Chapter 6: Water – Requirements and Impurities

Introduction

Water is an essential ingredient in the preparation of concrete and other construction activities. It serves multiple roles such as aiding hydration of cement, providing workability to concrete, and maintaining curing conditions to ensure strength development. However, not all water is suitable for construction purposes. The presence of impurities can severely affect the quality, durability, and strength of construction materials. This chapter delves into the functional requirements of water in civil engineering works and examines the types of impurities typically found in water that can affect its usability.

6.1 Requirements of Water for Construction

Water used in construction should be **clean and free from deleterious materials** such as oil, acid, alkali, salts, sugar, organic materials, or other substances that may be harmful to concrete or steel. The requirements for water can be categorized based on its use:

6.1.1 For Mixing Concrete

Water used for mixing concrete should:

- Facilitate proper hydration of cement.
- Ensure sufficient workability without segregation.
- Not contain substances that adversely affect setting time or strength.

Specifications:

- pH should generally be between 6 to 8.
- Total dissolved solids (TDS) should be less than 2000 mg/L.
- Organic content should not exceed 200 mg/L.
- Chloride content should be less than 500 mg/L for RCC and less than 1000 mg/L for plain concrete.

- Sulphate content should be less than 400 mg/L.

6.1.2 For Curing Concrete

Curing water is used to maintain moisture in concrete for hydration.
Requirements:

- Should not contain large amounts of salts or acids that can react with concrete.
- Clean and free from contaminants.
- Especially important when using recycled or groundwater sources.

6.1.3 For Cleaning Construction Equipment

- Water must not leave deposits on equipment.
- Must be free from oils and suspended particles that can affect reuse or pollute surrounding materials.

6.2 Effects of Impurities in Water

Impurities in water can have various detrimental effects on concrete and reinforcement:

6.2.1 Effect on Setting Time

- **Sugars** and **organic matter** can **delay setting time**.
- **Acids** may cause **rapid setting** and premature hardening.

6.2.2 Effect on Strength

- **Chlorides** and **sulphates** interfere with cement hydration, leading to **reduced compressive strength**.
- Impurities may create voids or weak zones in concrete microstructure.

6.2.3 Effect on Reinforcement Steel

- **Chlorides** accelerate corrosion in steel reinforcement.
- **Acidic water** can degrade protective alkaline environment around steel bars.

6.2.4 Effect on Durability

- Long-term exposure to **sulphates**, **alkalies**, and **salts** can lead to deterioration, spalling, and cracking.

- Promotes **efflorescence** and surface deterioration.

6.3 Common Impurities Found in Water

6.3.1 Suspended Solids

These include clay, silt, organic matter, and fine sand.

- Increase water demand.
- Lead to bleeding and segregation.
- Affect bond between cement and aggregates.

6.3.2 Dissolved Solids

Includes calcium, magnesium, sodium, potassium, sulphates, chlorides, nitrates, bicarbonates.

- **Chlorides** and **sulphates** are most harmful.
- High TDS affects cement chemistry and curing effectiveness.

6.3.3 Organic Matter

Includes algae, plant debris, sewage waste.

- Retards hydration reaction.
- Introduces air pockets or foam in mix.
- Leads to unpredictable setting and strength loss.

6.3.4 Oils and Greases

Often come from industrial waste or machinery.

- Inhibit bonding in concrete.
- Affect workability and cohesion.

6.3.5 Acids and Alkalis

- Cause serious deterioration of cementitious materials.
- Lower pH values can break down concrete matrix.
- Promote corrosion in steel reinforcement.

6.4 Acceptable Limits for Impurities

The **IS: 456-2000** code provides general guidelines for the permissible limits of impurities in water:

Impurity	Permissible Limit (mg/L)
Organic matter	200
Inorganic matter	3000
Sulphates (as SO_4)	400
Chlorides (as Cl) – Plain concrete	200
Chlorides (as Cl) – RCC	500
pH value	≥ 6.0

If water is not meeting these standards, it should be tested and treated before use in construction.

6.5 Testing of Water for Construction Use

6.5.1 pH Test

- Determines acidity or alkalinity.
- Use a pH meter or indicator paper.
- Desired range: 6–8.5.

6.5.2 Chemical Analysis

- Standard laboratory tests for:
  - Chloride content
  - Sulphate content
  - Organic impurities
  - TDS (Total Dissolved Solids)
- Often done as per IS: 3025 and IS: 456 guidelines.

6.5.3 Setting Time Comparison Test

- Mix cement with test water and compare initial and final setting time against distilled water.
- Acceptable if setting time does not deviate by more than 30 minutes.

6.5.4 Compressive Strength Test

- Concrete cubes prepared with test water should give **at least 90%** of strength of cubes made with distilled water after 7 days.

6.6 Sources of Water and Their Suitability

6.6.1 Tap Water (Municipal Supply)

- Generally suitable.
- May require testing for large projects.

6.6.2 Groundwater (Wells and Borewells)

- Often contains high TDS, chlorides, and sulphates.
- Requires proper testing.

6.6.3 River and Surface Water

- May contain organic matter and silt.
- Suitability depends on proximity to industrial discharge or urban waste.

6.6.4 Sea Water

- **Not suitable** for concrete, especially reinforced concrete, due to high chloride content.
- Can be used only for plain concrete in special cases with approval and under strict design.

6.7 Treatment Methods for Impure Water

If the water does not meet the construction standards, treatment may be necessary:

6.7.1 Filtration

- Removes suspended particles and organic debris.
- Sand filters or cloth filters are common.

6.7.2 Neutralization

- Acids and alkalies can be neutralized by adding appropriate reagents.
- Lime is commonly used for acid neutralization.

6.7.3 Distillation or Reverse Osmosis

- For removing salts and dissolved solids.
- Used in sensitive projects (e.g., nuclear power plants, dams).

6.7.4 Aeration and Settling

- Removes volatile organics and allows suspended particles to settle before use.

6.8 Practical Considerations in Construction Projects

In real-world scenarios, engineers often encounter constraints regarding the availability and quality of water. Some important practical aspects are discussed below:

6.8.1 Water Availability at Site

- Remote or rural construction sites may lack access to piped or treated water.
- In such cases, groundwater or nearby surface water is used, but **mandatory testing** must be performed before use.

6.8.2 Storage and Handling of Water

- Water tanks (preferably overhead or raised) should be used to avoid contamination.
- Pipes and hoses should be cleaned regularly to prevent algae or sediment buildup.
- Separate tanks should be maintained for potable water and construction water to avoid mix-ups.

6.8.3 Water Use in Different Weather Conditions

- In **hot climates**, more water is required for curing due to evaporation.
- **Cold weather** may delay setting time, so warm or lukewarm water may be needed for mixing.
- During the **monsoon**, ensure water used is not mixed with floodwater or contaminated sources.

6.9 IS Codes and International Standards

Engineers must adhere to standard practices outlined by national and international codes. Some relevant standards include:

6.9.1 Indian Standards (IS)

- **IS 456:2000** – Plain and Reinforced Concrete – Code of Practice.
- **IS 3025 (Part 22)** – Methods of Sampling and Test (Physical and Chemical) for Water and Wastewater.
- **IS 4925:2004** – Concrete Batching and Mixing Plant: Requires water used in plant to meet quality specifications.

6.9.2 International Standards

- **ASTM C1602** – Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete.
- **BS EN 1008** – Mixing Water for Concrete – Specification for Sampling, Testing, and Assessing the Suitability of Water.

Compliance ensures safety, longevity, and legal reliability of civil structures.

6.10 Case Studies of Water-Related Failures

Case Study 1: RCC Building Near a Coastal Zone

- *Issue*: Corrosion observed in reinforcement bars just 3 years post-construction.
- *Cause*: Sea water used for mixing and curing, high chloride levels accelerated corrosion.
- *Lesson*: Chloride limits must not be exceeded, especially in reinforced concrete.

Case Study 2: Delayed Setting in a Road Project

- *Issue*: Concrete mix showed delay in initial setting time by over 4 hours.
- *Investigation*: Organic contamination from pond water used for mixing.
- *Solution*: Water source changed, and sugar content tests made mandatory.

6.11 Environmental and Sustainability Aspects

With growing concern for environmental conservation and sustainable development, water use in construction should follow eco-friendly practices.

6.11.1 Recycled Water Use

- Treated greywater or wastewater from construction activities (like wash water) can be reused after treatment.
- Must comply with IS/ASTM limits before use.
- Useful for non-structural applications: cleaning tools, curing, site cleaning.

6.11.2 Rainwater Harvesting

- Rainwater can be collected and stored at the site for curing and washing.
- Reduces dependency on groundwater and municipal supply.

6.11.3 Water Footprint of Concrete

- A typical cubic meter of concrete may require 150–200 liters of water.
- Using admixtures and water reducers can optimize this quantity.

6.12 Field Guidelines for Engineers and Supervisors

1. **Always test water quality** before the start of construction—especially if using non-municipal sources.
2. **Store water** in closed or covered tanks to avoid algae, debris, or mosquito breeding.
3. **Test monthly** for large construction projects if the source is not guaranteed safe (e.g., open well).
4. **Train workers** on not mixing drinking water lines with construction lines.
5. **Label water tanks** clearly as “For Construction Use Only” if not potable.
