Chapter 8: Fresh Concrete – Segregation, Bleeding, Slump Loss, Re-tempering

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Introduction

Fresh concrete is a plastic, workable mixture of cement, water, fine and coarse aggregates, and sometimes admixtures, that can be molded or placed into formwork before hardening. The properties of fresh concrete are crucial for ensuring the quality, durability, and strength of the final hardened concrete. Several phenomena such as segregation, bleeding, slump loss, and re-tempering can significantly affect the performance of concrete in its fresh state. Understanding these behaviors is vital for proper handling, placement, compaction, and finishing of concrete on construction sites.

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1. Segregation

Definition:

Segregation is the separation of the constituents of concrete, mainly due to differences in particle size and density. In simple terms, it's when the coarse aggregates separate from the mortar (cement paste and fine aggregates), resulting in non-uniform composition and reduced homogeneity.

Types of Segregation:

- **Coarse Aggregate Settling:** Heavier and larger aggregates settle down due to gravity, leaving a paste-rich layer at the top.
- **Paste Separation:** In very wet mixes, the cement paste and water may rise to the top, separating from the aggregates.
- **Water Separation:** Excessive water rises to the top surface, carrying cement particles with it, forming a laitance layer.

Causes:

- Poorly graded aggregates.
- Excessive vibration or compaction.
- High water-cement ratio (overly wet mixes).
- Dropping concrete from excessive heights.
- Insufficient cohesive strength of the mix (low fines or improper mix design).

Effects:

- Non-uniform strength in the structure.

- Formation of voids and honeycombing.
- Weak interfacial transition zone (ITZ) between aggregate and paste.
- Poor surface finish and durability issues.
- Structural weaknesses and potential failure under loads.

Prevention Methods:

- Use well-graded and properly proportioned aggregates.
- Optimize the water-cement ratio.
- Limit concrete drop height (preferably < 1.5 m).
- Use proper compaction techniques.
- Incorporate admixtures like plasticizers to improve workability without increasing water content.

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2. Bleeding

Definition:

Bleeding is a specific type of segregation where water in the mix rises to the surface of freshly placed concrete due to the settlement of solid particles (cement and aggregates).

Types of Bleeding:

- **Normal Bleeding:** Occurs gradually and can be reabsorbed during finishing.
- **Channel Bleeding:** Water forms continuous channels, especially along rebar or formwork, leading to weak zones.
- **Delayed Bleeding:** Occurs after finishing, leaving a weak surface layer.

Causes:

- High water-cement ratio.
- Over-sanded or under-sanded mix.
- Poor cement quality or insufficient fines.
- Use of poorly graded aggregates.

Effects:

- Formation of laitance on the surface.
- Weak bond between layers or with reinforcement.
- Cracking due to plastic shrinkage.
- Reduced durability and resistance to wear.
- Poor surface texture.

Control Measures:

- Use low bleeding cements (e.g., blended cement with fly ash).
- Optimize fine content and gradation.
- Include mineral admixtures (e.g., silica fume, fly ash).
- Use air-entraining agents to stabilize the mix.
- Avoid excessive water addition during mixing.

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3. Slump Loss

Definition:

Slump loss refers to the reduction in workability or slump of fresh concrete over time after mixing. It indicates the stiffening of concrete which can make placement and compaction difficult if delayed.

Typical Timeline:

Slump loss may start within 20 to 60 minutes after mixing, depending on ambient conditions, cement type, and admixtures.

Causes:

- High ambient temperature and wind.
- Rapid hydration of cement.
- Evaporation of water due to high temperature or low humidity.
- Delays in transportation, placing, or compaction.
- High cement content leading to faster stiffening.
- Inadequate use of water-retaining or workability-enhancing admixtures.

Effects:

- Difficulty in placement and finishing.
- Poor compaction leading to voids and honeycombing.
- Cold joints due to non-continuous placement.
- Lower bond with reinforcements.
- Reduction in final strength and durability.

Control Measures:

- Use retarders to delay setting time.
- Employ chilled water or ice flakes in mixing to lower concrete temperature.
- Use of set-controlling or slump-retaining admixtures.
- Reduce transportation time or use ready-mix trucks with agitation.
- Schedule batching and placing in sync to avoid delays.

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4. Re-tempering

Definition:

Re-tempering is the addition of water or mixing of concrete after initial setting has started to regain workability.

Context:

Concrete begins to lose workability as hydration progresses. Sometimes, workers add water to regain the slump and ease placement, especially if delays occur on site.

Consequences:

- Weakening of concrete due to disrupted hydration.
- Reduced compressive and tensile strength.
- Increased permeability and shrinkage.
- Inconsistent setting times leading to cracks.
- Reduced bond strength between aggregate and paste.

IS Code Guidelines:

As per IS 456:2000, re-tempering should be avoided after 30 minutes of initial mixing. If water has to be added, it should be done under strict supervision and re-mixed thoroughly to maintain consistency.

Alternatives to Re-tempering:

- Use of slump-retaining admixtures or retarders at batching.
- Plan placing and finishing works efficiently.
- Use of ready-mix concrete with extended setting times for long distances.
- Re-dosing with admixtures instead of water (only under technical guidance).

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5. Field Practices to Minimize Defects in Fresh Concrete

While understanding theoretical causes of segregation, bleeding, slump loss, and re-tempering is essential, it is equally important to adopt appropriate site practices. Here's how these issues are managed on-site:

5.1 Site Handling and Transportation:

- **Use wheelbarrows, dumpers, or pumps** that minimize jolting or shaking during transport.
- Avoid long vertical drops. Use **elephant trunks, tremie pipes, or chutes** when placing concrete in deep forms.

- **Agitate concrete during transit** in transit mixers to prevent premature slump loss.

5.2 Placing Techniques:

- Place concrete **close to its final position** to reduce handling.
- Ensure **layer-wise placement** with proper vibration (usually 150–200 mm thick layers).
- Avoid over-vibration, which can cause segregation.

5.3 Timing and Supervision:

- Concrete should ideally be **placed and compacted within 30–45 minutes** of mixing.
- Supervisors should monitor **temperature, slump, and time logs**.
- Concrete that begins to stiffen should not be used unless revalidated by testing or admixture addition under supervision.

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6. Testing of Fresh Concrete Properties

Fresh concrete is tested on-site to assess its workability, cohesiveness, and suitability for placement. Some standard tests related to this chapter's topics are as follows:

6.1 Slump Test (IS 1199:1959):

- Measures workability by **vertical slump height** after lifting a standard cone.
- Acceptable range: 75–125 mm for normal construction; lower for pavement concrete, higher for pumped concrete.

6.2 Bleeding Test:

- Conducted in a cylindrical container to measure the amount of **free water** rising to the top.
- Acceptable bleeding: **less than 1%** by weight of cement (for well-proportioned concrete).

6.3 Segregation Resistance Test:

- Performed via **visual observation** or by using segregation column tests (measuring coarse aggregate concentration at different heights).
- High-performance concrete should exhibit **less than 5% variation** between top and bottom aggregate content.

6.4 Temperature and Setting Time:

- Use a **thermometer and penetration resistance test** to measure concrete temperature and initial/final setting times.
- Excessive temperature (>35°C) accelerates slump loss and can increase bleeding risk.

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7. Role of Admixtures in Controlling Fresh Concrete Behavior

Admixtures are chemical or mineral additives that enhance specific properties of concrete. The following types are particularly useful for improving fresh concrete behavior:

7.1 Plasticizers and Superplasticizers:

- Increase workability **without increasing water content**.
- Help in reducing segregation and slump loss.

7.2 Air-Entraining Agents:

- Introduce **microscopic air bubbles** that improve cohesion and reduce bleeding.
- Enhance freeze-thaw resistance as well.

7.3 Retarders:

- **Delay the initial setting time**, allowing more time for placing and finishing.
- Useful in hot weather concreting or long transit operations.

7.4 Viscosity-Modifying Admixtures (VMAs):

- Control segregation in **self-compacting concrete (SCC)**.
- Increase paste viscosity without affecting slump.

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8. Guidelines from Indian Standards and Codes

Concrete quality and practices are governed by a set of standards in India:

Standard Code	Subject
IS 456:2000	General concrete design and practices
IS 1199:1959	Methods of sampling and testing concrete

Standard Code	Subject
IS 10262:2019	Concrete mix proportioning
IS 9103:1999	Use of chemical admixtures
IS 4926:2003	Ready-mixed concrete

Note: Codes recommend **rejection** of concrete that shows signs of segregation or excessive slump loss unless corrective action is taken.

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9. Effects on Hardened Concrete and Long-term Durability

Improper behavior in the fresh state directly affects long-term performance:

Fresh Concrete Issue	Effect on Hardened Concrete
Segregation	Non-uniform strength, voids, and cracking
Bleeding	Weak top surface, poor abrasion resistance
Slump Loss	Incomplete placement, poor compaction, cold joints
Re-tempering	Lower strength, increased porosity, inconsistent setting

Therefore, **early quality control of fresh concrete** ensures the long-term strength and durability of the structure.
