Unit - 1

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Concrete :—

Concrete is a mixture of fine aggregate, coarse aggregate & water.

In the concrete mixture cement having a range of 9-15 %.

Fine Aggregate having a range of 25-30 %.

Coarse Aggregate having a range of 30-45 %.

Water having a range of 15-16 %.

Air having a range of 2-6 %.

Fine Aggregate :—

Nōlmally we are called it as sand. this component can be obtained by natural proces of aroding rock due to rivers flowing (or), the crushing of stones.

Coarse Aggregate :—

It may be either gravel (or) the crushed stone.

The coarse Aggregate present in the concrete mixture around 45 %.

Generally greater than 4mm size aggregate is callec coarse Aggregate.

* In 1824 Josphin Asphadin, an England Engineer invented the modern pōrtland cement in our construction process.
* The First Cement testing was done in Germany in 1936.

→ Tests are Tensile & compressive Strength Tests

* In 1850, the first concrete road was appeared in Austria and 1865 in England and 1891 in U.S

* The First reinforced concrete was introduced in 1854 by william B & willinkson.

Manufacturing of Ordinary portland cement :—

The raw materials required for manufacturing Ordinary portland cement (or) calcareous materials such as lime stone & chalk and Argillaceous materials such as clay (or) shale.

The process of cement manufacturing consists grinding the raw material mixing them in to required proportions. It is depends upon the purity & compositions.

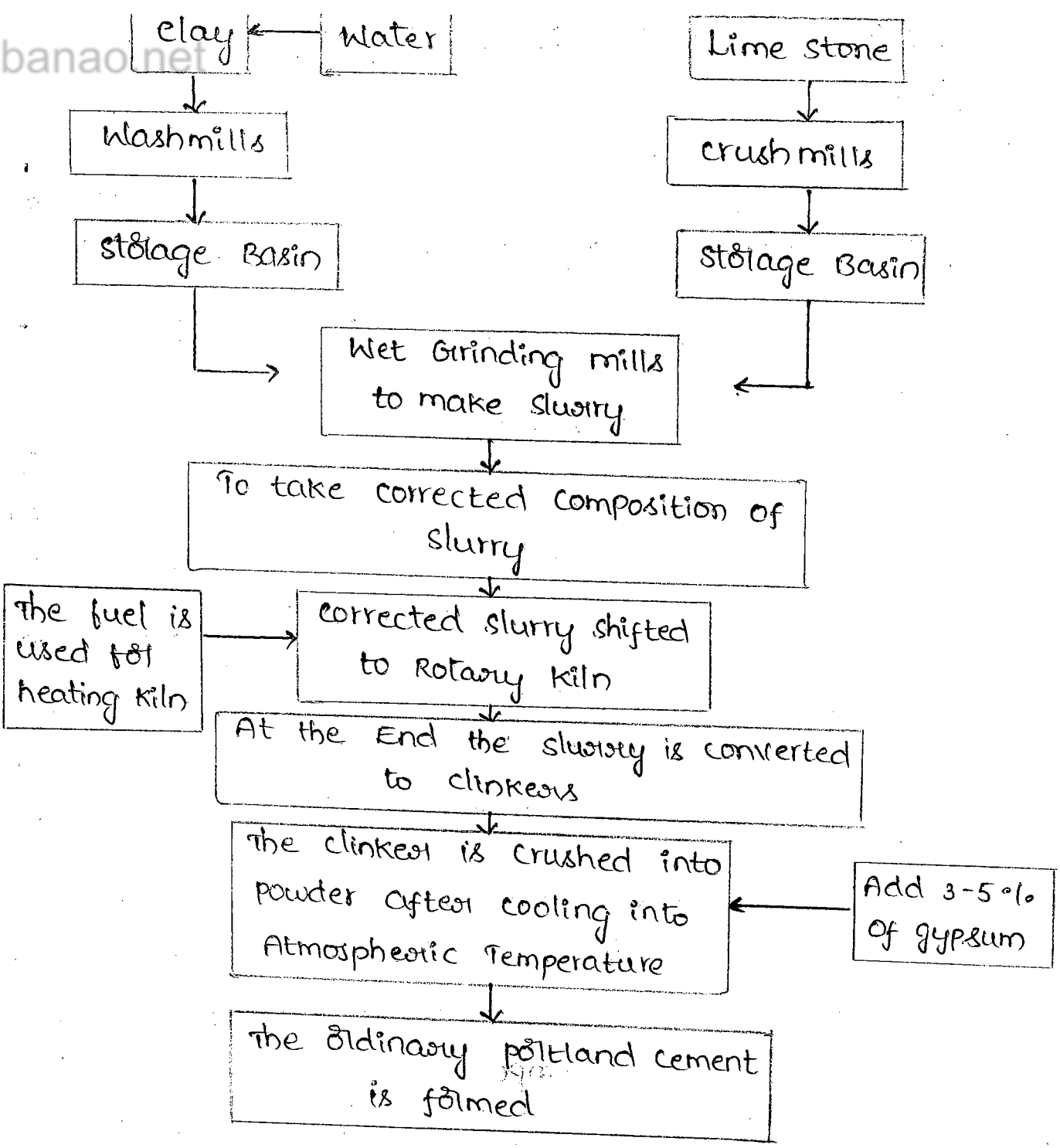
there are two processes for manufacturing of cement (opc)

1. Dry process
2. Wet process

Wet process :—

Rotary kiln is a important component in cement factories. It is a thick steel cylinder having a diameter 3m to 8m.

It having a length 30m to 200m in the process of cement manufacturing 20-30% material are get fused.



those are Lime, Alumina & silica in recombined State. After completion of oxidation reactions a Hardned clinkers are deposited at the end of rotary kiln. the cooling process takes place in various conditions. After that the clinkers are powdered & adding 3-5% of Gypsum to form O.P.C

Note:

The clinkers are in Nodular form & of size 3mm to 20mm.

Influence of rate of cooling on compressive strength :—

MPa (or) N/mm²

Type of cement	cooling condition	Compressive strength		
		3 days	7 days	28 days
Normal cement	Quick	9.9	15.3	26
	Moderate	9.7	21.0	27
	Slow	9.7	19.3	24
	Very slow	8.7	18.7	23
High early strength cement	Quick	10.2	18.8	29
	Moderate	14.2	26.7	33
	Slow	10.2	21.0	29
	Very slow	9.1	18.1	28

From the above table the moderate rate of cooling condition is gives high compressive strength results. By modern cooling condition we are brought down the clinkers temperature 1200°c to 500°c in 15 min time and we are brought down the temperature 500°c to atmospheric temperature in 10 min of time.

Chemical compositions of cement :—

The raw material used for the manufacturing of cement consists of Lime, Silica, Alumina & Iron oxide.

These materials interact with one another to form complex compounds (Bogues compounds). The relative proportions of these oxide compounds are

responsible for physical properties of cement in addition to rate of cooling & Fineness of Grinding.

The approximate chemical composition content

Oxide		Content
CaO	–	60-67%
SiO_2	–	17-25%
Al_2O_3	–	3-8%
Fe_2O_3	–	0.5-6%
MgO	–	0.1-4%
Alkalies K_2O, Na_2O	–	0.4-1.3%
SO_3	–	1.3-3%

Whether the change in chemical composition in raw material. The type of cement may vary.

Bogues compounds :—

1. Tri calcium silicate — $3CaOSiO_2$ — C_3S
2. Dicalcium silicate — $2CaOSiO_2$ — C_2S
3. Tri calcium Aluminate — $3CaOAl_2O_3$ — C_3A
4. Tetra calcium Alumino Ferrate — $4CaOAl_2O_3Fe_2O_3$ — C_4Af

Also known as complex compounds

Hydration of cement :—

The Hydration of portland cement is systematically as follows :

Raw materials ⟶ Lime, shale, clay — Calcareous and Argilleceous

↓

chemical compositions in raw materials - Ca, Al, Mg, Si, O_2, Fe

↓

Oxide composition in raw materials - CaO, MgO, SiO_2, Al_2O_3, Fe_2O_3

↓

Burn in Rotary Kiln

↓

Complex compounds are formed - C_3S, C_2S, C_3A, C_3AF

↓

Adding gypsum 3-5 %

↓

It turns into portland cement

↓

After completion of hydration process

↓

$$C-S-H_{gel} + Ca(OH)_2$$

the extent of hydration of cement and the resultant micro structure of hydrated cement influences the physical properties of cement.

$$2(3CaOSiO_2) + 6H_2O \longrightarrow 3CaO.2SiO_2.3H_2O + 3Ca(OH)_2$$

$$2C_3S + 6H \longrightarrow C_3S_2H_3 + 3Ca(OH)_2$$

$$2(2CaOSiO_2) + 4H_2O \longrightarrow 3CaO.2SiO_2.3H_2O + Ca(OH)_2$$

$$2C_2S + 4H \longrightarrow C_3S_2H_3 + Ca(OH)_2$$

$C_3A + C_4AF + H \longrightarrow C_4AH_{13} + C_2AH_8 \longrightarrow 2C_3AH_6 + 9H$

$C_4AF + 7H \longrightarrow C_3AH_6 + CFH.$

Reaction in the presence of Gypsum :—

$C_3A + 32H + 3CaSO_4 \longrightarrow C_3A \cdot 3CSH_{32} \longrightarrow C_6AS_3H_{32}$

$C_3A + 18H + CaSO_4 \longrightarrow C_3ACSH_{18} \longrightarrow C_4ASH_8$

Types of cements :—

Based on the chemical composition and the process of manufacturing cement. cement may classified as follows :

1. Ordinary portland cement
   a. Opc of 33 grade IS 269 - 1989
   b. Opc of 43 grade IS 8112 - 1989
   c. Opc of 53 grade IS 12269 - 1987
2. Rapid Hardening cement IS 8041 - 1990
3. Extra Rapid Hardening cement
4. Sulphate Resisting cement IS 12330 - 1988
5. portland slag cement IS 445 - 1989
6. Quick setting cement
7. Super sulphated cement IS 6909 - 1990
8. Low Heat cement Is 12600 - 1989
9. portland pozzolana cement IS. 1489 part I - 1991
10. Air Entering cement
11. coloured cement (White colour IS 8042 - 1989
12. Hydrophobic cement IS 8043 - 1991

13. Masonry cement IS 3466-1988
14. Expansive cement
15. Oil well cement IS 8299-1986
16. OPC Grade 53-S special cement IRS-T-40-1985
17. High Alumina cement IS 6452-1989
18. Very High strength cement

Cement classification based on American Society for Testing machine (ASTM) :

According to ASTM the classification cement is done by its necessity and the general information available in the raw materials.

The classification as follows.

1. Type - I
2. Type - II
3. Type - III
4. Type - IV
5. Type - V

there are major classification according to ASTM

Type - I :—

this is the cement used for general construction purpose where the special properties of cement is not required.

Eg: Masonry work, Beam & column layouts.

In this type - I cement OPC is used for the construction work.

Type - II :—

→ This is the cement used for general construction work in addition to moderate sulphur reactions are takes place.

→ Sulphate resisting cement is comes under this type of cement.

→ And at the same time where the heat of the Hydration is occured in the construction process.

Type - III :—

→ This is the cement is used where the Early strength is required in the construction process.

→ The Rapid Hardening cement (RHC) comes under these type of cement.

→ These type - III cement is used in construction where the saturated soils are present

Type - IV :—

→ This is the cement used where the low heat of Hydration takes place.

Eg : Low Heat cement.

Type V :—

This type of cement is used where the sulphate Content is high in water

Super Sulphated cement & Sulphate resisting elements are comes under Type - V cement

The minor classification of cement according to ASTM

1. Type - Is 2. Type - Ip

Type - IS :

This is cement obtained by intimated uniform mix of portland cement of Type - I & fine granulated slag (waste material obtain from steel Industry). slag content is between 25 % & 75 % of Total weight of cement. This is also known as "PORTLAND BLAST FURNACE SLAG CEMENT."

Type - Ip : —

this cement consists of Intimated and uniform mix blend of portland cement (or) portland blast furnace slag cement & fine pozzolana. This pozzolana cement is between 15 & 40 %. This is called "PORTLAND POZZOLONA CEMENT"

Air Entering Agents : —

Type - IA :

Type - IIA

Type - IIIA

these type of cements is used to fill the air voids which are present in the cement compou concrete mix.

Influence of cement quality : —

* the chemical & mineralogical composition of raw material
* The chemical & mineralogical composition of complex compounds.
* Rate of Heating & cooling process
* Mechanical Grinding of clinkers

* Circulation phenomena

What are the physical & chemical properties of cement ?

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Physical properties :—

1. Fineness of cement
2. Soundness of cement
3. consistency of cement
4. Strength of cement
5. Setting time of cement
6. Heat of Hydration
7. Loss Of Ignition
8. Bulk Density
9. Specific Gravity

chemical properties :—

1 Tri calcium silicate present in the cement
2. Tri calcium Aluminate present in the cement
3. Di calcium silicate
4. Ferrite content
5. Magnesia content
6. SO_3 content
7. Fe_2O_3 content
8. Alkalies (K_2O & Na_2O)
9. Free lime
10. Alumina content

Structure Of Hydrated Cement :—

Hydration of cement :

The water molecule reacts with cement the chemical reaction takes place. It is called Hydration of cement.

The behaviour of cement concrete is observed considerably in two phases of material those are i, Paste phase ii, Aggregate phase

The understanding of paste phase is more important as it is influence in the behaviour of the concrete much extend to the strength, permaebility, Durability, dory shinkage, Elastic properties and creep of concrete.

These properties are greatly Influence by paste phase of Hydrated cement.

The Aggregate phase is Influence these properties Verry less extent when compared with paste phase So, We need to understand the structural behaviour Of Hydrated cement in paste phase in a phenominal Extent.

Labaratoly Tests :—

1. Fineness Test :

→ The fineness of a cement is a impoltant factol fol the rate of Hydration and rate of gaining of strength and also the rate of Evaulation of Heat.

→ the Finer cement Offers great surface Hydration

Failure
detolate early & it gets air set lumps.

→ The max particle size in a sample of cement is less than 100 (μ) microns and at same time the smallest particle size in the cement is 1.5 microns

→ On an average the size of the cement particles may be taken as 10 microns according to IS standards

→ If the cement consists 3 micron size particles High percentage present it affects predominently on strength parameter. and the cement consists 3 - 25 (μ) micron size particles.

→ It mainly Influence on 28 days strength

* the Increasing of Fineness of cement is directly propotional to drying shrinkage ratio of concrete

* In commercial use of cement 25 - 30 % of particles having 7 microns of size

There are 2 methods are having to test Fineness of cement

1. By Sieving process
2. By using Air permaebility Apparatus

to determine the specific surface area in terms of cm^2 / gms (or) m^2 / kgs

Seive Method :—

→ Take 100 grs of fresh cement & avoid the air lumps by using Fingers

→ The 100 grs of cement is seived by 90 microns Seive (or) Seive No. 9

→ the Seiving process is continuously done by

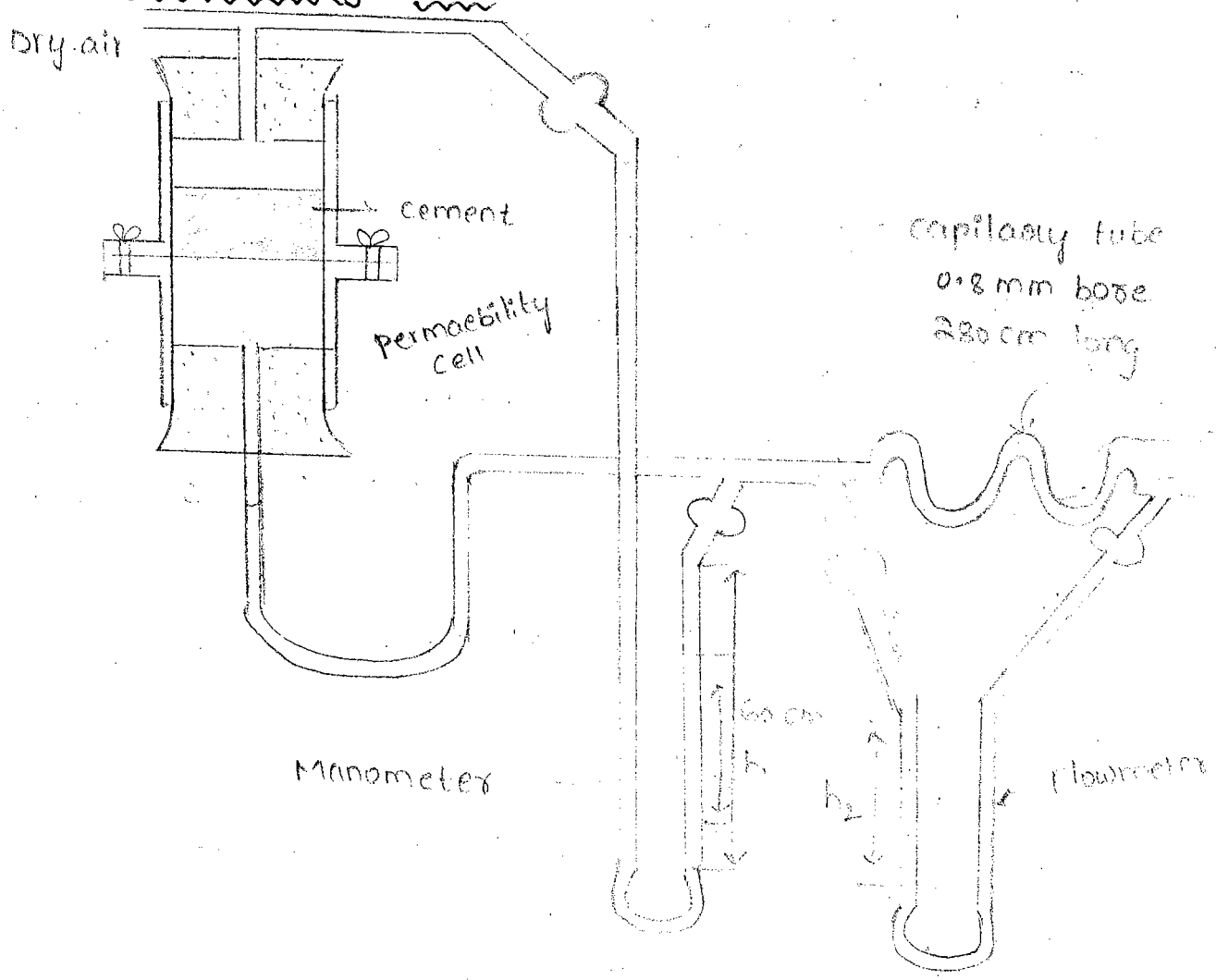
15 min using circular rotations & vertical moments

→ the seiving process is done by either manual (or) mechanical process.

→ Finally the residue amount shouldn't exceed 10 % to the Ordinary cement.

→ But Now-a-days we aren't using this seiving process to find Fineness of cement

Air Permaebility Test :—



By using Air permaebility Apparatus we are finding the Specific Surface Area S_w.

In this Air permaebility Apparatus consists a permaebility shell which is connected with capilary tube in one side and Flow meter and manometer connections on other side.

The cement bed is prepared with 1cm Height & 2.5 cm diameter in permeability cell

The dry air is passing to the permaebility chamber continuously with constant velocity then Intially we are measuring h_1 & h_2 readings in manometer & Flowmeter.

The pressure difference is occured after continuous flowing of air.

In generally the difference in levels is 30 - 50 cms

By repeating the observations we are calculating the Specific surface S_w.

Specific surface $S_w = k\sqrt{\frac{h_1}{h_2}}$ &

$$k = \frac{14}{d(1-x)}\sqrt{\frac{x^3 A}{cL}}$$

x = porosity of cement bed i.e 0.475

A = Area of cement bed 5.066 cm^2

L = length of cement bed 1cm

d = density of cement g/cm^2

c = Flowmeter constant

h_1 = pressure drop across that bed

h_2 = pressure drop across the flowmeter capilary.

Addmixture :—

It is defined as a material other than cement, water & Aggregate i.e used as a ingradient of concrete and it is added to the batch immediaetly before (or) during the concrete mixing.

Additive :—

Additive is a material which is added at the time of grinding of cement clinkers in cement Factory.

Addmixtures are classified into 2 different types

1. mineral Addmixture
2. chemical Addmixture

Mineral Addmixture :

→ Mineral Addmixtures are the Finegrain solid materials those are Fly ash, silica fume, slag

→ these are generally used in concrete mix to acheive an ability of workability & Durability properaties and also acheive good Finishing work

→ the mineral Addmixtures are replaced large amount of cement in concrete mix. so, the mineral addmixtures is also known as "supplementary cementing materials."

→ By using these materials we are observed the changes in cement concrete mix.

→ Moleover on strength, Durability, improving of impermaebility capacity (or) increase (or) decreaae workability of concrete mix.

... Mineral Admixtures in cement the cost of construction is predominantly decreases.

→ By using mineral Admixtures the environmental damage & air pollution is decreases about 6-7 % of CO_2 emission by using cement

→

% by mass	P.C	GGBFS	F.F.A	C-FA	S.F
SiO_2	21	35	50	35	90
Al_2O_3	5	8	25	20	2
Fe_2O_3	2	3	10	5	2
CaO	65	40	1	20	—

P.C → portland cement

GGBFS → Ground Granular Blast Furnace slag (Bayyavaram plant)

F.F.A → Type F - Fly Ash

C.F.A → Type C - Fly Ash

S.f → Silica Fumes (In Powder form)

→ the mineral Admixtures are the waste materials of various Industries. by using these waste materials as a raw material to another Industry.

→ We are maintaining the sustainability of Environment. the usage of these materials depending on supply & demand forces as well as potential of market

Chemical Addmixture :

Eg: Sodium bentonate, calcium carboxylic acid

* chemical Addmixtures are mixtures that are added to concrete in a veoty small amount for a specific function to concrete.

* If the chemical Addmixture is added more than the required propotion it is directly affects the concrete properties like strength, Durability, wokability & permaebility.

and At the same time the hardenidg of Cement concrete also.

* Generally the chemical Addmixtures used as a retarding agents, accerlating agents, plastisizers & Air entaning agents.

* Using these chemical Addmixture the setting time of cement also ~~de~~change that means we get more Wokability and at the same time we get Early strength is acheived in concrete.

Retarders :—

→ also known as Water Reducing agents

Generally for ~~atwing~~ acheiving good concrete Wokability we need to add more water to concrete mix. By adding more Water to the concrete mix there is the Properties such as strength is directly effected due to the segregation of concrete is occurs thats why We need to add the ~~rec~~ water reducing agents to Concrete to get more Wokability in less w/c ratio

Generally the plasticizers are used to decrease the w/c ratio in concrete mix. At the same time

[illegible] percentage to concrete mix because of improper chemical reactions.

The limits of plasticizers adding to the concrete is 0.1 - 0.4 % by the weight of the cement

the Dosage is depends on practical working conditions.

By using these plasticizers we are achieve the water reducing levels 5 - 15 %.

At a same time there is a chance of occuring air voids in case of improper mixing of add mixture to the concrete

Eg: Ligno Sulphate in addition to Ca, Mg, Na

Generally the plasticizers are allowed only 1-2 % of air voids in concrete mix of total volume

Super plasticizer :

By using these super plasticizers in concrete mix we are acheiving an expected amount of 30 % of water reduction in concrete mix

Eg: Sulphonated malanic formaldehyde (SMF)
Sulphonated napthalene Formaldehyde
Modified Ligno Sulphate
Poly carboxlic Easter

Accerlators :

Accerlating addmixtures are adding to concrete to increase the rate of Early strength development in concrete.

the Factors that are influenced by accerlators are

→ It permits Early removal of Form work

→ It reduces the curing period

3. It allows advanced usage of structure
4. Generally the accerlators are used in concrete repair works

Eg:; Dam Repair works, Bridge pier (Column)

Sodium Benzonate $NaC_6H_{12}O_2$ is the Example of Accerlators

Air Entraining Agents :—

Generally in cement concrete construction there is a chance to develop voids in concrete structures due to these voids present in concrete structure the strength of the structure is decreases so we need to avoid the air voids in concrete by using these air Entraining agents

Generally the air voids are developed in concrete mix due to improper selection of raw materials improper compaction, Negligency in curing and due to improper mixing of Add mixture.

So we need to avoid all these factors by adding air Entraining Agents.

At the same time due to the Environmental conditions like Freezing & thawing Effects occured in concrete construction.

Aggregates :

The classification of Aggregates is done by following factors

1. Based on size → { Fine Aggregate / Coarse Aggregate }

Fine Aggregate :

The Aggregates having ≤ 4.75 mm . It is called fine Aggregate

Coarse Aggregate :

Aggregates having > 4.75 mm those are called coarse Aggregate

2. Based on source

a) Rock forming Aggregates :

Igneous rocks :

Formed by the Molten magma and solidify the masses & cool down.

Sedimentary Rocks :

Due to the Wheathering Action these rocks are formed

Metamorphic Rocks :

the combination of Igneous & sedimentary Rocks are Metamorphic Rocks

b) Artificial & Synthetic Aggregates :

Eg: Robo sand

c) Recycled Aggregates :

d) Marginal materials

3. Based on Density of Aggregates :

Normal Weight

Light Weight

Heavy Weight

Light Weight :

the Expanded vermiculate & Expanded prelite are the light Weight Aggregates used in Insulating concrete Works.

Pumice is the light Weight Aggregate which is used in insulating & filling concrete works.

Expanded slag & Expanded shale & clay these are generally used in structural construction works

Properties of Aggregates :-

Quality of Aggregate :

1. Presence of Deleterious (Harmful) materials
2. Aggregate crushing value
3. Aggregate Abrasion value
4. Aggregate Impact value
5. Soundness of Aggregate

Properties Controlled by porosity :

Specific gravity test
Bulk density
Water Absorbtion & surface moisture

Crushing Test Of Aggregate :

We need to determine the quality of Aggregate by using Aggregate crushing value

To find the crushing value of Aggregate by using the standard procedure recommended by IS: 2386-(part-4)-1963 and We have some limitations regarding to Aggregate crushing value.

The recommendations are given in IS - 383 - 1970

Type of Aggregate	Applications	Crushing Value
Coarse Agg (12.5 - 10mm)	using in wearing Coating in runways Roads & pavements	≯ 30 %.
Coarse Agg (12.5 - 10mm)	other than wearing coating	≯ 45 %.

Impact Test :—

Type of Aggregate	Applications	Impact Value
Coarse Agg (12.5 - 10mm)	using in wearing Coating in runways Roads & pavements	≯ 30%
Coarse Agg (12.5 - 10mm)	Other than wearing Coating	≯ 45 %

Hammer Weight → 15 Kgs
Hammer Height → 30.5 cms
No. Of Blows → 25 blows

2.35 → passing Sieve ∝ value of Agg

Abrasion Test :—

Abrasion :

It is the Frictional Resistance offered by the material against another material (over the surface)

Eg. Vehicles moving on Road

Attrition :

It is the Frictional Resistance offered by the material over the surface of same material. It is called Attrition.

Eg: Agg rubbing action in Railway Ballast

Aggregate Abrasion Test :

By using Los Angels machine & Devals Abrasion Test Apparatus to find the Abrasion value of the Aggregate. the Test procedure is given in IS : 2368 - part 4 - 1963 and limitations of the Abrasion value is recommended in IS : 383 - 1970.

Type of Aggregate	Applications	Abrasion value
Coarse Agg (12.5 - 10 mm)	Using in Wearing coating, pavements, Runways	≯ 30%
Coarse agg (12.5 - 10mm)	Other than Wearing coating	≯ 50%

Soundness Test :

Soundness of the Aggregate is measured of resistance to disintegration of aggregate due to chemical attack (or) freezing & thawing actions

The soundness of Fine & Coarse Aggregates is represented by the loss of Weight after 5 cycles of drying & Immersion in standard chemical sol of Na_2SO_4 (or) $MgSO_4$

The soundness of Agg is directly proportional to Porosity of Aggregate

The limits of loss of weight in soundness test suggested by IS : 383 - 1970

Type of Agg	Reagent used	Soundness of Agg
Fine Agg ≤ 4.75 mm	Sodium sulphate	≯ 10 %
	Magnesium sulphate	≯ 15 %
Coarse Agg > 4.75 mm	Sodium sulphate	≯ 12 %
	Magnesium sulphate	≯ 18 %

Fineness Modulus Of The Aggregate : 7 6.3

The Fineness Modulus is the measure of Fineness of the Aggregate the magnitude of Fineness modulus is determined by

$$F.M = \frac{\Sigma \text{Cumulative \% of Weight retained on IS seive}}{100}$$

the Magnitude of Fineness Modulus is Increases the Fineness of Aggregate is Increases

the Approximate Range of Fineness Modulus for coarse Aggregate is 3 - 5 & for Fine Aggregate the Range varies b/w 5 - 8

In case two different types of Aggregates are mixed together then find the Fineness modulus of combined mixture

$$F.M_{combined} = (FM_1)V_1 + (FM_2)V_2$$

Where V_1, V_2 → volume factors of those 2 materials

FM_1 & FM_2 → Fineness Modules of 2 diff Agg's

Find Fineness Modulus of a Sample Aggregate which Seive Analysis is done ?

IS sieve size	% passing	% Retained
25	100	0
20	95	5
16	56	44
12.5	30	70
10	15	85
4.75	3	97
2.36	0	100

$$\Sigma \% \text{ retain} = 401$$

$$F.M = \frac{401}{100}$$

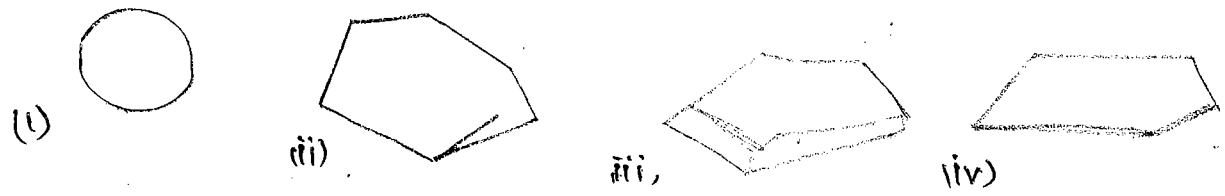
$$F.M = 4.01$$

Shape & Texture of the Aggregate :

the shape is a important parameter in Aggregates why because it is directly influences the strength and workability of the concrete.

the shape of the Aggregate is classified into 4 major types

1. Spherical
2. Irregular
3. Flaky (or) Flat
4. Needle shaped



Rounded Aggregates are more preffered in concrete mix calculation because of its Bonding property

The irregular shaped Aggregates are not suitable in concrete mix design and the Flaky and Elongated Aggregates also neglible in concrete mix design because of its improper shape & surface area.

Needle shape Aggregated are surely avoided in concrete mix design because of its sharp Edges.

The Flakious Index. & Elongation Index & Angularity number is measured for the shape of the Aggregate of size greater than > 6.3 mm.

Shape of Aggregates :

Shape of Aggregates	Details
Angular shape	Well defined edges
Elongated shape	The length of Agg is more when compared to other dimension
Flaky	The Agg having thin in thickness relative to other dimensions
Irregular	The Randomness is present in perfection of shape
Rounded Agg	Absence of sharp Edges

Surface Texture :

the surface Texture of the Agg is important in developing Bond in Interface. The surface Texture depends upon the crystalline structure, pre structure, Transpot media & various other factors including the climatic conditions also

Surface Texture	Details
Crystalline Texture	Disability Of crystalline Prop's on the surface
Glassy Texture	It having sharp Edges
Granular Texture	these are the uniform round grained aggregates
Honey coombed Texture	Visibility pores on surface
Rough Texture	Medium grained (Proper shaped)
Smooth Texture	No sharp Edges on the Surface of the Aggregate

5M(07)M

Specific gravity, Density, Water Absorption of Agg :—

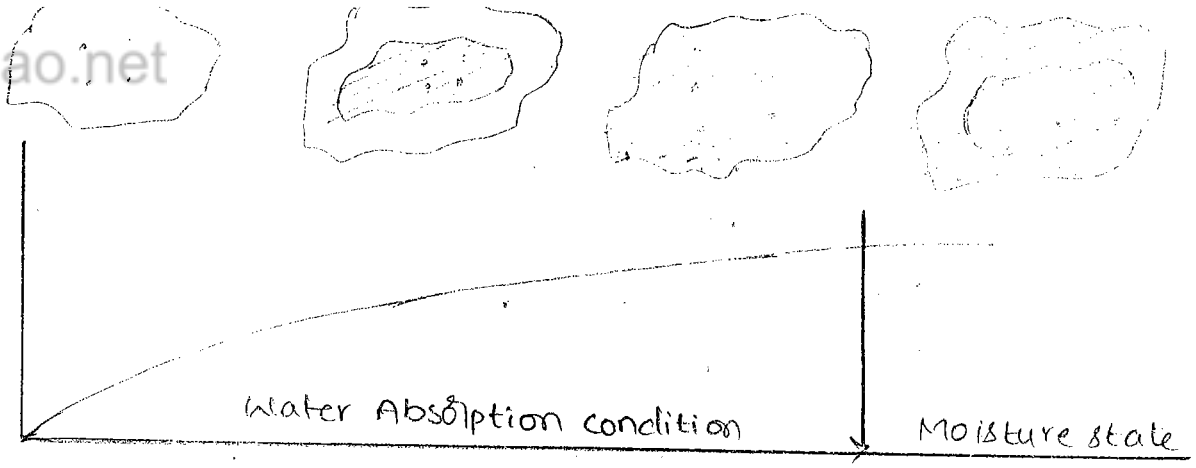
The Specific gravity of Aggregate is the ratio of Density of Aggregate to Density of Water. The Aggregate Exists under 4 different moisture conditions (Water Absorption conditions) namely

i) Bone dry condition
ii) Air dry condition
iii) Saturated surface dry condition
iv) Moisture condition.

the Water content present in these conditions are different.

the specific gravity of the Aggregates are determined under these conditions

Generally, the specific gravity of the saturated surface dry condition of Aggregate is used in concrete mix design



Generally, the aggregates consists inherent pores. Some of the poles are interlinked with surface texture and remaining are interlinks with Interiol structure of the material (or) Aggregate.

Because of these condition the Bone dry sample may having some moisture content in the Interiol structure after 24 hrs of oven dry also.

thats way the Bone dry sample specific gravity is not used in concrete mix Design

the oven dry sample is acheived by drying the sample in oven at 100°c in 24 hrs.

Air dry sample completely depends upon climatic conditions. So, we neglible this condition.

the saturated surface dry condition is acheived by taking an Agg sample & it is immersed in water at 30°c in 24 hrs. After that taking the agg sample from water & clean the surface with cotton cloth It is called saturated surface dry condition of Agg

$$\text{Specific gravity of Agg} = \frac{\text{Unit weight of Agg}}{\text{Unit Weight of } H_2O}$$

(or)

$$\frac{\text{Density of Agg}}{\text{Density of water}}$$

$$S.P.G = \frac{M_2 - M_1}{(M_2 - M_1) - (M_3 - M_4)}$$

M_1 = Empty Wt of picnometer

M_2 = Empty + Agg

M_3 = Empty + Agg + water

M_4 = Empty + Water.

To find specific gravity of Agg we use picnometer & Density Bottle methods

Normal specific gravity of Agg varies in range of 2.5 - 2.8

Thermal Properties of the aggregates:

The rocks and aggregates and passes thermal propeties. which are Significant in established the quality of the aggregates in concreate construction work.

The properties of aggregates as fallows

1. co-efficient of thermal Expansion.
2. specific heat
3. Thermal Conductivity.

Out of these specific heat and conductivity of found very important in mass concreate work.

where rigorous control as temparature is necessary also these properties are consequent of in case of light weight concrete used for multipurpose.

An average value of linear thrmal co-efficient of Expansion of concreate may be taken as 9.98×10^{-6} in Same condition the range may be taken as range may $\times 10^{-6}$/c is depending

upon the other Concreate properties the range of may Varrying from 10.8×10^{-6}/c to 16.2×10^{-6}/c.

Similarly for Cement Mortar it may varries from 7.9×10^{-6}/c to 12.6×10^{-6}/c. Generally the linear thermal Coefficient of is Common Rocks in varies between 0.9×10^{-6} to 26×10^{-6}/c.

Types of Cement :-

* Ordinary portland Cement :-

* Ordinary portland cement (OPC) is by far the most important type of cement
* It has been possible to upgrade the qualities of cement by using high quality limestone modern equipment, maintaining better particle size distribution, finer grinding and better packing.
* Generally use of high grade cements offers many advantages for making stronger concrete.
* Although they are little costlier than low-grade cement.
* One of the most important benefits is the faster rate of development of strength.
* In the modern construction activities, becomes so popular that 33 grade cement is almost out of the market.

* Rapid Hardening Cement (IS 8041-1990).

* This Cement is similar to Ordinary portland cement.
* The rapid rate of development of strength is attributed to the higher fineness of grinding and higher C_3S and lower C_2S content.
* Consequently, rapid hardening cement gives out much greater heat of hydration during the early period.
* The use of rapid heading cement is recommended in the following situations;-
  - → In pre-fabricated concrete construction.
  - → Where formwork is required to be removed early for re-use elsewhere.
  - → Road repair works.
  - → In cold weather concrete where the rapid rate of development of strength reduces the vulnerability of concrete to the frost damage.

* **Extra Rapid Hardening Cement :-**

* Extra rapid hardening cement is obtained by intergrinding calcium chloride with rapid hardening portland cement.
* It should be transported, placed and compacted and finished within about 30 minutes. This cement should not be stored for more than a month.
* A large quantity of heat is evolved in a very short time after placing.
* The gains of strength will disappear with age and at 90 days.
* The strength of extra rapid hardening cement or the ordinary portland cement may be nearly the same.

* **Sulphate Resisting Cement (IS 12330-1988).**

* Ordinary portland cement is susceptible to the attack of sulphates.
* Their expansion within the frame works of hardened cement paste results in cracks and subsequent disruption.
* Solid sulphate do not attack the cement compound.
* To remedy the sulphate attack, the use of cement with low C_3A content is found to be effective.
* Such cement with low C_3A and comparatively low C_4AF content is known as Sulphate Resisting cement.
* The use of sulphate resisting cement is recommended under the following conditions:
  - → Concrete to be used in marine condition
  - → concrete to be used in foundation and basement, where soil is infested with sulphates;
  - → concrete to be used in the construction of sewage treatment works.

* portland Slag Cement (PSC) (IS 455-1989).

* portland Slag cement is obtained by mixing portland cement clinker, gypsum and granulated blast furnace slag in suitable proportions.
* It has low heat of hydration and is relatively better resistant to chlorides, soils etc... this can be used for marine works with advantages.
* The quantity of granulated slag mixed with portland clinker will range from 85-70 percent.
* In cold weather the low heat of hydration of portland blast furnace cement coupled with moderately low rate of strength development, can lead to frost damage.
* The major advantages currently recognised are:-
  - → Reduced heat of hydration,
  - → Refinement of pore structure;
  - → Reduced permeability.
  - → Increased resistance to chemical attack.

* Quick Setting Cement :-

* This cement as the name indicates sets very early.
* It is used mostly in under water construction where pumping is involved.
* Quick setting cement may also find its use in some typical grouting operations.

* Super Sulphated Cement (IS 6909-1990).

* Super Sulphated cement is manufactured by grinding together a mixture of 80-85 percent granulated slag, 10-15 percent hard burnt gypsum, and about 5 percent portland cement clinker.
* This cement is rather more sensitive to deterioration during storage than portland cement
* This cement has high sulphate resistance, it is also used in the marine works.
* Super-Sulphated cement, like high alumina cement, combines with more water on hydration than portland cement.

* Low Heat Cement (IS 12600 - 1989).

* It is well-known that hydration of cement is an exothermic action which produces large quantity of heat during hydration.
* where temperature rise by the heat of hydration can become excessively large.
* The rate of evolution of heat will, therefore, be less and evolution of heat will extend over a longer period.
* But the ultimate Strength of low-heat cement is the same as that of ordinary portland cement.

* The heat of hydration of low-heat portland cement shall be as follows:

7 days — not more than 65 calories per gm.

28 days — not more than 75 calories per gm.

* Such as Setting time and Soundness are Same as that of ordinary portland cement.

* portland pozzolana Cement (IS 1489 - 1991)

* A pozzolanic material is essentially a silicious or aluminous material which while in itself possessing no cementitious properties,
* portland pozzolana cement (PPC) is manufactured by the intergrinding of opc clinker with 10 to 25 percent of pozzolanic material.
* The pozzolanaic materials generally used for manufacture of ppc are calcined clay or fly ash.
* Fly ash is a waste material, generated in the thermal power Station, when powdered coal is used as a fuel.
* The use of fly ash performs such a role. The pozzolanic action is shown below:

Calcium hydroxide + pozzolana + water → C - S - H (gel).

portland pozzolana cement produces less heat of hydration and offers greater resistance to the attack of aggressive waters than ordinary portland cement.

* Advantages of ppc:-

→ In ppc, costly clinker is replaced by cheaper pozzolanic material - Hence economical.

→ ppc consumes calcium hydroxide and does not produce calcium hydroxide as much as that of opc.

→ It generates reduced heat of hydration and the too at a low rate.

→ Reduction in permeability of ppc offers many other alsoundadvant -ages.

* Applications of ppc:-

The use of ppc would be particularly suitable for the following situations.

*→ For hydraulic structures;

*→ For mass concrete structures like dam, bridge piers and thick foundation

*→ for marine structures;

*→ For sewers and sewage disposal works etc....

* Air- Entraining Cement :-

* This cement is made by mixing a small amount of an air-entrain ng agent with ordinary portland cement clinker at the time of grinding.

* The following types of air-entraining agents could be used:

→ Alkali salt of wood resins.

→ Synthetic detergents of the alkyl- aryl sulphonate type.

→ Calcium lignosulphate derived from the sulphite process in paper making

→ Calcium salts of glues and other proteins obtained in the treatment of animal hides.

* There are ~~add~~ other additives including ~~and~~ animal and vegetable fats, oil and there acids could be used.

* Wetting agents, aluminium pocoder, hydrogen peroxide could also be used.

* **Coloured Cement (White Cement IS 8042-1989).**

* For manufacturing various coloured cements either white cement or grey portland cement is used as a base.

* The use of white cement as a base is costly.

* Coloured cement consists of portland cement with 5-10% of pigment. It is usual to grind the cement and pigment together.

* A chemical composition such that the pigment is neither effected by the cement nor detrimental to it, and the absence of soluble salts.

* The two famous brands of white cement namely Birla white and J.K white cements are manufactured near Jodhpur.

* The raw materials used are high purity limestone.

* Sea shells and coral can also be used as raw materials for production of white cement.

* **Hydrophobic Cement (IS 8043-1991)**

* Hydrophobic cement is obtained by grinding ordinary portland cement clinker with water.

* The water-repellant film formed around each grain of cement, reduces the rate of deterioration of the cement during long storage, transport, or under unfavourable conditions.

* The transportation and storage of cement in such places causes deterioration in the quality of cement.

* The hydrophobic cement is made actually from ordinary portland cement clinker.

* The cost of this cement is normal nominally higher than ordinary portland cement.

* Masonry Cement (Is 3466 : 1988).

* Ordinary cement mortar through good when compared to lime mortar with respect to strength and setting properties.
* Masonary cement is a type of cement which is particularly made with such combination of materials.
* This kind of cement is mostly used, as the name indicates, for masonry construction.
* It contains certains amount of air-entraining agent and mineral admixtures to improve the plasticity and water retentivity.

* Expansive Cement :-

* Concrete made with ordinary portland cement shrinks while setting due to loss of free water. This is known as drying shrinkage.
* This type of cement which suffers no overall change in volume on drying is known as expansive cement.
* Since expansion takes place only so long as concrete is moist, curing must be carefully controlled.
* Another similar type of cement is known as Self-Stressing Cement.

* Opc 53 Grade S - Earlier it was called IRS T40 :-

* Opc 53 grade S cement is manufactured as per specification laid down by ministry of Railway under IRS-T40: 1985.
* This cement can also be used with advantage for other applications where high early strength concrete is required.
* This cement can be used for prestressed concrete elements, high rise buildings, high strength concrete.

* Oil-well Cement (IS 8229-1986).

* Oil-wells are drilled through stratified Sedimentary rocks through a great depth in search of oil.
* The pressure required may go upto 1300 kg/cm^2.
* It may also have to resist corrosive conditions from Sulphur gases or waters containing dissolved salts.
* The desired properties of oil-well cement can be obtained in two ways;
  → By adjusting the compound composition of cement or by adding retarder to ordinary portland cement
  → Many admixtures have been patented as retarders.
* Sometimes workability agents are also added to this cement to increase the mobility.

* Rediset Cement :-

* Calcium chloride, lignosulfonates and cellulose products form the base of some of admixtures.
* High alumina cement, though good for early strengths, shows retrogression of strength when exposed to hot and humid conditions.
* Associated cement company of india have developed an equivalent cement by name "REDISET" cement.

Applications :- "REDISET" can be used for:

* Very-high-early strength concrete and mortar.
* patch repairs and emergency repairs.
* Quick release of forms in the precast concrete products industry.
* palletisation of iron ore dust.
* Slip-formed concrete construction,
* construction between tides.

* **High Alumina Cement (IS 6452:1989).**

* The raw materials used for the manufacture of high alumi alumina cement are limestone and bauxite.
* These raw materials with the required proportion of coke were charged into the furnace.
* The fusion take place at a temperature of about 1550-1600°c.
* The cement is maintained in a liquid state in the furnace.
* These castings are known as pigs.
* The hydration and conversion can be shown as follows:

$$CA + 10H \longrightarrow CAH_{10};$$

$$3CAH_{10} \longrightarrow C_3AH_6 + 2AH_3 + 18H.$$

* **Refractory Concrete :-**

* High alumina cement concrete loses considerable strength only when subjected to humid condition and high temperature.
* At a very high temperature alumina cement concrete exhibits good ceramic bond instead of hydraulic bond as usual with other cement concrete.
* Crushed firebrick is one of the most commonly used aggregates for making refractory concrete with high alumina cement.
* Concrete can withstand temperature upto about 1350°c.
* It is also used in fire pits, construction of electric furnaces, Ordinary furnaces and Kilns.
* High alumina cement can be used for making refractory mortars.

* **Very High Strength Cement :-**

* MDF refers to the absence of relatively large voids or defects which are usually present in conventional mixed cement pastes because of entrapped air and inadequate dispersion.
  [MDF refers to Macro- defect-free].
* Densely packed System (DSP).
* The size of cement particles may very from 0.5 to 100μ and that of Silica fume varies from 0.005 to 0.5μ.
* Silica fume is generally added from 5 to 25%.
* A new approach has been developed for achieving very high strength by a method called "Warm pressing." to cement paste.
* Super high early strength and durable cement called by trade name "pyrament cement."
* Lithium Salts have been effectively used as accelerators in high alumina cement.