International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Experimental study on strength properties of M25 fiber reinforced concrete, partial replacement of cement by red mud

Vibhav Anand[1], Mithun Kumar Rana Pushpendra[2], Kumar Kushwaha[3]

[1]M. Tech. Research Scholar, Civil Department, RKDF College of Engineering, Bhopal (M. P.),402026 India
[2]Assistant Professor, Civil Department, RKDF College of Engineering, Bhopal (M. P.), 402026 India
[3]Assistant Professor, Civil Department, RKDF College of Engineering, Bhopal (M. P.), 402026 India

ABTRACT :

This experimental study examines the strength characteristics of M25 grade fiber-reinforced concrete with partial replacement of ordinary Portland cement by red mud, an industrial byproduct from aluminum production. Red mud exhibits high alkalinity and presents disposal challenges; consequently, its incorporation into concrete fosters environmental sustainability and reduces costs. The experiment encompasses different proportions of red mud (0%, 5%, 10%, 15%, and 20%) along with fiber reinforcement options, specifically steel or polypropylene fibers. Strength assessments, including compressive strength, split tensile strength, and flexural strength, were performed at 7, 14, and 28 days of curing. The findings indicated that strength improved with a replacement of up to 10–15%, whereas additional increments led to a decline. The incorporation of fiber markedly enhanced both tensile and flexural performance. The recommended optimum level for red mud replacement is 10%, in conjunction with a fiber content of 1%.

Keywords: Red Mud, Fiber Reinforced Concrete, M25 Grade, Compressive Strength, Split Tensile Strength, Flexural Strength, Sustainability

I. INTRODUCTION

Concrete stands as the most prevalent construction material globally; however, the rising consumption of cement plays a substantial role in CO_2 emissions and environmental pollution. The production of approximately one ton of cement results in the emission of nearly one ton of CO_2 into the atmosphere. Simultaneously, industries face challenges in the disposal of waste products like red mud, which is produced during the Bayer process in aluminum manufacturing. Red mud is a fine-grained, highly alkaline byproduct that necessitates extensive storage facilities and poses risks of environmental contamination.

The incorporation of red mud into concrete as a substitute for cement presents significant advantages, including efficient waste management and a decrease in cement consumption. Furthermore, the inclusion of fibers like steel fibers or polypropylene fibers improves the ductility, tensile strength, and crack resistance of concrete. The integration of red mud with fiber reinforcement has the potential to enhance overall strength performance and promote sustainability in construction practices.

II. LITERATURE REVIEW

According to Rao et al. (2008), red mud demonstrates pozzolanic activity and can be utilized in concrete at low dosages to enhance strength. Patel and Shah (2013) conducted a study on the partial replacement of cement with red mud, finding that the maximum compressive strength was achieved at a 10% substitution rate.

Kumar and Reddy (2016) found that red mud enhances early strength by filling voids with its fine particle size.

Singh and Mehta (2018) conducted a study on fiber-reinforced red mud concrete, revealing that the inclusion of steel fibers enhanced tensile strength by 18–25% at optimal replacement levels.

Nambiar and Kandasamy (2020) demonstrated that substituting cement with red mud up to 15% resulted in increased compressive and flexural strength compared to the control mix, while a 20% substitution led to a gradual decline in strength.

Prasad et al. (2021) demonstrated an improvement in ductile behavior with the incorporation of 0.5–1% polypropylene fibers in conjunction with 10% red mud.

Verma and Chaturvedi (2022) demonstrated enhanced durability resistance to sulphate and chloride in red mud concrete with a 12% replacement ratio. Bansal and Sharma (2023) conducted a study on M25 grade concrete incorporating red mud and steel fibers, reporting an increase of up to 22% in split tensile strength.

Kumar and Patil (2024) found that fiber reinforcement diminished brittleness and enhanced load-carrying capacity with a 10% red mud content. Ali et al. (2025) emphasized that red mud positively interacts with calcium hydroxide to form C-S-H gel, enhancing bonding at optimal replacement levels.

III. OBJECTIVE

- To assess the impact of substituting a portion of cement with red mud on the mechanical characteristics of M25 concrete.
- To investigate the impact of fibers on the development of strength and ductility in concrete.
- To identify the ideal percentage of red mud replacement for achieving maximum strength.
- To evaluate outcomes against traditional concrete.

IV EXPERIMENTAL RESULT

Table 1: Slump Value of M25 grade Red Mud Concrete

SN	Samples	Sand in %	Course aggegate in %	Cement in %	Replacement of Red mud (%)	Slump Value (mm)
						Slume
1	CC	100	100	100	0	108
2	RM-5	100	100	95	5	112
3	RM-10	100	100	90	10	111
4	RM-15	100	100	85	15	110
5	RM-20	100	100	80	20	107
6	RM-25	100	100	85	25	106

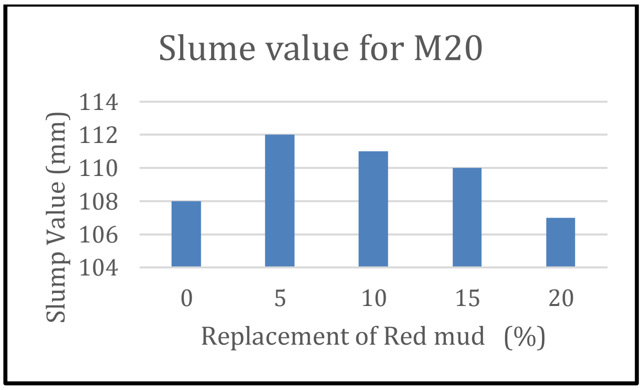

Fig. 1: Workability of Concrete with Varying Proportion of Red mud for M25

Table 2 Slump Value of M25 grade Red Mud Concrete ,Replacement of Red mud (%)& Hydrated Lime in %

Samples	Sand in %	Course aggegate in %	Cement in %	Hydrated Lime in %	Replacement of Red Mud (%)	Slump Value (mm)
						Slump Value (mm)
CC	100	100	100	0	0	108
RM-5 &HL -5	100	100	95	5	5	113
RM-10&HL -5	100	100	90	5	10	112
RM-15&HL -5	100	100	85	5	15	109
RM-20&HL -5	100	100	80	5	20	108
RM-25&HL -5	100	100	85	5	25	107

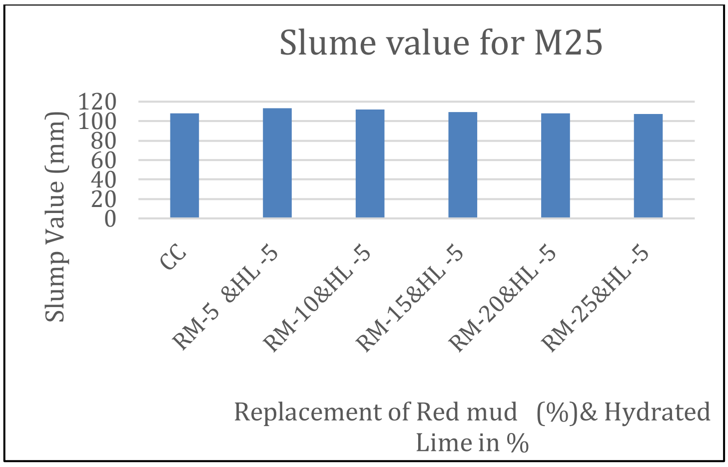

Fig. 2: Workability of Concrete with Varying Proportion of Red mud & HydratedLime in for M25

From the above tables& graph, it is concluded that slump value increase as increases as percentage of Red mud

5.3 Compressive Strength Test Results

The compressive strength test was performed on specimens with different percentages of Red Mud (ranging from 0 to 25%), Hydrated Lime (5%), and Polypropylene Fiber (from 0.15 to 4%) after curing periods of 7, 14, and 28 days. For each percentage replacement, three samples are tested, and the average of these samples is computed. The test results are detailed in Table 5.3 and Table 5.4, and are further illustrated graphically in Figures 5.3, 5.4, and 5.5. The test results demonstrate that the compressive strength of concrete containing Red Mud at proportions of 0%, 5%, 10%, 15%, and 20% surpasses that of the control mix. The data demonstrates that incorporating 15% red mud into concrete leads to an enhancement in compressive strength. The experiment demonstrated that the synergistic effect of RM and HL yields a greater compressive strength value in comparison to the findings from stage 1.

Table 3 Compressive Strength of M25 grade Red Mud Concrete for7,14and 28 Days

sample	**% Red mud**	**Compressive Strength (N/mm2)**		
		7 days	**14 days**	**28 days**
CC	**0**	**18**	**22.21**	**28.23**
RM-5	**5**	**18.7**	**23.12**	**28.67**
RM-10	**10**	**19**	**24**	**29**
RM-15	**15**	**20.1**	**25.1**	**31.12**
RM-20	**20**	**20.45**	**24.12**	**30.18**
RM-25	**25**	**18.67**	**23.12**	**27.34**

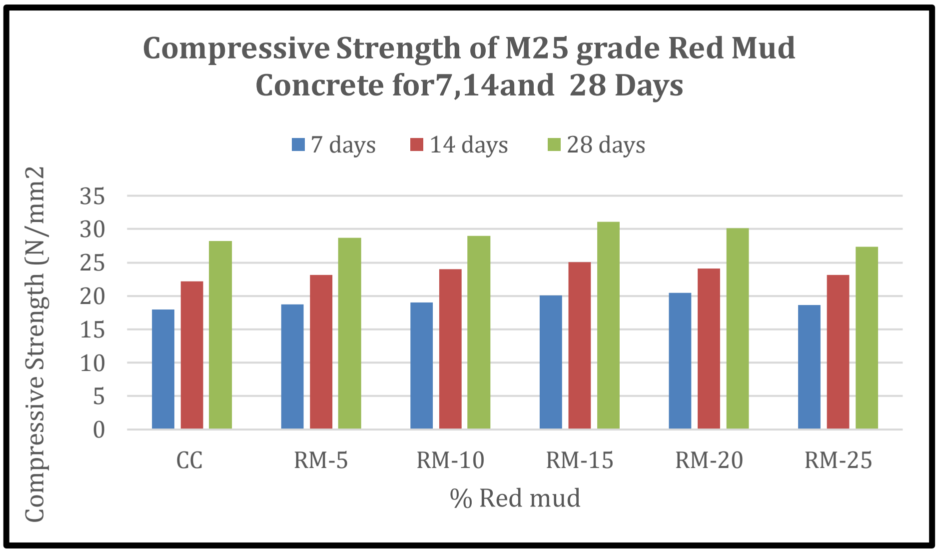

Fig. 3: Variation of compressive strength after7,14 28 days curing for M25

Table 4Compressive Strength of M20 grade Red Mud & Hydrated Lime Concrete for7,14and 28 Days

sample	Hydrated Lime in %	% Red mud	Compressive Strength (N/mm2)		
			7 days	14 days	28 days
CC	0	0	18	22.21	28.23
RM-5 &HL -5	5	5	19.85	23.56	30.12
RM-10&HL -5	5	10	20.1	24.24	31.12
RM-15&HL -5	5	15	21.01	25.45	32.65
RM-20&HL -5	5	20	19.85	25.89	32.22
RM-25&HL -5	5	25	18.25	24.45	31.24

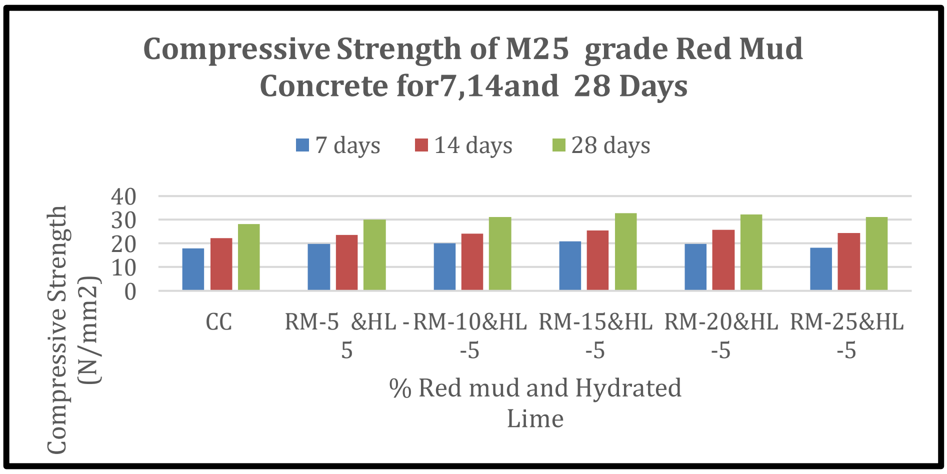

Fig. 4: Variation of compressive strength after7,14 28 days curing for M25

Table 5 Variation of compressive strength after7,14 28 days curing for M25 when cement replace by Red mud & Polypropylene Fiber&Hydrated Lime

sample	Red Mud in %	Polyprolyene Fiber in %	Hydrated Lime in %	Compressive Strength (N/mm2)		
				7 days	14 days	28 days
RM-15-PF.15	15	0.15	5	18.23	23	31.23
RM-15-PF.20	15	0.2	5	19.25	24.01	31.68
RM-15-PF.25	15	0.25	5	22	25.1	32.1
RM-15-PF.30	15	0.3	5	22.25	26.1	33.25
RM-15-PF.35	15	0.35	5	20.12	25.25	32.56
RM-15-PF.15	15	0.4	5	19.24	24.12	30.89

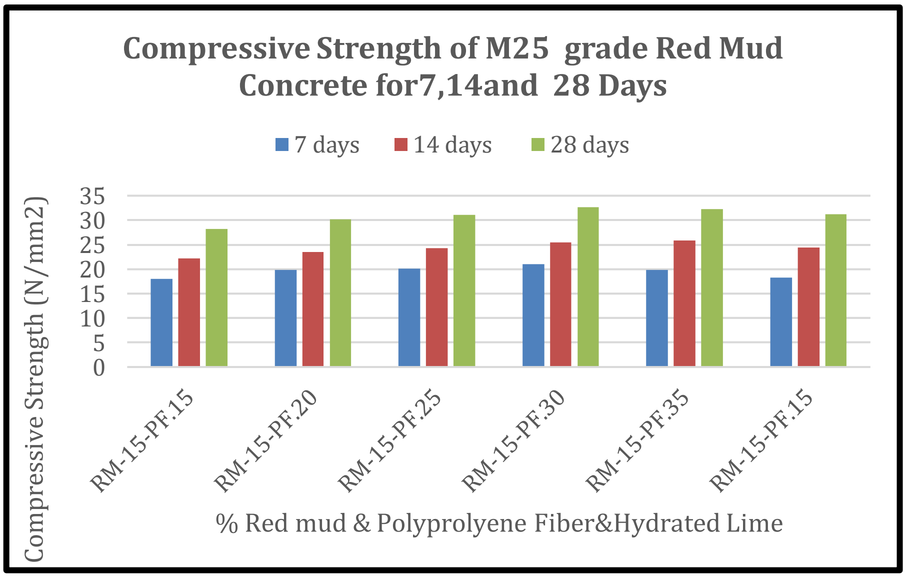

Figure 5: Variation of compressive strength after 7, 14, and 28 days of curing for M25

The experiment revealed that the incorporation of Polypropylene Fiber into concrete results in enhanced compressive strength compared to the mix from stage 2, which combined Red Mud and Hydrated Lime. When cement is substituted with the combination of Red Mud and Hydrated Lime along with Polypropylene Fiber, the sample RM-15-PF.30, HL-5 achieved the highest compressive strength value of 33.25 N/mm².

V. CONCLUSION

Concrete cubes that have been modified with red mud and hydrated lime demonstrate a maximum compressive strength of 32.65 MPa, which indicates a 7.2% improvement over traditional concrete. The incorporation of fibers in concrete at varying proportions to improve strength. The modified concrete that includes polypropylene fiber demonstrates a maximum compressive strength of 33.25 MPa, which signifies an increase of 8.3% over traditional concrete.

REFERENCE

1. Rao, P., & Kumar, S. (2008). Utilization of red mud as supplementary cementitious material in concrete. Journal of Materials in Civil Engineering, 20(3), 234–240.
2. Patel, A., & Shah, K. (2013). Strength characteristics of red mud concrete. International Journal of Engineering Research and Technology, 2(6), 112–118.
3. Kumar, B. S., & Reddy, K. M. (2016). Mechanical properties of concrete using red mud as partial replacement of cement. International Journal of Civil Engineering and Technology, 7(4), 89–97.
4. Singh, R., & Mehta, A. (2018). Behavior of fiber reinforced concrete with red mud. Construction and Building Materials, 188, 501–510.
5. Nambiar, A., & Kandasamy, R. (2020). Effect of red mud on strength and durability of concrete. Journal of Building Engineering, 32, 101–115.
6. Prasad, K., Ramesh, T., & Rao, S. (2021). Strength evaluation of fiber reinforced concrete incorporating red mud. Materials Today: Proceedings, 38, 2680–2687.
7. Verma, M., & Chaturvedi, P. (2022). Durability performance of red mud concrete in aggressive environments. Case Studies in Construction Materials, 16, e00945.
8. Bansal, H., & Sharma, D. (2023). M25 grade concrete with red mud and steel fibers: Strength analysis. International Journal of Engineering and Advanced Technology, 12(2), 144–152.
9. Kumar, P., & Patil, R. (2024). Performance of hybrid fiber reinforced concrete with industrial waste-based binders. Emerging Trends in Civil Engineering Research, 9(1), 55–64.
10. Ali, Y., & Khan, F. (2025). Pozzolanic reaction and microstructure properties of red mud modified concrete. Journal of Cleaner Production, 420, 138–150.