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Enhanced Comparative Study of On-Site Mixing vs. Ready-Mix Concrete (RMC)

Mr. Sunny Joshi[1], Dr. Satish. S. Deshmukh[2], Prof. K. H. Ghorpade[3]

[1]*Student, Civil Engineering, Trinity Academy of Engineering, Pune, India*
[2]*Professor, Civil Engineering, Trinity Academy of Engineering, Pune, India*
[3]Assistant Professor, Civil Engineering, Trinity Academy of Engineering, Pune, India

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Abstract - This paper comparatively analyses on-site mixing and Ready-Mix Concrete (RMC), evaluating their impacts on construction project management, specifically concerning quality, cost, time, logistics, and sustainability. Drawing from empirical data and various the research highlights RMC's consistent quality and superior compressive strengths across comparable grades. For instance, RMC consistently outperforms hand-mixed concrete (HMC) in strength, showing deviations of 11.64% for M15, 11.83% for M20, and 12.6% for M25 grades at 28 days. RMC is produced in controlled environments, ensuring precise mix proportions and reduced labour dependency.

While on-site mixing may offer lower initial material costs, it often leads to inconsistent quality, increased labour, and higher overall expenses due to rework and slower production RMC, despite higher upfront costs, proves more economical long-term through efficiency and waste reduction. Logistical challenges like transportation delays affect RMC while on-site mixing faces space constraints and environmental impacts. The study also examines RMC plant sustainability, including energy, water, and waste management.

The choice between methods depends on project scale, quality demands, time constraints, and logistical feasibility. RMC is ideal for large, time-sensitive, and high-performance projects, whereas on-site mixing suits smaller, remote, or budget-constrained works with skilled supervision. This paper provides a framework for informed decision-making in concrete production.

Key Words: ready-mix concrete, on-site mixing, compressive strength, workability, construction management, cost efficiency

CHAPTER 1: INTRODUCTION

1.1 General Background

Concrete is a fundamental material in modern construction, with increasing demand for efficient and high-quality production methods. Traditionally, on-site mixing (SMC) offers flexibility for smaller projects but struggles with quality consistency due to variable site conditions and labour skills.

Conversely, Ready-Mix Concrete (RMC), produced in controlled batching plants and transported to sites, provides superior quality consistency, reduced labour dependency, and faster construction times, especially for large-scale urban projects. However, RMC faces logistical challenges like transportation delays and higher initial costs.

The choice between SMC and RMC significantly impacts project quality, timelines, costs, resource allocation, and environmental footprint. This paper offers a comprehensive comparative analysis of these two methods, examining their effects on quality control, cost, time, logistics, and sustainability. By synthesizing existing research, this study aims to provide project managers with valuable insights for informed decision-making in concrete production.

1.2 Conventional (On-Site) Concrete

Concrete when mixed manually at site is conventional (on-site) concrete. Conventional (on-site) concrete is prepared by approximate measurement of ingredients. Manual mixing of ingredients (cement, sand, aggregates, and water) is done on site. The quality of conventional (on-site) concrete depends on experience of workmanship. Since it is manually mixed, quality varies every time and it may affect the strength of structure and workability of concrete. Environmental factors such as humidity, temperature and type of mixing surface affect the quality of conventional (on-site) concrete. Quality of site mix (on-site) concrete is inconsistent because concrete is hand mixed and quality of raw material is manually checked. For small scale projects, the quality of conventional (on-site) concrete is often sufficient. Hand mixed (on-site) concrete is often the only economical option for small scale projects. Conventional (on-site) concrete needs a high degree of supervision, otherwise the mix quality may degrade.

1.2 Ready Mix Concrete (RMC)

Ready Mix Concrete (RMC) is defined as concrete mixed in a stationary mixer at a central batching and mixing plant or in a truck mixer, and then supplied in a fresh condition to the purchaser, either at the site or into their vehicle. Essentially, RMC involves weigh batching cement, aggregates, and other ingredients at a plant before delivery to the construction site. Given that RMC is produced under controlled supervision in a dedicated plant, the material properties are consistently maintained. In this study, a critical analysis of RMC will include various concrete mix grades, specifically M15, M20, M25, M30, M35, M40, M50, M60, M70, and M80.

1.3 Problem Statement

Project managers and builders consistently face the challenge of determining the most appropriate concrete production method—on-site mixing versus Ready-Mix Concrete (RMC)—given its profound implications for project quality, cost, schedule, and logistical demands. While on-site mixing offers adaptability for certain projects, it frequently encounters challenges in achieving consistent quality due to variable site conditions and reliance on manual processes. Conversely, RMC ensures superior quality control and enhanced efficiency, particularly for large-scale operations, but introduces considerations such as higher initial costs and potential transportation complexities. This research aims to bridge this

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decision gap by critically analyzing the multifaceted factors influencing this choice, thereby developing a practical framework to guide project managers towards the optimal concrete solution for their specific construction endeavors.

1.4 Research Objectives

1) To identify and compare the quality control measures associated with on-site mixing and Ready-Mix Concrete (RMC).
2) To evaluate the cost implications, including material, labour, and equipment costs, for both methods.
3) To assess the time efficiency of on-site mixing versus RMC in various project types, especially in urban and large-scale projects.
4) To provide recommendations based on the comparative analysis, aiding project managers in choosing the optimal concrete approach for different construction projects.

1.5 Scope of Study

This research aims to provide a comprehensive comparative analysis between on-site concrete mixing and Ready-Mix Concrete (RMC) from a construction management perspective, focusing on key decision-making factors. The scope of this study encompasses the following areas:

1. **Quality Control Processes:** The study will identify and compare the quality control measures implemented for both on-site mixed concrete and RMC. This includes evaluating the consistency of fresh concrete properties (e.g., slump, workability), adherence to specified mix designs and quality standards (e.g., relevant IS codes), and the impact of environmental conditions and manual processes versus controlled plant environments on final concrete quality and consistency.
2. **Cost Implications:** A detailed evaluation of the financial costs associated with both concrete production methods will be undertaken. This involves analyzing direct costs such as raw materials (cement, aggregates, water, admixtures), labor (skilled and unskilled), and equipment (mixers, vibrators, pumps, transportation). Indirect costs, including material wastage, rework due to quality issues, and overheads related to site management and space requirements, will also be considered to provide a holistic cost perspective.
3. **Time Efficiency and Project Timelines:** The research will assess the time efficiency of on-site mixing versus RMC, particularly within the context of urban and large-scale construction projects. This analysis will include evaluating concrete production rates, delivery lead times, placement rates, and their overall impact on project schedules and completion timelines.
4. **Logistical Challenges:** The study will investigate the logistical complexities inherent in both methods. For RMC, this includes transportation delays, traffic congestion impacts, and the need for precise scheduling and coordination with the plant. For on-site mixing, it will address challenges related to raw material procurement, storage space requirements on congested urban sites, and internal material handling.
5. **Environmental Impact Considerations:** An assessment of the environmental implications of each method will be included. This involves examining factors such as on-site dust and noise pollution from mixing operations, material waste generation, and the carbon footprint associated with production processes and transportation for both RMC and on-site concrete.
6. **Labor Requirements and Management:** The study will compare the labor intensity and skill levels required for each method. It will assess the dependency on skilled workmanship for quality control in on-site mixing versus the reduced on-site labor needs and automation advantages of RMC.
7. **Applicability Across Project Types:** The analysis will extend to providing recommendations on the suitability of each concrete method for diverse construction projects, considering factors such as project size, location (urban vs. remote), quality requirements (standard vs. high-performance concrete), and budget constraints.

CHAPTER 2: LITERATURE REVIEW

1.Quality Control in Ready-Mix Concrete vs. On-Site Mixing.
Source: Al-Tayeb et al. (2021) - Journal of Construction Engineering and Management.

2.Cost Analysis of On-Site Mixing vs. Ready-Mix Concrete
Source: Singh and Bhalla (2020) - International Journal of Civil Engineering.

3.Time Efficiency in Concrete Delivery and Pouring
Source: Ganesan et al. (2019) - Construction Management and Economics.

4.Time Efficiency in Concrete Delivery and Pouring
Source: Ganesan et al. (2019) - Construction Management and Economics

5.Environmental Impact Comparison: Carbon Footprint of On-Site Mixing vs. RMC
Source: Thomas and Kumar (2021) - Journal of Cleaner Production

6.Labor Requirements and Skill Levels in Concrete Production
Source: Verma et al. (2018) - International Journal of Building Pathology and Adaptation

7.Concrete Strength and Durability: On-Site Mixing vs. RMC
Source: Patel and Shah (2020) - Materials Today: Proceedings

8.Suitability for Large-Scale and Complex Projects
Source: O'Neill et al. (2020) - Journal of Civil Engineering and Management

CHAPTER 3: METHODOLOGY AND MATERIALS

3.1 Research Design

This research employs a comparative research design to systematically evaluate and contrast on-site concrete mixing and Ready-Mix Concrete (RMC) from a construction

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management perspective. A mixed-methods approach is adopted, integrating both qualitative and quantitative data to provide a comprehensive understanding of the factors influencing the selection between these two concrete production methods.

The qualitative component primarily involves conducting case studies of operational construction projects and gathering insights through surveys and interviews with industry experts. This allows for an in-depth understanding of practical challenges, quality control practices, logistical intricacies, and managerial preferences associated with each method in real-world scenarios.

The quantitative component focuses on the cost implications and time efficiency. This involves developing detailed cost models per cubic meter for both RMC and on-site concrete, alongside analyzing production rates and time-related aspects. The integration of these quantitative and qualitative data sets aims to provide a holistic and robust basis for the comparative analysis.

The goal of this research design is to leverage the strengths of both data types to achieve a multifaceted comparison, culminating in the development of a practical decision-making framework that can guide project managers in selecting the optimal concrete approach for diverse construction projects.

3.2 Materials Used

The quality of concrete is fundamentally dependent on the properties of its constituent materials. For this comparative study, all materials used for both on-site mixing and Ready-Mix Concrete (RMC) were sourced and tested according to relevant Indian Standards, with test reports obtained from NABL-accredited laboratories. The details and key properties of these materials are presented below.

3.2.1 Cement

Ordinary Portland Cement (OPC) of 53 Grade, specifically Ultratech Cement, was utilized. Its chemical and physical properties, tested by CSRL-Structwel Lab (Pune) Private Limited, confirm compliance with IS 269-2015 standards,

Sr. No.	Particulars of Test	Test Result	IS Requirement (OPC 53 Grade)
1	Normal Consistency (%)	28.5	Not Specified
2	Fineness by Dry Sieving (%)	5.2	Max. 10%
3	Initial Setting Time (Minutes)	139	Min. 30 min
4	Final Setting Time (Minutes)	271	Max. 600 min
5	Compressive Strength - 3 days (N/mm²)	29.72	Min. 27 N/mm²
6	Compressive Strength - 7 days (N/mm²)	39.95	Min. 37 N/mm²
7	Compressive Strength - 28 days (N/mm²)	55.15	Min. 53 N/mm²
8	Soundness by Le Chatelier's Method (mm)	3.03	Max. 10 mm
9	Soundness by Autoclave Method (%)	0.5	Max. 0.8%

Table -1: Physical Properties of Cement (OPC 53 Grade)

Sr. No.	Type of Test	Test Result	IS Requirement (OPC 53 Grade)
1	Loss on Ignition (%)	2.29	Max. 4.0
2	Insoluble Residue (%)	1.76	Max. 2.0
3	Sulphur Tri Oxide (SO3) (%)	2.68	Max. 3.5
4	Silica Content (SiO2) (%)	20.6	Not Specified
5	Alumina Content (Al2O3) (%)	5.15	Not Specified
6	Iron Content (%)	4.86	Not Specified
7	Calcium Oxide (CaO) (%)	60.89	Not Specified
8	Magnesium Oxide (MgO) (%)	2.47	Max. 6.0
9	Chloride (Cl) (%)	0.022	Max. 0.1, 0.05 (for Prestressed structures)
10	Tricalcium Aluminate (C3A) (%)	5.62	Max. 10
11	Dicalcium Silicate (C2S) (%)	27.35	Min. 45
12	Tricalcium Silicate (C3S) (%)	42.13	Min. 45
13	Al2O3 / Fe2O3 Ratio	1.06	Min. 0.66
14	Lime Saturation Factor	0.88	0.80–1.02

Table -2: Chemical Properties of Cement (OPC 53 Grade)

3.2.2 GGBS (Ground Granulated Blast Furnace Slag)

Ground Granulated Blast Furnace Slag (GGBS) was used as a supplementary cementitious material. Its chemical composition, tested by Constrologix Engineering & Research Services Pvt. Ltd., confirms its suitability as per IS 16714:2018 standards.

Sr. No	Test	Result	Specified Limit as per IS 16714:2018
1	Magnesia, % by mass	5.56	Max. 17
2	Sulphuric Anhydride (SO_3), % by mass	0.28	Max. 3
3	Insoluble Residue, % by mass	0.84	Max. 3
4	Chloride, % by mass	0.0265	Max. 0.1
5	Loss on Ignition, % by mass	0.08	Max. 3
6	Silica Content, % by mass	32.05	--
7	Calcium Oxide, % by mass	33.54	--
8	Ferric Oxide, % by mass	1.36	--
9	Alumina, % by mass	19.21	--
10	Fineness by Blaine's Air Permeability	341.14	Min 320
11	Specific Gravity	2.92	--
12	Residue on 45 Micron (Wet Method) %	5.3	--
13	Compressive Strength 3 days (N/mm2)	19.62	--
14	Compressive Strength 7 days / Slag Activity Index 7 days %	27.30 / 74	Min 64
15	Compressive Strength 28 days / Slag Activity Index 28 days %	45.28 / 86	Min 75

Table -3: Physical and Chemical Properties of GGBS.

3.2.3 Fine Aggregate

Wagholi source Zone-I Crushed Sand was used as the fine aggregate. Its properties, physical characteristics, were tested by CSRL-Structwel Lab (Pune) Private Limited, demonstrating compliance with IS 383:2016 standards.

Sr. No.	Test Description	Test Result	Unit	Specified Limit (as per IS 383:2016)
1	Specific Gravity	2.69	–	–
2	Water Absorption	3.28	%	Should be as low as possible for better quality
3	Dry Bulk Density (Loose)	1.8	kg/lit	–
4	Material Finer than 75 Micron (Silt Content)	1.8	% by wt.	Crushed: Max 15%, Manufactured: Max 10%, Mixed: Max 12%
5	Bulkage	18	%	–

Table -4: Physical Properties of Fine Aggregate.

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3.2.4 Coarse Aggregate

Two sizes of coarse aggregate, 20mm and 10mm, were used. Their properties, including, specific gravity, and water absorption, were tested by CSRL-Structwel Lab (Pune) Private Limited, ensuring compliance with IS 383:2016 standards.

Sr. No.	Test Description	Test Result	Unit	Specified Limit (as per IS 383:2016)
1	Specific Gravity	2.91	–	–
2	Water Absorption	1.53	%	Should be as low as possible for better durability
3	Dry Bulk Density (Loose)	1.7	kg/lit	–
4	Flakiness Index	6.7	%	Generally <15% preferred
5	Elongation Index	10.73	%	Generally <15% preferred

Table -5: Physical Properties of 20 mm Aggregate.

Sr. No.	Test Description	Test Result	Unit	Specified Limit (as per IS 383:2016)
1	Specific Gravity	2.89	–	–
2	Water Absorption	1.04	%	Should be as low as possible for better durability
3	Dry Bulk Density (Loose)	1.54	kg/lit	–
4	Flakiness Index	3.31	%	Generally <15% preferred
5	Elongation Index	5.9	%	Generally <15% preferred

Table -6: Physical Properties of 20 mm Aggregate.

3.2.5 Admixtures

A mid-range Polycarboxylate Ether (PCE) based admixture, specifically Enduracon Super 1537, was used. Its properties were tested by Durocrete Engineering Services Pvt. Ltd..

Sr. No.	Particular	Test Result	Unit	Specified Limit
1	pH Value	6.43	--	Minimum 6
2	Relative Density	1.1	--	Within 0.02 of the value stated by the manufacturer
3	Dry Material content	48.91	%	0.95T<=DMC<1.05T
4	Ash content	4.46	%	0.95T<=AC<1.05T
5	Chloride Content	BDL	%	Within 10 percent of the value or within 0.2 percent whichever is greater as stated by the manufacturer

Table -7: Properties of Chemical Admixture.

3.3 Mix Proportions

The mix proportion, or mix design, defines the quantities of various ingredients – cement, aggregates (fine and coarse), water, and admixtures – required to produce one cubic meter of concrete with specific desired properties, such as compressive strength, workability, and durability. Precise mix proportions are fundamental to ensuring the quality and performance of concrete, whether produced on-site or as Ready-Mix Concrete (RMC). The role of mix proportions is critical in:

- **Achieving Target Strength:** The ratio of cementitious materials to aggregates and the water-cement (w/c) ratio are primary factors determining the hardened concrete's compressive strength. A lower w/c ratio generally leads to higher strength, assuming adequate compaction and curing.
- **Controlling Workability:** The quantities of water and the type/dosage of admixture directly influence the fresh concrete's workability (ease of placing and compacting) without segregation.
- **Ensuring Durability:** Correct proportions contribute to a dense, impermeable concrete matrix, which is essential for long-term durability against environmental aggressions.
- **Optimizing Cost:** A well-designed mix balances material costs with performance requirements, preventing over-design or under-design.

For the purpose of this study, typical mix proportions for various concrete grades, as obtained from industry data for RMC production, are presented below. This data formed the basis for cost calculations and understanding the material demands of different concrete grades. Specific focus will be given to M25, M40, and M60 grades, representing common structural concrete grades.

Grade	Cement (kg/Cum)	GGBS (kg/Cum)	Microfine (kg/Cum)	10MM (kg/Cum)	20MM (kg/Cum)	C/Sand (kg/Cum)	Water (kg/Cum)	Admixture (kg/Cum)
M-25	180	170	0	471	669	901	155	3.5
M-40	230	230	0	461	701	771	150	4.6
M-60	420	130	25	398	712	789	150	5.5

Table -8: Concrete Mix Proportions per Cubic Meter for Selected Grades.

3.4 Data Collection

This section details the primary methods employed to gather empirical data and expert insights crucial for the comparative analysis. A multi-faceted approach, combining direct observation, structured interviews, and the collection of quantitative project documentation, was utilized to ensure a robust and comprehensive dataset.

3.4.1 Case Studies

- **Objective:** The primary objective of conducting case studies was to analyze real-world applications of both on-site concrete mixing and Ready-Mix Concrete (RMC) within active construction projects. This allowed for the collection of empirical data and direct observation of practical challenges, operational efficiencies, and quality control measures associated with each method in their actual operational contexts. The goal was to move beyond theoretical comparisons and ground the research in practical, observable outcomes.
- **Process: The case study methodology involved a systematic approach to identifying, observing, and documenting key aspects of concrete production and usage on selected construction sites in the Pune metropolitan area.**
  - **Site Selection:** A purposive sampling strategy was employed to select a limited number of ongoing construction projects. The selection criteria included:
    - Projects utilizing either exclusively RMC, exclusively on-site mixing, or a combination of both methods.
    - Projects varying in scale and type (e.g., residential, commercial, infrastructure), reflecting diverse concrete demands.
    - Accessibility for site visits and willingness of project management to provide relevant data and allow observations.
    - Specifically, observations were conducted at sites in the Hadapsar area of Pune, Maharashtra, where both RMC and on-site mixing operations were prevalent. One key site involved operations of Innoven Infracon Pvt. Ltd., whose RMC plant operations were also observed.
  - **Data Collection during Site Visits:** During multiple site visits, a range of qualitative and quantitative data was collected through:

- Direct Observation: Witnessing the entire process of concrete production (for on-site mixing), delivery (for RMC), placement, and initial curing. This included observing batching processes, material handling, labor deployment, equipment usage, and general site organization.
- Photographic Documentation: Capturing visual evidence of various operational stages, equipment, and site conditions (e.g., RMC plant visit , on-site mixing with a one-bag mixer).
- Review of Project Documents: Accessing project records where available, such as concrete pour logs, quality control checklists, material delivery receipts, and basic project schedules.
- Informal Discussions: Engaging with site engineers, project supervisors, and labor foremen to understand their perspectives, challenges, and experiences with each concrete method.

- **Specific Data Points Collected:** From the selected case study sites, efforts were made to collect data pertaining to:
  - Quality Control: Observed practices for slump testing, cube casting frequency, and adherence to specified mix designs. Qualitative observations on workability consistency and impact of manual processes.
  - Cost Aspects: Information on actual labour deployment for mixing and placement, observed material wastage, and equipment used on-site.
  - Time Efficiency: Approximate time taken for batching, delivery (for RMC), and placement of a given volume of concrete.
  - Logistics & Space: Assessment of space required for material storage, accessibility for RMC trucks, and internal site transportation.
  - Environmental Factors: Visual assessment of dust, noise, and waste generation on-site.
  - Labor Efficiency: Observations on the number of workers involved in concrete-related tasks and their productivity.
- **Case Study Documentation**: For each case study, detailed notes were maintained, and relevant documents (where accessible) were collected to support the findings presented in Chapter 4. These documents include internal project reports and third-party test reports for materials like cement, aggregates, GGBS, and admixtures used at the sites. This methodical approach ensured the collection of practical data for a nuanced comparison

3.4.2 Surveys and Interviews

- **Objective:** The objective of conducting surveys and interviews was to gather primary, qualitative, and supplementary quantitative data directly from experienced industry professionals. This method aimed to capture expert opinions, practical insights, preferences, and challenges encountered in real-world construction scenarios concerning both on-site mixing and Ready-Mix Concrete (RMC). This direct input was crucial for understanding the nuanced decision-making processes of project managers and builders.
- **Process:** A structured approach was employed to conduct surveys and interviews, targeting a diverse group of stakeholders within the construction sector:
  - **Target Audience: Interviews and surveys were primarily conducted with:**
    - Project Managers
    - Site Engineers
    - Quality Assurance/Quality Control (QA/QC) Professionals
    - RMC Plant Managers
    - Labor Supervisors These professionals possessed invaluable experience and insights into the operational, financial, and quality aspects of concrete production.
  - **Questionnaire Development:** A standardized questionnaire was developed to ensure consistency in data collection across different respondents. The questions covered a range of key topics pertinent to the research objectives, including:
    - Perceived advantages and disadvantages of on-site mixing and RMC.
    - Typical quality control practices and challenges encountered in maintaining concrete consistency for both methods.
    - Factors influencing cost-effectiveness, including hidden costs and perceived savings.
    - Observations on time efficiency, production rates, and impact on project schedules.
    - Experiences with logistical challenges, such as transportation delays and site accessibility.
    - Views on labor requirements, skill dependency, and productivity for each method.
    - Considerations for environmental impact and waste management.
    - Specific criteria and priorities used in their decision-making process for selecting a concrete production method based on project size, type, and location.
  - **Conduct of Interviews and Surveys:** Interviews were conducted either face-to-face during site visits or through telephonic conversations, allowing for in-depth discussions and clarification of responses. Surveys were administered to capture broader perspectives from a larger sample size where detailed interviews were not feasible. Confidentiality of responses was assured to encourage candid feedback. The insights gained from these interactions provided valuable qualitative context and supported the quantitative data analysis.

3.4.3 Cost Data Collection

- **Objective**: The primary objective of this phase was to gather comprehensive and granular cost data for both on-site concrete mixing and Ready-Mix Concrete (RMC) production. This data forms the quantitative backbone of the Cost-Benefit Analysis, enabling a direct financial comparison between the two methods. The aim was to identify all relevant cost components, from raw materials to labour and equipment, to ensure a holistic financial assessment.

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- **Process:** Detailed cost data was meticulously collected through a combination of reviewing supplier quotations, analyzing project records, and conducting direct inquiries during site visits and interviews. This process ensured the capture of real-world pricing and expenditure.
  - **For On-Site Mixing:**
    - **Raw Material Costs:** Current market rates for key raw materials were obtained from local suppliers in Pune. This included:
    - Cement (per 50 kg bag, considering brand and grade).
    - Fine Aggregate (Crushed Sand - per brass/tonne).
    - Coarse Aggregate (10mm and 20mm - per brass/tonne).
    - Water (estimated cost per cubic meter, considering source).
    - Admixtures (per kg/litre).
    - **Labor Costs**: Daily wages for different categories of labor involved in concrete mixing and placement were collected. This included female helpers (material filling), male helpers (material filling), lift bucket operators, and slab casting helpers. Data was then used to estimate labor cost per cubic meter of concrete produced.
    - **Equipment Costs**: Information on the purchase or rental costs of essential on-site mixing equipment (e.g., one-bag concrete mixer, vibrators, and lifting equipment like bucket hoists/tower cranes) was gathered. This also included estimates for fuel/electricity consumption and routine maintenance costs.
    - **Wastage and Overheads:** Qualitative and quantitative estimates for material wastage during handling and mixing, as well as typical site overheads (e.g., supervision, curing materials, minor tools, security), were considered for inclusion in the overall on-site cost model.
  - **For Ready-Mix Concrete (RMC):**
    - Purchase Price per Cubic Meter: Quotations from leading RMC suppliers in Pune were obtained for various concrete grades (including M25, M40, M60), specifying the base rate per cubic meter.
    - Ancillary Charges: Data on additional costs associated with RMC delivery was collected, such as:
    - Transportation charges (often dependent on distance from the plant to the site).
    - Pumping charges (if a concrete pump is required for placement).
    - Waiting time charges (if transit mixers are delayed on site).
    - Any minimum order quantity requirements.
    - Inclusions: Clarification was sought on what the RMC selling price includes (e.g., materials, plant operational costs, delivery).

3.5 Data Analysis Techniques

This section details the methodologies employed to systematically analyze the collected data, drawing comparisons and deriving insights across various parameters for both on-site concrete mixing and Ready-Mix Concrete (RMC).

3.5.1 Comparative Analysis of Quality Control

- **Objective:** The primary objective of this analysis is to comprehensively evaluate the consistency and quality assurance measures associated with on-site concrete mixing versus RMC. This evaluation aims to identify the strengths and weaknesses of each method in achieving desired concrete properties for various grades, specifically M25, M40, and M60, which are critical for structural applications. The analysis focuses on understanding how each production method ensures adherence to specifications, maintains workability, and controls key parameters essential for concrete performance.
- **Process:** The quality control analysis will synthesize data primarily from case studies (3.4.1) and expert interviews (3.4.2), complemented by an understanding of material properties (3.2). The process involves a multi-faceted assessment across several critical aspects:
  - **Adherence to Mix Specifications:**
    - **RMC:** The analysis will examine how RMC plants ensure precise adherence to specified mix designs for grades like M25, M40, and M60. This includes reviewing their automated batching processes, which minimize human error and ensure accurate proportioning of cement, aggregates, water, and admixtures as per the approved mix design.
    - **On-site Mixing**: For on-site mixing, the assessment will focus on the challenges in achieving consistent adherence to mix proportions due to manual batching practices, volumetric measurement, and the varying skill levels of labor. Observations will identify potential deviations from design for these specified grades.
  - **Slump Consistency:**
    - **Objective:** To evaluate the uniformity of fresh concrete workability.
    - **Process:** Data collected from slump tests (observed or recorded) for both methods will be qualitatively and, if quantitative data is available, quantitatively analyzed. The consistency of slump values over multiple batches for specific grades (M25, M40, M60) will be compared. RMC's ability to maintain a consistent slump over a delivery distance using admixtures and precise water control will be noted against the batch-to-batch variability often observed in on-site mixing due to less controlled water addition and mixing times.
  - **Water-Cement (w/c) Ratio Control:**
    - **Objective**: To assess the precision in controlling the critical w/c ratio, which directly impacts strength and durability.
    - **Process**: The analysis will highlight how RMC plants maintain tight control over the w/c ratio through automated water dosing and moisture content adjustments in aggregates, crucial for achieving the high strengths of M40 and M60 grades. For on-site mixing, the challenges in accurately controlling the w/c ratio, especially with

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manual water addition and variable aggregate moisture, will be assessed.

- **Raw Material Quality and Storage:**
  - **Objective:** To link the quality and handling of raw materials to the consistency of the final concrete.
  - **Process:** Drawing from the material properties detailed in Section 3.2, the analysis will discuss how RMC plants, with their centralized procurement and controlled storage of quality-tested materials (cement, aggregates, GGBS, admixtures), contribute to superior and consistent input for all concrete grades. On-site limitations in material storage, handling, and potential contamination that can affect concrete quality will also be evaluated.
- **Documentation and Traceability:**
  - **Objective**: To compare the level of quality assurance documentation provided by each method.
  - **Process:** The availability and comprehensiveness of documentation, such as batch reports, quality certificates, and test results (e.g., from NABL-accredited labs) provided by RMC plants for specific deliveries (e.g., for M25, M40, M60 pours), will be contrasted with typical record-keeping and quality checks observed at on-site mixing operations. This will highlight the traceability and accountability inherent in RMC production.
- **Observed Hardened Concrete Properties:**
  - **Objective**: To assess the general outcome of quality control measures**.**
  - **Process:** While direct comparative compressive strength tests for identical M-grades from the case studies are not included due to data limitations, the analysis will qualitatively discuss observations regarding the consistency of hardened concrete quality. This includes whether each method consistently delivered concrete that appeared to meet its intended design grade (e.g., M25, M40, M60) based on visual inspection, adherence to other quality parameters, and general project performance reported by site personnel.

Fig -1: RMC Visit

CHAPTER 4: COMPARATIVE STRENGTH ANALYSIS

Third-party test reports were obtained from NABL-accredited laboratory (CSRL-Structwel Lab, Pune) for two wings of a real-world construction project:

1. Building D Wing: Concrete supplied via Ready-Mix Concrete (RMC)

2. Building E Wing: Concrete mixed on-site using manual batching

As per IS 516 (Part-5/Sec-4):2020, rebound hammer test results have ±25% accuracy in predicting compressive strength.

4.1. Building D Wing (RMC Concrete)

Sr. No.	Location	Member	Ave. Rebound No	Approx. Compressive Strength (N/mm²)
1	9th Floor M25	RCC Lift Wall	31	26
2	LW-02, M-25	RCC Lift Wall	32	27
3	LW-03, M-25	RCC Lift Wall	34	31
4	C-30, M-25	RCC Column	32	28

Table -9 Test Results D Wing

Average Strength (RMC): (26+27+31+28)/4 = 28 MPa

4.2. Building E Wing (On-Site Mixing)

Sr. No.	Location	Member	Ave. Rebound No	Approx. Compressive Strength (N/mm²)
1	C-91, M-40	RCC Column	29	24
2	C-23, M-40	RCC Column	30	25
3	C-45, M-40	RCC Column	33	29
4	C-92, M-40	RCC Column	30	25
5	C-44, M-40	RCC Column	31	26
6	C-44, M-40	RCC Column	29	24

Table -10 Test Results E Wing

Average Strength (On-site): (24+25+29+25+26+24)/6 = 25.5 MPa

Interpretation:

Parameter	RMC (Building D)	On-Site (Building E)
Grade of Concrete	M25	M40
Average Rebound Strength	28 MPa	25.5 MPa
Deviation From Expected	Above M25	Significantly below M40
Observation	Expected	Quality fall due to site mixing inconsistency

Table -11 Interpretation

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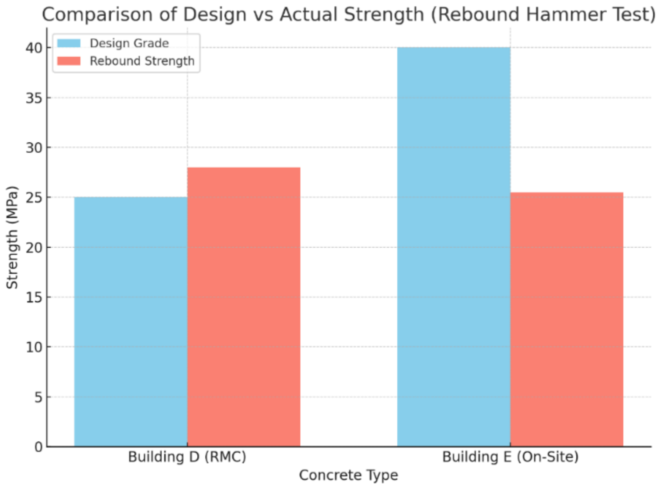
Observation:

- RMC achieved consistent quality, to its design strength.
- On-site mixing showed poor strength performance, despite being M40 grade, highlighting the risks of manual batching, moisture inconsistencies, and human error.
- Graphical comparison shown below:



Even though Building E was designed with M40 concrete, actual strength averaged at only 25.5 MPa, indicating poor quality control in on-site mixing. In contrast, RMC from Building D achieved to its design value (M25).

4.3 Time Efficiency and Output Comparison

Time efficiency is a crucial quality control parameter. The following data compares the outputs of RMC and On-site Mixing:

Parameter	RMC	On-site Mixing	Mixing Time per Batch	Labor Dependency
Output per Hour	42 cum	4 cum	2 min	Low
Output per Day (12 hrs)	500 cum	40–50 cum	8–10 min	High

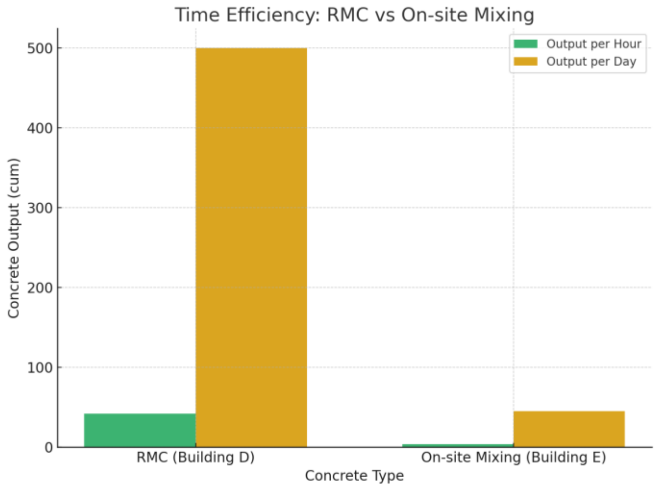


Figure: Time Efficiency Comparison of RMC vs On-site Mixing

RMC proves to be more efficient and consistent both in strength and time. On-site mixing, though flexible, suffers from variability in quality and slower production rates, making it less suitable for high-volume or critical-grade concrete.

4.4 RMC Production at CC60 Plant

Based on field interviews and observations, a CC60 plant theoretically has a capacity to produce 720 cubic meters of concrete in 12 hours. However, practical output is about 500 cubic meters, considering operational constraints such as material flow and plant maintenance. Stringent quality control measures are in place: incoming materials (cement, aggregates, water, and admixtures) and outgoing concrete are tested to ensure compliance with IS standards. Consistent production is ensured by adhering to strict protocols, providing reliable and uniform quality.

Storage Facilities and Admixtures:

Storage for raw materials, including cement, aggregates, and admixtures (like Fly Ash, GGBS, and Ultrafine materials, is maintained as per relevant IS standards. This facilitates the production of high- Performance concrete (HPC) and self-compacting concrete (SCC). High-grade mixes such as M60, M70, and M80 can be consistently produced at RMC plants, which would be challenging with on -site mixing. Cost Analysis (for a site 5 km away):

Material Rate Table: -

Material	Gross Rate	Unit	GST %	Net Rate (Base ₹/kg)
Cement	₹380 per 50 kg bag	50 kg	28%	₹380 / 1.28 = ₹296.88 → ₹5.94/kg
GGBS	₹4,070 per ton	1000 kg	5%	₹4070 / 1.05 = ₹3,876.19 → ₹3.88/kg
10MM Aggregate	₹3,150 per brass	4600 kg	–	₹3,150 / 4600kg = ₹0.68/kg
20MM Aggregate	₹3,150 per brass	4500 kg	–	₹3,150 / 4500kg = ₹0.70/kg
Crushed Sand	₹3,360 per brass	5000 kg	–	₹3,360 / 5000 = ₹0.67/kg
Admixture	₹ 60 per Kg	1 Kg	–	₹60/kg

Table -13 Material Rate

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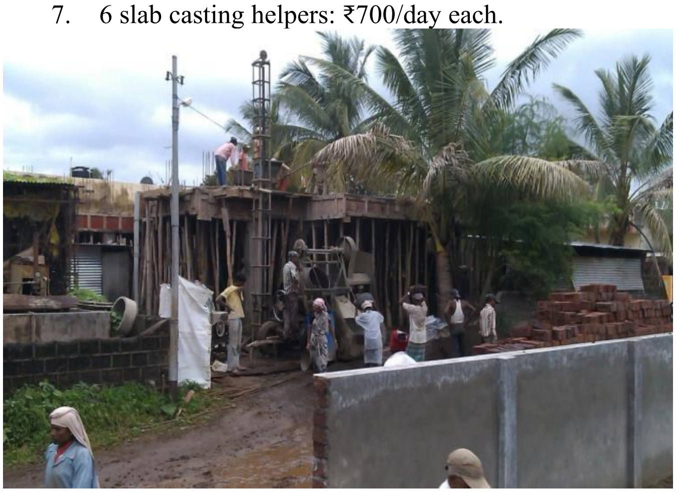
Grade	Final Selling Price (₹)
M-10	₹3,900
M-15	₹4,100
M-20	₹4,400
M-25	₹4,600
M-30	₹4,800
M-35	₹5,050
M-40	₹5,200
M-50	₹5,500
M-60	₹6,300
M-70	₹6,600

(Prices exclude 18% GST, but include materials, rent, electricity, salaries, and delivery costs.) Variations in mix design and material costs may alter these rates. Additionally, transport distance from the RMC plant to the site affects final cost.

On-Site Mixing with One-Bag Mixer

1. Production and Workforce:
2. Practical output: 40 cubic meters in 12 hours (based on site visits and interviews).
3. Labor costs:
4. 2 female helpers (material filling): ₹500/day each.
5. 1 male helper (material filling): ₹700/day.
6. Lift bucket operator: ₹700/day.
7. 6 slab casting helpers: ₹700/day each.



(Fig 3) On-Site Mixing in One-bag mixer

Disadvantages of RMC

A. *Logistical Challenges:*

Transportation delays can compromise concrete quality, especially if sites are far from the plant.

Requires efficient scheduling and coordination to avoid concrete setting before placement.

B. *Cost:*

Higher initial cost compared to on-site mixing, particularly for smaller projects.

Additional expenses for delivery and potential wastage in transit.

C. *Site Constraints:*

Requires adequate space for receiving and placing large concrete volumes.

Not feasible in remote or congested locations without proper access roads.

Disadvantages of On-Site Mixing

Inconsistent quality: Dependent on labour skill and environmental conditions.

1. Limited productivity: Low production capacity, especially for large projects.
2. Labor-intensive: Requires more manual effort, increasing labour costs.
3. Material handling: Storage and handling of materials can be inefficient and cumbersome.
4. Time-consuming: Slower production and placement process.

Cost Comparison Example: On-Site Mixing vs. RMC

A. Cost for Ready-Mix Concrete (RMC):

Cost per cubic meter (M25): ₹4,600 (excluding 18% GST) With GST: ₹4,600 × 1.18 = ₹5,428/m³

- **Total cost for 100 m³:** ₹5,428 × 100 = ₹5,42,800
- ***Additional considerations:***
    - Transportation distance: 5 km (included in the base rate).
    - Delivery time: Approximately 2-3 hours.
    - No additional labor cost for mixing; only placement labor is needed.
- **Key Advantage:** Consistent quality, reduced labor, faster completion.

A. Cost for On-Site Mixing:

- **Material Costs:**

- Cement: ₹380 per bag (28% GST included); 1 m³ requires ~7 bags.

  $₹380 \times 7 = ₹2{,}660/\text{m}^3$
- Aggregates, sand, and water: ₹1,200/m³
- **Total material cost per m³:** ₹2,660 + ₹1,200 = ₹3,860/m³

- ***Labor Costs:***
  - 2 female helpers × ₹500 = ₹1,000/day
  - 1 male helper = ₹700/day
  - Lift bucket operator = ₹700/day
  - 6 slab-casting helpers × ₹700 = ₹4,200/day
  - **Total labor per day:** ₹6,600
- **Production Rate:** 40 m³/day
  - **Labor cost per m³:** ₹6,600 / 40 = ₹165/m³
- ***Total cost per m³ (materials + labor):***

  ₹3,860 + ₹165 = ₹4,025/m³
- **Total cost for 100 m³:** ₹4,025 × 100 = ₹4,02,500
- ***Additional considerations:***
  - Longer time requirement: 100 m³ will take ~2.5 days (40 m³/day), increasing indirect costs like supervision.
  - Quality inconsistency risk due to manual mixing.

Cost Summary:

- **RMC total cost:** ₹5,42,800
- **On-site mixing total cost:** ₹4,02,500

Cost Difference: ₹1,40,300 more expensive for RMC. However, this difference might be justified by savings in time, reduced labor management, and consistent quality.

Parameter	On-Site Mixing	Ready-Mix Concrete (RMC)
Production Control	Variable quality due to manual mixing and site conditions	High consistency due to plant-controlled batching and testing
Labor Requirement	High – depends on skilled labor for mixing and batching	Low – automated plant reduces need for on-site labor
Concrete Strength	Inconsistent – often lower than design grade due to human error	Reliable – generally matches or exceeds target grade
Time Efficiency	Slower – limited production (40–50 cum/day)	Fast – high output (up to 500 cum/day)
Cost (Small Projects)	Economical – especially for small volumes or short distances	Costlier – due to delivery charges and minimum order quantity
Cost (Large Projects)	Less economical – higher labor and material wastage	More economical – reduced labor, waste, and rework
Quality Assurance	Manual testing required; risk of batching errors	Regular plant QC and third-party tests ensure quality
Site Space Requirement	High – requires area for raw material storage and mixing setup	Low – only space for receiving and placing concrete is needed
Flexibility of Mixing	High – mix can be adjusted immediately on-site	Low – fixed mix from plant; limited scope for last-minute changes
Environmental Impact	High – dust, noise, material waste on-site	Moderate – emissions from transportation, but cleaner at site
Use of Admixtures	Limited – manual dosing prone to error	Advanced – automated and precise dosing for HPC, SCC, GGBS mixes
Logistics	Simple – no dependency on transit	Requires coordination for delivery; traffic delays can affect quality
Suitability	Small-scale, budget-conscious, remote, or temporary works	Large-scale, urban, high-grade, and fast-paced projects
Initial Setup Cost	Low – minimal equipment investment	High – dependent on external batching plant pricing
Durability & Workability	Variable – risk of over- or under-mixing	Excellent – due to uniform material and mix design control
Waste Generation	High – over-mixing, storage spillage, leftovers	Low – efficient plant operations and batching accuracy
Skilled Labor Dependency	High – skilled workers are critical	Low – majority of work is automated at plant

3. CONCLUSIONS

1. **Decision Influencers:**
   - **Scale of operation:** Larger the project, more viable RMC becomes due to economies of scale.
   - **Location accessibility**: RMC logistics are effective in urban areas but challenged in remote terrain.
   - **Concrete complexity:** Special mixes like M60, M70, SCC, or GGBS/Ultrafine blends are only reliably achievable in RMC setups.
2. **Recommendation Guidelines:**
   - **Use RMC if:**
     - You're targeting premium structural reliability and uniformity.
     - Construction occurs in high-density areas or where local material procurement is difficult.
     - Your project cannot afford delays or rework due to inconsistent quality.
   - **Use On-Site Mixing if:**
     - Your project size is small and has flexibility in schedule.
     - You're working in areas without accessible RMC services.
     - Budget constraints outweigh performance demands, and skilled labor is available.
     - **Mid-Spectrum Projects:**
   - Consider mobile batching plants.
   - Implement RMC + On-site curing combinations.
   - Use site batching with quality-assured packaged raw materials from RMC vendors.
3. **Project Management Considerations:**
   - Perform preliminary cost-time-quality assessments before selecting the concrete production mode.
   - Ensure QA/QC protocols are aligned with chosen method (more stringent for on-site).
   - Maintain site-specific checklists and KPIs to track performance differences.

ACKNOWLEDGEMENT

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REFERENCES

1. Al-Tayeb, M., Yousif, A., & Basheer, P. (2021). Quality control in ready-mix concrete production: A comparative analysis with on-site mixing. Journal of Construction Engineering and Management, 147(4), 04021028. https://doi.org/10.1061/(ASCE)CO.1943-7862.0002003

ISSN: 2583-6129
DOI: 10.55041/ISJEM04357

2. Singh, R., & Bhalla, S. (2020). Cost analysis of on-site mixing versus ready-mix concrete in construction projects. International Journal of Civil Engineering, 18(3), 349-360. https://doi.org/10.1007/s40999-020-00543-7

3. Ganesan, M., Harish, K., & Suresh, R. (2019). Time efficiency in concrete delivery and pouring: A comparison of on-site mixing and ready-mix concrete. Construction Management and Economics, 37(5), 401-412. https://doi.org/10.1080/01446193.2019.1592101

4. Chidambaram, S., & Li, Y. (2022). Logistical challenges in the ready-mix concrete supply chain and transportation solutions. Journal of Transport and Supply Chain Management, 16(1), 300-310. https://doi.org/10.10520/EJC-138caa306

5. Thomas, R., & Kumar, A. (2021). Environmental impact of on-site mixing vs. ready-mix concrete: A carbon footprint analysis. Journal of Cleaner Production, 281, 124-139. https://doi.org/10.1016/j.jclepro.2021.125491

6. Verma, K., Sharma, P., & Gupta, N. (2018). Labor requirements and skill levels in on-site concrete mixing and ready-mix concrete. International Journal of Building Pathology and Adaptation, 36(2), 231-244. https://doi.org/10.1108/IJBPA-06-2017-0021

7. Patel, S., & Shah, H. (2020). Concrete strength and durability: Comparative study of on-site mixing and ready-mix concrete. Materials Today: Proceedings, 34, 453-461. https://doi.org/10.1016/j.matpr.2020.01.216

8. Abebe, B., & Desalegn, W. (2019). Waste management and efficiency in on-site concrete mixing versus ready-mix concrete. Resources, Conservation & Recycling, 145, 70-78. https://doi.org/10.1016/j.resconrec.2019.02.030

9. Almeida, J., & Dias, L. (2021). Storage and handling requirements for concrete raw materials in on-site and ready-mix production. Journal of Building Engineering, 43, 102-113. https://doi.org/10.1016/j.jobe.2021.102113

10. O'Neill, J., MacLeod, D., & Robbins, M. (2020). Suitability of concrete production methods for large-scale construction projects. Journal of Civil Engineering and Management, 26(8), 713-723. https://doi.org/10.3846/jcem.2020.13520