SNS COLLEGE OF TECHNOLOGY

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COIMBATORE

DEPARTMENT OF CIVIL ENGINEERING

23GET102 – BASIC CIVIL AND MECHANICAL ENGINEERING

I YEAR / I SEMESTER

Unit 1 : Civil Engineering Materials and Surveying

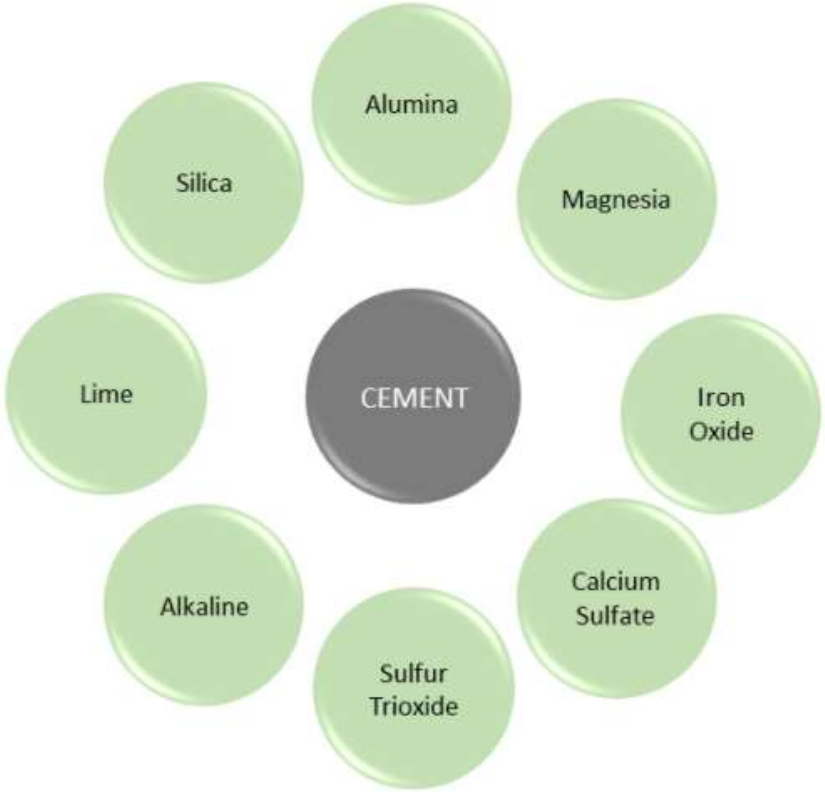
Topic : Cement Ingredients

Cement

- Cement, as a binding material, is a very important building material.
- Almost every construction work requires cement.
- Therefore, the composition of cement is a matter of great interest to engineers.
- For understanding cement composition, one must know the functionality of Cement ingredients.
- By altering the amount of an ingredient during cement production, one can achieve the desired cement quality.

Composition of Cement

- There are eight major ingredients of cement. The following image is showing the ingredients of cement:



Cement Ingredients

- The general percentage of these ingredients in cement is given below:

Ingredient	Percentage in cement
Lime	60-65
Silica	17-25
Alumina	3-8
Magnesia	1-3
Iron oxide	0.5-6
Calcium Sulfate	0.1-0.5
Sulfur Trioxide	1-3
Alkaline	0-1

Functions of Cement Ingredients

Lime:

- Lime is calcium oxide or calcium hydroxide.
- The presence of lime in a sufficient quantity is required to form silicates and aluminates of calcium.
- Deficiency in lime reduces the strength of property to the cement.
- Deficiency in lime causes the cement to set quickly.
- Excess lime makes cement unsound.
- The excessive presence of lime causes the cement to expand and disintegrate.

Functions of Cement Ingredients

Silica:

- Silicon dioxide is known as silica, chemical formula SiO_2.
- The sufficient quantity of silica should be present in cement to dicalcium and tricalcium silicate.
- Silica imparts strength to cement.
- Silica usually presents to the extent of about 30 percent cement.

Functions of Cement Ingredients

Alumina:

- Alumina is Aluminium oxide.
- The chemical formula is Al_2O_3.
- Alumina imparts quick setting property to the cement.
- Clinkering temperature is lowered by the presence of the requisite quantity of alumina.
- Excess alumina weakens the cement.

Functions of Cement Ingredients

Magnesia:

- Magnesium Oxide.
- The chemical formula is MgO.
- Magnesia should not be present more than 2% in cement.
- Excess magnesia will reduce the strength of the cement.

Functions of Cement Ingredients

Iron oxide:

- Chemical formula is Fe_2O_3.
- Iron oxide imparts color to cement.
- It acts as a flux.
- At a very high temperature, it imparts into the chemical reaction with calcium and aluminum to form tricalcium alumino-ferrite.
- Tricalcium alumino-ferrite imparts hardness and strength to cement.

Functions of Cement Ingredients

Calcium Sulfate:

- Chemical formula is $CaSO_4$
- This is present in cement in the form of gypsum($CaSO_4.2H_2O$)
- It slows down or retards the setting action of cement.

Functions of Cement Ingredients

Sulfur Trioxide:

- Chemical formula is SO_3
- It should not be present for more than 2%.
- Excess Sulfur Trioxide causes the cement to unsound.

Functions of Cement Ingredients

Alkaline:

- It should not be present more than 1%.
- Excess Alkaline matter causes efflorescence.

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Unit 1 : Civil Engineering Materials and Surveying

Topic : Grades of Cement

Grades of Cement

- The grade indicates the strength of cement.
- Strength is generally measured as compressive strength.
- Before buying the cement, you should check the grades because it highly affects the strength of your structure.
- The strength gets further measured as the compressive strength, which is the molded cement in the standard cube.
- After 28 days of curing, it gets estimated.
- The measurements are in Mega-Pascal or N/mm.

Types of Cement Grades

There are different grades of cement, which are specified by IS 1489: 1991 as below of cement grade list.

1. OPC 33 Grade Cement
2. OPC 43 Grade Cement
3. OPC 53 Grade cement

OPC 33 Grade Cement

The Cement, which has Compressive strength of 33 N/ mm^2 after the 28 days when tested, is known as 33-Grade Cement.

Fineness (specific area) of 33 Grade Cement = 300 m^2/kg

- 3 days compressive strength = 16 N/mm^2
- 7 days compressive strength = 22 N/mm^2
- 28 days compressive strength = 33 N/mm^2

OPC 33 Grade Cement

Properties of 33-Grade Cement:

- This grade of cement has high workability and is mainly used for masonry work and for plastering work.
- The initial strength of 33 Grade Cement continues to gain even after 28 days.
- The heat of hydration of 33 Grade Cement is lower as compared to the 43 grade and 53-grade cement.

OPC 33 Grade Cement

Uses of 33-Grade Cement:

- It is widely used in plastering work.
- It is also used for the brickwork of walls.
- In the tiling work.
- It is generally used for work, which required low compressive strength of below M20.
- The Code of reference for 33-grade cement is IS Code – IS 269: 1989.

OPC 43 Grade Cement

The Cement, which has Compressive strength of 43 N/ mm^2 after the 28 days when tested, is known as 43-Grade Cement.

Fineness (specific area) of 43 Grade Cement = 225 m^2/kg

- 3 days compressive strength = 23 N/mm^2
- 7 days compressive strength = 33 N/mm^2
- 28 days compressive strength = 43 N/mm^2

OPC 43 Grade Cement

Properties of 43-Gradee Cement:

- It has low chloride content, so it doesn't cause corrosion of steel reinforcement.
- It gives good workability of concrete.
- The initial strength of 43 Grade Cement continues to gain even after 28 days.
- The heat of hydration of 43 Grade Cement is medium.
- This will give a better surface finish to the structures.
- It is moderately sulfate resisting.

OPC 43 Grade Cement

Uses of 43 Grade Cement

- It is used in the preparation of Ready Mix Concrete (RMC).
- It is used for PCC and RCC work.
- It is used in the construction of RCC bridges.
- For Construction of Silos and Chimneys.
- It is used for finishing of all types of structures like buildings, bridges, roads, and water retaining structures.
- It is used in precast and prestressed concrete.
- It is also used in Ship form Construction.
- It is used in the construction where a grade of concrete up to M30.
- The Code of reference for 43-Grade Cement is IS Code – IS 8112: 1989.

OPC 53 Grade Cement

The Cement, which has Compressive strength of 53 N/ mm^2 after the 28 days when tested, is known as 53-Grade Cement.

Fineness (specific area) of 53 Grade Cement = 225 m^2/kg

- 3 days compressive strength = 27 N/mm^2
- 7 days compressive strength = 37 N/mm^2
- 28 days compressive strength = 53 N/mm^2

OPC 53 Grade Cement

Properties of 53 Grade Cement:

- It is a Sulphate resisting cement.
- It has low chloride content.
- It can be used in speedy Construction.
- It saves shuttering cost due to early removal.
- The initial strength of 53 Grade Cement continues to gain even after 28 days.

OPC 53 Grade Cement

Uses of 53 Grade Cement:

- It is used the construction of concrete sleepers for Railways.
- It is used in pre-stressed girders.
- The 53-Grade Cement achieves early strength.
- It is used in industrial buildings roads and runways.
- It is used in the construction of RCC bridges and precast concrete.
- Generally used for M25 and above concretes.
- It is used in the construction of all RCC components like a beam, columns, footings, and slabs.
- The Code of reference for 53-Grade Cement is IS Code – IS 12269: 1987.

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Unit 1 : Civil Engineering Materials and Surveying

Topic 3 : Manufacturing process of Cement

Manufacturing Process of Cemnet

- The manufacture procedures of Portland cement is described below.

1. Mixing of raw materials
2. Burning
3. Grinding
4. Storage and packaging

Mixing of Raw Materials

- The major raw materials used in the manufacture of cement are Calcium, Silicon, Iron and Aluminum. These minerals are used in different form as per the availability of the minerals. Table shows the raw materials for Portland cement manufacture.

Calcareous Materials	Argillaceous Materials		
Calcium	**Silicon**	**Aluminum**	**Iron**
Limestone	Clay	Clay	Clay
Marl	Marl	Shale	Iron ore
Calcite	Sand	Fly ash	Mill scale
Aragonite	Shale	Aluminum ore refuse	Shale
Shale	Fly ash		Blast furnace dust
Sea Shells	Rice hull ash		
Cement kiln dust	Slag		

Mixing of Raw Materials

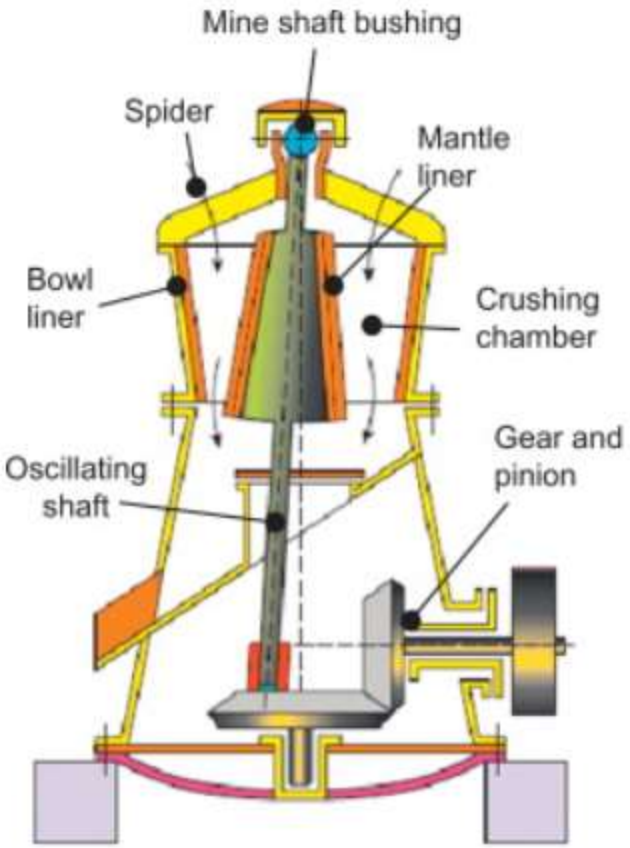
- The mixing procedure of the manufacture of cement is done in 2 methods,

1. Dry process
2. Wet process

Dry Process

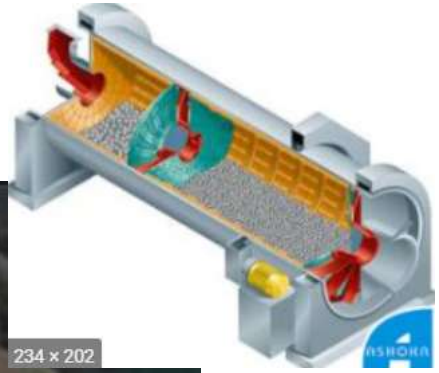
- The both calcareous and argillaceous raw materials are firstly crushed in the gyratory crushers to get 2-5cm size pieces separately.
- The crushed materials are again grinded to get fine particles into ball or tube mill.
- Each finely grinded material is stored in hopper after screening.
- Now these powdered minerals are mixed in required proportion to get dry raw mix which is then stored in silos and kept ready to be sent into rotary kiln.
- Now the raw materials are mixed in specific proportions so that the average composition of the final product is maintained properly.

Gyratory Crusher



Gyratory crusher

Ball Mill



Hopper

Silos

Rotary Kiln

Wet Process

- The raw materials are firstly crushed and made into powdered form and stored in silos.
- The clay is then washed in washing mills to remove adhering organic matters found in clay.
- The powdered limestone and water washed clay are sent to flow in the channels and transfer to grinding mills where they are completely mixed and the paste is formed, i.e., known as slurry.
- The grinding process can be done in ball or tube mill or even both.
- Then the slurry is led into collecting basin where composition can be adjusted.
- The slurry contains around 38-40% water that is stored in storage tanks and kept ready for the rotary kiln.

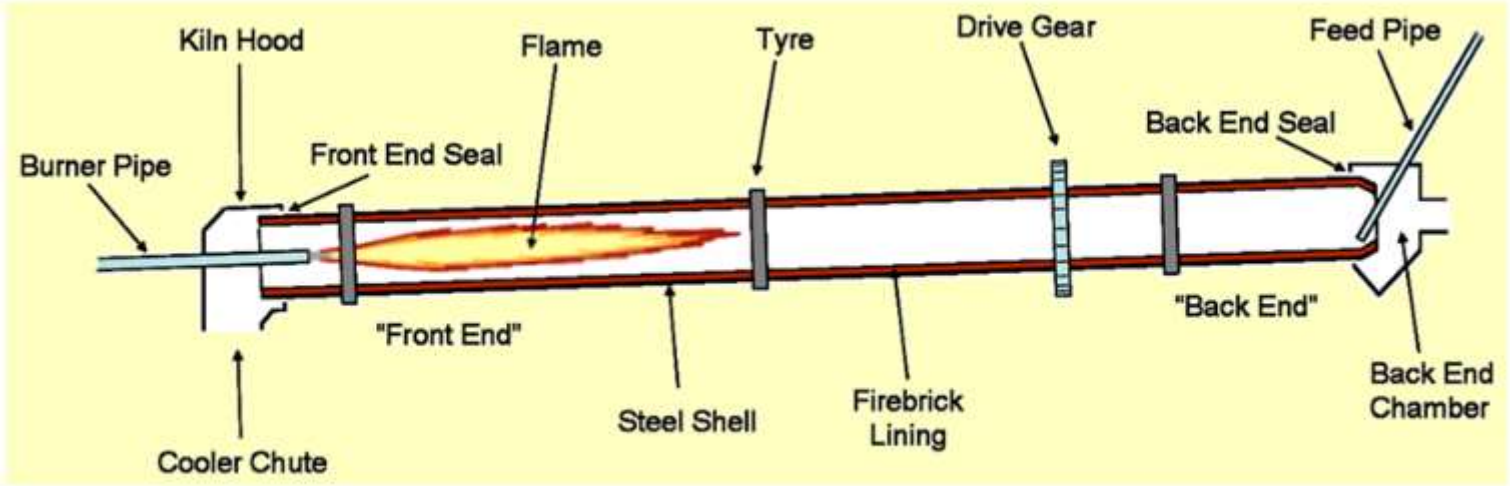
Comparison of Dry Process and Wet Process of Cement Manufacture

Criteria	Dry process	Wet process
Hardness of raw material	Quite hard	Any type of raw material
Fuel consumption	Low	High
Time of process	Lesser	Higher
Quality	Inferior quality	Superior quality
Cost of production	High	Low
Overall cost	Costly	Cheaper
Physical state	Raw mix (solid)	Slurry (liquid)

Burning of Raw Materials

- The burning process is carried out in the rotary kiln while the raw materials are rotated at 1-2rpm at its longitudinal axis.
- The rotary kiln is made up of steel tubes having the diameter of 2.5-3.0 meter and the length differs from 90-120meter.
- The inner side of the kiln is lined with refractory bricks.
- The kiln is supported on the columns of masonry or concrete and rested on roller bearing in slightly inclined position at the gradient of 1 in 25 to 1 in 30.
- The raw mix of dry process or corrected slurry of wet process is injected into the kiln from the upper end.

Rotary Kiln



Rotary kiln terminology

Burning of Raw Materials

- The kiln is heated with the help of powdered coal or oil or hot gases from the lower end of the kiln so that the long hot flames is produced.
- As the kiln position is inclined and it rotates slowly, the material charged from upper end moves towards lower end at the speed of 15m/hr.
- In the upper part, water or moisture in the material is evaporated at 400oC temp, so this process is known as Drying Zone.
- The central part i.e. calcination zone, the temperature is around 1000oC, where decomposition of lime stone takes place.
- The remaining material is in the form of small lumps known as nodules after the CO2 is released.

$$CaCO3 = CaO + CO2$$

Burning of Raw Materials

- The lower part i.e. clinkering zone has the temperature around 1500-1700oC.
- In the region lime and clay reacts to yield calcium aluminates and calcium silicates.
- This products of aluminates and silicates of calcium fuses together to form hard and small stones known as **clinkers**.
- The size of the small and hard clinkers varies from 5 to 10mm.

Clinkers

Burning of Raw Materials

$2CaO + SiO_2 = Ca_2SiO_4$ (diclaim silicate (C2S))

$3CaO + SiO_2 = Ca_3SiO_5$ (tricalcium silicate (C3S))

$3CaO + Al_2O_3 = Ca_3Al_2O_6$ (dicalcium aluminate (C2A))

$4CaO + Al_2O_3 + Fe_2O_3 = Ca_4Al_2Fe_2O_{10}$ (tetracalcium aluminoferrite(C4AF))

- The clinker coming from the burning zone are very hot.
- To bring down the temperature of clinkers, air is admitted in counter current direction at the base of the rotary kiln.
- The cooled clinkers are collected in small trolleys.

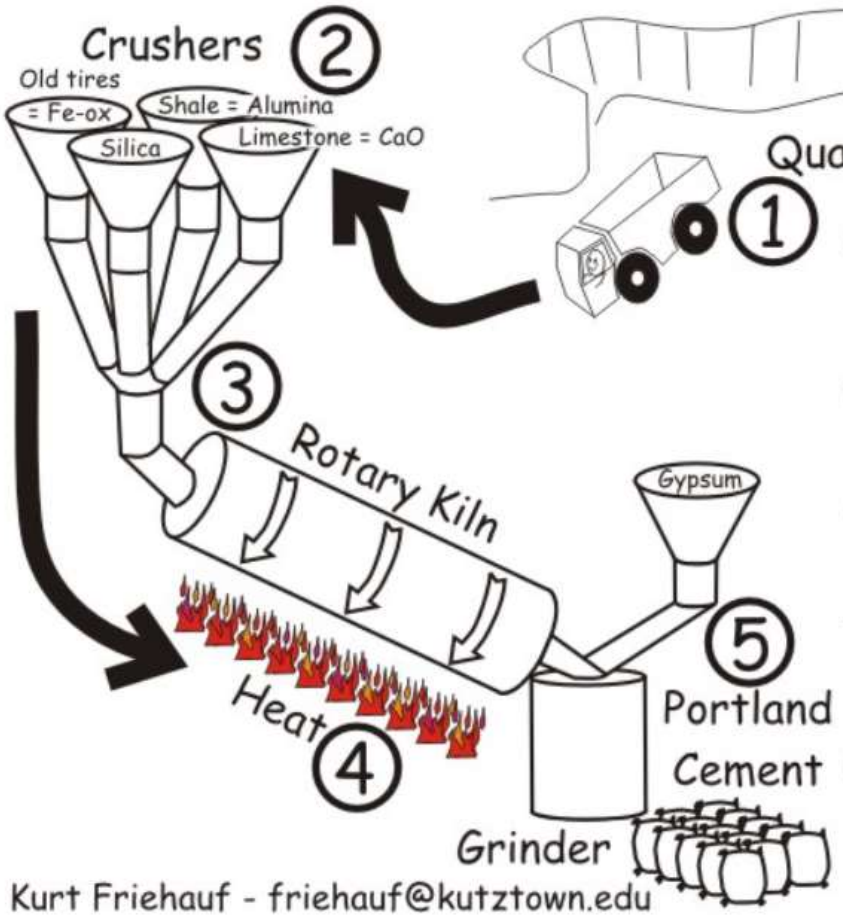
Grinding of Clinkers

- The cooled clinkers are received from the cooling pans and sent into mills.
- The clinkers are grinded finely into powder in ball mill or tube mill.
- Powdered gypsum is added around 2-3% as retarding agent during final grinding.
- The final obtained product is cement that does not settle quickly when comes in contact with water.

Storage and Packaging

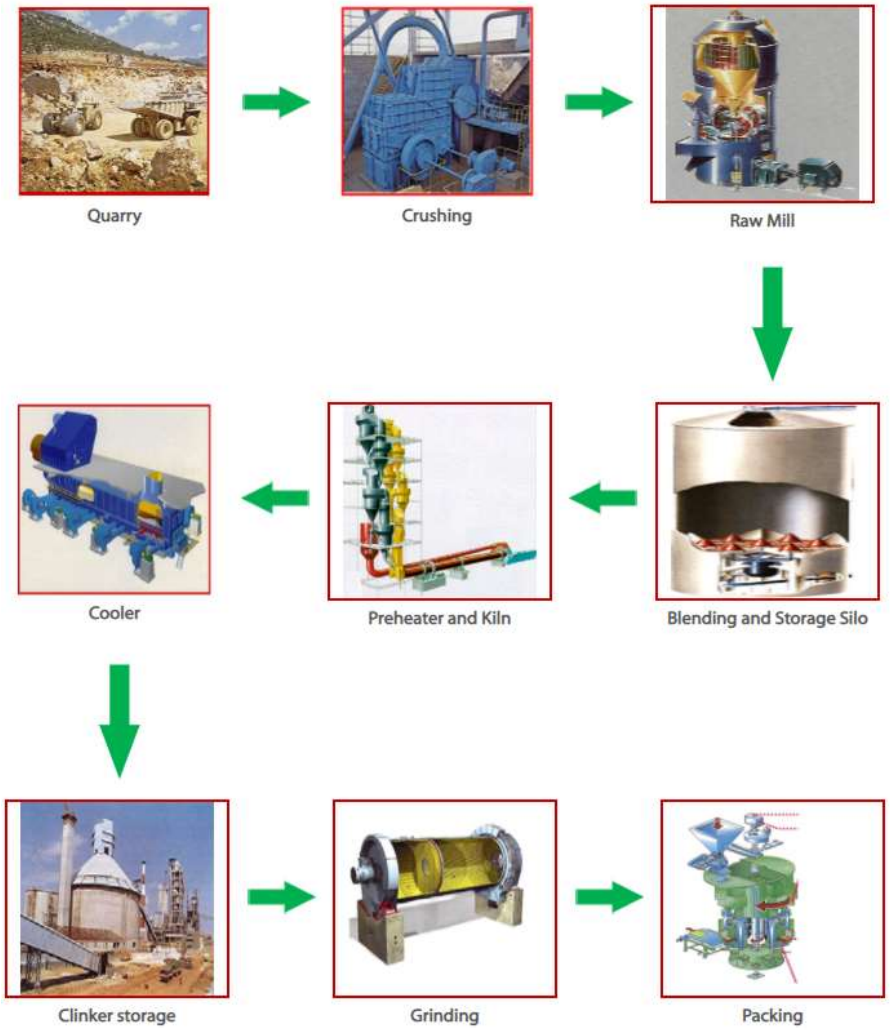
- The grinded cement is stored in silos, from which it is marketed either in container load or 50kg bags.

Cement Manufacturing



1. Limestone, shale, silica, and iron oxides are quarried from the ground. (Some limestones already contain enough silica).
2. Rock materials are run through a crusher that turns rock into smaller pieces.
3. Crushed limestone + silica + shale + iron oxides are mixed together and run through a rotary kiln.
4. Rotary kiln continuously mixes ingredients and "calcines" limestone so that CO_2 is driven off, forming clinker.
5. Clinker is ground to fine powder and mixed with gypsum (helps moderate how fast the cement "sets), then bagged for sale.

Cement Manufacturing



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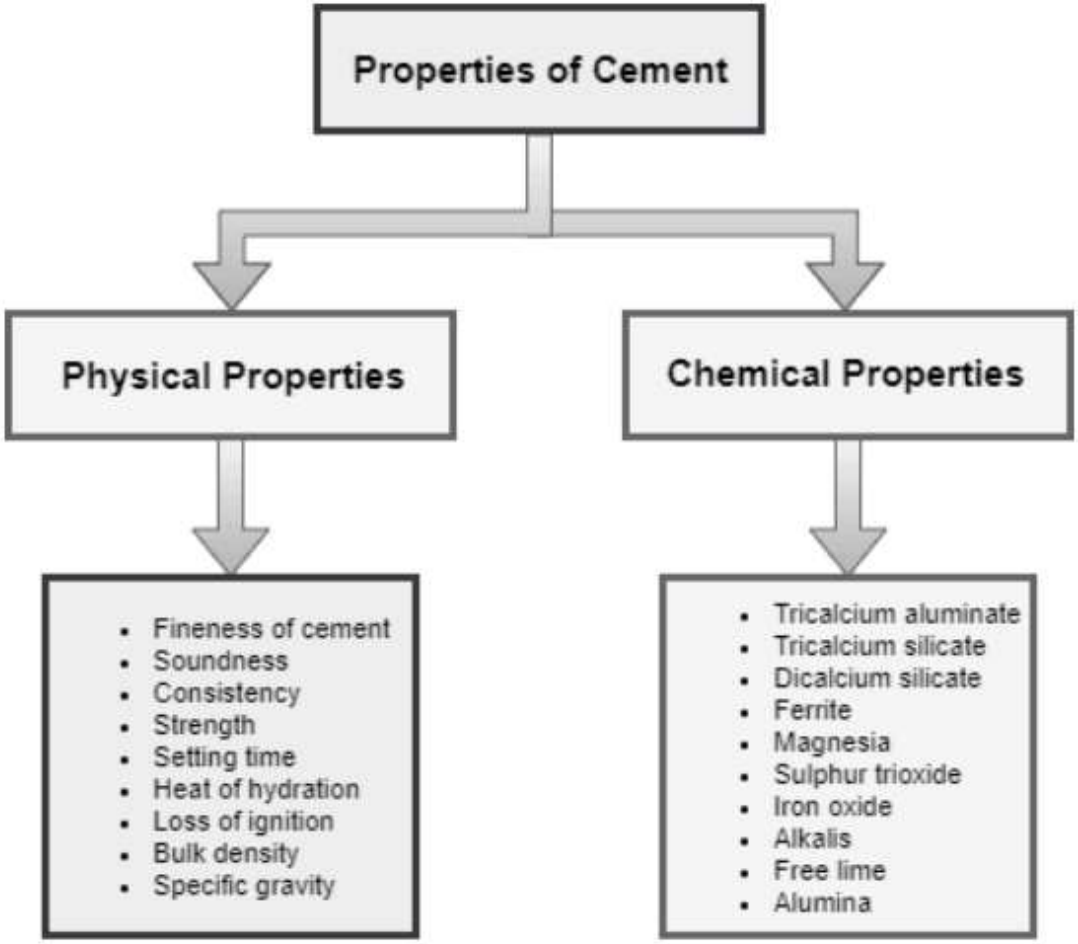
23GET102 – BASIC CIVIL AND MECHANICAL ENGINEERING

I YEAR / I SEMESTER

Unit 1 : Civil Engineering Materials and Surveying

Topic 3 : Properties of Cement

Properties of Cement



Fineness of Cement

- The size of the particles of the cement is its fineness.
- The required fineness of good cement is achieved through grinding the clinker in the last step of cement production process.
- As hydration rate of cement is directly related to the cement particle size, fineness of cement is very important.

Soundness of Cement

- Soundness refers to the ability of cement to not shrink upon hardening.
- Good quality cement retains its volume after setting without delayed expansion, which is caused by excessive free lime and magnesia.
- The unsoundness of cement is caused by the undesirable expansion of some of its constituents, sometimes after setting.
- The large change in volume accompanying expansion results in disintegration and severe cracking. the unsoundness is due to the presence of free lime and magnesia in the cement.

Soundness of Cement

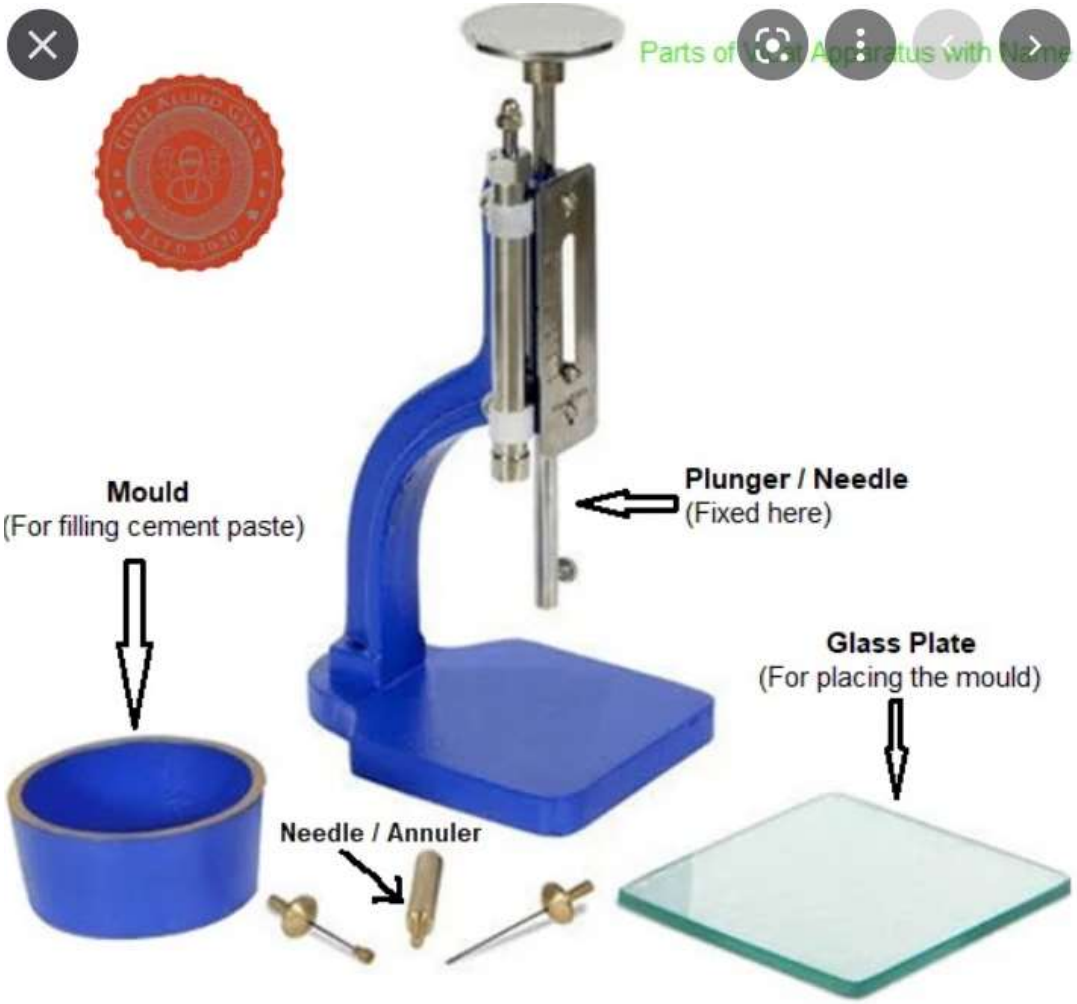
The unsoundness may reduce by

- Limiting the MgO content to less than 0.5%.
- Fine griding.
- Allowing the cement to aerate for several days.
- Thorough mixing.

Consistency of Cement

- The physical state of cement paste is called consistency.
- The purpose of the consistency test is to estimate the quantity of mixing water to form a paste of normal consistency.
- It is measured by the Vicat apparatus Test.
- If the water content in the cement paste is such that the Vicat's plunger penetrates up to 5 to 7 mm from the bottom of the mould, the cement paste is called to be of normal consistency.

Consistency of Cement



Strength of Cement

- Three types of strength of cement are measured – compressive, tensile and flexural.
- Various factors affect the strength, such as water-cement ratio, cement-fine aggregate ratio, curing conditions, size and shape of a specimen, the manner of molding and mixing, loading conditions and age.
- While testing the strength, the following should be considered:
  - Cement strength is merely a quality control measure.
  - Cement gains strength over time, so the specific time of performing the test should be mentioned.

Setting Time of Cement

- Cement sets and hardens when water is added.
- This setting time can vary depending on multiple factors, such as fineness of cement, cement-water ratio, chemical content, and admixtures.
- Cement used in construction should have an initial setting time that is not too low and a final setting time not too high.
- Hence, two setting times are measured:
  - **Initial set:** When the paste begins to stiffen noticeably (typically occurs within 30-45 minutes)
  - **Final set:** When the cement hardens, being able to sustain some load (occurs below 10 hours)
  - Again, setting time can also be an indicator of hydration rate.

Heat of Hydration

- When water is added to cement, the reaction that takes place is called hydration.
- Hydration generates heat, which can affect the quality of the cement and also be beneficial in maintaining curing temperature during cold weather.
- On the other hand, when heat generation is high, especially in large structures, it may cause undesired stress.
- The heat of hydration is affected most by C_3S and C_3A present in cement, and also by water-cement ratio, fineness and curing temperature.
- The heat of hydration of Portland cement is calculated by determining the difference between the dry and the partially hydrated cement (obtained by comparing these at 7th and 28th days).

Loss of Ignition

- Heating a cement sample at 900 - 1000°C (that is, until a constant weight is obtained) causes weight loss.
- This loss of weight upon heating is calculated as loss of ignition.
- Improper and prolonged storage or adulteration during transport or transfer may lead to pre-hydration and carbonation, both of which might be indicated by increased loss of ignition.

Bulk Density

- When cement is mixed with water, the water replaces areas where there would normally be air.
- Because of that, the bulk density of cement is not very important.
- Cement has a varying range of density depending on the cement composition percentage.
- The density of cement may be anywhere from 62 to 78 pounds per cubic foot.

Specific Gravity

- Specific gravity is generally used in mixture proportioning calculations.
- Portland cement has a specific gravity of 3.15, but other types of cement (for example, Portland-blast-furnace-slag and Portland-Pozzolan cement) may have specific gravities of about 2.90.

Chemical Properties of Cement

- The raw materials for cement production are limestone (calcium), sand or clay (silicon), bauxite (aluminum) and iron ore, and may include shells, chalk, marl, shale, clay, blast furnace slag, slate.
- Chemical analysis of cement raw materials provides insight into the chemical properties of cement.

Chemical Properties of Cement

Tricalcium aluminate (C3A)

- Low content of C3A makes the cement sulfate-resistant.
- Gypsum reduces the hydration of C_3A, which liberates a lot of heat in the early stages of hydration.
- C3A does not provide any more than a little amount of strength.
- Type I cement: contains up to 3.5% SO_3 (in cement having more than 8% C_3A)
- Type II cement: contains up to 3% SO_3 (in cement having less than 8% C_3A)

Chemical Properties of Cement

Tricalcium silicate (C_3S)

- C3S causes rapid hydration as well as hardening and is responsible for the cement's early strength gain an initial setting.

Dicalcium silicate (C_2S)

- As opposed to tricalcium silicate, which helps early strength gain, dicalcium silicate in cement helps the strength gain after one week.

Ferrite (C_4AF)

- Ferrite is a fluxing agent. It reduces the melting temperature of the raw materials in the kiln from 3,000°F to 2,600°F.
- Though it hydrates rapidly, it does not contribute much to the strength of the cement.

Chemical Properties of Cement

Magnesia (MgO)

- The manufacturing process of Portland cement uses magnesia as a raw material in dry process plants.
- An excess amount of magnesia may make the cement unsound and expansive, but a little amount of it can add strength to the cement.
- Production of MgO-based cement also causes less CO2 emission.
- All cement is limited to a content of 6% MgO.

Sulphur trioxide

- Sulfur trioxide in excess amount can make cement unsound.

Iron oxide/ Ferric oxide

- Aside from adding strength and hardness, iron oxide or ferric oxide is mainly responsible for the color of the cement.

Chemical Properties of Cement

Alkalis

- The amounts of potassium oxide (K_2O) and sodium oxide (Na_2O) determine the alkali content of the cement.
- Cement containing large amounts of alkali can cause some difficulty in regulating the setting time of cement.
- Low alkali cement, when used with calcium chloride in concrete, can cause discoloration.
- In slag-lime cement, ground granulated blast furnace slag is not hydraulic on its own but is "activated" by addition of alkalis.
- There is an optional limit in total alkali content of 0.60%, calculated by the equation $Na_2O + 0.658\ K_2O$.

Free lime

- Free lime, which is sometimes present in cement, may cause expansion.

Chemical Properties of Cement

Silica fumes

- Silica fume is added to cement concrete in order to improve a variety of properties, especially compressive strength, abrasion resistance and bond strength.
- Though setting time is prolonged by the addition of silica fume, it can grant exceptionally high strength.
- Hence, Portland cement containing 5-20% silica fume is usually produced for Portland cement projects that require high strength.

Alumina

- Cement containing high alumina has the ability to withstand frigid temperatures since alumina is chemical-resistant.
- It also quickens the setting but weakens the cement.

Properties of Cement Mortar

- It should be easily workable.
- It should develop adequate strength in tension, compression, and bond for the work.
- It should be durable.
- It should not affect the durability of other materials.
- It should be set quickly so that the speed of construction is ensured.
- It should be cheaply available.
- It should bind the bricks or stones to give a tight joint through which water cannot penetrate.
- The joints form by mortar should not develop cracks and they should be able to maintain their appearance for quite a long time.

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I YEAR / I SEMESTER

Unit 1 : Civil Engineering Materials and Surveying

Topic : Types of Cement

Types of Cement

1. Ordinary Portland Cement (OPC)
2. Portland Pozzolana Cement (PPC)
3. Rapid Hardening Cement
4. Extra Rapid Hardening Cement
5. Low Heat Cement
6. Sulphates Resisting Cement
7. Quick Setting Cement
8. Blast Furnace Slag Cement
9. High Alumina Cement
10. White Cement

Ordinary Portland Cement (OPC)

- In usual construction work, Ordinary Portland Cement is widely used.
- Portland cement clinker is a hydraulic material which shall consist of at least two-thirds by mass of calcium silicates, ($3CaO \cdot SiO_2$, and $2CaO \cdot SiO_2$), the remainder consisting of Aluminium- and iron-containing clinker phases and other compounds.
- The ratio of CaO to SiO_2 shall not be less than 2.0.
- The magnesium oxide content (MgO) shall not exceed 5.0% by mass.

Ordinary Portland Cement (OPC)

The composition of Ordinary Portland Cement:

- Argillaceous or silicates of alumina (clay and shale)
- Calcareous or calcium carbonate (limestone, chalk, and marl)

Uses of Ordinary Portland Cement:

- It is used for general construction purposes.
- It is also used in most of the masonry works.

Portland Pozzolana Cement (PPC)

- Pozzolans are natural or synthetic materials that contain silica in reactive forms.
- It reacts with calcium hydroxide generated by hydrating cement to form additional cementations materials when it is finely divided.
- The composition of Portland Pozzolana Cement:
    - OPC clinker
    - Gypsum
    - Pozzolanic Materials (Fly ash, volcanic ash, and Calcined clay or silica fumes.)

Portland Pozzolana Cement (PPC)

Uses of Portland Pozzolana Cement:

- PPC is usually used in hydraulic structures, marine structures, construction near the seashore, dam construction, etc.
- It is also used in pre-stressed and post-tensioned concrete members.
- As it gives a better surface finish, it is used in decorative and art structures.
- It is also used in the manufacture of precast sewage pipes.

Rapid Hardening Cement

- When finely grounded Tri-calcium silicate (C3S) is present in OPC with higher content, it gains strength more quickly than OPC.
- This type of OPC is called Rapid Hardening Cement.
- It's initial Setting Time 30 minutes and Final Setting Time 600 minutes.

Uses of Rapid Hardening Cement

- Rapid hardening cement is mostly used where rapid construction is needed like the construction of pavement.
- It also gives high strength.

Quick Setting Cement

- Quick setting cement is the cement which sets in a very short time.
- The initial setting time is 5 minutes and the final setting time is 30 minutes.
- The composition of Quick Setting Cement:
  - Clinker
  - Aluminum sulfate (1% to 3% by weight of clinker)
  - The aluminum sulfate increases the hydration rate of silicate.

Quick Setting Cement

Uses of Quick Setting Cement:

- It is used in underwater construction.
- It is also used in rainy & cold weather conditions.
- It is used a higher temperature where water evaporates easily.
- Used for anchoring or rock bolt mining and tunneling.

Low Heat Cement

- It is a spatial type of cement which produces low heat of hydration during the setting.
- Some chemical composition of Ordinary Portland Cement is modified to reduce the heat of hydration.
- The chemical composition of low heat cement:
  - A low percentage (5%) of tricalcium aluminate (C3A)
  - A higher percentage (46%) of dicalcium silicate (C2S).

Low Heat Cement

Uses of Low Heat Cement:

- It is used for the construction of dam's large footing, large raft slabs, and wind turbine plinths.
- It is also used for the construction of chemical plants.

Sulphate Resisting Cement

- Sulfate resisting cement is used to resist sulfate attacks in concrete.
- Due to the lower percentage of Tricalcium aluminate, the production of calcium sulpho-aluminates gets reduced.

Uses of Sulphates resisting Cement:

- Construction in contact with soils or groundwater having more than 0.2% or 0.3 % g/l sulfate salts respectively.
- Concrete surfaces subjected to alternate wetting and drying such as bridge piers, concrete surface in the tidal zone, apron, Building near the seacoast.
- Effluent treatment plans, Chimney, Chemical industries, water storage, sumps, drainage works, Cooling towers, Coastal protective works such as sea walls, breakwaters, etc.

Blast Furnace Cement

- Portland cement clinker and granulated blast furnace slag (obtained by quenching molten iron slag) are intergraded to make blast furnace cement.
- A maximum of 65 percent of the mixture could be comprised of blast furnace slag.

Uses of Blast Furnace Cement:

- It is highly sulfate resistant
- Frequently used in seawater construction.

High Alumina Cement

- High Alumina cement is obtained by mixing calcining bauxite (it's an aluminum ore) and ordinary lime with clinker during the manufacture of OPC.
- In which the total amount of alumina content should not be lesser than 32% and it should maintain the ratio by weight of alumina to the lime between 0.85 to 1.30.

Uses of High Alumina Cement:

- It is used where concrete structures are subjected to high temperatures like workshops, refractory, foundries, etc.
- It also used where the concrete is subjected to frost and acidic action.

White Cement

- White cement is quite similar to Ordinary Portland Cement except for color.
- Amounts of iron oxide and manganese oxide are low in White Cement.
- It is expensive then OPC so not economical for ordinary work.

Uses of White Cement:

- It is usually used in decorative work.
- It can also use for traffic barriers, tile grouts, swimming pools, roof tiles patching materials, and terrazzo surfaces.

Colored Cement

- To make 5 to 10 percent of suitable pigments are ground with OPC.
- Types of pigments are selected according to the desired color.

Uses of Colored Cement:

- Colored cement is used for different decorative work.

Air Entraining Cement

- It is seen that entrainment of air or formation of gas bubbles while applying cement increases resistance to frost action, fire, scaling, and other similar defects.
- Air-entraining cement is a special type of cement which entrains tinny air bubbles in concrete.
- It is produced by grinding minute air entertaining materials with clinker by adding some resinous materials e.g. vinsol resin to ordinary Portland cement.
- When the water in concrete gets frizzed due to low temperature, it expands.
- When air-entraining cement, the air voids in concrete provides space for water to expand without cracking concrete.
- But this type of cement does not provide high strength in concrete.

Air Entraining Cement

Uses of Air-Entraining Cement:

- Especially it is used in areas where the temperature is very low.
- It also resists the Sulphate attack.
- It is used where the de-icing chemical is used.

Expansive Cement

- In the hydration process, the expansive cement expands its volume.
- It can be possible to overcome shrinkage loss by using expansive cement.

There are three types of expansive cement:

1. K Type expansive cement
2. M Type expansive cement
3. S Type expansive cement

Expansive Cement

K Type expansive cement

Raw materials of these types of cement

- Portland cement
- Anhydrous tetracalcium trialuminate sulfate (C4A3S)
- Calcium sulfate (CaSO4)
- Lime (CaO).

M Type Expansive Cement

Raw materials of these types of cement

- Portland cement clinkers
- Calcium sulfate.

Expansive Cement

S Type Expansive Cement

Raw materials of these types of cement

- Portland cement clinkers
- Calcium sulfate (High amount)
- Tricalcium aluminate (C3A) (High amount)

Uses of Expansive cement:

- It is used in the construction of the pre-stressed concrete component.
- It is also used for sealing joints and grouting anchor bolt.
- In the construction of different hydraulic structures, this type of cement is used.

Hydrophobic Cement

- To resist the hydration process in the transportation or storage stage, clinkers are ground with water repellent film substance such as **Oleic Acid or Stearic Acid**.
- These chemicals form a layer on the cement particle and do not allow water to mix and start the hydration process.
- When cement and aggregate are thoroughly mixed in the mixer, protective layers break and start normal hydration with some air-entrainment which increases workability.

Hydrophobic Cement

Uses of Hydrophobic Cement

- Usually, it is used in the construction of water structures such as dams, spillways, or other submerged structures.
- It is also used in the construction of underground structures like tunnel etc.

Thank You!!