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BUILDING MATERIALS

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Presents

Building Materials

A Presentation by

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Building Materials

Topics

1. Cement
2. Lime
3. Mortar
4. Concrete
5. Timber
6. Bricks
Cement

Argillaceous (clay)  Calcareous (lime)
## Constituents of Cement

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lime (CaO)</td>
<td>62-65%</td>
</tr>
<tr>
<td>Silica (SiO₂)</td>
<td>17-25%</td>
</tr>
<tr>
<td>Alumina (Al₂O₃)</td>
<td>3-8%</td>
</tr>
<tr>
<td>Gypsum (CaSO₄)</td>
<td>3-4%</td>
</tr>
<tr>
<td>Iron Oxide (Fe₂O₃)</td>
<td>3-4%</td>
</tr>
<tr>
<td>Magnesia (MgO)</td>
<td>1-3%</td>
</tr>
<tr>
<td>Sulphur (S)</td>
<td>1-3%</td>
</tr>
<tr>
<td>Alkalies (K₂O, N₂O)</td>
<td>0.2-1</td>
</tr>
</tbody>
</table>
Functions of Different Constituents of Cement

1. Lime (62-65%)
   - Imparts strength and Soundness (volume)
   - Excess- makes cement unsound, causes it to expand & disintegrate
   - Deficiency- reduces strength of cement, causes it to set quickly

2. Silica (17-25%)
   - Imparts Strength to cement
   - Excess- increases strength of cement BUT increases setting time of cement

3. Alumina (3-8%)
   - Imparts quick setting property
   - Reduces clinkering temperature, if it is in excess weakens the cement
Functions of Different Constituents of Cement

4. **Gypsum (3-4%)**
   - Present in form of calcium sulphate
   - Used to increase initial setting time of cement

5. **Iron Oxide (3-4%)**
   - Imparts Colour, Strength and hardness to cement
   - It induces reddish brown tint to the cement

6. **Magnesia (1-3%)**
   - Imparts Strength and colour to cement (yellowish tint)
   - Excess- makes cement unsound
Functions of Different Constituents of Cement

7. Sulphur (1-3%)
   - It is also responsible for imparting soundness

   Note: Soundness due to lime and Magnesia can be measured directly but no test is available to measure soundness due to sulphur

8. Alkalis (0.2-1%)
   - Presence of alkalis causes efflorescence and staining of structure
   - Alkalis react with water and white grey spots are formed
Bougues Compounds

Water reacts with ingredients of Cement chemically, resulting in formation of Complex Chemical Compounds termed as Bogues Compounds, *which are not formed simultaneously*

1. TriCalcium Aluminate
2. TetraCalcium Alumino Ferrate
3. TriCalcium Silicate
4. DiCalcium Silicate
Bouguès Compounds

1. **TriCalcium Aluminate (C₃A or 3CaO.Al₂O₃)**
   - 4-14% by weight
   - Formed within 24 hours of addition of water in cement
   - Responsible for maximum amount of heat of hydration

2. **TetraCalcium Alumino Ferrate (C₄AF or 4CaO.Al₂O₃,Fe₂O₃)**
   - 10-18% by weight
   - It is also formed within 24 hours of addition of water to cement
   - Amount of heat of hydration evolved during formation of this compound **initially** is comparatively more which goes on decreasing with time
Bouguès Compounds

3. TriCalcium Silicate (C₃S or 3CaO·SiO₂)
   • 45-85% by weight
   • Formed within a week of addition of water in cement
   • Responsible for development of early strength of cement in initial stages

4. DiCalcium Silicate (C₂S or 2CaO·SiO₂)
   • 15-35% by weight
   • It is formed very slowly after addition of water in cement and may require a year or so for its formation
   • It is responsible for progressive strength of cement in later stages

Note:

✓ If early strength is required- increase C₃S

✓ Strength in required to be increased in later stages- increase C₂S (emergency road work, prefabricated construction work, etc.)
Hydration of Cement

• Heat of hydration of Ordinary Portland Cement during 7 days is about 89-90cal/gm and during 28 days is about 90-100gm

• Water- About 23% of by weight of cement is required to carry out the complete hydration

• About 15% of water is used up in filling voids of the cement particles, hence effectively 38% of water (by wt of cement) is required to carry out complete hydration
Manufacturing of Cement

Manufacturing of cement includes three basic operations:

1. Mixing  ➔  2. Burning  ➔  Grinding
Methods of Manufacturing of Cement

1. Dry Method (New)
2. Wet Process (Old)
Methods of Manufacturing of Cement

1. Dry Process (New Method)

- Argillaceous (slate/laterite)
  - crushing (25mm)
  - Fine Grinding in tube/ball mill
  - Storage
  - Mixing of raw ingredients in correct proportions

- Calcareous Compounds (lime/marble)
  - crushing (25mm)
  - Fine Grinding in tube/ball mill
  - Storage
  - Mixing of raw ingredients in correct proportions

- Mixing of raw ingredients in correct proportions
  - Pre heating at 800 degree celsius by exhaust gases
  - Fed to rotary kilns for burning
  - clinkers are formed
  - fine grinding in tube mills
  - cement silos/particles
  - Cooled down and packed
Methods of Manufacturing of Cement

2. Wet Process (Old Method)

**Argillaceous (slate/laterite)**
- Crushing (25mm)
- Storage
- Channel
- Wet grinding in Ball mill to form slurry
- Blending of slurry to corrected proportions
- Fed to rotary kilns for burning

**Calcareous Compounds (lime/marble)**
- Crushing (25mm)
- Storage
- Channel
- Fed to rotary kilns for burning

- Fed to rotary kilns for burning
- Clinkers are formed
- Fine grinding in tube mills
- Cement silos/particles
- Cooled down and packed
Testing of Cement

Testing of cement is carried out to analyze the presence of desirable properties in it.
Testing of Cement

I. **Field Test**

1. **Colour Test:** Cement should possess uniform grey colour

2. **Physical Property Test:**
   - Should feel smooth when rubbed in between fingers
   - Cement should sink in water and should not float over the surface
   - Sample should be free from presence of any lumps which are formed due to absorption of moisture

3. **Strength Test**
   - Prepare a block of cement to be tested of size 25x25x200 cubic mm
   - Immerse in water for 7 days
   - Now remove the mould and subject it to point load of 340N by placing it over supports 150mm apart
   - Sample should show no sign of failure under the application of this load
Testing of Cement

II. Lab Test

1. Fineness Test: used to check proper grinding which has direct impact on rate of hydration, rate of gain of strength and evolution of heat

A. Sieve Test:
   - Take 100gm of cement and place it on IS Sieve no. 9 (90 micron)
   - Perform sieving for 15mins
   - Weight of residue should not exceed 10% of original weight for OPC

B. Air Permeability Test: represented in terms of specific surface area (cm²/gm)
   - Blaines air permeability apparatus is used
   - Based on relationship between flow of air through cement bed and surface area of cement particles forming the bed
   - For OPC, SSA should not be less than 2250cm²/gm
Testing of Cement

2. Standard Consistency Test:

- Standard Consistency should be known before we know about Setting time, soundness
- Standard Consistency permits penetration of vicat plunger of size 10mm dia and 50 mm height up to a depth of 33-35mm from top into the mould
- We find the water content at which the cement consistency is produced
- Take 500gm of cement and add 23% of water by weight of cement in first trial
- Lower the plunger gently up to surface of mould and release quickly
- The moisture content at which this cement paste of standard Consistency is produced is termed as “P”.

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Testing of Cement

3. **Setting time Test**: carried out to know whether cement is deteriorated due to storage. Two times are associated with setting of cement:
   A. Initial Setting Time
   B. Final Setting time

A. **Initial Setting time**: time which is being measured from the instant water is added to cement up to the time cement starts losing its plasticity.
   - Take 500gm cement and gauge it with 0.85P
   - Lower the square needle gently and release it quickly
   - Note time required by needle to penetrate 33-35mm from top
   - This time is called Initial Setting time
   ✓ *For OPC, initial setting time is 30 mins*
Testing of Cement

B. Final Setting time: time which is being measured from the instant water is added to cement up to the time cement completely looses its plasticity and attains sufficient firmness.

- Take 500gm cement and gauge it with 0.85P
- Lower the annular collar with needle gently and release it quickly
- Final setting time is the time when annular collar fails to make an impression over the mould but needle does show

✓ For OPC, final setting time is 10 hours
Testing of Cement

4. Soundness Test:

It is important that cement after setting does not show any appreciable change in volume as it seriously affects the durability of the structure

- Soundness of Cement is due to LIME, MAGNESIA and SULPHUR

A. Soundness due to Lime

- Gauge the cement with 0.78P and fill the paste in mould
- Cover top and bottom with glass plates and immerse entire assembly in water having temperature 27-32°C for 24 hours
- Remove mould and note the displacement of split with help of indicator arms
- Then again we immerse entire assembly, increase temperature in 25-30 mins upto boiling point, and maintain it for next three hours
- Note the displacement of split with the help of indicator arms
- **The difference in reading in both the parts of test should not exceed 10mm for OPC**
Testing of Cement

4. Soundness Test:

B. Soundness due to Lime and Magnesia

- This test is sensitive to both Lime and Magnesia
- Prepare a mould of lean cement of size 25mm(cube)
- Place in autoclave in which steam pressure is increased upto 21kg/cm² and is maintained for next three hours
- The mould is removed, percentage expansion of the mould is noted in each direction which should not exceed 0.8% for OPC
Testing of Cement

5. Strength Test:

Compressive strength Test

- Cement : annure sand = 1:3
- Wt of sand 550gm and water cement ratio 0.4
- Mortar is filled in size of 75mm mould and immersed in water for 7 days curing period
- Compressive strength of cement is tested in Universal Testing Machine (UTM)

✓ At 28 days = 33N/mm²
✓ At 7 days = 2/3(Strength at 28 days)
✓ At 3 days = 50%(Strength at 28 days)
Testing of Cement

6. Chemical Composition Test:

- The ratio of alumina to iron oxide should not be less than 0.66
- The ratio of lime to silica, Alumina and iron oxide should not be greater than 1.02 and should not be less than 0.66. This ratio is termed as lime saturation factor

\[
0.66 < \frac{\text{CaO} - 0.7 \text{SO}_3}{2.8 \text{SiO}_2 + 1.2 \text{Al}_2\text{O}_3 + 0.65 \text{Fe}_2\text{O}_3} < 1.02
\]
Some Important Points

• Total weight of Magnesia should not be greater than 5%
• Total loss on ignition should not be greater than 4%
• Total sulphur content should not be greater than 2.75%
• Weight of insoluble residue should not be greater than 1.5%
Types of Cement

1. Rapid Hardening Cement

   • Higher rate of development of strength
   • Must not be confused with quick setting cement
   • Strength of RHC at the age of 3 days is same as that of OPC at 7 days
   • After 90 days, strength of RHC and OPC is almost same
   • Produced by fine grinding of clinkers, increasing proportion of C₃S and reducing C₂S
   • Used in Pre fabricated construction work, cold weather concreting where framework is used for speedy construction
Types of Cement

2. Extra Rapid Hardening Cement

- Produced with intergrinding rapid hardening cement clinkers with CaCl₂, proportion of which should not be greater than 2% of weight of cement
- This cement should be mixed, transported, compacted and finished within 20 minutes of its formation
- This cement has approx. 20-25% higher strength than rapid hardening cement at the age of one or two days and 10-15% higher strength at the age of 7 days
- After 90 days, strength is almost same as that of OPC
- Application- same as Rapid hardening cement
Types of Cement

3. Sulphate Resisting Cement

- OPC is highly susceptible to attack of sulphates
- It is manufactured by reducing proportion of $C_3A$ and $C_4AF$ such that $C_3A$ is not greater than 5% and $2C_3A + C_4AF$ should not be greater than 25%
- Used in foundation work, sewage treatment work, marine structures and construction of pipes in marshy areas
Types of Cement

4. Super Sulphated Cement
   • Produced by intergrinding granulated blast furnace slag and 10-15% hard burned Gypsum and 5% cement clinkers
   • Application – same as sulphate resisting cement

5. Portland Slag Cement
   • Granulated Blast Furnace slag+ Gypsum + cement clinkers
   • Offer high resistance against attack of chlorides and sulphates
   • Higher water tightness property due to less permeability

6. Quick Setting Cement
   • Produced by adding small quantity of Aluminum Sulphate, fine grinding the cement clinkers and reducing proportion of Gypsum
   • Used in grouting operations and under water concreting
Types of Cement

7. Low Heat Cement
   • Produced by reducing proportion of $C_3A$ and increasing the proportion of $C_2S$
   • This cement shows slow rate of development of strength
   • Used where bulk concreting is required
• Watch Videos
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• Performance Analysis