Chapter 26: Special Concrete and Concreting Methods – Hot & Cold Weather Concreting

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Introduction

Concrete is one of the most versatile and widely used construction materials in the world. However, its properties and performance can be significantly influenced by environmental conditions during mixing, transporting, placing, and curing. Among such conditions, extreme temperatures—either high (hot weather) or low (cold weather)—pose substantial challenges that affect the strength, durability, workability, and integrity of concrete.

To overcome these challenges, special concreting techniques are employed. This chapter focuses on the various **methods, materials, and precautions** involved in *hot weather concreting* and *cold weather concreting*, both of which are essential for ensuring the quality and longevity of concrete structures in challenging environments.

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1. Hot Weather Concreting

1.1 Definition of Hot Weather Concreting

Hot weather concreting refers to the placement of concrete in conditions where **ambient temperatures are high**, typically above **40°C** for plain concrete and **35°C** for reinforced concrete, **including the effects of wind and humidity**. These conditions accelerate the rate of evaporation of moisture from the concrete surface, potentially leading to plastic shrinkage cracks, lower workability, reduced strength, and poor durability.

1.2 Challenges in Hot Weather Concreting

- **Increased Rate of Evaporation**: Rapid moisture loss leads to plastic shrinkage cracking.
- **Reduced Workability**: Water evaporates quickly, making the mix stiffer and difficult to place and compact.
- **Accelerated Setting Time**: Cement hydrates faster at higher temperatures, reducing the time available for placing and finishing.
- **Higher Risk of Thermal Cracks**: Due to temperature gradients between surface and core.
- **Decreased Long-Term Strength**: High initial temperatures accelerate hydration but reduce later strength gain.

- **Increased Water Demand**: Often leads to higher water-cement ratio, reducing strength and durability.

1.3 Measures to Control Effects of Hot Weather

A. Before Concreting

- **Use of Admixtures**:
  - Retarders to delay setting.
  - Water-reducing admixtures to maintain workability without increasing water content.
- **Pre-Cooling of Ingredients**:
  - Use chilled water or ice flakes instead of normal mixing water.
  - Cool aggregates by shading or spraying with water.
- **Material Storage**:
  - Store cement and aggregates in shaded areas.
  - Avoid direct exposure to sunlight.

B. During Concreting

- **Night or Early Morning Concreting**: Perform operations when temperatures are lower.
- **Use of Wind Breaks and Sunshades**: Around work areas to minimize wind and direct sun exposure.
- **Rapid Placement and Finishing**: Minimize delay between mixing, placing, and curing.

C. Curing Techniques

- **Immediate and Continuous Curing**: Use wet burlaps, curing compounds, or water ponds.
- **Evaporation Reducers**: Spray on surface to prevent rapid moisture loss.
- **Fogging and Mist Sprays**: To maintain surface moisture and temperature.

1.4 Special Techniques in Hot Weather Concreting

- **Cooling Concrete Internally**:
  - Embedded pipes circulating chilled water through large structures.
- **Use of Fly Ash or Slag Cement**:

  - Reduces the heat of hydration and enhances long-term strength.
- **Use of Superplasticizers**:
  - Enhance workability without extra water.
- **Concrete Mix Design Modifications**:
  - Lower cement content, increase coarse aggregate, and optimize gradation.

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2. Cold Weather Concreting

2.1 Definition of Cold Weather Concreting

Cold weather concreting is defined as placing concrete **when the air temperature falls below 5°C** for more than 24 hours or **when temperatures below 10°C** are expected within the first 24 hours after placement. In such conditions, the hydration process slows drastically, potentially halting altogether, resulting in poor strength development, freezing of mixing water, and serious durability issues.

2.2 Challenges in Cold Weather Concreting

- **Delayed Strength Gain**: Hydration is slower at low temperatures.
- **Freezing of Water**: Mixing water can freeze, expanding and damaging the concrete.
- **Thermal Cracking**: Due to freezing and thawing cycles or internal temperature gradients.
- **Inadequate Curing**: Cold slows down or halts the curing process.
- **Reduced Bonding**: Between concrete and reinforcement if ice or frost is present on bars.

2.3 Measures to Control Effects of Cold Weather

A. Before Concreting

- **Heating of Materials**:
  - Heat mixing water and/or aggregates to achieve desired mix temperature.
- **Removal of Ice and Snow**:
  - From formwork, reinforcement, and base surface before placement.
- **Use of Accelerating Admixtures**:

    - Calcium chloride (up to 2% by weight of cement) or non-chloride accelerators.
- **Use of Low Water-Cement Ratio**:
    - Prevents excess water from freezing.

B. During Concreting

- **Insulated Formwork**:
    - Use of polystyrene boards, blankets, or tarps to retain heat.
- **Enclosed and Heated Work Area**:
    - Tents or enclosures with heaters and temperature monitoring systems.
- **Rapid Placement and Finishing**:
    - Avoid long exposure to freezing air before finishing.

C. Curing Techniques

- **Thermal Curing**:
    - Use of heated enclosures or steam curing.
- **Blanket Curing**:
    - Use of thermal blankets to retain the heat of hydration.
- **Monitoring Temperature**:
    - Ensure concrete temperature does not fall below 5°C during the first 48 hours.
- **Extended Curing Periods**:
    - Concrete in cold weather requires longer curing durations for adequate strength.

2.4 Special Techniques in Cold Weather Concreting

- **Use of Air-Entrained Concrete**:
    - Improves freeze-thaw resistance by providing space for ice expansion.
- **Thermal Insulation of Forms and Slabs**:
    - Maintain internal temperature and avoid rapid cooling.
- **Electric Heating Cables**:
    - Embedded in large concrete pours to maintain internal temperature.

- **Use of Early Strength Cement or Type III Cement**:
  - Achieves required strength more quickly.

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3. Comparative Table: Hot Weather vs Cold Weather Concreting

Aspect	Hot Weather Concreting	Cold Weather Concreting
Main Concern	Rapid evaporation, shrinkage, and cracking	Freezing, delayed hydration, poor strength gain
Critical Temperature	> 35–40°C	< 5°C
Admixtures Used	Retarders, water-reducers	Accelerators, air-entraining agents
Cement Content	Reduced to lower heat of hydration	Often increased or replaced with early strength cement
Timing of Work	Done in cooler hours (night or early morning)	Often done with heating enclosures
Water Handling	Use chilled water or ice	Heated water to prevent freezing
Special Curing	Evaporation control, fog sprays	Heated enclosures, thermal blankets

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4. Codes and Standards (IS Codes)

- **IS 7861 (Part 1)**: Guidelines for Hot Weather Concreting
- **IS 7861 (Part 2)**: Guidelines for Cold Weather Concreting
- **IS 456:2000**: Plain and Reinforced Concrete – Code of Practice
- **IS 10262**: Concrete Mix Proportioning – Guidelines

Sure! Here's **Chapter 26: Special Concrete and Concreting Methods – Hot & Cold Weather Concreting** for your **BTech Civil Engineering e-book** on *Materials, Testing & Evaluation*, presented with an **introduction** and **complete in-depth explanation** of topics without a summary.

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5. Field Practices and Quality Control

In extreme temperature concreting, **on-site practices** and **continuous quality control** play a vital role in achieving desired concrete performance. This section outlines field-based strategies:

5.1 Pre-Concreting Inspection

- **Weather Monitoring**: Temperature, wind speed, and humidity must be recorded continuously.
- **Equipment Readiness**:
  - Water chillers, aggregate cooling or heating systems.
  - Enclosures and heating elements in cold weather zones.
- **Material Check**:
  - Cement should be stored in dry, cool places.
  - Aggregates should be clean, free from frost or excessive moisture.
- **Formwork Preparation**:
  - Insulated in both weather extremes.
  - Free of snow or extremely hot surfaces.

5.2 In-Situ Temperature Measurement

- **Thermometers or Thermocouples** are embedded in the concrete mass to monitor:
  - Initial concrete temperature.
  - Temperature rise or drop during setting.
  - Differential between core and surface temperatures.

5.3 Slump and Workability Checks

- Conduct **slump test (IS 1199)** at the time of placing to ensure proper workability.
- In hot weather, a loss in slump over time should be recorded to decide on retarder dosage.
- In cold weather, ensure slump is not falsely increased due to added heated water.

5.4 Setting Time Determination

- Use of **penetration resistance method** or **Vicat needle apparatus** to determine initial and final setting time.
- Accelerators and retarders influence setting time and must be checked against standard control specimens.

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6. Testing of Concrete Under Extreme Conditions

Testing of concrete prepared or placed in hot and cold conditions helps in verifying compliance with structural design criteria.

6.1 Compressive Strength Tests

- **Cube/Cylinder Tests (IS 516)** at 3, 7, 28 days.
- In cold weather, strength gain may be delayed; testing at 56 or 90 days is recommended for realistic assessment.

6.2 Temperature-Maturity Relationship

- Use of **Maturity Method**:
  - $M = \sum(T_a - T_0) \times \Delta t$
  - Where T_a is average concrete temperature, T_0 is datum temperature.
- Helps in predicting strength based on cumulative heat development.

6.3 Surface Crack Inspection

- **Plastic Shrinkage Cracks** in hot weather are detected using early-age inspection.
- **Thermal Cracking** in cold weather is measured using strain gauges or crack width measuring tools.

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7. Case Studies and Applications

7.1 Hot Weather Project – Dubai Metro Project

- Extreme desert temperatures (> 45°C) challenged the use of traditional OPC.
- Solution:
  - Use of **fly ash blended cement**.
  - **Chilled water and aggregate pre-cooling**.
  - **Night-time concreting and fogging**.
- Result:
  - Achieved required 28-day strength and avoided cracking.

7.2 Cold Weather Project – Moscow Underground Parking

- Winter temperatures dropped to -10°C.
- Solution:
  - Use of **heated tents with blowers**.
  - **Accelerated curing methods** with embedded heating coils.
  - Type III cement to increase early strength.
- Result:

– Controlled heat loss and avoided early-age freezing.

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8. Safety Considerations

Extreme weather concreting introduces specific **health and safety hazards** that must be mitigated on site.

8.1 Hot Weather Safety

- Risk of **heat exhaustion** and **dehydration** to workers.
- Measures:
  - Schedule work during cooler periods.
  - Provide water breaks and shaded rest areas.
  - PPE with reflective clothing.

8.2 Cold Weather Safety

- Risk of **frostbite**, **slips**, and **hypothermia**.
- Measures:
  - Heated rest zones.
  - Anti-slip footwear and gloves.
  - Careful handling of heated water and steam.

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9. Future Innovations in Special Concreting Methods

9.1 Self-Curing Concrete

- Uses **polymer-based admixtures** to retain internal moisture.
- Reduces the need for external curing in both hot and cold climates.

9.2 3D Printing of Concrete in Varying Temperatures

- Uses **temperature-controlled extruders**.
- Allows printing in controlled thermal chambers for precision curing.

9.3 Smart Sensors and IoT Monitoring

- Embedded sensors in concrete track:
  - Internal temperature.
  - Humidity.
  - Strength gain (linked to mobile apps).
- Allows **real-time adjustment** of curing methods.