Study on the Behaviour of M25 grade Concrete under Laboratory and RMC mix conditions

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Abstract: *Concrete's versatility, durability, and cost-effectiveness, it as the most widely used construction material globally. It is typically a composite mixture of fine aggregates (such as sand), coarse aggregates (like gravel or crushed stone), and a binding paste made from water and cement often Ordinary Portland cement (OPC). Admixtures are frequently added to enhance specific properties. A proper understanding of concrete fundamentals and an optimized mix design are essential for achieving the desired strength, workability, and durability, while also maintaining cost efficiency and minimizing material waste. This experimental study focuses on evaluating the strength characteristics of M25 grade concrete produced in both laboratory and site environments. Given that site conditions such as exposure to varying temperatures, curing methods, and casting durations differ significantly from controlled laboratory conditions, this investigation aims to assess whether laboratory-tested concrete strength translates effectively to real-world site performance. The study further examines how concrete strength varies over time (0h, 1h, and 2h) through slump tests conducted at 30-minute intervals for simulate site conditions, both with and without the addition of admixtures. Compressive strength is evaluated for 7, 28, and 90-day cured specimens.*

Keywords: Concrete Mix Design, M25 Grade Concrete, Admixture, Compressive Strength, Slump Test.

1 INTRODUCTION: The study investigates overall performance of concrete depends not only on the mix design but also on site-specific factors such as mixing methods, placing techniques, and curing conditions. Laboratory-mixed concrete is prepared under controlled conditions using standardized equipment, which allows precise control over mix proportions and uniform mixing. However, small-scale laboratory mixers may not always replicate the mixing efficiency of commercial Ready-Mix Concrete (RMC) plants. RMC benefits from mechanized, large-capacity mixers that generally provide more uniform and consistent mixing, potentially resulting in improved workability and strength. Despite these advantages, site-specific factors such as transportation delays, temperature fluctuations, and curing practices can affect the strength development and performance of RMC on-site. Comparing the behaviour of M25 grade concrete produced in laboratory and RMC environments is essential to identify discrepancies in strength, workability, and durability. Such evaluation enables better understanding and optimization of mix designs and handling procedures, ensuring reliable and consistent concrete quality in real-world construction projects.

2 Review of Literature

[2]**Er.Khalil Rahman Farhat and Er. Masood Jamali (2022).,** This research paper gives the Effect of Admixture on Properties of Concrete. Concrete is a man or machine-made construction material, and that has more usage in the construction field, it is necessary to make construction secure and safe for making high strength concrete.

[3]**Izabela Skrzypczak, Agnieszka Le´sniak, Piotr Ochab, Monika Górka, Wanda Kokoszka and Anna Sikora (2021).,** This study shows RMC concrete quality performed for concrete mix and hardened concrete, whereas individual analysis of the results allows the laboratory quality system to be improved.

[6]**S. Manikandan and P. Jaya Karthik Reddy (2022).,** Explored Artificial Intelligence (AI) in concrete quality control. By using sensors to analyse water-cement ratio and mix proportions, their approach reduces manual labour, cost, and time while improving concrete quality.

[4]**Ishfaq Bashir Wani, Dr. R. Venkata Krishnaiah (2022).,** This paper shows the behaviour of high strength concrete addition of super plasticizer, stone dust and laboratory investigation. High- grade strength Concrete is mostly used for various applications in the construction of concrete structures.

[5]**Prashant M. Dhamanage and V. Nagendra (2020).,** examined high strength concrete using mineral admixtures. Their findings suggest that partial cement replacement enhances workability, strength and making it suitable for specialized structures.

[1]**Akoba A.S, Phulari R.C, Kembhavi S.B(2020).,** This study shows Materials scientists, substances named admixtures. developed Eco and Crack-Free High-performance concrete incorporating recycled recycled (Eco-HPC), materials for sustainability. Their study optimized binder systems, aggregate packing, and shrinkage resistance, validating structural performance for pavements (Eco-Pave-Crete) and bridges (Eco-Bridge-Crete).

3. Objectives: The present investigation aims to achieve several key objectives(1) To compare the strength parameters of concrete produced at an RMC plant and at the construction site, (2) To estimate the effective strength development of concrete over time, with and without the use of admixtures, under laboratory conditions, (3) To compare the strength parameters of concrete from site-cast samples and laboratory-prepared specimens, (4) To assess the variation in concrete strength corresponding to changes in slump over different time intervals.

4. Materials and Methodology

4.1 Cement: The experiment made use of regular Ordinary Portland Cement (OPC) 53 as per IS 12269:1987 and The below Table 1 shows the Physical properties of the Cement.

Table 1 Physical Properties of OPC 53 grade Cement (UltraTech)

Physical Properties		Values	Limits
Specific Gravity		3.15	3.1 – 3.5 as per IS4031 part 11 (1988)
Compressive Strength (N/mm^2)	3 days	38.5	Min 27 N/mm^2
	7 days	47.5	Min 37 N/mm^2
	28 days	62	Min 53 N/mm^2
Initial Setting Time (min)		160	Not less than 30min
Final Setting Time (min)		250	Not more than 600 min

4.2 Fine Aggregate: The fine aggregates were collected from pachikapallem, near by Tirupati and their properties are presented in Table 2

Table 2 *Physical Properties of Manufacture Sand*

Physical Properties		Values	Limits As per IS 383-2016
Specific Gravity		2.66	2.1 - 3.2
Water absorption (%)		2.45	Max.5.0% by weight
Fineness Modulus		2.52	Not exceed 3.2
Bulk density (g/cc)	Loose	1.680	-
	Rodded	1.900	-
Sieve analysis		Zone -II	-

4.3 Coarse Aggregate: The 20mm and 12.5mm two types of coarse aggregates were used in this project, properties are shown in table 3 and 4

Table 3 Physical properties of 20mm coarse aggregate

Physical Properties		Values	Limits As per IS 383-2016 and IS 2386(Part-1)
Specific Gravity		2.58	2.1 - 3.2
Water absorption (%)		0.5	Max.5.0% by weight
Fineness modulus		6.11	6-7
Bulk density(g/cc)	Loose	1.447	-
	Rodded	1.584	-
Sieve analysis		Single size	-
Flakiness Index		8.48%	Acceptance limit is15%
Elongation Index		9.39%	Acceptance limit is15%

Table 4 Physical properties of 12.5mm coarse aggregate

Physical Properties		**Values**	**Limits As per IS 383-2016**
Specific Gravity		2.69	2.1 - 3.2
Water absorption (%)		0.4	Max.5.0% by weight
Fineness modulus		5.7	5.5 -6.5
Bulk density(g/cc)	Loose	1.334	-
	Rodded	1.448	-
Sieve analysis		Single size	-
Impact value (%)		16.48	Acceptance limit is 30%

4.4 Water: Two type of water samples are used in the project, one sample at site and another sample at laboratory. The test data is

pH value at Site - 8
pH value at Laboratory - 6.52

4.5 Chemical Admixture: The Super- Plasticizer of SC Maximo Plast PC 200 is used in the concrete for the preparation of concrete mix, properties are shown in Table 5.

Table 5 Properties of Super -Plasticizer

S. No	**Tests**	**Obtained Values**	**IS: 9103 Limits (Re affirmed 2018)**	**UOM**
1	Appearance	Light brown coloured liquid	--	No unit
2	Dry material content	26.42%	$\pm$5 of value stated by the manufacturer	% by mass
3	Relative density	1.078	$\pm$0.02 of the value stated by the manufacturer	-
4	Chloride content	0.019%	Within 10 percent of the value or within 0.2 percent whichever is greater as stated by the manufacturer	% by mass
5	pH	7.61	Min.6	No unit

4.6 Methodology: This study investigates the strength performance of M25 grade concrete through a combination of field and laboratory testing. Standard cubes (150 mm × 150 mm × 150 mm) were cast and tested at 7, 28, and 90 days. Field investigations involved concrete site inspections at an in-situ. In the laboratory, concrete mixes were prepared with and without polycarboxylate-based superplasticizer admixtures and tested at different time intervals to study strength variations for detailed investigation shown in below Fig 1.

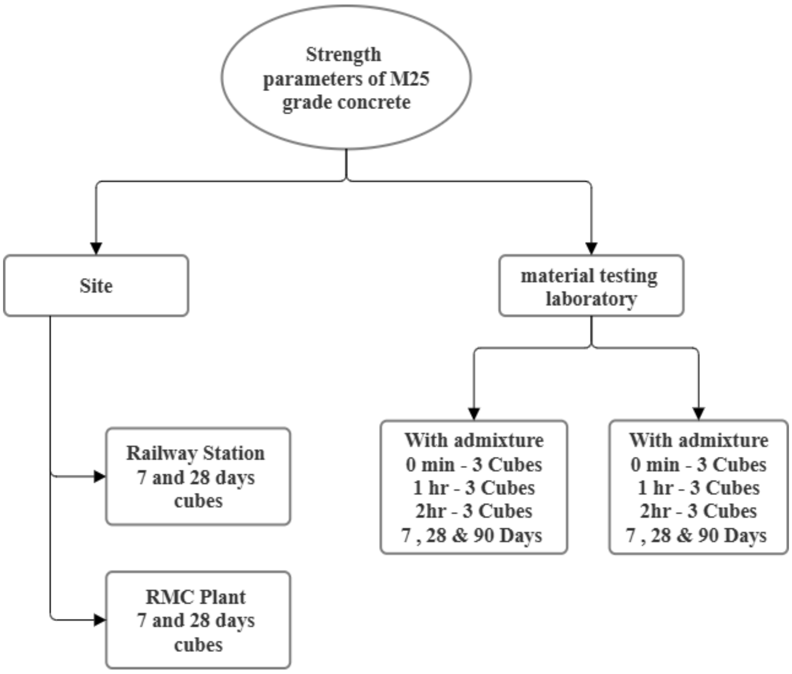

Fig 1 Methodology

4.7 Mix Design

The two types of M25 grade concrete mix designs are used in this project like with and without admixture designed as per codes IS10262-2019, IS 456-2000 and proportions are listed below Table 6 and 7.

Table 6 M25 Grade Concrete Design Mix with Admixture

CEMENT	FA	CA	WATER	ADMIXTURE
337	849	1038	165	6.61
kg/m^3	kg/m^3	kg/m^3	kg/m^3	kg/m^3
1	2.51	3.08	0.49	1.96

Table 7 M25 Grade Concrete Design Mix without Admixture

CEMENT	FA	CA	WATER
337	849	1038	168.5
kg/m^3	kg/m^3	kg/m^3	kg/m^3
1	2.51	3.08	0.5

5 Tests Conducted on Concrete

5.1 Wet Concrete: Slump Cone Test

The below Fig 2 graphically compares the change in slump value (workability) over time for concrete mixes with admixture (Modified Mix) and without admixture (Control Mix), demonstrating the admixture's critical role in slump retention.

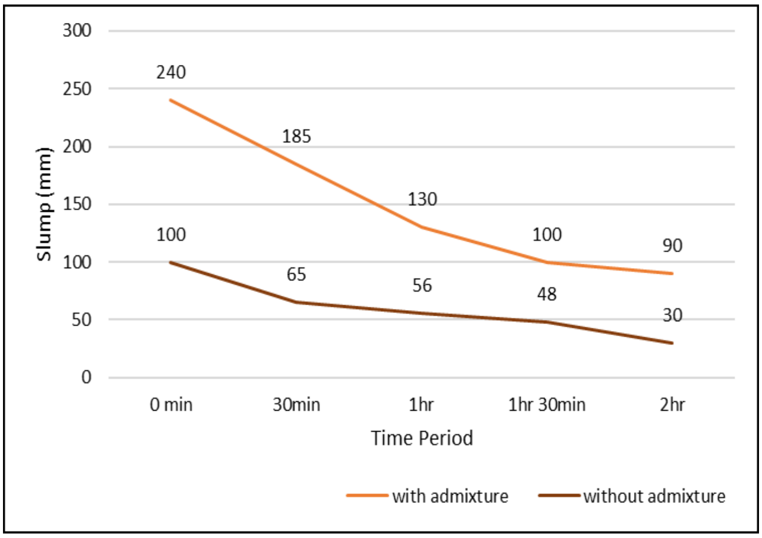

Fig 2 Slump Effects on Concrete with Time Duration

6 Results and Discussions

6.1 Compressive Strength Test: The below Fig 3, shows the variation in compressive strength of concrete between the RMC plant and the site. The compressive strength values at 7 and 28 days are 32.3 N/mm^2 and 42.5 N/mm^2 at the RMC plant, and 25.17 N/mm^2 and 33.54 N/mm^2 at the site, respectively. These variations are observed along with the slump changes and are based on considerations of transportation time and concrete dumping at the site.

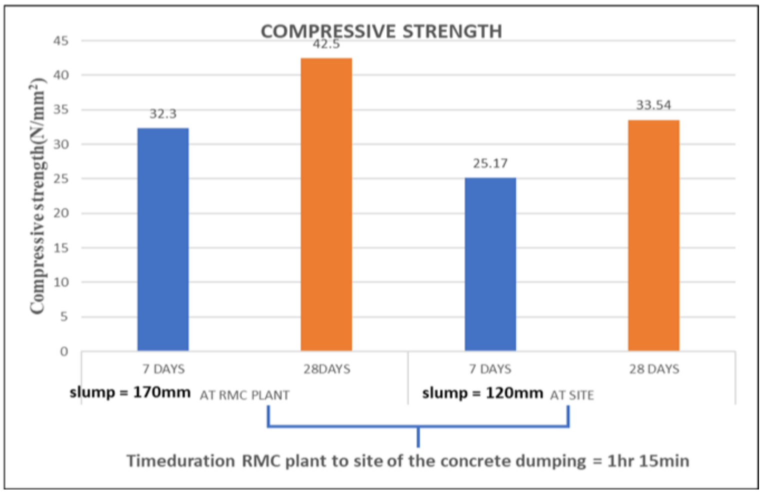

Fig 3 Compressive Strength

By observing the two Figures below, the behaviour of concrete with and without the addition of admixture over time can be understood. From the reference of these graphs, it is observed that when admixtures are used, the compressive strength decreases with time, as shown in Fig 4. In contrast, the concrete without admixture shows an increase in compressive strength with time duration, as illustrated in Fig 5.

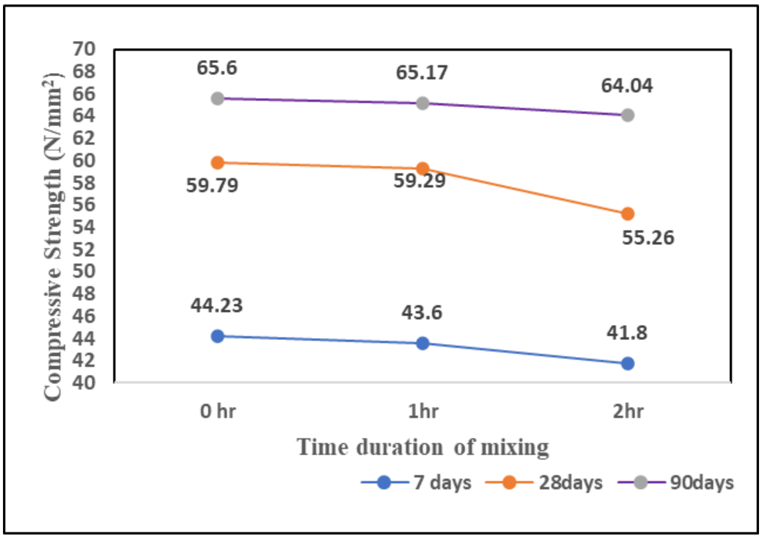

Fig 4 Effect of Mixing Time on Strength of Concrete with Admixture

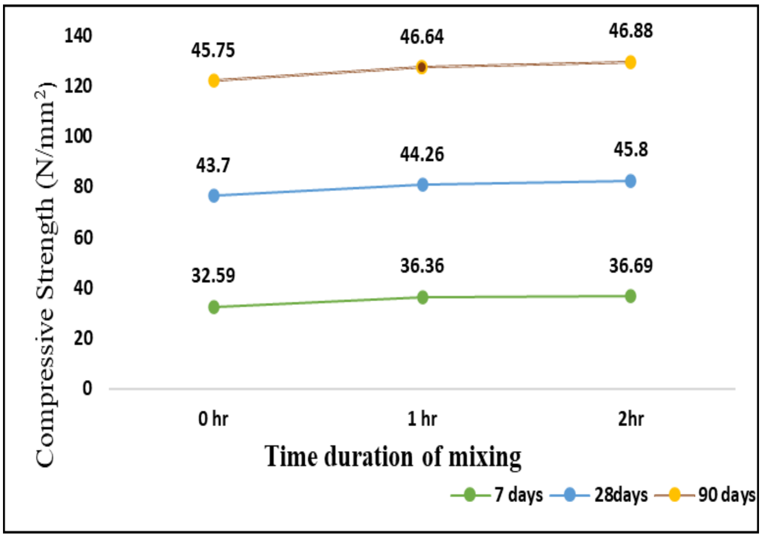

Fig 5 Effect of Mixing Time on Strength of Concrete without Admixture

6.2 Summary of Results

- At the RMC plant of fresh concrete is 29% and 27% higher the compressive strength than site concrete 7 and 28 days respectively.
- The usage of concrete with addition of admixtures leads to decrease in strength in linear manner with time duration.
- The Maximo Plast PC 200 was prepared by Polycarboxylic ether chemical, this will cause air-entrainment in concrete and the improvement of workability also causes air-entrainment in concrete.
- The air-entrainment in concrete reduces the compressive strength of concrete along with time duration.
- Concrete without admixtures tends to gain strength gradually in a linear manner with time duration.
- A long -time mixing of concrete will result in increase of compressive strength of concrete within limits, due to mixing over long periods the effective water/cement ratio gets reduced, owning to the absorption of water by aggregate and evaporation and it is also possible that the increase in strength may be due to the improvement workability on account of excess fines, resulting from the abrasion and attrition of coarse aggregate in the mix, and from the coarse aggregate becoming rounded.
- At laboratory fresh concrete is 24% and 27% higher the compressive strength than site concrete 7 and 28 days respectively.

7. CONCLUSION

- Adding admixture in concrete overall strength about 30% high than normal concrete and durability of the Admixtures are helping to control the water content in concrete, thereby improving its workability and enhancing mix.
- The workability of concrete has a direct influence on its strength development about 27%, as proper workability ensures adequate compaction and gain the uniform strength.

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