Ready Mix Concrete (RMC): A Review of Materials, Production, Testing and Applications

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***Abstract*—Ready Mix Concrete (RMC) is concrete that is batched and mixed in a central plant under controlled conditions and delivered to the construction site in a fresh, workable state, usually in transit mixers. It is widely used in modern civil engineering because it gives uniform quality, saves site space, reduces wastage of materials and speeds up construction. This paper reviews the meaning, types, materials, mix design principles, manufacturing and transportation, testing methods, advantages, limitations, cost aspects and applications of RMC. The review is based on the relevant Indian Standards, mainly IS 4926, IS 456 and IS 10262, and on standard textbooks of concrete technology. The main advantages of RMC are consistent quality, better durability, faster construction, reduced labour and storage requirements, less dust and noise at the site and accurate quantity control. Its main limitations are higher initial cost, dependence on traffic and transport time, the need for a nearby plant, and the need for proper planning and site coordination. The paper also discusses the future scope of RMC in India.**

***Index Terms*—Ready Mix Concrete, transit mixer, batching plant, mix design, admixtures, IS 4926, quality control, slump test.**

I. INTRODUCTION

The construction industry provides residential buildings, commercial buildings, roads, bridges, metro rail systems, schools and hospitals. With increasing population and urbanisation, the demand for construction is growing rapidly. Concrete is the most widely used construction material after water, and its quality directly affects the strength, safety and durability of a structure.

In conventional construction, concrete is prepared at the site, where materials are stored, measured by volume and mixed in small mixers. This needs large storage space, many workers and continuous supervision, and the quality often varies from batch to batch because of inaccurate measurement, variation in the moisture content of aggregates and differences in worker skill. Ready Mix Concrete was developed to overcome these problems.

As defined in IS 4926:2003, RMC is concrete mixed in a central batching and mixing plant, or in a truck mixer, and supplied in a fresh, unhardened condition to the purchaser. The producer is responsible for quality up to the point of delivery, and the contractor is responsible for placing, compacting and curing. The objectives of this paper are (i) to understand the concept and growth of RMC, (ii) to identify its types and materials, (iii) to study its manufacture, transport and placing, (iv) to study tests and quality control, and (v) to study its advantages, limitations, cost and applications.

II. LITERATURE REVIEW

A. Development of RMC

Supply of concrete from a central plant was introduced in the early twentieth century, with first commercial deliveries in Europe and the United States in the early 1900s. The truck-mounted rotating drum mixer of the 1920s allowed concrete to be mixed or agitated in transit and delivered over longer distances. After the Second World War, growth in roads, housing and industry greatly increased the use of RMC.

B. RMC in India

RMC was introduced in India in the early 1990s, first in cities such as Pune, Mumbai, Chennai and Bengaluru, and its use grew with high-rise buildings, flyovers, metro rail and highways. The Bureau of Indian Standards published IS 4926 as the code of

practice for ready-mixed concrete, covering materials, batching, mixing, transport, sampling and testing. BIS also offers third-party certification of RMC plants against IS 4926.

C. Site-Mixed Concrete versus RMC

Site-mixed concrete generally shows greater variation in strength and workability because of volume batching, uncontrolled water content and differences in worker skill. RMC plants use weigh batching and computer control, so the standard deviation of strength is generally lower and the target strength can be achieved with less cement. However, quality at the point of placing also depends on transport time, weather, discharge arrangements and site practice. Uncontrolled addition of water at the site raises the water-cement ratio and reduces strength and durability.

D. Admixtures, Quality Control and Durability

Water-reducing admixtures and superplasticisers allow high workability at a low water-cement ratio, and retarders keep concrete workable during long transport. Fly ash and ground granulated blast furnace slag (GGBS) improve workability, reduce heat of hydration, increase long-term strength and reduce carbon emissions per cubic meter. Durability depends on grade, cement content, water-cement ratio, cover, compaction and curing, and IS 456 gives limiting values for different exposure conditions.

E. Research Gap

The literature shows that (1) RMC quality may change between plant and placing because of delays, traffic, hot weather and site addition of water; (2) use of RMC in small towns and small projects is limited by distance, minimum order quantity and cost; and (3) environmental aspects such as cement consumption, wash water and returned concrete need continuous improvement.

III. TYPES OF READY-MIX CONCRETE

A. Based on Method of Mixing

- Transit-mixed (truck-mixed): all ingredients including water are batched at the plant and mixed in the drum of the transit mixer during travel or just before discharge. It is the most common type in India.
- Shrink-mixed: concrete is partially mixed in the plant mixer and the mixing is completed in the transit mixer, which shortens truck mixing time and increases plant output.
- Central-mixed: concrete is fully mixed in the plant mixer and carried in an agitator truck. It gives good control but needs a high-capacity mixer and a site close to the plant.

B. Based on Specification

Designed mix concrete is specified by performance (grade, slump, aggregate size, exposure) and the producer is responsible for strength; it is the most common type. In nominal mix concrete the purchaser specifies proportions and is responsible for strength. Standard grade mixes such as M15, M20, M25 and M30 can be ordered directly.

C. Grades and Special Types

Grades are classified by characteristic compressive strength at 28 days as per IS 456 (Table I). Modern plants also supply self-compacting concrete, high-strength concrete (M50 and above), pumpable concrete, fibre-reinforced concrete, low-heat concrete and coloured concrete.

TABLE I. Common grades of RMC and typical uses

Grade	f (N/mm^2) ck	Typical use
M10, M15	10, 15	Blinding, levelling, lean concrete
M20	20	Residential slabs, beams, columns, mild exposure
M25	25	General RCC, commercial buildings
M30, M35	30, 35	High-rise buildings, bridges, severe exposure
M40 and above	40+	Prestressed concrete, pavements, high-strength columns

IV. MATERIALS AND MIX DESIGN PRINCIPLES

A. Materials

- Cement: conforming to IS 269 (OPC), IS 1489 Part 1 (PPC) or IS 455 (PSC). OPC 43 and 53 grade are common for higher grades; blended cements give good durability and lower heat of hydration. Cement is stored in silos protected from moisture.

- Aggregates: about 65 to 75 percent of concrete volume, conforming to IS 383. Fine aggregate is smaller than 4.75 mm; coarse aggregate common maximum sizes are 10-, 20- and 40-mm. Surface moisture must be measured and corrected in every batch.
- Water: clean and free from harmful oils, acids, alkalis, sugar, salts and organic matter as per IS 456; pH not less than 6. Treated wash water may be reused only after testing (Table II).
- Chemical admixtures (IS 9103), usually below 2 percent by weight of cement: plasticisers and superplasticisers, retarders, accelerators and air-entraining agents.
- Mineral admixtures: fly ash (IS 3812), GGBS and silica fume, used as partial cement replacement to improve workability, durability and long-term strength.

TABLE II. Permissible limits of impurities in mixing water (IS 456)

Impurity	Max. limit (mg/litre)
Organic matter	200
Inorganic matter	3000
Sulphates (as SO_3)	400
Chlorides, plain concrete	2000
Chlorides, reinforced concrete	500
Suspended matter	2000

B. Mix Design

Mix design selects the proportions of cement, aggregates, water and admixtures to obtain the required strength, workability and durability at least cost, following IS 10262 and the exposure requirements of IS 456. Concrete is designed for a target mean strength higher than the characteristic strength:

$$f_{target} = f_{ck} + 1.65\,s \qquad (1)$$

where f_{target} is the target mean strength at 28 days, f_{ck} the characteristic strength and s the standard deviation (N/mm^2). IS 10262 assumes s = 4.0 for M20 and M25, and 5.0 for M30, M35 and M40; a well-controlled RMC plant often achieves lower values.

For example, for M25 with s = 4.0, f_{target} = 25 + 1.65 x 4.0 = 31.6 N/mm^2 Strength and durability depend mainly on the water-cement ratio: as per Abrams' law, strength decreases as the ratio increases. Superplasticisers let RMC achieve low water-cement ratios with good workability. Exposure limits for reinforced concrete are given in Table III. The steps of mix design are: decide grade, exposure and aggregate size; calculate target strength; select water-cement ratio and water content; compute cement content and check the minimum; find aggregate proportions; and make and adjust trial mixes.

TABLE III. Requirements for reinforced concrete for different exposures (IS 456)

Exposure	Min. cement (kg/m^3)	Max. w/c	Min. grade
Mild	300	0.55	M20
Moderate	300	0.50	M25
Severe	320	0.45	M30
Very severe	340	0.45	M35
Extreme	360	0.40	M40

V. MANUFACTURING AND TRANSPORTATION

A. RMC Plant

An RMC plant consists of aggregate storage and feeding bins, cement silos, water and admixture tanks, weigh batchers with load cells, a mixer (pan, twin-shaft or drum type), a computerised control room, transit mixers and pumps, and a laboratory with a recycling unit. The plant should be easily accessible by road and close to the main areas of demand.

B. Process

The process (Fig. 1) is: receipt of order with grade, quantity and slump; setting of mix design in the plant computer; weigh batching of ingredients; mixing in the plant mixer or transit mixer drum; transport within the time limit; and testing, placing, compaction and curing at site.

C. Batching and Mixing

All solid ingredients are measured by weight, which is more accurate than the volume batching used at sites. Cement, water and admixtures are generally batched to about two to three percent accuracy and aggregates to about three percent, and equipment is calibrated regularly.

Quantities of water and aggregates are corrected for aggregate moisture before every batch, and mixing time must be sufficient to give uniform colour and consistency.

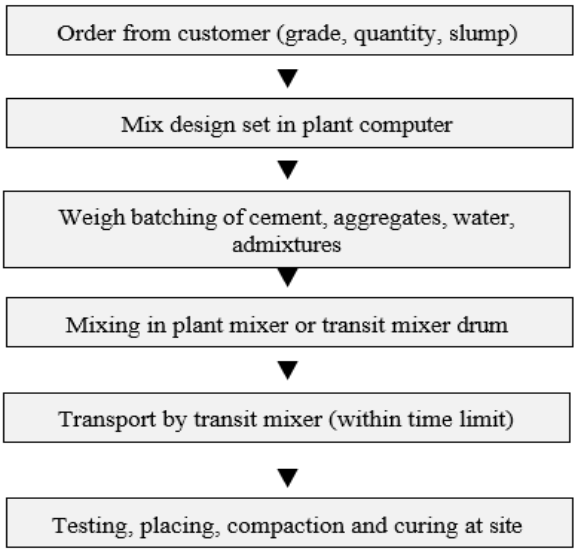

Fig. 1. Process of production and supply of Ready-Mix Concrete

D. Transportation

RMC is carried in transit mixers, trucks with a rotating drum fitted with internal blades, commonly of about 6 m^3 capacity. IS 4926 limits the time between addition of water to cement and discharge; under normal conditions concrete should be discharged within about two hours, less in hot weather, and retarders can extend workable time. The number of transit mixers required is

$$N = (Q \times T) / C \qquad (2)$$

where Q is the rate of placing (m^3/h), T the truck cycle time (h) and C the truck capacity (m^3). For Q = 30 m^3/h, T = 1.5 h and C = 6 m^3, N = (30 x 1.5)/6 = 7.5, so 8 transit mixers are arranged. Precautions include route planning, keeping the drum clean and rotating, no unauthorised addition of water at site, and a delivery challan with every load.

E. Placing, Compaction and Curing

The site must be ready before concrete arrives. Concrete is placed by chute, wheelbarrow, crane and bucket or pump, avoiding free fall from a large height. It is compacted with needle vibrators (beams, columns, walls) or screed vibrators (slabs). As per IS 456, curing continues for at least 7 days for OPC, and at least 10 days where mineral admixtures or blended cements are used or in hot weather.

F. Plant Quality Control

Quality control covers raw material inspection, calibration of load cells and dosing units, comparison of actual and design batch quantities, testing of slump, temperature and cube strength, and maintenance of batch records and delivery challans for traceability.

VI. TESTING AND PERFORMANCE EVALUATION

A. Slump Test (IS 1199)

Workability is measured by the slump test on every load at site. The cone is 300 mm high with 200 mm bottom and 100 mm top diameter, and a 16 mm diameter, 600 mm long tamping rod is used. The cone is filled in three layers, each given 25 strokes; the cone is lifted vertically and the subsidence of the concrete is the slump. A shear or collapse slump indicates an unsuitable mix and the test is repeated. Typical values are in Table IV.

TABLE IV. Typical slump ranges for different work (IS 456)

Type of work	Slump (mm)
Blinding, shallow sections, pavements	25 to 75
Mass concrete, lightly reinforced slabs, beams, walls, columns	50 to 100
Heavily reinforced sections	100 to 150
Pumped concrete	80 to 100 or higher with admixtures

B. Compressive Strength Test (IS 516)

Samples are taken at the point of discharge, cast in 150 mm cube moulds, kept covered for 24 hours and then cured in water at 27 +/- 2 C until testing at 7 or 28 days. The load is applied on the sides as cast at 14 N/mm^2 per minute until failure, and

$$f_c = P / A \qquad (3)$$

where P is the failure load (N) and A the loaded area (150 x 150 = 22500 mm^2). For example, a failure load of 675 kN gives 675000/22500 = 30 N/mm^2. Each sample consists of three cubes and the result is their average. Minimum sampling frequency is in Table V.

TABLE V. Minimum frequency of sampling (IS 456)

Quantity of concrete (m^3)	Samples
1 to 5	1
6 to 15	2
16 to 30	3
31 to 50	4
51 and above	4 + 1 for each additional 50 m^3 or part

For M20 and above, the average of four consecutive results must not be less than f_{ck} + 0.825 times the established standard deviation, or f_{ck} + 3 N/mm^2, whichever is greater, and no individual result may be less than f_{ck} - 3 N/mm^2.

C. Other Tests and Delivery Inspection

Other tests include compacting factor, flow table and slump flow (for self-compacting concrete), temperature, density and air content, non-destructive tests (rebound hammer and ultrasonic pulse velocity) and core tests when cube results are doubtful. At delivery, the engineer checks the challan, uniformity and absence of segregation, performs the slump (and temperature) test, casts labelled cubes, and rejects the load if slump or time limits are not met.

VII. ADVANTAGES, LIMITATIONS AND COST

A. Advantages

- Uniform, better quality from accurate weighing, controlled mixing and regular testing.
- Faster construction through continuous supply of large quantities.
- Saving of site space, labour and storage, which is valuable in congested cities.
- Reduced wastage from spillage and poor storage; less dust, noise and pollution at the site.
- Controlled use of admixtures, mineral additives and special concretes.

B. Limitations and Risks

- Dependence on transport: traffic and distance may cause stiffening and loss of workability.
- Need for careful planning; poor coordination leads to waiting trucks and wastage.
- Higher initial cost per cubic metre than the material cost of site mixing.
- Limited availability in small towns and difficulty ordering small quantities.
- Risk of water addition at site, and faster workability loss in hot weather.

C. Cost and Environmental Aspects

Cost should be judged on overall project economy and not only price per cubic metre. The rate depends on grade, cement content, admixtures, distance and pumping; savings arise from reduced site storage, mixing, labour and supervision, faster completion, and lower long-term maintenance. For very small works, site mixing may still be more economical. Environmentally, RMC reduces site dust and noise, fly ash and slag reduce cement use and CO_2 emissions, and wash water and returned concrete can be recycled, although plants must control dust and manage waste water.

VIII. APPLICATIONS, RECOMMENDATIONS AND FUTURE SCOPE

A. Applications

RMC is used in residential buildings, commercial buildings (offices, malls, hotels, hospitals), high-rise buildings (pumped to great heights, with high-strength columns and cores), infrastructure (flyovers, bridges, metro rail, tunnels, runways, concrete roads, water-retaining structures) and industrial buildings (foundations, floors, machine bases).

B. Recommendations for Local Use

In regions such as Maharashtra, with high summer temperatures and heavy monsoon rain, the following are recommended: select an IS 4926-compliant plant with a laboratory and test records; plan formwork, reinforcement, pumps and truck numbers before ordering; specify grade, slump, aggregate size, exposure, cement type and admixtures; avoid adding water at site and consult the supplier instead; use retarders, cooler-hour pours and rain protection; and provide proper curing for the full required period.

C. Future Scope

Future development areas are automation and digital control with moisture and slump sensors; GPS tracking of transit mixers; low-carbon concrete with higher fly ash and slag content; recycled water and aggregates with proper testing; high-performance and self-compacting concrete for taller buildings and long-life infrastructure; and mobile or small plants to serve small towns.

IX. CONCLUSION

Ready Mix Concrete, produced in a controlled plant with accurate batching and mixing, overcomes the main problems of site mixing: variation in quality, wastage of materials and lack of space. Tests such as

the slump test and cube compressive strength test are essential to confirm quality. RMC offers uniform quality, saving of time and space, reduced wastage and use of admixtures and special concretes, but transport time, planning, cost and site addition of water must be managed. With careful planning, supervision and good curing, RMC can deliver fast, economical and high-quality construction, and developments in automation, low-carbon concrete and recycling will make it a more sustainable choice for India.

ACKNOWLEDGMENT

The author thanks Prof. A. J. Bhaybhang (Guide and Subject Incharge), Prof. M. M. Dusane (Head of Civil Engineering Department), Prof. G. A. Wadnere (Principal) and the faculty of Late Annasaheb Patil Polytechnic, Nashik, for their guidance and support.

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