c ratio.
- as a consequence of increased strength with lower w/c ratio, it also permits a reduction of cement content.

④ Classification of super plasticizers :-

- Sulphonated melamine formaldehyde condensate
- Propyl - trimethyl ammonium bagasse
to nitroso - modified ligno sulfonates (MLS) u (SNF)
- Other types, adding them self

④ Super plasticizers mechanism :- Same as plasticizers

which reduce the water demand and increase the workability of concrete.

④ Problems in the use of super plasticizers/ plasticizers :-

- Slump of reference mixing
- Insufficient laboratory mixer for trial batch below $\frac{1}{2}$ m³
- Sequence of addition of plasticizers & consistency required with other super plasticizers
- Problem with crusher dust
- Incompatibility with crushed sand is due to non-removal of sharp and grading of CA.
- Selection of plasticizers and super plasticizers
- Determination of dosing ratio super plasticizers and Slump loss due to sand and FA -

- Casting of cubes
- Compaction at site
- Segregation & bleeding
- Finishing
- Removal of form work

→ Inert materials

④ Retarders:- A retarder is an admixture that slows down the chemical process of hydration so that concrete remains in plastic and workability for a long time than concrete without retarders. Retarders are used to overcome the acceleration effect of high temperature on setting properties of concrete in hot water concreting. Sometimes concrete may have to be placed in difficult conditions and delay may occur in transporting and placing. In ready mixed concrete practices, concrete is manufactured in central batching plant and transported over a long distance to the job sites which may take considerable time. In the above state, the setting of concrete will have to be retarded. So that concrete when finally placed and compacted is in perfect plastic state.

④ Air-entraining admixtures:-

The air voids present in concrete can be brought under two groups

- i) Entrained air
- ii) Entrapped air

- Animal & vegetable tates and oils
- Various wetting agents & sulphonated organic compounds
- Water soluble soaps of resin acids and animal and vegetable fatty acids.
- The sodium salts of petroleum sulphonate acids, hydrogen peroxide and aluminium powder

④ Factors affecting amount of air entrainment:-

- The type and quantity of air entraining agents used
- Water/cement ratio of the mix
- Type & grading of aggregate
- Mixing time
- The temperature
- Type of cement
- Influence of compaction
- Admixtures other than air entraining agents

⑤ Effect of air entrainment on the properties of concrete

- Increased resistance to freezing and thawing
- Improvement in workability
- Reduction in strength
- Reduces the tendencies of segregation
- Reduces the bleeding

- Decreases the permeability.
- Increases the resistance to chemical attack.
- Permits reduction in sand content.
- Improves placeability and early finishing.
- Reduces the unit weight.
- Permits reduction in water content.
- Reduces the cement content & heat of hydration.

② Accelerators:- Accelerating admixtures are used in concrete to increase the rate of early strength development.

- Permit earlier removal of formwork.
- Reduce the required period of curing.
- Advance the time that a structure can be placed in service.
- Partially compensate for the retarding effect of low temp. during cold weather concreting.
- In the emergency repair work.

Corrosion of Metals

Defn: Corrosion can be defined as the destruction of metals (or alloys) through unintentional chemical or electrochemical reactions at its surface. It is essentially conversion of metal into its salt.

④ Types:-

- 1) Dry corrosion
- 2) Wet corrosion

④ Dry corrosion :- It occurs due to the chemical reaction of gases i.e. oxygen, sulphur, halogen & nitrogen with metal or alloy surfaces some organic and anhydrous inorganic liquids as well as liquid metals may corrode solid metals as a result of direct chemical attack. The extent of dry corrosion depends on

- chemical affinity b/w the corrosive environment either gas or liquid and metal.
- Ability of metal to form a protective film.

If the film is strong and not easily removed, it protects the metal and prevents corrosion. But if the film is removed, new film forms & hence corrosion occurs and continues.

④ Formation & growth of oxide film:-

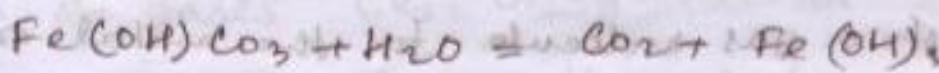
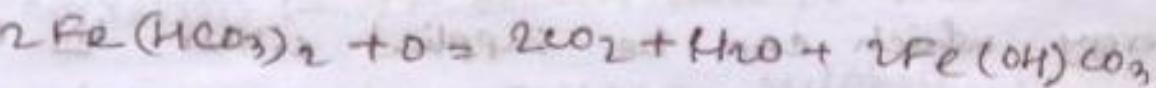
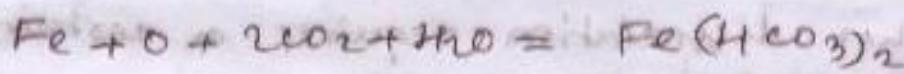
When a completely clean oxide free metal surface is exposed to oxygen of the air, an instantaneous adsorption of gas into the metal surface takes place. In the second stage, the oxygen gradually enters into chemical combination with metal by electron transfer or electron sharing betn oxygen & metal atoms. In order that, gas molecules must dissociate into atoms or ions. This dissociation requires a certain amount of energy which can be supplied either by the chemical affinity of a gas molecule for the metal or by a rise temp. Once the surface of the metal is covered by a single layer of oxide, the growth of the film i^t to the surface commences, which may ultimately result in the formation of a thick oxide layer.

⑤ Wet corrosion:-

Wet corrosion occurs by mechanism essentially electrochemical in nature. It requires that the liquid in contact with metal must be conducting and that there must exist a difference of potentials either betn two dissimilar metals or betn different areas on the surface of metal or alloy.

The most common mechanism of wet corrosion is formation of anodic & cathodic areas. Presence of moisture provides an electrolyte media for the movement of electron from anode to cathode. Then metal is oxidized due to loss of electron & gets corroded.

For example rust on iron. Rain water carries dissolved carbon dioxide in it. The following reactions take place :-



With the liberation of CO_2 corrosion becomes a continuous process & corrosion product (rust) contains all three iron products.

④ Factors influencing corrosion:-

- Dissolved oxygen in aqueous solution
- Partial pressure of dissolved oxygen
- Anaerobic bacteria
- Dissolved salts
- Temp. of the aqueous medium
- pH of the aqueous medium
- Presence of moisture & CO_2 in air
- Presence of acids in aqueous medium.

④ Types of corrosion damages :-

With respect to outward appearance, the corrosion damages of metals may be classified into five main types, namely

1) Uniform attack :- When metal surfaces are corroded uniformly by chemical attack, the damage formed is termed as uniform attack.

2) Pitting :- When metals, corrosion is localized, i.e., the rate of corrosion of the metal is greater at some areas than at other, the corrosion damage is termed as pitting.

3) Dermicification :- It is a type of attack occurring with Zn-alloys which Zn corrodes leaving a porous residue of corrosion products.

4) Intergranular corrosion :- It is a localized type of attack at the grain boundaries of a metal, resulting in loss of strength and ductility.

5) Cracking :- If a metal cracks subjected to repeated tensile stresses in a corrosive environment, it is said to fail by corrosion fatigue.

④ Prevention of corrosion:- corrosion of metals can can be prevented in any of the following ways -

- By the selection of suitable metal or alloy that will withstand specific corrosive environment particular to a locality.

- By modifying the corrosive environment in which the removal of harmful constituents or the addition of a substance that will neutralize the effect of corrosive constituents.

- By purifying & alloying of metals.

- By electric protection

- By the application of protective inorganic coating such as galvanizing, shearduring, tin plating or by organic coating such as painting, varnishing, bituminous coating.

⑤ Rushing :- It applies to the corrosion of iron or iron base alloys with the formation of corrosion products consisting largely of hydrous ferric-oxides.

⑥ Distinction b/w erosion & corrosion :- The destruction of metals by mechanical agencies i.e. by physical cause is called the erosion, whereas, their destruction by chemical attack is called corrosion. In erosion, no chemical compounds are formed whereas, in corrosion, always some chemical compounds are formed.

and compacted is in perfect plastic state

Accelerators:

Accelerating admixtures are used in concrete to increase the rate of early strength development in concrete to

- permit earlier removal of form work
- reduce the required period of curing
- advance the time that a structure can be placed in service.
- partially compensate for the retarding effect of low temp. during cold weather concreting.
- In the emergency repair work.

31.03.08

Timber

(one set question in exam)

Advantages:

Timber has several distinctive advantages over other materials of construction. They are as follows-

- ① Timber can be easily worked with tools of any size and can take good polish
- ② It is comparatively stronger than other materials commonly used when considered in proportion to weight.
- ③ It can be used both load bearing and non-load bearing member in structures and structural connection can be made very easily.

- ④ Timber construction is very economic because even a small piece can be utilized in one way or the other and therefore minimizing waste.
- ⑤ Timber has low thermal conductivity, high electrical resistance and good sound proofing properties. All these have always contributed to its importance as a very useful building materials.
- ⑥ Various types of Timber products like plywood, veneers, laminated boards and other reconstructed woods are mostly used now a days for their lightness and beauty.

Timber tree:

- All trees are primarily divided into two botanical groups according to their manner of growth and these are —
- ✓ Exogenous trees or Exogens
 - ✗ Endogenous trees or Endogens
- Exogens →
- needle leaved tree (Evergreen tree)
 - broad leaved tree
- small lms →
- | |
|-------------------|
| spring - G (hot) |
| summer - G (hot) |
| winter - G (cold) |
- (Fig. 1.51 → see notes under)

Conversion of felled tree:

"Log," "Lumber," "Balk" or squared timber, "Plank,

"Deal" "Batten," "Board," "Scantlings," "Poles.

Defect in timbers:

A defect is any irregularity or imperfection in or on wood which may lower its strength, durability or utility. Defects are usually two types -

- > Natural defects > Artificial defects
- Natural defects due to abnormal growth and rupture of tissues. Artificial defects arising due to conversion and uses.

Natural defects:

There are various types of natural defects

- Knots
- Twisted fibre
- Shakes
- Gaps
- Rind gall
- Forness
- Compression wood
- Pitch pockets

Knots: Knots originate in timber out from the stem or branches of tree because of the encasement of a limb, either living or dead, by the successive annual layer of wood. Knots are of various

unsound knots - not as hard as the wood itself.

Sound knots - as hard as the wood itself.

→ Pin knots - less than $\frac{1}{2}$ in diameter

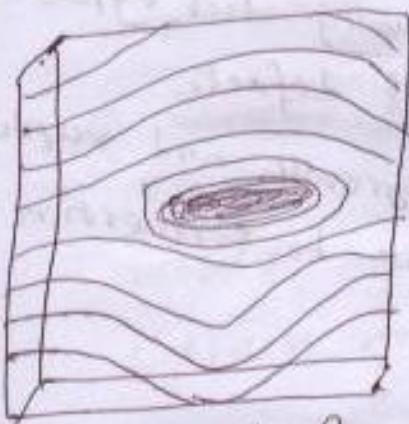
Standard knots - not over $1\frac{1}{2}$ in. diameter.

Large knots - having diameter more than $1\frac{1}{2}$
Encased knots - the knot seen the new stem wd
and dead wood of the limb.

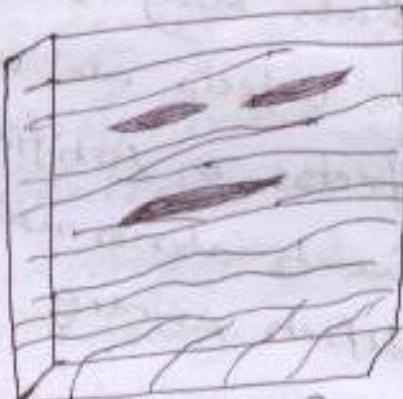
Pith knot - located in the pith of the stem.

Rotten knot - is one which has been decomposed

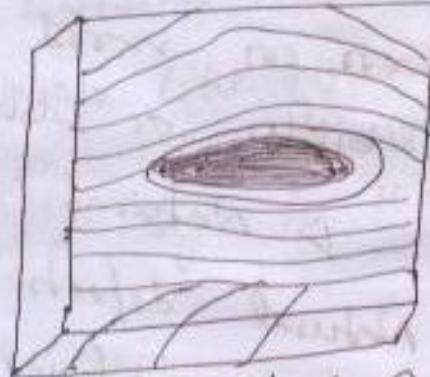
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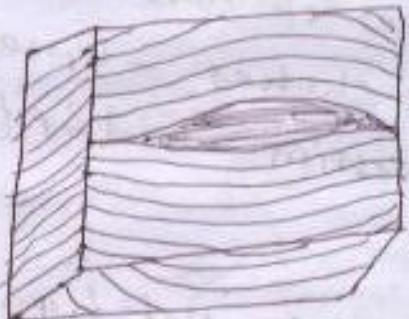
large knot



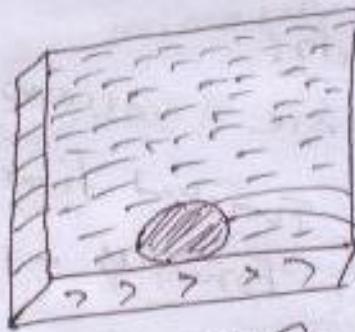
pin knot



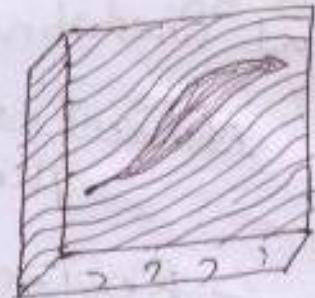
standard knot



pitch knot



rotten knot



encased knot

Twisted fibres: This defect is developed in a living tree by the prevailing wind which tend to turn the tree constant in a particular direction causing its fibers to get twisted longitudinally.

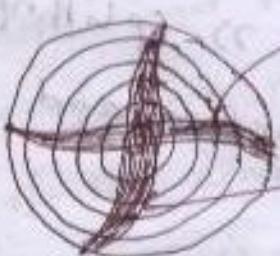
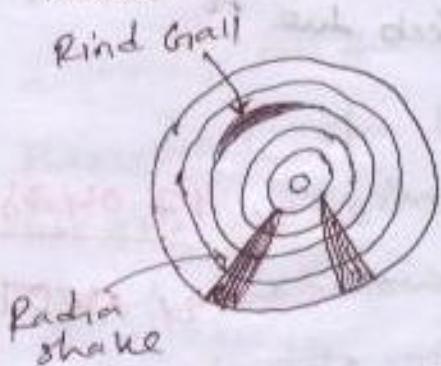
Shakes: Shakes are splits or cracks in timber which cause the separation of the wood tissues, shakes

are caused by the action of wind on trees and by the shrinkage when it dries.

Shakes are of various types —

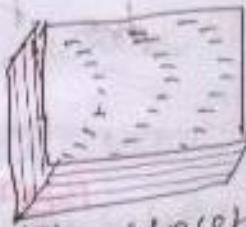
1) Ring shake → separation occurs b/w the annual ring.
2) Through shake → cracks extending between the two faces of a piece of timber
3) Radial shakes → cracks extending radially from the periphery towards the centre.
4) Cup shake → If the split is curved along annual rings.
5) Heart shake → crack radiates from the centre and extends in direction of the medullary rays. If this is more than one it is called star shake.

Check: A check is a lengthwise separation of the wood b/w two consecutive annual rings.



Star (Heart) shake

Through shake



Figs. upsets

Fig. Different types of shakes

Upsets: These defects are caused in timber trees in which the fibres have been injured by shock of crushing usually during their growth.

Rind galls: swellings are caused by the growth layers over the remnant of imperfectly cut branch which are termed as rind balls.

Foxiness: This is a yellow or red stain which disfigures the wood. This is caused by the decay of the timber.

Compression wood: It is abnormal wood formed on the lower side of branches and of leaning trunks of softwood tree mainly which has relatively wide annual rings, a large amount of summer wood and a dark reddish to brown color.

Pitch pockets: pitch pockets are openings betn the fibres of the wood.

Artificial defects: Artificial defects are -
1) warping 2) splitting and cracking 3) defects due to fungi action and 4) defects due to insects.

17.04.08

Book

Absent

Note the class lecture (Ok now 20% E)

4.04.08

2

24.04.05

Ferro cement:

Ferro cement is a relatively new material consisting of wire meshes and cement mortar. It consists of closely spaced wire meshes which are impregnated with the cement mortar mix. The wire mesh is usually of 0.5 to 10 mm dia wire at 5mm to 10mm spacing and cement mortar is of cement sand ratio of 1:2 or 1:3 with water cement ratio of 0.40 to 0.45. The ferrocement elements are usually of the order of 2 to 3 cm in thickness with 2 to 3mm external cover to the reinforcement.

The basic idea behind this material is that concrete can undergo large strains in the neighbourhood of the reinforcement and the magnitude of strains depends on the distribution and subdivision of reinforcement throughout of the mass of concrete. The main advantages are simplicity of its construction, lesser dead weight of the elements due to their small thickness, its high tensile strength, less crack widths compared to conventional concrete, easy repairability, non-corrosive nature and easier mouldability to any desired shape.

There is also saving in basic materials in cement and steel. This material is more suitable to special structures like shells, roofs, water tanks and pipelines.

Rubber : 359

27.04.08

Vulcanization : 360

243 Aluminium: It is derived from bauxite and cryolite. Bauxite is a mixture of alumina & ferric hydrates containing widely varying amount of alumina, ferric oxide, titanium oxide, silica, calcium and magnesium carbonates, water etc. Most bauxite carry from 55% to 56% alumina. Cogolite is a double boride of sodium and aluminium and when pure containing 13 percent aluminium and when pure containing 13 percent aluminium.

05.05.08

Brick

08.05.08

Corrosion of Metals

Definition: Corrosion can be defined as the destruction of metals (or alloys) through unintentional chemical or electrochemical reactions at its surface. It is essentially conversion of metal into its salt.

Types: 1) Dry corrosion \Rightarrow wet corrosion

Rusting: It applies to the corrosion of iron or iron base alloys with the formation of corrosion products consisting largely of hydrous ferric-oxides.

Distinction betw erosion & corrosion: The destruction of metals by mechanical agencies i.e. by physical causes is called the ~~erosion~~ erosion, whereas their destruction by chemical attack is called corrosion. In erosion, no chemical compounds are formed whereas, in corrosion, always some chemical compounds are formed.

05.06.08

Damp proof course (D.P.C):

Strength depends on $\frac{W/C}{\text{compaction}}$ (Neville/269 page)

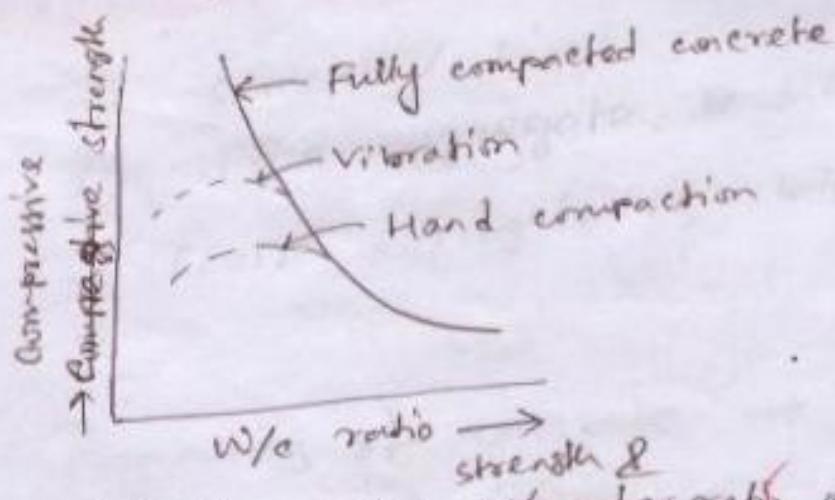


Fig. Relation betw ~~W/C ratio~~ of concrete & strength

Q) What air necessary ~~is~~ necessary or Page 41/111 No 18/537 - Neville next class

09.06.05

① Concrete - go fast or after 27 days of age 2nd part
 density over the right answer (15.4) & the concrete
 expands due to the water concrete or pass air bubble
 excess of cement over the concrete over weight

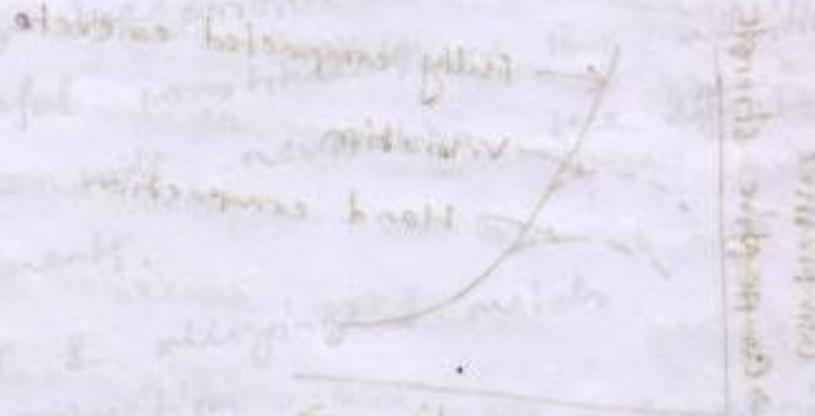
② air voids workability W/V

Assignment on lecture.

workability (fineness): 132 MA Air

Creep of concrete & sulphate attack - next class

point 2



PAINTS

Purpose of paints:

- To protect metal, timber, or plastered surfaces from the corrosive effects of weather, heat, moisture, gases etc.
- To improve the appearance
- To perform specialized functions i.e. heat and fire resistance, improve visibility etc.

Components of paints:

- 1) Base, 2) Vehicle, 3) Pigment, 4) Drier and 5) Thinner.

Base: It provides body to the paint. White lead, red lead, zinc oxide (or zinc white), iron oxide and metallic powders such as aluminium, copper, bronze etc. are the commonly used bases. Paints are often named after the bases used i.e. lead paints, zinc paints, aluminium paints etc.

Functions of bases:

- It provides body to the paints.
- It makes the paints film harder and more resistant to abrasion.
- It forms an opaque layer to obscure the surface of the substance to be painted.
- It reduces shrinkage cracks formed on drying.

White lead: This is carbonate of lead available in powder form or paste form. Cheap and can easily be applied. Commonly used for building works. It produces an elastic film which reduces the possibility of cracks in the covering film. It is water proof and very well suited for application to timber surfaces. It darkens on contact with air containing sulphuretted hydrogen and it can not be used for the top coats. It is very poisonous and proper care should be taken in mixing.

Red lead: Available as rust-coloured powder. Retains this colour permanently. Often used as first coat on wood works and as a base coat on iron and steel works to prevent the formation of rust. Lead paints are poisonous and hence necessary precautions should be taken while painting with spray machine or while scraping old paints.

Zinc white: It is nonpoisonous and is unaffected by weathering actions but it is very costly. It retains its colour well and takes a fine polish. It is more commonly used for interior decorations.

Oxide of iron: It is used primarily in the finishing coat for painting iron works. It prevents rust formations. It is comparatively cheaper.

Vehicle: It is an oily liquid in which the base and pigments are soluble. Linseed oil of various grades are most commonly used as vehicle in Bangladesh. Other oils can also be used i.e. wood oil, nut oil, dehydrated castor oil, soybean oil, cotton seed oil, tung oil, fish oil etc.

Linseed oil: It is used in either raw or boiled form. Raw linseed oil does not dry quickly and therefore not suitable for exterior (exposed to weather) works. On the other hand, boiled linseed oil is thicker, darker and durable than raw linseed oil. It dries quickly and suitable for exterior works.

Functions of Vehicle:

- It allows the paints to be conveniently spread evenly over the surface by means of a brush.
- It acts as a binder for the base and causes it to stick to the surface.
- On drying it forms a tough and elastic film.

Drier: Drier is added to paint to quicken the drying process of vehicles (commonly linseed oil). Linseed oil dries by absorbing oxygen. Therefore, compounds used as driers are those that can absorb oxygen from air and impart it to the vehicle. Commonly used driers are litharge, red lead, lead acetate, manganese dioxide, zinc oxide etc.

Driers have a tendency to destroy elasticity of paints and cause "flaking of paint". Hence driers should not be used in excess and should not be used with paints that dries well.

Thinner: Thinners are solvents that are added to paints to increase fluidity to desired consistency. It helps paints to be spreaded uniformly and to penetrate porous surfaces. Common thinners are turpentine, solvent naphtha. An excess of thinner reduces the protective value of film.

Distemper: Distempers are widely used water paints. They are used for treatment of masonry walls. Powdered chalk is used as the base of distempers which is mixed with glue, starch or resin. Colouring pigments are added to get desired colour. Water or oil is used as thinning agent. As distempers are affected by weather and are easily washable, they are used only for interior works.

White wash: It is prepared by slaking quick lime. Slaking is done by mixing quick lime with excess of water and allowing it to remain in a tank for at least two days. Lime paste is then drawn off in another drum to which water is added to bring the moisture to the consistency of thin cream. It is then strained through a coarse cloth. Then "Gum Arabic", copper sulphate etc. are added to it and they are thoroughly mixed.

VARNISH

Varnish: It is a solution of resin in either oil of turpentine, linseed oil or alcohol. It dries after applying leaving a hard, transparent and glassy film of resin over the varnished surface.

Purpose of varnish:

- To increase brilliance of painted surface and to protect it from atmospheric action.
- To brighten plain surfaces of wood / timber in furniture or other building works.

Ingredients of varnish:

- 1) Resin, 2) Solvent and 3) Drier.

Resin: Resin is an amorphous, vitreous or semi-solid organic substance which is insoluble in water but soluble in organic liquid or in drying oils. Resins are classified as natural resin (plant or animal origin) and artificial resin. Commonly used resins are Copal, Mastic, Amber gum and Lac.

Solvent: These must suit the resins used. Boiled linseed oil is used for Copal and Amber, Turpentine oil for Mastic and Methylated spirit for Lac.

Drier: Driers are used only in small quantities. An excess injures varnish and reduces its durability. Litharge or lead acetate are the commonly used driers.

✓ Types of varnish: Based on the different solvents used, varnishes are classified as:

1. Oil Varnish
2. Turpentine Varnish
3. Spirit Varnish
4. Water Varnish

FERROCEMENT

✓ Definition: Ferrocement is a type of thin wall reinforced concrete construction where usually a hydraulic cement is reinforced with layers of continuous and relatively small diameter mesh. Mesh may be made of metallic material or other suitable materials.

✓ Advantages of ferrocement over ordinary reinforced concrete: Within certain loading limits, it behaves as a homogeneous elastic material and these limits are wider than for normal concrete. The uniform distribution and high surface area to volume ratio of its reinforcement results in better crack arrest mechanism i.e. the propagation of cracks are arrested resulting in high tensile strength of the material.

Materials: Wire meshes are usually 0.5 mm to 1.0 mm in diameter and spaced at 5 mm to 25 mm apart and the volume of the mesh ranges from 1% to 8% of the total volume of the structural element. The thickness of ferrocement sections vary from 10 mm to 40 mm. The cover to the outermost layer of wires is usually 1.5 mm to 2.0 mm.

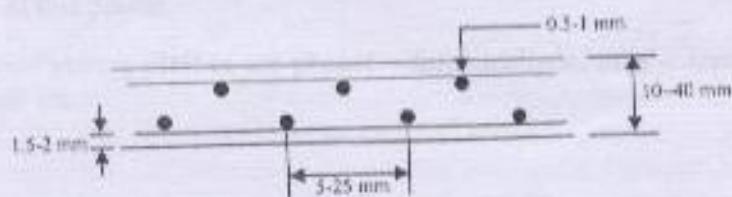


Figure: Typical section of a ferrocement element.

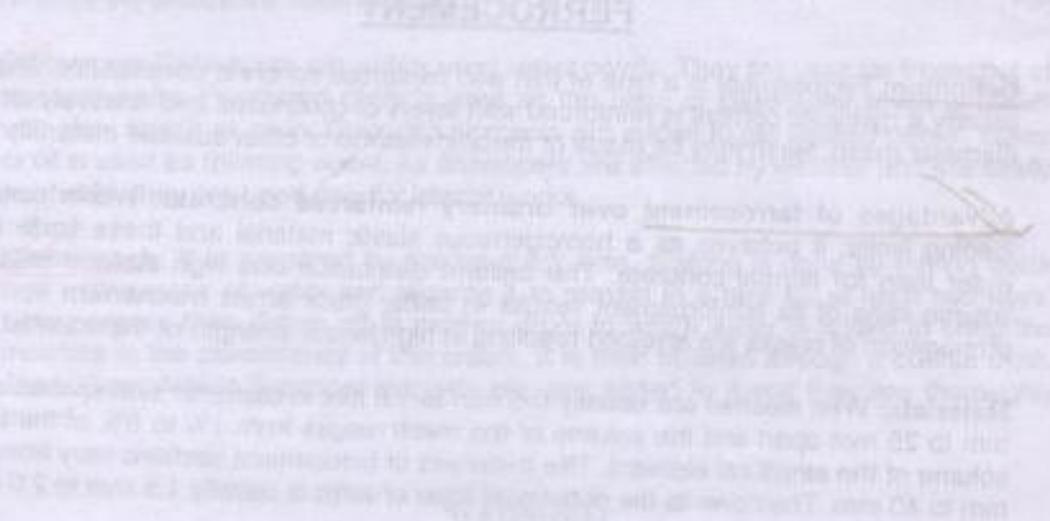
The concrete mortar consists of ordinary Portland cement, water and finely grained aggregate (natural sand) which rarely exceeds 5 mm to 7 mm in size and is often around 2 mm in order to permit a more closely spaced mesh. The cement mortar is of cement-sand ratio 1:2 or 1:3 with w/c ratio of 0.40 to 0.45.

Advantages:

- Simplicity of construction.
- Better mechanical properties and durability than ordinary reinforced concrete.
- High tensile strength.
- Lesser dead weight of the elements due to their small thickness.
- Less crack widths compared to conventional concrete.
- Easy mold ability to any desired shape.
- Low cost, nonflammable and high corrosion resistance.

Applications:

- It has been successfully used for casting domestic overhead water tank.
- With a few modifications, ferrocement tanks can be used as septic tank units.
- The properties of ferrocement make it an ideal material for boat building.
- Ferrocement manhole cover is becoming very popular to replace cast iron manhole cover over sewers where they are not subjected to heavy vehicular traffic.
- It is suitable for pressure pipes.
- It is a suitable material for casting curved benches for parks, garden and open-air cinema theater.



Generally, the thickness of concrete depends on the application. Thickness of concrete may vary from 150 mm to 300 mm. In case of walls, thickness of concrete will be roughly 150 mm and thickness of roof slab by using hollow core units approximately 100 mm to 150 mm.

Thickness of walls:

- For walls intended for load-bearing purposes, 4 times minimum thickness.
- For load-bearing plain surface walls and load-bearing surfaces of other buildings where bending stress will have determined bending stresses by allowing column eccentricity not more than one of min. 5 to 10 mm & maximum greater than the column radius eccentricity of 100 mm distance with plain bearing. French code of practice requires in min. 5 cm thick walls, eccentricities of 100 to 150 mm and min. 7 cm thickness for large eccentricities.

Plastic

Plastic is an organic material prepared from resins, natural or synthetic, with or without fillers, plasticisers, solvents or pigments. Wax, shellac, pitch, bitumen etc. are natural resins. Now the plastic has been improved to such an extent that it has assumed important place as engineering materials.

Plastics are of two types (according to sources): (i) Natural Plastics
 (ii) Synthetic Plastics

Natural plastics: These are manufactured from natural resins such as shellac, wax, tar, bitumen etc. The properties of natural resins can not be controlled easily, and therefore natural plastics are not much important as engineering materials.

Synthetic plastics: These are manufactured from synthetic resins. The properties of synthetic resins can be controlled easily, and therefore this type of plastic is most commonly used by the engineers. Styrene is a synthetic plastic compound.

Classification:

Based on behaviour with respect to heating

1. Thermo – setting plastics
2. Thermo plastics

Thermo – setting plastic:

- Thermo – setting plastic sets into permanent shape, when heat and pressure are applied to it.
- Reheating will not soften it again. It sets at a temperature varying from 127 °C to 177 °C.
- This plastic is soluble in alcohol and in some certain organic solvents, when they are in thermo – plastic stage.
- This plastic is strong, hard and durable.
- If this plastic is once broken or scrapped can not be remolded or reshaped. This is the main disadvantage of this plastic.
- The famous thermo – setting plastics are phenol – formaldehyde, urea – formaldehyde, epoxy resins polyester etc.

Thermo plastic:

Thermo – plastic becomes soft when heated and harden when cooled, regardless of the number of times the process is repeated.

It is thus possible to shape and reshape these plastics by means of heat and pressure.

The famous thermo – plastics are nylon, polyvinyl formal, polyvinyl butyl, polyvinyl chloride (PVC) etc.

Properties of plastic:

1. **Chemical resistance:** plastic offers great resistance to chemicals, solvents and moisture.
2. **Durability:** plastic is quite durable if they are sufficient hard.
3. **Electric insulation:** It has excellent electric insulation properties.
4. **Fire resistance:** All the plastics are combustible but the degree of resistance varies from plastic to plastic.
5. **Durability:** the plastic is not ductile and hence its member may fail without any warning.
6. **Weight:** The plastic has S.G. of about 1.3 to 1.4. Being light in weight, its transportation is very cheap.
7. **Sound absorption:** the acoustical board is made of plastic fibre glass with phenolic resins. Its absorption coefficient is about 0.67.
8. **Maintenance:** Particularly there is no maintenance as plastic surface do not required any protective coat.

Use of plastic:

1. Used as thermo plastic vinyl tiles.
2. **Roofing:** corrugated sheets of phenolic-resin-bonded paper are used as roof. They are strong, corrosion resistance and transparent.
3. **Pipes:** plastic pipes are finding more and more usage in water supply, sanitation and industrial application.
4. **Decorative laminated plastic veneer:** These are versatile sheets marketed under trade names of formica, sunmica, sungloss etc.
5. **Doors and windows frame:** The light weight standard flash doors and windows frame can be made of FRP.
6. Used as photographic films.

Fibre glass reinforced plastic (FRP):

1. The fibre glass reinforced plastic (FRP) is obtained by using two materials in conjunction with each other. One is fibre glass and another is plastic.
2. In FRP, the fibre glass provide stiffness and strength while resin (plastic) provides a matrix to transfer load to the fibre.
3. Aesthetic appearance, corrosion resistance, durability, dimensional stability, light transmission, and lightweight are the favourable properties, which have made FRP the most commercial successful composite material of construction.

Uses of FRP:

Concrete shuttering: The molds and forms of FRP give the cast of concrete shapes of very high quality. Doors and windows, Internal partitions, Temporary shelters etc.

Glass

Glass is a material consisting of a number of metallic silicates. It is hard, brittle, transparent, translucent and amorphous material. It is made by fusion of silica with varying proportions of oxides of sodium, potassium, calcium, magnesia, iron and other materials.

Composition of glass:

Soda – lime glass	= $\text{Na}_2\text{O} \text{ CaO } 6\text{SiO}_2$
Potash – lead glass	= $\text{K}_2\text{O} \cdot \text{PbO } 6\text{SiO}_2$
Potash – lime glass	= $\text{K}_2\text{O} \cdot \text{CaO } 6\text{SiO}_2$

Properties of glass:

1. It is hard, brittle and ductile at high temperature.
2. It varies in weight, but generally is about two and half times as heavy as water.
3. It is comparatively chemically stable and resistant to acid attack.
4. Glass possesses very excellent optical properties. It may be transparent and obtained in variety of colours.

Varieties of glass:

Sheet glass: It is generally used for doors and windows

Plate glass: It is used mainly for glass curtain, wall, long ranges of windows and partitions.

Safety glass / laminated glass: This glass is manufactured by placing a sheet of plate glass of transparent celluloid between two sheets of plate glass and the whole is molded together. This is mainly used for car windshield, doors and windows.

Fibre glass: This is a very important variety of glass. It is used mainly for sound and thermal insulation in walls, floors, ceilings and covering of hot water pipes and cylinders and electric insulation purpose. It has resistance to attack by fire, acid, oil and sea water. It can also resist high temperature (2760°C). For this reason, it is now-a-days used in jet aircraft and guided missiles.

Bullet – proof glass: This glass is prepared by sandwiching vinyl – resin plastic between several layers of plate glass. It consists of minimum 4 layers of glass and 3 layers of vinyl-resin in between them. The outer layer of the glass is thinner than inner layers. Total thickness of the may vary from 15 mm to 75 mm or more. The main property of this glass is that it does not allow bullet to pierce through it. It is extensively used for glazing bank tellers booths and cash booths, jewellery stores, display case, wind screen of cars etc.

Ultra – violate ray glass: This type of glass is used for protection from ultra-violate rays from sun. It can protect 70% of ultra-violate ray of sun.

Insulating glass: this type of glass is used for different types of insulating purpose.

Damp Proof Courses (DPC)

Definition: Damp proof courses are used to prevent moisture from the ground rising into the internal fabric of the structure. They should be installed 150 mm (6 in.) minimum above external ground level and sealed to the general damp proof membrane protecting floor slabs.

- **Soil surface:** The surface of earth, which passes through trees, shrubs, grass, etc.
- **Groundwater:** Water in the soil or rock beneath the surface.
- **Capillary action:** The movement of water along a porous surface.
- **Hydrostatic pressure:** Pressure exerted by a liquid at rest.

- **Hygroscopic water:** Water held by attraction to the surface of a material.
- **Hygroscopic salt:** Salt held by attraction to the surface of a material.
- **Hygroscopic lime:** Lime held by attraction to the surface of a material.
- **Hygroscopic gypsum:** Gypsum held by attraction to the surface of a material.

- **Hygroscopic salts:** Salts held by attraction to the surface of a material.
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Epoxy Coating: A coating consisting of epoxy resin and hardener. It results in a tough, very thin, waterproof film. Epoxy resin is a thermosetting polymer produced by reacting epichlorohydrin with a diamine. It has a high melting point and can withstand high temperatures. Epoxy based coatings are widely used in marine structures, ship hulls, industrial structures, piping systems, valves, etc. They are also used in cavity walls.

Fig: A typical use of DPC.

Water repellent paints: Especially for concrete walls, which are porous, they have a low water absorption coefficient and are usually hydrophobic. They are used in exterior walls to reduce water penetration.

Fig: Use of DPC in cavity wall.

Materials of DPC: This may consist of a thin strip of plastic, a course of engineering brick or slate, or a layer of bitumen. A common method in masonry walls is to drill holes into the wall at regular intervals and inject a penetrating chemical (e.g. silicone) into the holes. The chemical is absorbed into the masonry where it dries to form a waterproof barrier.

Use of damp proof courses:

- To prevent moisture rising through the structure by capillary action.
- To allow the slab dry out and keep out groundwater.
- In a cavity wall, there is usually a DPC in both the outer and inner wall.

Disadvantage of ferrocement:

- Ferrocement is preferable for some special type of structure (shell structure, water tank) i.e. it is not suitable for bridge or high rise building.

- Its construction process is laborious as compared to conventional reinforced concrete.
- Its framework is complex.

Characteristics of an ideal paint:

- It should possess a good spreading power.
- The paint should be fairly cheap and economical.
- The paint should be such that it can be easily and freely applied on the surface.
- The paint should be such that it dries in reasonable time and not too rapidly.
- The paint should form a hard and durable surface.

Defects in painting:

- Blistering: It is due to water vapour trapped behind the painted surface.
- Bloom: It is due to defect in paint or bad ventilation.
- Fading: It is due to the effect of sunlight on pigments of paint.
- Flaking: It is due to poor adhesion.
- Flashing: It is due to poor workmanship.

Characteristics of an ideal varnish:

- It should render the surface glossy.
- The protecting film should be tough, hard and durable.
- It should not shrink or show cracks after drying.
- It should dry rapidly and present a uniform finished surface.

Properties of Distempers:

- On drying, the film of distemper shrinks.
- The coatings of distemper are usually thick.
- The coatings of distemper are more brittle than other types of water paints.
- The film developed by distemper is porous in character and it allows water vapour to pass through it.
- They are less durable than oil paints.

Cement paint:

- This paint consists of white cement, pigment, accelerator and other additives.
- It is available in dry powder form.
- It exhibits excellent decorative appearance.

Advantages of cement paint:

- It requires less skill and time for applying cement water paints.
- The preparation of surfaces is easier in a cement paint system.
- They are suitable for painting fresh plasters having high alkalinity.
- They prove to be economical as compared to oil paints.
- They dry more rapidly than oil paints.

Plastic paint: This paint contains the necessary variety of plastics and it is available in the market under different trade names.

Guidelines for the use of plastic paints:

- Application: It is widely used for interior jobs.
- Base surface: The success of paints will depend on the characteristics of base surface.
- Brushes: The application of these paints should be done with clean brushes.
- Metallic surfaces: They are not suitable for metallic surfaces.
- Moisture resistance: These paints allow moisture to evaporate.

Epoxy Coating: A paint in which thermosetting resins are contained in a vehicle that results in a tough, very hard, chemically resistant coating; Epoxy coating starts out as a dry powder produced by combining organic epoxy resins with curing agents, fillers, pigments, and flow control agents. When heated, the powder melts and the constituents react to form complex cross-linked polymers. Once cured, the coating will not soften at higher temperatures. Epoxy based powder coating that is widely used to protect steel pipe used in pipeline construction, concrete reinforcing rebars and on a wide variety of piping connections, valves etc. from corrosion.

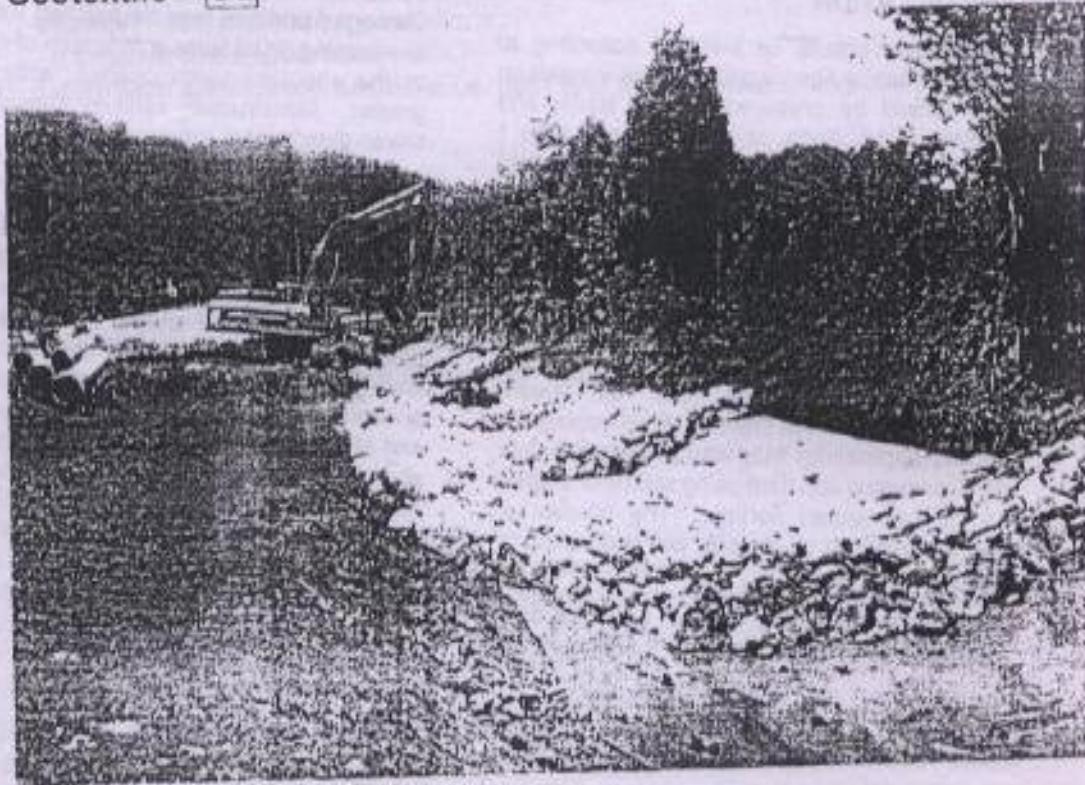
Water repellent paints: A paint for outdoor surfaces and surfaces in wet rooms, especially for concrete walls exposed to strong weathering, contains pigment, binder of which a part is (meth)acrylic polymers and/or copolymers, volatile solvent(s), fillers and optionally known additives and it is characterized by

- having a pigment-volume concentration of 47 to 65%, preferably 55 to 60%,
- containing diatom shells as part of the filler, and
- containing one or more oligomeric alkyl-alkoxy-organosiloxanes as part of the continuous binder phase.

There is obtained on one hand a high degree of imperviousness to water in the liquid form and on the other hand a high degree of diffusion of aqueous vapor.

Colourwashing: This is prepared by adding the colouring pigment to the screened white wash. It should be seen that the colouring pigment is not affected by the presence of lime. Ordinarily yellow earth is popular for colourwashing. Generally, the walls are colour washed and ceilings are whitewashed. The mixture is to be kept constantly stirred during use.

Geotextile - GE



DEFINITION

A geosynthetic fabric, either woven or non-woven, applied to either the soil surface or between materials.

PURPOSE

To reduce erosion by and sediment found in, storm generated water by providing filtration, separation, or stabilization properties.

CONDITIONS

Geotextiles provide stabilization, filtration, and separation properties. This standard may be used when there is a need for separation between two materials that are likely to otherwise interfere with one another. Examples of this situation include:

- Separating subsoil from aggregate within a subsurface drain
- Separating subsoil from aggregate placed at the soil surface
- Stabilization of soil surface during temporary stream diversion

- To prevent the buildup of hydrostatic pressure behind gabion, decorative, or retaining walls.

DESIGN CRITERIA

The application of geotextile does not require professional design for most uses. If hydrostatic pressure is a concern for stability of a retaining wall, consult a professional experienced in the selection of geotextile fabric.

Geotextile selection should be based on guidelines within AASHTO M288 Standard Specification.

CONSTRUCTION SPECIFICATIONS

Geotextiles should be non-toxic to vegetation, be inert to common chemicals, and be mildew and rot resistant. Materials should meet or exceed the strength, elongation, permittivity, apparent opening size, and ultraviolet stability properties of the requirements outlined in AASHTO M288 for the respective use.

INSTALLATION

Geotextiles should be installed according to manufacturer's specifications. The installation site should be prepared without voids, and without rocks, clods, or debris greater than 1 inch in size. The geotextile should be placed loosely, with no wrinkles or folds, in direct contact with the soil surface.

Overlap of successive sheets should place the upstream or upslope sheet on top of the downslope sheet. Field joining of sheets should be accomplished by sewing or thermal welding for critical applications such as stream diversions or steep slopes. Field joining for regular applications may also be accomplished by overlapping and then using stakes or staples in the overlapped portion. The amount of overlap depends on the size and positioning of the stakes or staples.

Aggregate should be placed carefully onto geotextile to prevent damage. It should never

be dumped from a height greater than five feet. Damaged portions may be patched with fabric overlapping on all sides a minimum of one foot, or the specified seam overlap, whichever is greater. Construction vehicles should not be driven directly onto the geotextile.

MAINTENANCE

Geotextiles are generally installed in conjunction with some other practice. Inspections should be conducted simultaneously, and should be made before anticipated storm events (or series of storm events such as intermittent showers over one or more days) and within 24 hours after the end of a storm event of 0.5 inches or greater, and at least once every fourteen calendar days. Maintenance needs identified in inspections or by other means shall be accomplished before the next storm event if possible, but in no case more than seven days after the need is identified.

- ④ Strength of concrete depends on
- Water / cement ratio
 - Compaction

Navile - 269

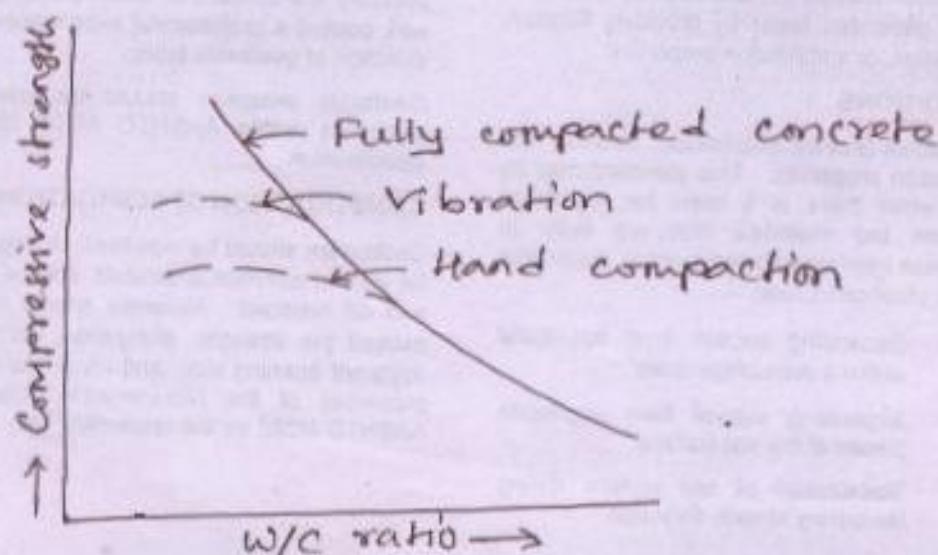


Fig. Relation betn strength & w/c ratio of concrete.