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Experimental Investigation Of Concrete Quality Control In RMC Plants

Prof. Karuna Ambhore[1], Shinde Avadhoot[2],

1Faculty Civil Engineering Vidya Prasarini Sabha's College of Engineering and Technology ,Lonavala

2Student Civil Engineering Vidya Prasarini Sabha's College of Engineering and Technology ,Lonavala

ABSTRACT

This study presents a detailed analysis of quality control practices implemented in a Ready Mix Concrete (RMC) plant to achieve consistent production of high-performance concrete. Quality control plays a vital role in ensuring the strength, durability, workability, and overall reliability of concrete used in modern construction. The study covers the inspection and monitoring of raw materials, mix proportioning, batching operations, transportation, placement, and testing procedures for both fresh and hardened concrete. Standard quality assessment tests such as slump test, compressive strength test, and moisture content analysis were carried out to evaluate concrete performance and conformity with specified standards. The findings demonstrate that effective quality control measures significantly enhance concrete quality, minimize material wastage, improve operational efficiency, and ensure compliance with construction specifications. The study emphasizes the importance of systematic quality assurance practices in achieving durable, economical, and sustainable concrete production in RMC plants.

Keywords — Ready Mix Concrete (RMC), Quality Control, Quality Assurance, Compressive Strength, Workability, Slump Test, Concrete Durability, Mix Design, Batching Process, Sustainable Construction.

1. INTRODUCTION

Concrete Technology has become an essential part of modern construction practices, where quality, speed, and durability are of prime importance. Among the various methods of concrete production, Ready Mix Concrete (RMC) is widely preferred due to its consistent quality, reduced labour requirement, faster construction process, and better control over material usage. Unlike conventional site-mixed concrete, RMC is manufactured in a controlled plant environment using automated batching and mixing systems, which ensures greater accuracy and uniformity in concrete production.

Quality control is one of the most important aspects of RMC production. Since concrete is produced in large quantities and supplied to different construction sites, strict monitoring and testing are necessary at every stage to achieve the desired performance characteristics. The primary objective of quality control in an RMC plant is to ensure that the concrete produced satisfies the required standards of strength, workability, durability, and overall structural performance.

The quality control process in an RMC plant begins with the inspection and testing of raw materials such as cement, fine aggregates, coarse aggregates, water, and chemical admixtures. Important properties including grading of aggregates, moisture content, specific gravity, water absorption, and cement quality are regularly checked to maintain consistency in mix proportions and concrete performance. Proper storage and handling of materials are also essential to prevent contamination and variations in quality.

In addition to raw material testing, continuous monitoring of batching, mixing, transportation, and placement operations is carried out to maintain uniformity in concrete production. Various tests on fresh concrete, such as slump test and workability assessment, are conducted to evaluate the ease of handling and placement. Similarly, hardened concrete tests, particularly compressive strength tests, are performed to verify whether the concrete meets the specified design strength requirements.

Effective quality control practices in an RMC plant help to:

- Maintain consistency in mix proportions
- Achieve the required strength and durability
- Ensure proper workability for placement and compaction
- Reduce material wastage and production errors
- Improve overall efficiency and reliability of construction projects

The quality control process generally includes:

- Testing of raw materials such as cement, aggregates, water, and admixtures
- Monitoring of batching and mixing operations
- Testing of fresh concrete properties
- Testing of hardened concrete strength and durability

Improper quality control can result in several defects and performance issues, including:

- Low compressive strength
- Segregation and bleeding
- Reduced durability
- Cracking and poor surface finish
- Increased maintenance and repair costs

Therefore, implementing systematic and effective quality control measures in an RMC plant is essential for producing durable, economical, and high-performance concrete suitable for modern construction requirements.

Table 1.1 Literature Review

Material / Aspect	Research Findings	Research Gap
ɅC Quality Control	Quality control practices in RMC plants ensure uniformity, consistency, and reduced variability in concrete production, leading to improved strength and durability.	Greater adoption of automation, sensor-based systems, and real-time monitoring technologies is required for more efficient quality management.
Slump Test	The slump test is widely used to determine the workability and consistency of fresh concrete during production and placement.	The test has limited accuracy and reliability for high-performance and self-compacting concrete mixes.
ɔmpressive Strength	Compressive strength is considered the primary indicator of concrete quality and structural performance.	More accurate early-age strength prediction techniques and rapid testing methods need further development.
Chemical Admixtures	Admixtures enhance workability, strength, setting time, and durability of concrete under different construction conditions.	Proper optimization of admixture dosage is required for varying climatic conditions and mix compositions.

2. METHODOLOGY

2.1 Material used Materials Used: -

2.1 Materials Used

- **Cement** – OPC 53 Grade, tested as per IS standards
- **Fine Aggregate** – River sand, Zone II
- **Coarse Aggregate** – 10mm & 20mm aggregates
- **Water** – Potable water
- **Admixture** – Superplasticizer

2.2 Mix Proportions : -

2.2 Mix Proportion

Mix Design: M25 Grade Concrete Material	**Quantity (kg/m³)**
Cement	400
Fine Aggregate	650
Coarse Aggregate	1200
Water	180
Admixture	1% of cement

2.3 Batching and Mixing Process

- **Storage of Raw Materials**
  Raw materials such as fine aggregates, coarse aggregates, cement, and admixtures are stored separately in designated bins or silos to prevent contamination and maintain material quality.
- **Batching of Aggregates**
  Fine and coarse aggregates are measured accurately using an automated batching plant to ensure correct proportioning as per the mix design requirements.
- **Cement Feeding through Silos**
  Cement is stored in silos and transferred automatically into the batching system in the required quantity for concrete production.
- **Addition of Water and Admixtures**
  Water and chemical admixtures are added automatically through a controlled dosing system to maintain consistency, workability, and desired concrete properties.

2.4 Mixing in Transit Mixer

The concrete ingredients are thoroughly mixed in a transit mixer to achieve a uniform and homogeneous concrete mix before transportation to the construction site.**Testing on Fresh Concrete**

2.4.1 Slump Test

- **Objective:-**

  To determine the workability and consistency of fresh concrete in the RMC plant.

- **Standard Dimensions of Slump Cone:**

1. Height = 300 mm
2. Top diameter = 100 mm
3. Bottom diameter = 200 mm

- **Procedure:-**

1. Clean the slump cone and base plate and moisten them properly.
2. Place the cone on a level, rigid, and non-absorbent surface.
3. Hold the cone firmly in position using footrests.
4. Fill the cone with fresh concrete in **three equal layers**.
5. Each layer is tamped **25 times** using the tamping rod uniformly.
6. After the top layer, strike off excess concrete with a trowel.
7. Lift the cone slowly and vertically in **5–10 seconds** without any lateral movement.
8. Allow the concrete to subside.
9. Measure the **difference between original height (300 mm)** and the **final height of concrete**.
10. Record the slump value in mm.

Slump Test

2.5 Testing on Hardened Concrete

2.5.1 Compressive Strength Test

Objective

To determine the compressive strength of hardened concrete cubes and verify whether the concrete satisfies the required design strength and quality standards.

Standard Specifications

1. Cube size = 150 mm × 150 mm × 150 mm
2. Number of specimens = Minimum 3 cubes for each test age
3. Testing ages = 7 days and 28 days
4. Loading rate = 140 kg/cm²/minute (as per IS standards)

Procedure

1. Prepare the concrete mix according to the required mix design (for example, M25 grade concrete).

2. Clean and oil the cube moulds properly before casting.
3. Fill the moulds with concrete in three equal layers.
4. Compact each layer either by giving 25 blows with a tamping rod or by using a table vibrator to remove air voids.
5. Level and finish the top surface smoothly using a trowel.
6. Keep the moulds undisturbed at room temperature for 24 hours.
7. After 24 hours, carefully demould the concrete cubes.
8. Immerse the cubes in a curing tank filled with clean water for curing periods of 7 days and 28 days.
9. Remove the cubes from the curing tank before testing and wipe off excess surface water.
10. Measure the dimensions of the cubes accurately using a measuring scale or caliper.
11. Place the cube specimen centrally in the Compression Testing Machine (CTM) such that the load is applied uniformly on opposite faces.
12. Apply the load gradually and continuously without shock at the specified loading rate until the specimen fails.
13. Record the maximum load carried by the cube at the time of failure.
14. Calculate the compressive strength using the formula:

$$f_c = \frac{P}{A}$$

Where:

- f_c= Compressive strength of concrete (N/mm²) , P= Maximum load at failure (N), A= Loaded area of cube specimen (mm²)

3. RESULT AND DISCUSSION

3.1 Result of Slump Test

Test on fresh concrete

The slump test was conducted on fresh concrete to determine its workability and consistency. The test results are presented in Table 3.1.

Trial	Slump (mm)	Type of Slump
1	80	True Slump
2	95	True Slump
3	110	True Slump

Table no. 3.1 Slump Test Results

Observations

- All the concrete samples exhibited **true slump**, indicating good cohesiveness and proper mix consistency.
- The workability of concrete increased with an increase in admixture dosage.
- The obtained slump values were within the suitable range for Ready Mix Concrete (RMC).
- The recommended slump range for RMC applications is generally between **75 mm and 125 mm**, which ensures proper handling, transportation, and placement of concrete.

3.2 Result of Compressive Strength Test

The compressive strength test was conducted on hardened concrete cubes after 7 days of curing to evaluate the early-age strength development of concrete.

Table No. 3.2 Compressive Strength Test Results

Sr. No.	Age of Concrete	Load at Failure (kN)	Compressive Strength (N/mm²)
1	7 Days	400	17.8
2	7 Days	420	18.7
3	7 Days	410	18.2
Average			**18.2 N/mm²**

Observations

- The concrete cubes attained an average compressive strength of **18.2 N/mm²** after 7 days of curing.
- The test results indicate uniform strength development among all specimens.
- The obtained strength values satisfy the expected early-age strength requirements for **M25 grade concrete**.
- Proper curing significantly contributed to improved hydration and strength gain of concrete.

3.3 Cost Analysis

The cost analysis was carried out to estimate the material cost involved in the production of concrete for the selected mix proportion. The details of quantities, rates, and total cost of materials are presented in Table 3.3.

Table No. 3.3 Cost Analysis

No.	cription	antity	it	te (Rs.)	ount (Rs.)
	nent			g	0
	e Aggregate			/kg	
	rse Aggregate	0		/kg	0
	ter		es	5/litre	
	mixture			kg	
	al				**44**

Observations

- Cement contributed the highest percentage of the total concrete production cost.
- The use of chemical admixtures slightly increased the material cost but improved the workability and performance of concrete.
- Aggregates constituted a major portion of the concrete volume while maintaining comparatively lower cost.
- Proper quality control and optimized mix design can help reduce unnecessary material wastage and overall production cost.

Discussion of Results

- The results obtained from the slump test indicate that the workability of concrete increases with the use of admixtures and an appropriate water–cement ratio. The slump values obtained (75 mm, 90 mm, and 110 mm) are within the acceptable range for Ready Mix Concrete (RMC), ensuring ease in handling, placement, and compaction without causing segregation.

- It was observed that an increase in the dosage of superplasticizer significantly improved the workability of concrete without increasing the water content. This helped in maintaining the required strength while providing better flow characteristics, which are highly essential in RMC operations and large-scale construction works.
- From the compressive strength test results, it is evident that the strength of concrete increases with curing time due to the continuous hydration of cement. The 7-day compressive strength achieved approximately 60–70% of the 28-day strength, which indicates normal and satisfactory strength development behavior of concrete.
- The 28-day compressive strength results satisfied the requirements of M25 grade concrete, confirming that the adopted mix design and quality control procedures in the RMC plant were effective and reliable.
- Proper batching, accurate proportioning, and uniform mixing under controlled plant conditions ensured consistency in concrete quality and strength. Any variation in material proportioning or mixing operations could lead to fluctuations in workability, durability, and compressive strength.
- The study also highlighted the importance of curing in achieving the desired concrete strength. Proper curing improved hydration, reduced surface cracking, and enhanced the durability of hardened concrete.
- From the overall experimental investigation, it can be concluded that maintaining strict quality control measures at every stage—from raw material testing and batching to transportation, placement, and final strength testing—is essential for producing durable, economical, and high-performance concrete in RMC plants.

4. CONCLUSIONS

- Quality control is a crucial aspect in the production of Ready Mix Concrete (RMC), as it ensures that the concrete produced satisfies the required standards of strength, durability, workability, and overall performance.
- The study revealed that proper selection, inspection, and testing of raw materials such as cement, fine aggregates, coarse aggregates, water, and chemical admixtures play a significant role in maintaining consistent concrete quality and achieving the desired mix performance.
- The use of automated batching and controlled mixing systems in RMC plants helps maintain accurate material proportions, minimizes human error, and improves production efficiency and uniformity of concrete.
- The workability of concrete, determined through the slump test, was found to be within the acceptable range, indicating that the concrete mix was suitable for proper handling, placement, and compaction without segregation or bleeding.
- The compressive strength test results confirmed that the concrete achieved the required strength for M25 grade concrete, demonstrating the effectiveness of the adopted mix design, curing practices, and quality control procedures.
- Proper curing and controlled production conditions contributed significantly to the strength development and durability of hardened concrete.
- Compared to conventional site-mixed concrete, RMC offers several advantages such as better consistency, faster construction, reduced material wastage, improved quality control, and enhanced durability.
- The overall study concludes that systematic implementation of quality control practices at every stage of RMC production—from raw material testing to final strength evaluation—is essential for producing reliable, economical, durable, and high-performance concrete for modern construction projects.

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