Chapter 8: Topics in Fresh Concrete

Introduction

Fresh concrete refers to the state of concrete in which it is fully mixed and can be easily placed, compacted, and finished. The behavior of concrete in this state significantly influences its performance in the hardened state. Understanding the characteristics and handling of fresh concrete is crucial for achieving the desired strength, durability, and workability. This chapter covers the essential properties, factors affecting behavior, and methods for measuring and enhancing the quality of fresh concrete.

1. Workability of Fresh Concrete

1.1 Definition

Workability is the ease with which concrete can be mixed, placed, compacted, and finished without segregation or bleeding. It is one of the most important properties of fresh concrete.

1.2 Factors Affecting Workability

- **Water Content**: More water increases workability but may reduce strength.
- **Aggregate Size and Shape**: Rounded aggregates improve workability; angular aggregates reduce it.
- **Grading of Aggregate**: Well-graded aggregates improve workability.
- **Cement Content**: Higher cement content enhances lubrication, improving workability.
- **Admixtures**: Plasticizers and superplasticizers can increase workability without changing water-cement ratio.
- **Time and Temperature**: Delay in placing and high temperatures can reduce workability due to rapid setting.

1.3 Measurement of Workability

- **Slump Test**: Measures the vertical settlement of concrete under its own weight.
- **Compacting Factor Test**: Measures the degree of compaction achieved under standard conditions.
- **Vee-Bee Consistometer Test**: Measures the time required to transform concrete from a slump cone shape to a cylindrical shape.
- **Flow Table Test**: Assesses the flowability of concrete, especially for very fluid mixes.

---

2. Segregation and Bleeding

2.1 Segregation

The separation of coarse aggregates from the cement paste or mortar during handling. It leads to non-uniform concrete and reduced strength.

Types of Segregation:

- **Coarse particles settling down**.
- **Paste separating from aggregates**.
- **Water rising to the top** (linked to bleeding).

Causes:

- Poorly graded aggregates.
- Excessive vibration.
- Dropping concrete from height.
- High water-cement ratio.

2.2 Bleeding

Bleeding is the movement of water to the surface of freshly placed concrete.

Effects:

- Formation of laitance.
- Weak surface layer.
- Increases permeability.
- Causes water pockets below aggregates and reinforcement.

Control Measures:

- Use of air-entraining agents.
- Proper mix design.
- Reduced water content.
- Use of finer cement or mineral admixtures.

---

3. Setting Time of Concrete

3.1 Definition

Time required for concrete to transition from a plastic to a hardened state.

3.2 Initial and Final Setting Times

- **Initial Setting Time**: Time when concrete starts losing its plasticity.
- **Final Setting Time**: Time when concrete hardens enough to resist certain pressure.

3.3 Factors Affecting Setting Time

- **Type of cement** (e.g., rapid hardening, ordinary Portland).
- **Temperature**: Higher temperatures accelerate setting.
- **Water-cement ratio**: High w/c ratio delays setting.
- **Admixtures**: Accelerators decrease, retarders increase setting time.

---

4. Mixing of Concrete

4.1 Hand Mixing

- Used for small works.
- Requires clean platform and tools.
- Prone to inconsistency if not done properly.

4.2 Machine Mixing

- Performed using drum-type mixers or pan mixers.
- Ensures uniform mixing of ingredients.
- Better quality and speed compared to hand mixing.

4.3 Ready Mix Concrete (RMC)

- Concrete manufactured in a batching plant and delivered to site.
- High quality control and consistency.
- Suitable for large-scale projects.

---

5. Transportation of Concrete

5.1 Methods

- **Wheelbarrows, trolleys, or pans**: For short distances.
- **Buckets or crane hoists**: For vertical transportation.
- **Transit mixers**: For ready-mix concrete.
- **Pumps**: For large-scale or inaccessible areas.

5.2 Precautions

- Avoid segregation and loss of moisture.

- Complete transportation within initial setting time.
- Cover during hot or rainy weather.

---

6. Placing of Concrete

6.1 Guidelines

- Concrete should be placed as near as possible to its final position.
- Avoid dropping from heights (use chutes or tremie).
- Place in horizontal layers of 150–300 mm.
- Compact each layer properly before placing the next.

6.2 Common Errors

- Delays in placing.
- Cold joints due to interruptions.
- Improper compaction.

---

7. Compaction of Concrete

7.1 Purpose

- To remove air voids.
- Ensure complete contact with reinforcement and formwork.
- Increase density and strength.

7.2 Methods

- **Hand Compaction**: Rodding, tamping, tamping bars.
- **Mechanical Vibration**:
  - **Internal Vibrators**: Poker vibrators.
  - **External Vibrators**: Fixed to formwork.
  - **Surface Vibrators**: Used for thin slabs.

7.3 Precautions

- Avoid over-vibration to prevent segregation.
- Ensure full coverage of reinforcement.
- Maintain uniform vibration throughout.

---

8. Curing and Its Early Requirements

(Though curing typically comes after fresh state, its initial actions can impact fresh concrete behavior)

8.1 Early Curing Measures

- Prevent rapid moisture loss.
- Cover with wet burlap, plastic sheets.
- Use of curing compounds or fog sprays in hot weather.

---

9. Temperature Effects on Fresh Concrete

9.1 Hot Weather Concreting

- Accelerated setting.
- Higher water demand.
- Greater risk of shrinkage cracks.
- Use chilled water, ice flakes, or retarding admixtures.

9.2 Cold Weather Concreting

- Delayed setting and hardening.
- Risk of freezing water.
- Use warm water, accelerators, or heated aggregates.

---

10. Admixtures and Their Role in Fresh Concrete

10.1 Types of Admixtures

- **Plasticizers/Superplasticizers**: Improve workability without increasing water.
- **Retarders**: Delay setting time.
- **Accelerators**: Speed up setting and strength gain.
- **Air-Entraining Agents**: Improve durability and workability.
- **Shrinkage-reducing Admixtures**: Control early-age cracking.

---

11. Rheology of Fresh Concrete

11.1 Definition

Rheology is the study of flow and deformation of materials. In concrete, it refers to its flow behavior under stress.

11.2 Parameters

- **Yield stress**: Stress required to initiate flow.
- **Plastic viscosity**: Resistance to flow once movement starts.
- **Thixotropy**: Reversible time-dependent decrease in viscosity (important during pumping and vibration).

---

12. Self-Compacting Concrete (SCC)

12.1 Definition

A special type of concrete that flows and compacts under its own weight without the need for vibration.

12.2 Fresh Properties

- High flowability.
- Resistance to segregation.
- High passing ability (flows through reinforcement).

12.3 Fresh Concrete Tests for SCC

- Slump flow test.
- L-box test.
- J-ring test.
- V-funnel test.

12.4 Advantages of SCC in Fresh State

- **No Vibration Required**: Reduces labor and noise at construction sites.
- **Uniform Quality**: Minimizes human error during compaction.
- **Improved Surface Finish**: Due to smooth flow and better mold filling.
- **Time-Saving**: Faster placement especially in congested reinforcement zones.
- **Reduced Risk of Voids**: Fills every corner without honeycombing.

12.5 Challenges of SCC in Fresh State

- **High Material Cost**: Requires increased use of cementitious materials and admixtures.
- **Mix Design Complexity**: Needs precise proportioning and testing.
- **Sensitivity to Variations**: Small changes in water content can cause segregation or flow loss.
- **Quality Control Demand**: Must conduct frequent rheological tests on-site.

---

13. Pumping of Fresh Concrete

13.1 Introduction

Pumping is a convenient and widely used method of transporting fresh concrete over long horizontal or vertical distances using pipelines and pumps.

13.2 Requirements for Pumpable Concrete

- Sufficient cohesiveness to avoid segregation.
- Proper mortar fraction to lubricate the pipe.
- Well-graded aggregate (maximum size typically $< 1/3$ of pipe diameter).
- Use of admixtures like plasticizers and viscosity-modifying agents.

13.3 Factors Affecting Pumpability

- **Aggregate Properties**: Angular aggregates reduce pumpability.
- **Water-Cement Ratio**: Low ratio may cause blockages; high may lead to segregation.
- **Pipeline Layout**: Bends and vertical rises add resistance.
- **Pumping Pressure and Equipment**: Must be optimized for the specific mix.

13.4 Common Problems

- **Blockage**: Caused by improper mix or segregation.
- **Bleeding During Pumping**: Can result in reduced strength zones.
- **Loss of Workability**: Due to frictional resistance and pipe length.

---

14. Hot and Cold Weather Concreting – Fresh State Behavior

14.1 Hot Weather Concreting

Issues:

- Rapid evaporation leads to plastic shrinkage cracks.
- Shortened setting time causes handling difficulties.
- Increased water demand reduces strength.

Measures:

- Use chilled water or ice in mix.
- Schedule pours during cooler hours.
- Use retarders and hydration stabilizers.

- Shade aggregates and formwork.

14.2 Cold Weather Concreting

Issues:

- Freezing water expands and damages the paste structure.
- Very slow hydration rate.

Measures:

- Heat mixing water and aggregates.
- Use accelerators (e.g., calcium chloride).
- Protect freshly placed concrete with insulated blankets.
- Avoid frozen subgrade placement.

---

15. Quality Control of Fresh Concrete on Site

15.1 Visual Inspection

- Consistency across batches.
- No signs of segregation or bleeding.
- Color and texture check.

15.2 Routine On-Site Tests

- Slump test (ASTM C143 / IS 1199).
- Temperature measurement.
- Air content test (for air-entrained concrete).
- Unit weight and yield check.

15.3 Sampling and Frequency

- As per IS 4926 and IS 456:2000.
- One sample per 5 m^3 or per batch for small projects.
- Maintain sampling records for traceability.

---

16. Effect of Time Delay on Fresh Concrete

16.1 Loss of Workability

- Due to continued hydration and moisture evaporation.
- Leads to stiffening and poor compaction.

16.2 Cold Joints

- Occur when new concrete is placed against hardened concrete.
- Weak interface if delay exceeds initial setting time.

16.3 Measures to Minimize Effects

- Use retarding admixtures.
- Reduce delay between mixing and placing.
- Re-tempering (adding water) is discouraged but can be done cautiously under strict quality control.

---

17. Use of Mineral Admixtures in Fresh Concrete

17.1 Fly Ash

- Improves workability due to spherical particles.
- Reduces heat of hydration.

17.2 Silica Fume

- Decreases workability, increases cohesiveness.
- Needs high-range water reducers.

17.3 GGBFS (Ground Granulated Blast Furnace Slag)

- Improves pumpability.
- Slower setting in cold weather.

17.4 Metakaolin and Rice Husk Ash

- Enhances cohesiveness.
- May demand more water unless plasticizers are used.

---

18. Hydration Control Techniques

18.1 Importance

In large pours, uncontrolled hydration can lead to excessive heat and cracking. Managing hydration in the fresh stage is vital.

18.2 Methods

- Use of hydration control admixtures.
- Cooling the mix using chilled water, ice, or liquid nitrogen.
- Use of supplementary cementitious materials to reduce cement content.

---

19. Use of Recycled Aggregates in Fresh Concrete

19.1 Fresh Concrete Behavior

- Increased water absorption reduces workability.
- Surface texture of recycled aggregates affects paste requirement.

19.2 Modifications Required

- Pre-soaking recycled aggregates.
- Adding extra water or admixtures.
- Careful grading to maintain consistency.

---

20. Recent Advances in Fresh Concrete Technology

20.1 3D Printable Concrete

- Requires high viscosity and thixotropy.
- Must be pumpable and extrudable but hold shape quickly.

20.2 Ultra-High-Performance Concrete (UHPC)

- Extremely low water-cement ratio (~0.2).
- Requires powerful mixers and superplasticizers.

20.3 Smart Admixtures

- Time-release admixtures that alter behavior based on ambient conditions.
- Self-adjusting mixes for temperature or humidity.
