UNIT 1 –
INTRODUCTION TO CONCRETE

1.1 Definition of Concrete

Concrete is an **artificial composite construction material** made by mixing:

- Cement
- Fine aggregate (sand)
- Coarse aggregate (gravel or crushed stone)
- Water

When **cement and water are mixed**, a chemical reaction called **hydration** takes place.
This reaction forms a **paste** which binds the aggregates together and gradually **hardens into a strong, solid mass**.

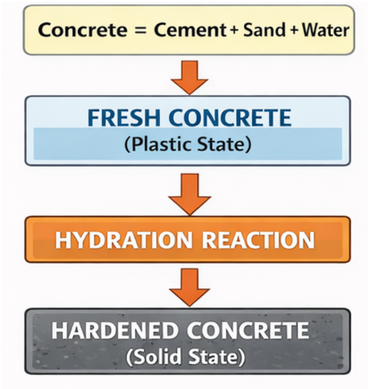
Simple Definition

Concrete = Cement + Sand + Aggregate + Water

It is a mixture that becomes hard like stone after some time.

Technical Definition

Concrete is a **stone-like material** obtained by mixing cement, aggregates, and water in proper proportions, which **hardens with time due to hydration reaction**.



How Concrete Works (Easy Explanation)

1. Cement + Water → forms paste
2. Paste covers sand and aggregates
3. Hydration reaction starts
4. Mixture slowly becomes hard
5. Final product = strong solid mass

Simple idea: *Liquid mix → becomes hard like rock*

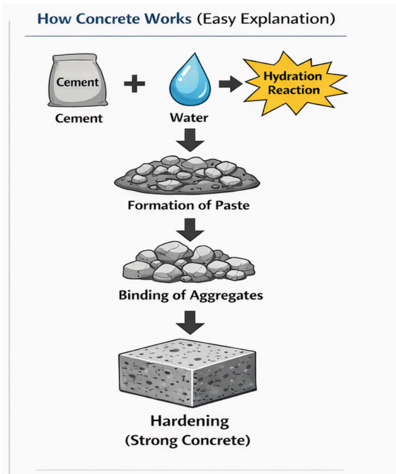


Figure: Components and Hydration Process of Concrete

Uses of Concrete (Compared to Other Materials)

Concrete is widely used in construction because of its **many advantages** over other materials like timber, steel, bricks, and stone.

1 Strength

- Concrete has **high compressive strength** (can bear heavy loads)
- Steel has **high tensile strength** (can resist pulling forces)

That's why both are used together to form **RCC (Reinforced Cement Concrete)**

Example:
Beams, columns, slabs in buildings

2 Durability

- Concrete is **very durable and long-lasting**
- It can resist:
  - Water
  - Weather
  - Fire
  - Chemicals (to some extent)

Comparison:

- Timber → affected by termites and decay
- Steel → affected by corrosion (rust)

Concrete lasts longer with less maintenance

3 Fire Resistance

- Concrete is **fire-resistant**
- It does not burn or weaken easily

Comparison:

- Steel loses strength at high temperature
- Timber burns easily

Used in buildings for safety

4 Economy (Cost Effectiveness)

- Concrete is **economical for large construction projects**
- Materials like sand and aggregates are easily available

Cost per unit becomes low in large works

5️⃣ Mouldability (Shape Flexibility)

- Concrete can be **cast into any shape and size**
- It is placed in moulds (formwork) before hardening

This makes it very flexible in design

Common Uses of Concrete

Concrete is used in almost all types of construction:

- Buildings (slabs, beams, columns)
- Bridges
- Dams
- Roads
- Water tanks
- Foundations

Example:
A bridge structure is made using concrete because it needs high strength and durability.

Final Conclusion

Concrete is one of the **most important construction materials** because it is:

- Strong
- Durable
- Fire-resistant
- Economical
- Easy to shape

That's why it is widely used in modern construction

UNIT 2 –

INGREDIENTS OF CONCRETE

Definition

Cement is a **binding material** which reacts with water and forms a **paste** that binds sand and aggregates together to form a hard mass.

Simple idea: *Cement acts like glue in concrete*

Functions of Cement

- Binds all ingredients together
- Fills gaps between aggregates
- Gives strength after hardening
- Provides durability to concrete

Physical Properties of Cement

1 Fineness

- Fineness means how **small the cement particles** are
- Finer cement has **larger surface area**

Effects:

- Faster hydration
- Higher early strength

- Better bonding

Disadvantage:

- Too fine cement may cause **cracking and shrinkage**

Tests:

- Sieve Test
- Blaine’s Air Permeability Test

2️⃣Standard Consistency

- It is the **amount of water required** to prepare a standard cement paste

Why important?

- It is used as a base for other tests like setting time

Test:

- Vicat Apparatus

3️⃣Setting Time

Time required for cement paste to start and finish hardening:

- **Initial Setting Time ≥ 30 minutes**
  - Time available for mixing and placing
- **Final Setting Time ≤ 600 minutes**
  - Time after which cement becomes fully hard

As per IS 4031

4️⃣Soundness

- Soundness means **volume stability of cement**
- Cement should not expand after setting

If unsound:

- Cracks may develop
- Structure becomes weak

Test:

- Le Chatelier Test

5️⃣ Compressive Strength

- Ability of cement to **resist compression loads**

Tested by:

- Making **1:3 cement mortar cubes**
- Tested in compression machine

Higher strength = better quality cement

Types of Cement (As per IS Codes)

1️⃣ Ordinary Portland Cement (OPC)

- Most commonly used cement

Grades:

- OPC 33 → Low strength
- OPC 43 → Medium strength
- OPC 53 → High strength

Higher grade = faster and stronger development

2️⃣ Portland Pozzolana Cement (PPC)

- Mixed with **fly ash**

Advantages:

- Low heat of hydration
- Better durability
- Eco-friendly

Used in mass construction

3️⃣ Rapid Hardening Cement

- Gains strength quickly

Used in:

- Road repairs
- Urgent construction

4️⃣ Sulphate Resisting Cement

- Resistant to sulphate attack

Used in:

- Marine structures
- Sulphate-rich soil

5️⃣ Low Heat Cement

- Produces less heat during hydration

Used in:

- Dams
- Large structures

🔹 **2.2 AGGREGATES**

Definition

Aggregates are **inert materials** like sand, gravel, or crushed stone which form about **70–75% of concrete volume**.

Simple idea: *They form the main body of concrete*

2.2.1 Classification According to Size

(a) Fine Aggregate

- Size < 4.75 mm
- Example: Sand

Function: Fills voids between coarse aggregates

(b) Coarse Aggregate

- Size > 4.75 mm
- Example: Gravel

Function: Provides strength

Classification According to Shape

Shape	Effect
Rounded	Smooth, weak bonding
Angular	Rough, strong bonding
Irregular	Medium strength
Flaky	Weak
Elongated	Weak

Best: **Angular aggregates**

2.2.2 Characteristics of Aggregates

1️⃣ Particle Size & Shape

- Affects **strength and workability**

2 Surface Texture

- Rough surface → better bonding
- Smooth surface → less bonding

3 Specific Gravity

- Normal range: **2.5 – 3**
- Indicates density and strength

4 Bulk Density

- Weight of aggregates including voids

5 Water Absorption

- High absorption → weak aggregate

6 Surface Moisture

- Extra moisture affects water content in mix

7 Bulking of Sand

- Increase in sand volume due to moisture

Maximum bulking at **4–6% moisture**

8 Deleterious Materials

- Clay, silt, organic matter

Reduce strength and durability

9 Soundness

- Resistance to weathering action

2.2.3 Grading of Aggregates

Definition

Grading means **distribution of particle sizes**

Types of Grading

Fine Aggregate Zones (IS 383):

- Zone I → Coarse sand
- Zone II → Medium sand
- Zone III → Fine sand
- Zone IV → Very fine sand

Fineness Modulus (FM)

Formula:
FM = (Sum of cumulative % retained) / 100

Higher FM → coarser aggregate

Importance of Grading

Well Graded Aggregate:

- Less voids
- Strong concrete
- Good workability

Poorly Graded:

- More voids
- Weak concrete

🔹 2.3 WATER

Functions of Water

- Helps in **hydration of cement**
- Provides **workability**

Quality Requirements (IS 456:2000)

- Water should be **clean and potable**
- pH ≥ 6
- Free from:
    - Oil
    - Acid
    - Alkali

Effects of Impure Water

- Reduces strength
- Causes corrosion of steel
- Affects durability

FINAL CONCLUSION

Concrete ingredients work together as:

- **Cement → Binder (glue)**
- **Aggregates → Strength & bulk**
- **Water → Hydration + workability**

Proper selection and proportion = **Strong and durable concrete**

UNIT 3 –

WATER-CEMENT RATIO

3.1 Hydration of Cement

Definition

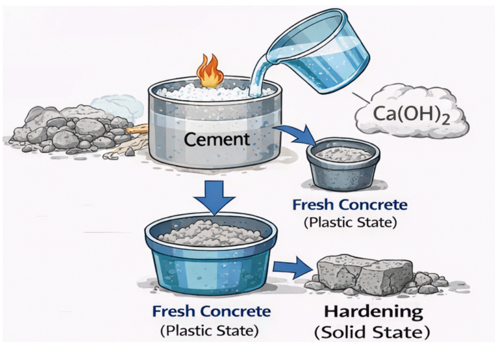
Hydration is a **c**hemical reaction between cement and water that forms a hard and strong mass.

Simple idea: *Cement + Water → Hard concrete*

What Happens in Hydration?

- When water is added to cement → reaction starts
- Heat is released (exothermic reaction)
- New compounds are formed:
  - **C-S-H gel** → gives strength
  - **Calcium hydroxide**

C-S-H gel is the **main reason for strength in concrete**



Explanation

- Cement paste is formed
- Paste surrounds sand and aggregates
- It binds everything together
- Slowly, the mix becomes hard and strong

This process continues for many days (strength increases with time)

Example

When concrete is used in a slab:

- Initially soft
- After some time → becomes hard
- After days → becomes very strong

This happens due to hydration

Water-Cement Ratio (w/c ratio)

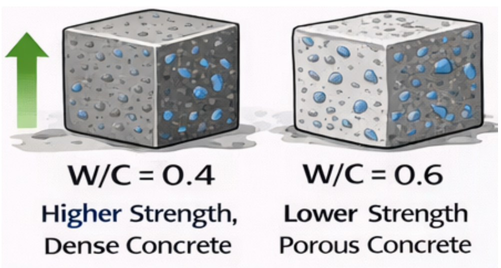
Definition

Water-cement ratio is the **ratio of weight of water to weight of cement** in a concrete mix.

Formula (simple):
w/c ratio = Water / Cement

Basic Principle

- Low w/c ratio → High strength
- High w/c ratio → Low strength but high workability



Explanation (Very Simple)

- Less water → dense concrete → strong
- More water → more pores (holes) → weak

Water creates spaces after evaporation → reduces strength

Duff Abrams' Water-Cement Ratio Law

Definition

Given by **Duff A. Abrams**

Statement:
"Strength of concrete is inversely proportional to water-cement ratio."

Meaning

- If water increases → strength decreases
- If water decreases → strength increases

Examples

- w/c = **0.4** → high strength concrete
- w/c = **0.6** → lower strength but easier to work

Limitations of Water-Cement Ratio Law

This law is not always perfect because:

- Not valid for very low or very high ratios
- Does not consider:
  - Compaction (how well concrete is pressed)
  - Curing (water treatment after placing)
  - Quality of aggregates

So, strength depends on many factors, not only water

Effects of Water-Cement Ratio on Concrete

Low Water-Cement Ratio

- High strength
- Less permeability
- Durable concrete

- But less workability (hard to mix)

High Water-Cement Ratio

- Low strength
- More pores
- More permeability (water can enter easily)
- Less durable

Final Conclusion

- Hydration is the **main process that makes concrete strong**
- Water-cement ratio is the **most important factor affecting strength**

Proper balance is necessary:

- Too little water → difficult to work
- Too much water → weak concrete

SUPER SHORT REVISION LINE

- Hydration → gives strength
- w/c ratio → controls strength

Less water = strong concrete
More water = weak concrete

UNIT 4: Workability

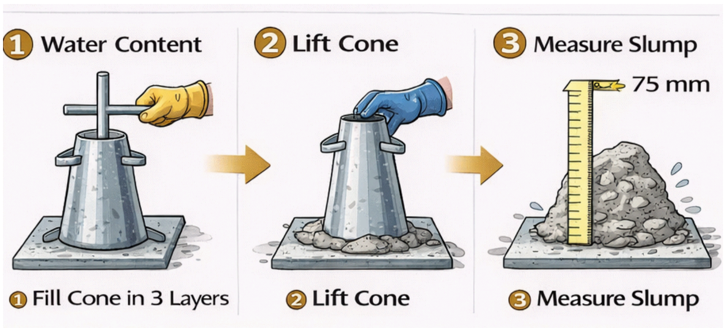
4.1 Workability

Definition

Workability is the **ease with which concrete can be mixed, placed, compacted, and finished**.

Simple idea: *How easily we can handle and use concrete*

Factors Affecting Workability



1. Water Content

- More water → more workability
- Less water → less workability

2. Aggregate Size & Shape

- Larger size → better workability
- Rounded → more workable
- Angular → less workable

3. Cement Content

- More cement paste → smoother mix → better workability

4. Temperature

- High temperature → reduces workability (water evaporates)

5. Admixtures

- Chemicals added to improve workability

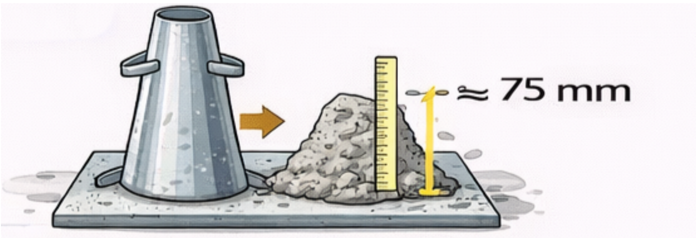
Example: Plasticizers increase workability

Measurement of Workability

1️⃣ Slump Test

Definition

A simple test to measure **consistency of concrete** using a slump cone.



Explanation

- Concrete is filled in a cone
- Cone is lifted
- Concrete settles (slumps)

👉 The height difference = slump value

Example

- Slump = **50–100 mm** → medium workability

2️⃣ Compacting Factor Test

Definition

Measures how much concrete can be compacted under standard effort

Use

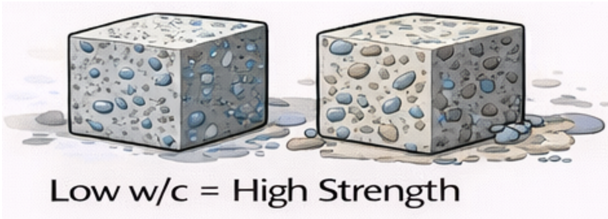
- Used for **low workability concrete**

Example: Road construction

3️⃣ Vee-Bee Consistometer Test

Definition

Measures time taken for concrete to change shape under vibration



Use

- Used for **very stiff concrete**

Recommended Slump Values

- Road work → **25–50 mm**
- Mass concrete → **25–75 mm**
- RCC beams/slabs → **50–100 mm**
- Columns → **75–150 mm**

Final Summary

- Workability = ease of handling concrete
- Affected by water, aggregates, cement, temperature, admixtures
- Measured by slump, compacting factor, Vee-Bee test

UNIT 5:

Properties of Concrete

Concrete has different properties in two stages:

1. Plastic State (fresh concrete)
2. Hardened State (after setting)

5.1 Properties in Plastic State (Fresh Concrete)

1. Workability

Definition:
Workability is the ease with which fresh concrete can be mixed, placed, and compacted.

Explanation:
Good workability means concrete can be handled easily without difficulty. It should not be too dry or too wet.

Example:
Concrete that flows easily into moulds and fills all gaps without segregation.

2. Segregation

Definition:
Segregation is the **separation of coarse aggregates from the cement paste**.

Explanation:
It happens when concrete is handled improperly or when too much water is added. Heavy particles settle down, and lighter paste moves up.

Example:
During pouring, gravel collects at the bottom and cement paste remains at the top.

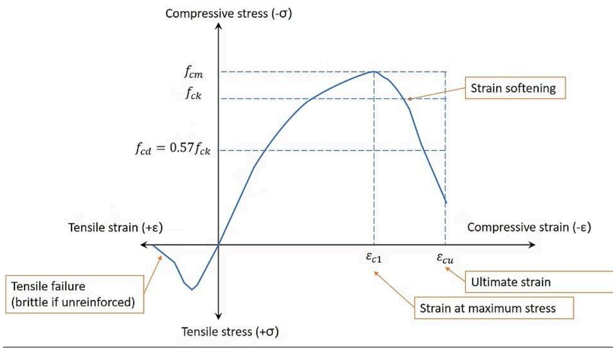
3. Bleeding

Definition:
Bleeding is the **upward movement of water to the surface** of fresh concrete.

Explanation:
After placing concrete, water comes up because heavier particles settle down. This forms a thin water layer on top.

Example:
Water seen on the surface of freshly placed concrete slab.

4. Harshness



Definition:
Harshness means concrete is **not smooth and difficult to work with**.

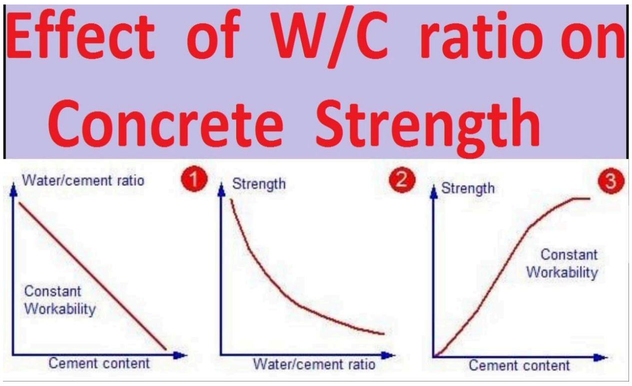
Explanation:
It occurs when there is less cement paste or poor grading of aggregates. Such concrete is hard to spread and compact.

Example:
Concrete that does not spread easily and requires more effort to level.

5.2 Properties in Hardened State

1. Strength

Definition:
Strength is the ability of concrete to **resist loads without failure**.



Explanation:
Concrete is strong in compression. Its strength depends on water-cement ratio, curing, and quality of materials.

Example:
Compressive strength is tested using concrete cubes in a testing machine.

2. Durability

Definition:
Durability is the ability of concrete to **withstand weather, chemicals, and wear over time**.

Explanation:
Durable concrete can last for many years without damage if properly designed and maintained.

Example:
Concrete bridges and buildings that remain strong for decades.

3. Impermeability

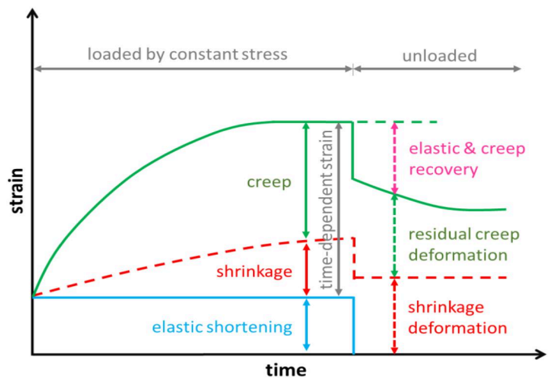
Definition:
Impermeability is the ability of concrete to **resist the entry of water**.

Explanation:
Less permeable concrete prevents leakage and protects reinforcement from corrosion.

Example:
Water tanks and dams are made with impermeable concrete.

4. Dimensional Changes

Definition:
Dimensional changes are changes in size or shape of concrete due to temperature and moisture.



- Blue line → Elastic shortening
- Red dashed → Shrinkage (moisture loss se)
- Green line → Creep (continuous load ke wajah se slow deformation)

Types:

(a) Shrinkage

- Reduction in size due to loss of moisture

Example:
Cracks formed when concrete dries

(b) Creep

- Slow deformation under continuous load

Example:
Concrete beam slightly bending over time under load

Final Summary

- Plastic state properties affect handling and placing
- Hardened state properties affect strength and life of structure

Concrete should be:

- Easy to work (workable)
- Strong
- Durable
- Impermeable

UNIT 6 –

PROPORTIONING FOR NORMAL CONCRETE

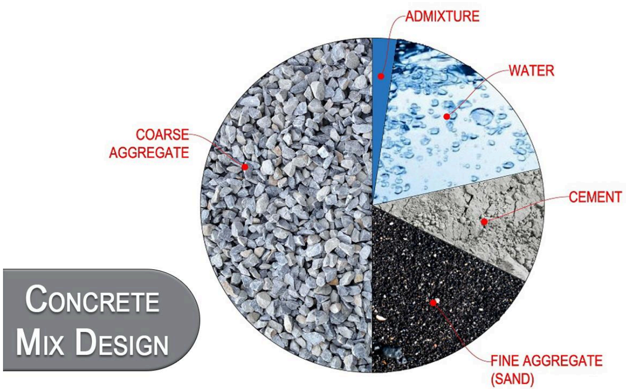
6.1 Objectives of Mix Design

Definition

Mix design is the process of **selecting suitable materials (cement, sand, aggregates, water)** and deciding their **correct proportions** to produce concrete of required strength, workability, and durability.

Simple idea: Deciding how much of each material is needed to make good quality concrete

Objectives of Mix Design



1. Achieve Required Strength

Concrete should have enough strength to carry loads safely.

Example:
Concrete used in buildings must support slabs, beams, and columns.

2. Ensure Workability

Concrete should be easy to mix, place, and compact.

Example:
Concrete should flow easily into moulds without difficulty.

3. Provide Durability

Concrete should resist weather, chemicals, and wear for a long time.

Example:
Concrete structures like bridges should last many years without damage.

4. Make Concrete Economical

Use minimum materials without reducing quality.

Example:
Avoid using excess cement to reduce cost.

Grades of Concrete (IS 456:2000)

Definition

Grades of concrete represent the **compressive strength of concrete after 28 days**.

Examples

- **M10, M15** → Ordinary concrete
- **M20, M25** → Standard concrete
- **M30 and above** → High strength concrete

Example:
M20 means **20 MPa strength after 28 days**

Nominal Mix Proportion (IS 456:2000)

Definition

Nominal mix uses **fixed ratios** of cement, sand, and aggregate without detailed calculations.

Simple idea: *Ready-made proportions*

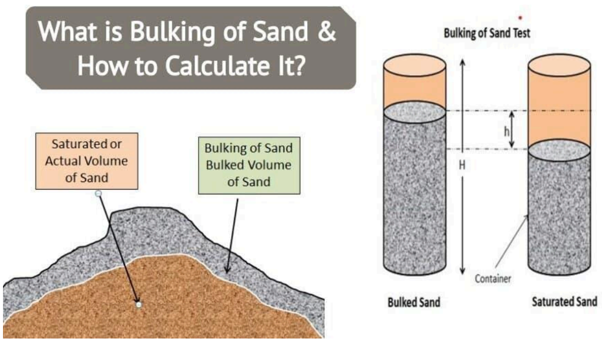
Examples

- M10 → **1 : 3 : 6**
- M15 → **1 : 2 : 4**
- M20 → **1 : 1.5 : 3**

Easy to use but less accurate

6.2 Adjustments on Site

1. Bulking of Fine Aggregate



Definition

Increase in volume of sand due to moisture.

Explanation

When sand is wet, it occupies more volume than dry sand.

Example

While measuring sand by volume, wet sand gives wrong quantity, so correction is needed.

2. Water Absorption of Aggregate

Definition

Amount of water absorbed by aggregates.

Explanation

Dry aggregates absorb water from concrete mix, reducing effective water.

Example

Extra water is added when aggregates are dry.

3. Workability Adjustment

Definition

Adjusting water or admixtures to get proper workability.

Explanation

Water is added carefully to make concrete easy to handle.

Example

Adding small amount of water to improve flow (but not too much)

6.3 Difference: Nominal vs Controlled Concrete

Basis	Nominal Concrete	Controlled Concrete
Mix	Fixed ratio	Designed mix
Accuracy	Low	High

Strength	Approximate	Precise
Quality Control	Low	High

Controlled concrete is used in important structures for better quality.

6.4 Introduction to IS 10262:2009

Definition

IS 10262:2009 is a **code for design mix of concrete**.

Explanation

- Mix is designed using **laboratory calculations**
- It considers:
    - Water-cement ratio
    - Required strength
    - Durability
    - Material properties

Provides **accurate and reliable proportions**

Final Conclusion

- Mix design helps in selecting correct proportions of materials
- Ensures strength, durability, and economy
- Nominal mix is simple but less accurate
- Controlled mix is better and more reliable

UNIT 7:

<u>Introduction to Admixtures</u>

Definition

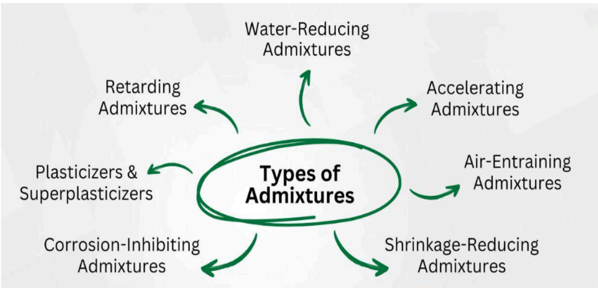
Admixtures are **materials added to concrete before or during mixing** to improve its properties.

Simple idea: *Extra materials added to make concrete better*

Why Admixtures are Used (Purpose)

- To improve **workability**
- To control **setting time**
- To increase **strength and durability**
- To reduce **water requirement**
- To improve performance in special conditions

Types of Admixtures



1. Chemical Admixtures

These are chemicals added in small quantities to change concrete properties.

(a) Accelerators

Function:

- Increase the **setting speed** of concrete

Use:

- Cold weather
- Urgent construction

Example:
Helps concrete set quickly in winter

(b) Retarders

Function:

- **Delay the setting time** of concrete

Use:

- Hot weather
- Long transportation

Example:
Concrete remains workable for longer time

(c) Plasticizers

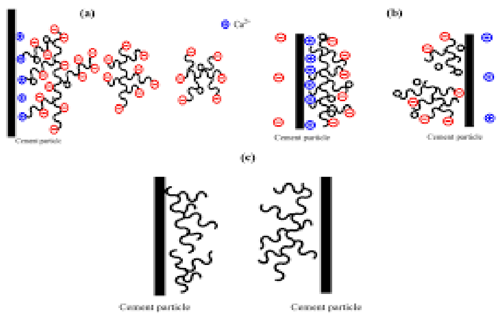
Function:

- Improve **workability** without adding extra water

Use:

- High strength concrete
- Easy placing

Example:



Concrete becomes easy to pour without reducing strength

2. Mineral Admixtures

These are fine materials added to improve strength and durability.

(a) Fly Ash

- By-product from thermal power plants
- Improves workability and durability

(b) Silica Fume

- Very fine material
- Increases strength and reduces permeability

(c) Slag

- By-product from steel industry
- Improves durability and reduces heat

Example (Very Important)

Adding a **plasticizer** makes concrete:

- Easier to mix and place
- More workable
- Without increasing water

This helps in maintaining strength

Advantages of Admixtures

- Improves workability
- Increases strength
- Controls setting time
- Improves durability
- Reduces cracks

Final Summary

- Admixtures are added to improve concrete properties
- Two main types:
    - Chemical admixtures
    - Mineral admixtures

They help in making concrete **stronger, more workable, and durable**

UNIT 8:
Special Concretes

8.1 Concreting Under Special Conditions

Definition

Concreting done under **extreme environmental conditions** like very cold, hot, or underwater situations.

Normal methods do not work properly, so special care is required.

8.1.1 Cold Weather Concreting

Difficulties

- Hydration becomes **slow**
- Water may **freeze**
- Strength development is delayed

Precautions

- Use **warm water** for mixing
- Protect concrete from **frost** using covers
- Keep temperature above freezing

8.1.2 Underwater Concreting

Difficulties

- Cement paste may **wash away**
- Causes **segregation**
- Reduces strength

Precautions

- Use **tremie method** (pipe method for placing concrete)
- Avoid direct contact with flowing water
- Use special mix with good cohesion

8.1.3 Hot Weather Concreting

Difficulties

- Rapid **evaporation of water**
- Causes **cracks**
- Reduces workability

Precautions

- Use **cold water**
- Place concrete quickly
- Do proper **curing** to retain moisture

8.2 Ready Mix Concrete (RMC)

Definition

Concrete that is **prepared in a factory or plant** and delivered to site in ready-to-use form.

Features

- Better **quality control**
- Saves **time and labour**
- Uniform mixing

Example

Concrete delivered by mixer trucks to construction site

8.3 Fibre Reinforced Concrete (FRC)

Definition

Concrete in which **fibres (steel, glass, plastic)** are added.

Features

- Increased strength
- Better **crack resistance**
- Improved durability

Example

Used in pavements and industrial floors

8.4 Polymer Concrete

Definition

Concrete in which **polymers are used instead of or along with cement**.

Features

- Very high strength
- High **chemical resistance**
- Fast setting

Example

Used in chemical plants and repair works

8.5 Fly Ash Concrete

Definition

Concrete in which **fly ash replaces a part of cement**.

Features

- Eco-friendly
- Reduces heat of hydration
- Improves durability

Example

Used in mass concrete structures like dams

8.6 Silica Fume Concrete

Definition

Concrete containing **silica fume (very fine material)**.

Features

- Very high strength
- Very low permeability
- Dense structure

Example

Used in high-strength structures like bridges

Final Summary

- Special concretes are used for **special conditions and requirements**
- Different types improve strength, durability, and performance