Chapter 25: Special Concrete and Concreting Methods – Ready-Mix Concrete

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Introduction

In the evolving domain of construction engineering, the demand for high-quality, time-efficient, and durable concrete has led to the development and use of various special concretes. One such innovation is **Ready-Mix Concrete (RMC)**—a tailor-made concrete that is manufactured in a centralized batching plant and delivered to the site in a fresh state. RMC not only enhances quality control but also reduces material wastage, optimizes labor usage, and increases construction speed.

This chapter delves into the concept of ready-mix concrete, its production, transportation, placement, and advantages over conventional site-mixed concrete. We also explore its types, mix design, quality control protocols, and the associated challenges.

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1. Definition of Ready-Mix Concrete

Ready-Mix Concrete (RMC) is a type of concrete that is manufactured in a **batching plant** according to a set engineered mix design and then delivered to the construction site in a plastic or unhardened state, typically using **transit mixer trucks**.

RMC is produced under controlled conditions using consistent quality raw materials, ensuring uniformity and quality of the concrete mix.

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2. Components of Ready-Mix Concrete

The basic constituents of RMC are the same as conventional concrete, but strict quality checks and automated processes ensure consistency.

2.1 Cement

- Ordinary Portland Cement (OPC), PPC, PSC, or other types depending on the requirement.
- Stored in silos to prevent contamination and moisture ingress.

2.2 Aggregates

- **Fine Aggregates:** River sand or manufactured sand conforming to IS:383.

- **Coarse Aggregates:** Crushed granite, basalt, or other hard stones.
- Aggregates are washed and graded before use.

2.3 Water

- Potable water or water conforming to IS:456 requirements.
- Accurate water-cement ratio is maintained through automation.

2.4 Admixtures

- Used to modify concrete properties like workability, setting time, or strength.
- Types: Plasticizers, Superplasticizers, Retarders, Accelerators, Air-entraining agents, etc.

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3. Types of Ready-Mix Concrete

3.1 Transit Mixed Concrete (Truck Mixed)

- All materials are batched at the plant and mixed in the truck en route to the site.
- Mixing can be started at the plant or delayed until the truck is en route.

3.2 Shrink Mixed Concrete

- Partially mixed at the batching plant and completed in the truck mixer.
- Offers better quality control than transit mixing.

3.3 Central Mixed Concrete (Plant Mixed)

- Fully mixed at the central batching plant before loading into the truck.
- Least variation in quality; often used for large projects.

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4. Production Process of Ready-Mix Concrete

4.1 Batching

- The proportioning of raw materials is done by **weight batching** (not volume).
- Batching plant operations are automated and controlled by software.

4.2 Mixing

- Mixing time depends on the type of plant and mixing method (central or truck).
- Uniform mixing is ensured using high-shear mixers.

4.3 Quality Control

- Slump, temperature, and air content are checked before dispatch.
- Cube samples are taken periodically to test compressive strength.

4.4 Transportation

- Concrete is transported in **agitating trucks** or **transit mixers**.
- Time from batching to placement should not exceed **90 minutes** (as per IS:4926).
- Agitation speed is reduced during transportation to avoid segregation.

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5. Placement and Handling of RMC

5.1 Site Preparation

- Site should be prepared with proper access roads, storage, and unloading space.
- Adequate formwork and compaction tools should be ready.

5.2 Pouring

- Concrete is discharged directly from the transit mixer or through chutes/pumps.
- Placement should be continuous to avoid cold joints.

5.3 Compaction

- Compacted using vibrators immediately after placement.
- Over-vibration should be avoided to prevent segregation.

5.4 Curing

- Curing must begin as early as possible to retain moisture and promote hydration.
- Water curing, curing compounds, or wet coverings may be used.

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6. Advantages of Ready-Mix Concrete

- **Quality Assurance:** Uniform and consistent concrete quality.
- **Speed:** Faster construction due to pre-prepared mix.
- **Material Efficiency:** Reduced wastage and better resource management.
- **Labor Reduction:** Minimizes on-site manpower requirements.
- **Environmental Benefits:** Reduced dust and noise pollution at site.
- **Space Saving:** No need to store aggregates or cement on-site.

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7. Disadvantages and Challenges

- **Time Constraints:** Limited time between mixing and placement.
- **Transportation Issues:** Traffic delays can affect the concrete setting time.
- **Cost:** Higher initial cost compared to site mix, though offset by savings in labor and time.
- **Site Access:** Requires good road connectivity for transit mixers.

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8. Applications of Ready-Mix Concrete

- **High-rise Buildings:** Ensures quick and quality-controlled concrete supply.
- **Infrastructure Projects:** Roads, bridges, flyovers.
- **Residential & Commercial Buildings:** Where speed and quality are critical.
- **Precast Concrete Manufacturing Units**

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9. Code and Standards

- **IS 4926:2003** – Code of Practice for Ready-Mixed Concrete
- **IS 456:2000** – Code of Practice for Plain and Reinforced Concrete
- **ASTM C94/C94M** – Specification for Ready-Mixed Concrete (for international reference)

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10. Safety and Environmental Considerations

- Workers must wear PPE while handling RMC at site.
- Dust suppression systems are in place at batching plants.
- Wash water and leftover concrete must be disposed of responsibly.
- Noise levels from mixers and batching equipment should be controlled.

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11. Developments in RMC Technology

11.1 Self-Compacting Ready-Mix Concrete (SCC)

- Eliminates the need for vibration.
- Ideal for congested reinforcement zones.

11.2 High-Performance Concrete (HPC)

- Enhanced durability, strength, and performance for specialized structures.

11.3 Green Concrete

- Incorporates industrial waste like fly ash, slag, and silica fume to reduce environmental impact.

11.4 Fiber-Reinforced Ready-Mix Concrete

Fiber-reinforced concrete (FRC) incorporates fibrous materials to enhance the structural integrity of concrete. When added to RMC at the batching plant, it improves tensile strength, crack resistance, and toughness.

Types of Fibers Used:

- **Steel Fibers:** Improve load-carrying capacity and impact resistance.
- **Glass Fibers:** Reduce plastic shrinkage and increase fire resistance.
- **Polypropylene Fibers:** Minimize cracking due to shrinkage and temperature changes.
- **Carbon and Aramid Fibers:** Used in specialized applications requiring high performance.

Benefits in RMC:

- Improved ductility and flexural strength.
- Enhanced durability under dynamic loads.
- Ideal for pavements, tunnels, and industrial flooring.

11.5 Lightweight Ready-Mix Concrete

Lightweight concrete is made using lightweight aggregates such as **expanded clay, pumice, or fly ash aggregates**. It reduces the dead load of structures, making it suitable for high-rise buildings and long-span bridges.

Characteristics:

- Density ranges from 800 to 2000 kg/m^3.
- Good thermal and sound insulation.
- Lower strength than normal-weight concrete but acceptable for many applications.

Uses in RMC:

- Roof insulation.
- Precast blocks and panels.
- Screeds and partitions.

11.6 Ready-Mix Concrete for Pumping

In urban construction, concrete must often be delivered to difficult-to-access locations like high floors or underground structures. **Pumpable RMC** is specially designed to have:

- High workability (slump 100–180 mm).
- Lubricating layer to reduce friction inside pipelines.
- Graded aggregates to prevent blockages.

Considerations:

- Use of superplasticizers to maintain fluidity without excess water.
- Continuous monitoring of pump pressure and flow rate.
- Special admixtures to prevent segregation and bleeding.

11.7 Sustainable Practices in RMC Plants

As the construction industry shifts towards sustainability, RMC manufacturers are adopting environmentally friendly practices.

Water Recycling:

- Water used for truck and mixer washouts is treated and reused.

Dust Control:

- Use of dust extractors and sealed conveyor systems.
- Enclosed silos with air filtration units.

Energy Efficiency:

- Use of solar panels or energy-efficient motors in plant operations.
- Scheduled maintenance to reduce fuel and electricity consumption.

Carbon Footprint Reduction:

- Partial replacement of OPC with **fly ash, GGBS**, or **silica fume**.
- Life-cycle analysis of concrete mixes.

11.8 Quality Control Measures in RMC Plants

Strict quality control is vital in RMC operations to ensure the desired performance on site.

In-Plant Testing:

- Batching accuracy of all materials verified before dispatch.
- Routine tests on aggregates (grading, moisture content, specific gravity).
- Water-cement ratio monitored through automated systems.

On-Site Testing:

- **Slump Test:** Ensures workability.
- **Cube Compression Test:** Strength testing at 7, 14, and 28 days.
- **Temperature Measurement:** Especially crucial in hot weather concreting.
- **Setting Time Tests:** When admixtures are involved.

Record-Keeping:

- Every batch has a unique identification with details of:
  - Mix design,
  - Batch time and date,
  - Truck number,
  - Target and actual slump,
  - Site delivered.

11.9 Automation and Digitalization in RMC Industry

Modern RMC plants are integrating **Industry 4.0** practices to streamline operations and minimize human error.

Features:

- **SCADA Systems:** Monitor batching, mixing, and dispatch in real time.
- **GPS-Enabled Trucks:** Track concrete delivery status.
- **Mobile Apps for Clients:** Provide real-time updates and quality data.
- **AI and ML Integration:** Predictive analysis for optimizing mix design and logistics.

Benefits:

- Reduced downtime and rework.
- Increased transparency with clients.
- Early detection of system failures or material shortages.

11.10 Challenges in RMC Adoption in Developing Nations

Despite its advantages, the adoption of RMC faces resistance in developing countries due to several constraints.

Major Issues:

- **High Initial Investment:** Batching plants and mixers are capital-intensive.
- **Poor Infrastructure:** Bad road conditions delay delivery, risking setting.
- **Untrained Workforce:** Lack of skilled operators and engineers.
- **Lack of Awareness:** Smaller contractors still rely on traditional mixing.

Possible Solutions:

- Government incentives and public-private partnerships.
- Mobile RMC units for rural or remote projects.
- Training and certification programs for plant operators.