Chapter 7: Fresh Concrete – Properties and Workability Tests (IS Standards)

Introduction

Fresh concrete refers to the concrete mixture in its plastic state—just after mixing and before setting begins. At this stage, concrete should be workable, cohesive, and homogeneous so that it can be placed, compacted, and finished effectively without segregation or excessive bleeding. The properties of fresh concrete directly affect the durability, strength, and finish of the final structure. To ensure quality and consistency, various standardized workability tests are employed, guided by Indian Standards, mainly **IS 1199 (1959)**: *Methods of Sampling and Analysis of Concrete*.

7.1 Properties of Fresh Concrete

Fresh concrete must exhibit specific characteristics for effective handling, placing, compaction, and finishing. The most crucial properties include:

7.1.1 Workability

Workability is the ease with which concrete can be mixed, transported, placed, and compacted without segregation. It is a composite property influenced by:

- Water-cement ratio
- Aggregate shape, size, and grading
- Admixtures
- Ambient temperature

  IS Code Reference: *IS 1199:1959* provides standard methods for assessing workability.

7.1.2 Consistency

Consistency refers to the relative mobility or flowability of fresh concrete. It indicates how wet or dry the concrete mix is and affects the ease of placement.

- High consistency: Easy to flow (used for deep/narrow sections)
- Low consistency: Stiff mix (used where formwork is open or well-supported)

7.1.3 Cohesiveness

Cohesiveness is the ability of concrete to remain homogenous during mixing and handling. A cohesive mix resists segregation and bleeding.

- A lack of fines or excessive water can reduce cohesiveness.

7.1.4 Segregation

Segregation is the separation of constituents of concrete, where coarse aggregates separate from the mortar.

- Causes: Improper mix proportions, excessive vibration, large differences in specific gravity
- Prevention: Proper grading, use of admixtures, adequate mix design

7.1.5 Bleeding

Bleeding is the emergence of water on the surface of freshly placed concrete due to settlement.

- Controlled by using air-entraining agents or reducing water content
- Excessive bleeding weakens the surface layer and increases permeability

7.1.6 Harshness

Harshness refers to the resistance offered by concrete to finishing operations. Harsh mixes are difficult to work and compact.

- Caused by deficient fines or angular coarse aggregates

7.2 Workability Tests of Fresh Concrete (As per IS Standards)

7.2.1 Slump Test

- **Purpose:** To assess the consistency and relative workability of fresh concrete.
- **Apparatus:** Slump cone (300 mm height, 100 mm top dia, 200 mm bottom dia), tamping rod, base plate.
- **Procedure:**
  a. Place the cone on a flat, non-absorbent base.
  b. Fill concrete in three layers, tamping each with 25 strokes.
  c. Remove the cone vertically.
  d. Measure the vertical slump (difference in height).
- **Types of Slump:**
  - **True Slump:** Uniform subsidence; desirable.
  - **Shear Slump:** One side shears off; indicates lack of cohesion.
  - **Collapse Slump:** Complete collapse; indicates very high workability.

- **Limitations:** Not suitable for very low or very high workability concrete.

  IS Code Reference: *IS 1199:1959* – Method of slump test.

7.2.2 Compacting Factor Test

- **Purpose:** Measures workability for low workability concrete, more accurate than slump test.
- **Apparatus:** Two hoppers and a cylinder mounted vertically, weighing scale.
- **Procedure:**
  a. Fill upper hopper, then release to lower hopper and finally to cylinder.
  b. Weigh the partially compacted concrete.
  c. Fill the cylinder fully with compacted concrete and weigh again.
  d. Calculate Compacting Factor:

$$\text{Compacting Factor} = \frac{\text{Weight of partially compacted concrete}}{\text{Weight of fully compacted concrete}}$$

- **Typical Range:** 0.7 to 0.95
- **Applications:** Suitable for stiff mixes used in road construction or roller-compacted concrete.

  IS Code Reference: *IS 1199:1959* – Method of compacting factor test.

7.2.3 Flow Table Test

- **Purpose:** To determine the flow of concrete of very high workability.
- **Apparatus:** Flow table (dia. ~700 mm), flow mold (cone-shaped), tamping rod.
- **Procedure:**
  a. Fill the mold with concrete in two layers, each tamped 25 times.
  b. Lift the mold and drop the table 15 times.
  c. Measure final spread in two directions and take the average.
- **Flow (%) Calculation:**

$$\text{Flow}(\%) = \frac{(D_1 + D_2)}{2} - D_0 \div D_0 \times 100$$

- Where D_0 is original dia., D_1 and D_2 are spread diameters.

- **Application:** Suitable for very fluid mixes, SCC (self-compacting concrete).

  IS Code Reference: *IS 1199:1959* – Method of flow table test.

7.2.4 Vee-Bee Consistometer Test

- **Purpose:** To determine the workability of very low slump concrete.
- **Apparatus:** Vee-Bee consistometer, slump cone, vibrating table, transparent cylinder.
- **Procedure:**
  a. Perform slump test inside the cylindrical container.
  b. Apply vibration until the concrete completely remolds to a cylindrical shape.
  c. Measure time taken for complete remolding (Vee-Bee time in seconds).
- **Interpretation:** More time → lower workability.
- **Application:** Ideal for stiff concrete used in pavements and precast work.

  IS Code Reference: *IS 1199:1959* – Method of Vee-Bee test.

7.3 Factors Affecting Workability

Several factors influence the workability of fresh concrete:

Factor	Effect on Workability
Water-Cement Ratio	Higher w/c ratio → increased workability
Aggregate Shape	Rounded → better workability; Angular → lower workability
Aggregate Size	Larger size → more workable mix
Grading of Aggregates	Well-graded → improved cohesiveness
Admixtures	Plasticizers/superplasticizers → improved flow without extra water
Temperature	High temp → rapid setting, reduced workability
Mixing Time and Method	Proper mixing → uniformity and better workability

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7.4 Acceptance Criteria and Field Application

- **Target Slump:** Based on structural application (as per IS 456:2000)
  - Mass concrete: 25–75 mm
  - Reinforced sections: 75–100 mm
  - Pumped concrete: 100–150 mm
- **Frequency of Testing:** Slump test should be performed for each batch or as directed by site QA/QC norms.
- **Record Keeping:** Maintain test logs for slump values, ambient conditions, and adjustments.

7.5 Special Considerations in Workability Assessment

7.5.1 Workability of Special Concretes

With the evolution of concrete technology, new types of concrete with unique performance characteristics have emerged. These require tailored workability tests and understanding.

(a) Self-Compacting Concrete (SCC)

- **Workability Requirements:** Extremely high.
- **Tests Used:** Slump flow test, L-box test, J-ring test, V-funnel test.
- **Standard:** EFNARC Guidelines (Europe), but often referenced in Indian mega projects.
- **Slump Flow Value (mm):** 650–800 mm (no slump cone removed, it flows on its own).

(b) Fiber-Reinforced Concrete

- Presence of steel, glass, or polypropylene fibers influences flow.
- Requires modified compacting techniques.
- Workability slightly reduced; fibers may cause balling if not mixed properly.

(c) Lightweight Concrete

- High air content leads to lower cohesion.
- Requires more attention during transport and placement.
- Use of air-entraining agents improves workability.

7.6 Modern Practices to Improve Workability

To address issues arising in high-performance construction, several modern strategies are used:

7.6.1 Chemical Admixtures

Admixture Type	Purpose
Plasticizers	Improve workability at same water content
Superplasticizers (High-range water reducers)	Significantly increase flowability
Retarders	Delay setting time, helpful in hot weather
Accelerators	Speed up setting, used in cold weather

> **IS Code Reference:** *IS 9103:1999* – Specification for Concrete Admixtures.

7.6.2 Mineral Admixtures

These improve cohesiveness, reduce bleeding, and improve pumpability:

- Fly Ash (IS 3812)
- Silica Fume
- Ground Granulated Blast Furnace Slag (GGBS)
- Metakaolin

7.7 Field Problems and Troubleshooting in Fresh Concrete

Understanding field-level challenges in workability is essential for site engineers.

7.7.1 Segregation during Pumping

- **Cause:** Over-vibration, excessive slump, improper mix grading.
- **Solution:** Use viscosity modifying admixtures (VMAs), proper mix proportioning.

7.7.2 Rapid Slump Loss

- **Cause:** High ambient temperature, prolonged transport, high cement content.
- **Solution:** Add retarders, limit mix travel time, use chilled water.

7.7.3 Bleeding at Top Surface

- **Cause:** Excessive water content, poorly graded aggregates.
- **Solution:** Reduce water-cement ratio, use supplementary cementitious materials (SCMs).

7.7.4 Harsh Mix in RMC Plants

- **Cause:** Coarse grading, insufficient fines.
- **Solution:** Re-balance fine/coarse aggregate ratio, use fly ash or fine sand.

7.8 Quality Control and Workability Monitoring at Site

7.8.1 Frequency of Testing

Concrete Volume	Number of Slump Tests (as per IS 4926:2003 for RMC)
< 5 m^3	1 test per batch
6–15 m^3	1 test per 2 batches
> 15 m^3	1 test per 3–4 batches

7.8.2 Recording & Interpretation

- Maintain daily logbook for:
  - Slump value
  - Ambient temperature
  - Mix design reference
  - Batch number
- Investigate if slump variation $> \pm 25$ mm occurs frequently.

7.8.3 Workability vs Strength Trade-off

- **Higher Workability:** Easier placement but may reduce strength due to higher water content.
- **Lower Workability:** Higher strength potential, but risks segregation and incomplete compaction.

  Balance is critical—achieve required slump without compromising water-cement ratio.

7.9 IS Codes Relevant to Fresh Concrete Testing

IS Code	Title
IS 1199:1959	Methods of Sampling and Analysis of Concrete
IS 456:2000	Plain and Reinforced Concrete – Code of Practice

IS Code	Title
IS 9103:1999	Specification for Concrete Admixtures
IS 4926:2003	Ready Mixed Concrete – Code of Practice
IS 10262:2019	Guidelines for Concrete Mix Design Proportioning

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7.10 Case Study: Workability Issues in a Metro Rail Project (India)

In a real-time metro rail viaduct construction project in Delhi:

- **Problem:** Frequent slump collapse in RMC, especially during noon deliveries.
- **Investigation:**
  - Ambient temperature ~42°C
  - Transit time 50–70 min
  - Water loss due to evaporation
- **Action Taken:**
  - Shifted to chilled water batching
  - Introduced retarder-based superplasticizers
  - Reduced delivery radius of batching plant

Outcome: Slump stabilized at 120 mm, without segregation or strength compromise.
