UTILIZATION OF RED MUD TO IMPROVE THE STRENGTH OF SELF COMPACTING CONCRETE

Mohammed Irfan Qureshi[1], Er Mahendra Saini[2]

[1]*PG Scholar, Department of Civil Engineering, Kautilya Institute of Technology & Engineering, Jaipur*
[2]*Assistant Professor, Department of Civil Engineering, Kautilya Institute of Technology & Engineering, Jaipur*

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Abstract - *One of the chief developments in the concrete world is the invention of Self Compacting Concrete (SCC). It is widely used in concrete industry as it offers fine equilibrium between deformability, compactability and stability. The study offers an experimental analysis on properties of self compacting concrete (SCC) containing red mud and class F fly ash. Red mud was substituted by weight of cement in varying proportion from 0% to 15% at the rate of 2.5% while fly ash was kept constant as 20% of total powder content in all mixes. Total of seven mixes were made including one control mix. The cement was replaced as 2.5%, 5%, 7.5%, 10%, 12.5% and 15% by weight of cement in various mixes. Total powder content was kept constant as 550 kg/m^3. The dosage of superplasticizer was kept as 0.4% of total powder content. Fresh SCC tests such as Slump flow, T_{50cm} time, V-funnel test, L-box test, U-box test and J-ring test were conducted to authenticate self-compactability parameters. Various other tests such as compressive strength test, split tensile strength test performed to accomplish the intent of research.*

Key Words: Red Mud, Self Compacting concrete, Compressive Strength, Fly Ash, Compactability.

1. INTRODUCTION

Self Compacting Concrete (SCC) is a meticulous form of concrete, which is suitable for placing in heavy reinforcement without any vibrations. A self compacting concrete must have following:

- Fluidity which permits self compaction of concrete exclusive of the requirement of external energy.
- It must remain uniform and consistent during placing.
- Flowable in congested reinforcement.
- No segregation and bleeding attributes.

Self Compacting Concrete has been used in numerous industrial applications and in precast industry but the fairly high cost of material still averts the extensive use of SCC in concrete industry, i.e., commercial and suburban constructions. Compared to conventional concrete the cost of SCC is somewhat more due to high cement content and chemical admixtures such as viscosity modifying admixtures (VMA) and high range water reducing admixture (HRWRA). Characteristically, the amount in cementitious materials can vary from 450 kg/m^3 to 600 kg/m^3 for SCC intended to fill highly constrained areas and for refurbishing applications. Such applications involve low aggregate volume to ease flow among restricted spacing without impasse and guarantee the filling of formwork devoid of consolidation. The incorporation high volume of finely ground powder materials is necessary to enhance cohesiveness and increase the paste volume required for successful casting of SCC. Reducing free water can lessen the VMA dosage crucial for stability. High binder content normally consists of replacement of cement with 20% to 40% fly ash or GGBS or other complementary cementitious materials which also helps in reducing the cost of SCC. Regardless of its binder composition, SCC is characterized by its low yield value to secure high deformability and moderate viscosity to provide even suspension of solid particles, both during casting and thereafter until setting.

1.1 Objective of the study

This endeavor is undertaken to study the properties of red mud in self compacting concrete, and an effort has been made to study the outcome of substitution of cement with red mud and performance of concrete using it. Following are few of the aims:

- Study of the properties of self compacting concrete in fresh and hardened state.
- Study of the outcome of red mud, in substitution of cement used in diverse proportions on the physical properties of self-compacting concrete.
- Evaluation of the properties of SCC when red mud is used in different proportions.

2. LITERATURE REVIEW

Diaz et al. (2015) replaced cementitious material in the mixture with 0%, 2% and 3% red mud by weight of cement and observed that red mud additions delayed both the chloride diffusion and carbonation of cement paste samples. The chloride diffusivity was found to be reduced by a factor of 9 if 3% of the cement weight is replaced by red mud. Regarding the carbon dioxide

Penetration, a reduction by a factor of 4 was measured for the carbonation coefficient with such a substituted amount. Concerning the CO_2 entrance, the weight increase was registered during the test provided reliable qualitative information about the carbonation depth.

Metilda et al. (2015) replaced cement in mixture with red mud by 0%, 5%, 10%, 15%, 20% and 25%and investigated the possibility of partially replacing Portland cement in concrete by red mud and evaluated its compressive strength, splitting tensile strength and flexural strength. The water-cement ratio was taken as 0.44. The study examined the effect of red mud on properties of hardened concrete and compared with conventional concrete. Cement replacement by red mud up to 15% yielded characteristic strength greater than conventional cubes. Further, increase in percentage of red mud by 20%, 25% and 30 % tended to decrease the compressive strength.

Shetty et al. (2014) replaced cementitious material in mixture with red mud at 1%, 2%, 3% and 4% with a replacement of 10% of fine aggregates with iron tailings at each red mud replacement level. It was observed that maximum compressive, tensile and flexural strengths were obtained at 2% red mud with 10% iron ore tailing with an increase of 13.11%, 1.5% and 6.42% in compressive, tensile and flexural strengths, respectively.

3. EXPERIMENTAL PROGRAM

Table 3.1: Properties of OPC-43 grade

Properties	Value	As per IS: 8112-2013
Specific gravity	3.15	3.15
Normal consistency (%)	29.5	-
Initial setting time (min.)	115	>30
Final setting time (min.)	165	<600
Fineness (%)	1.98	<10
Soundness (mm)	2	<10

3.1 Coarse aggregates

locally available coarse aggregates not greater than 10 mm were used in this study confirming to IS: 383-1970, various physical properties are given in Table 3.2 and 3.3.

Weight taken = 2 kg.

3.2 Mix Proportion

Table 3.8 shows the proportion of various materials in the mixes prepared. In all 7 mixes (CM, M1, M2, M3, M4, M5, M6) including one control mix were prepared. Control mix was constituted of OPC and fly ash only. Fly ash was kept constant as 20% (by weight) of total powder content. The total powder content was kept constant as 550 kg/m^3. OPC was replaced with red mud in diverse proportions as 0%, 2.5%, 5%, 7.5%, 10%, 12.5% and 15% by weight of cement. Water/powder ratio was kept 0.41 for each mix.

A polycarboxylic ether based superplasticizer was used as 0.4% by weight of total powder content to improve the workability of the mixes. The amount of water, fine aggregate and coarse aggregate were kept constant at 225.5 kg/m^3, 910 kg/m^3 and 590 kg/m^3 respectively.

Table 3.8: Mix proportion

Mix	Cement (kg/m^3)	Fly ash (kg/m^3)	% Red mud	Red mud (kg/m^3)	Total powder (kg/m^3)	Sand (kg/m^3)	Aggregate (kg/m^3)	Super-plasticizer (kg/m^3)	Water (kg/m^3)
CM	440	110	0	0	550	910	590	2.2	225.5
M1	429	110	2.5	11	550	910	590	2.2	225.5
M2	418	110	5.0	22	550	910	590	2.2	225.5
M3	407	110	7.5	33	550	910	590	2.2	225.5
M4	396	110	10.0	44	550	910	590	2.2	225.5
M5	385	110	12.5	55	550	910	590	2.2	225.5
M6	374	110	15	66	550	910	590	2.2	225.5

4. RESULTS AND ANALYSIS

4.1 Fresh properties

The fresh properties of concrete were evaluated to ensure resistance to segregation, passing ability and filling ability. Table 4.1 shows the values obtained from various tests

Table 4.1: Values of various fresh properties in various mixes

MIX	U-Box filling ht. (H_2-H_1) (mm)	L-Box blocking ratio (H_2/H_1)	Slump Flow Dia. (mm)	T_{500mm} time (sec.)	J-Ring difference in ht. (mm)	V-Funnel time (sec)
CM	22	0.976	680	2.6	2.125	8
M1	23.25	0.957	678.3	2.73	2.463	8.33
M2	24.77	0.935	674.6	2.98	2.66	9.05
M3	26.58	0.91	669.8	3.44	3.25	9.46
M4	27.83	0.867	666.1	3.81	4.05	9.66
M5	28.25	0.85	661.83	4.11	4.3	10
M6	29.1	0.832	654.5	4.56	4.83	11.13

Table 4.2: Conformity criteria for properties of SCC

Sr. No.	Method	Unit	Typical range of values	
1	**U-box**	H_2-H_1 (mm)	**MIN**	**MAX**
2	**L-box**	H_2/H_1	0	30
3	**Slump flow dia.**	mm	0.8	1.0
4	**T_{500mm} time**	sec.	550	850
5	**J-ring**	mm	2	5
6	**V-funnel**	sec.	0	10

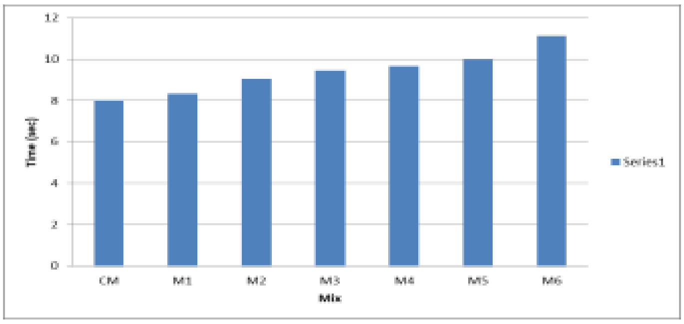

Figure 4.1: V-funnel time for various mixes (in seconds)

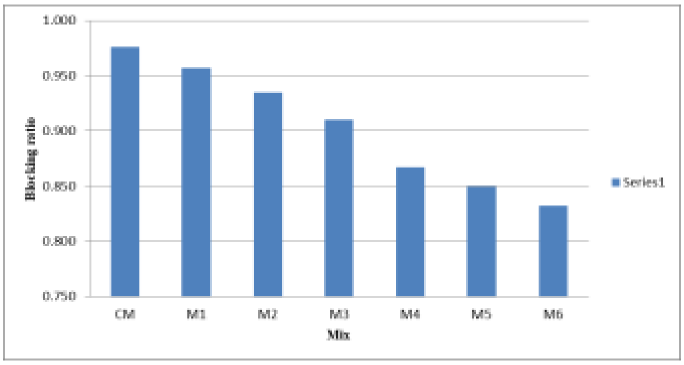

Figure 4.2: Blocking ratio (H_2/H_1) for various mixes

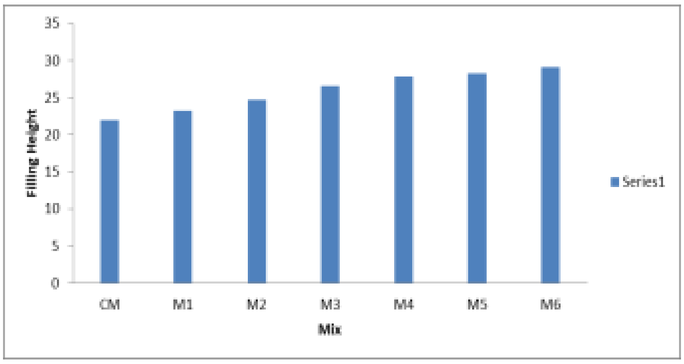

Figure 4.3: Result of U-box filling height

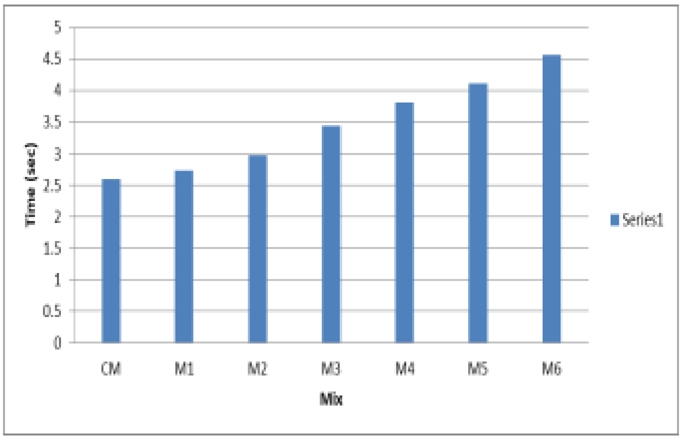

Figure 4.4: Time required for passing 500 mm circle.

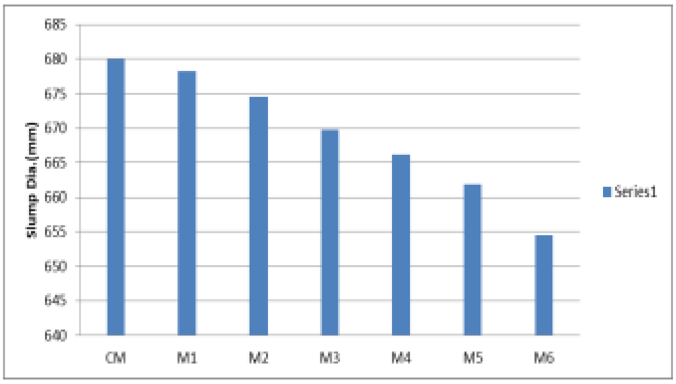

Figure 4.5: Slump flow diameter for all mixes

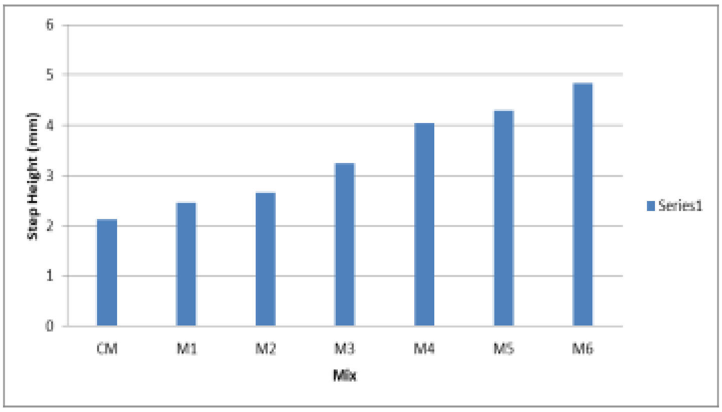

Figure 4.6: Results of J-Ring step height.

4.2 Compressive Strength

4.2.1 Compressive Strength by UTM

Compressive strength of various SCC mixes at 7, 28, 35, 56 and 90 days are represented in Table 4.3. Cube samples were immersed and cured in water and tested in Compression Testing Machine (CTM).

Table 4.3: Compressive strength of SCC

	Compressive strength (N/mm²)				
MIX	**7 days**	**28 days**	**35 days**	**56 days**	**90 days**
CM	19.6	27.01	28.78	29.58	35.05
M1	20	27.02	29.39	31.47	35.38
M2	20.23	29.15	32.94	33.66	36.53
M3	23.58	31.56	34.34	35.95	36.54
M4	23.91	32.28	35.46	36.31	36.93
M5	24.78	35.74	36.17	36.48	37.88
M6	19.48	23.19	24.66	28.47	30.92

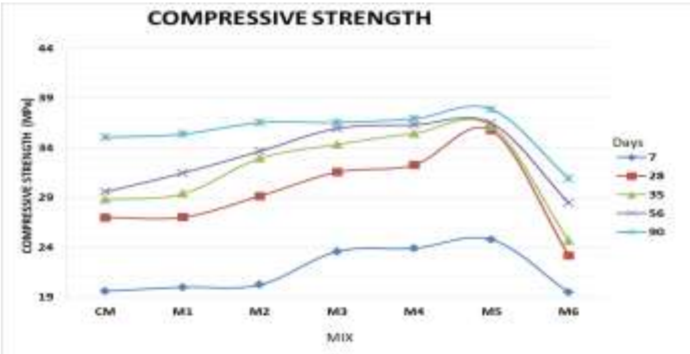

Figure 4.7: Compressive strength for various mixes

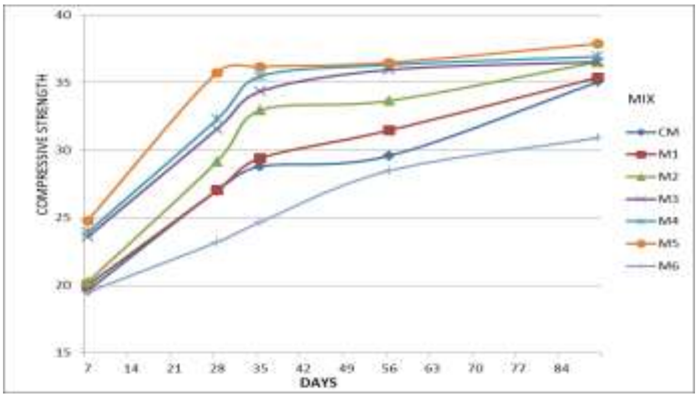

Figure 4.8: Compressive strength of concrete mixes versus curing age.

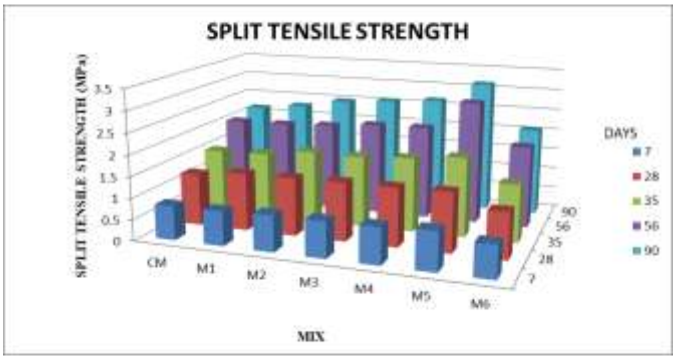

Figure 4.9: Split tensile strength at various ages

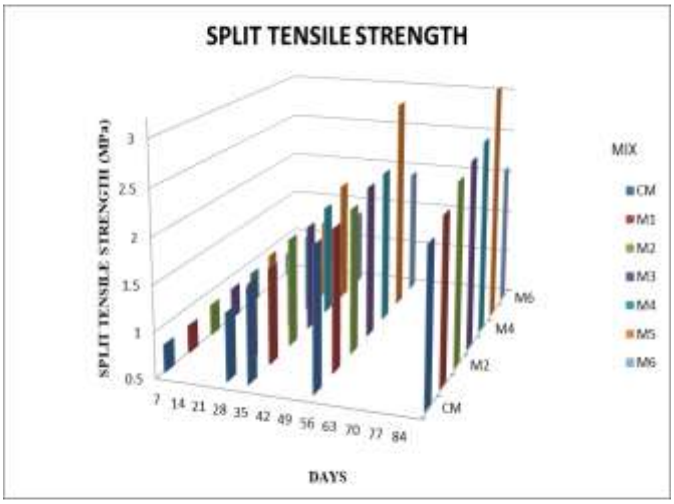

Figure 4.12: Split tensile strength versus curing age.

5. CONCLUSIONS

The main aim of present work was to explore the consequence of substitution of red mud as partial replacement of cement in concrete and mortar. In the current study, fresh, hardened and durability properties of mortar and concrete were analysed after using red mud as supplementary cementitious material. This section comprises of the analysis of results and depiction of the conclusions.

The conclusions which can be made from the research work carried out to assess fresh, hardened and durability properties of SCC incorporating fly ash and red mud based on the experimental analysis are as follows:

1. Observations from the results of fresh properties depict that affinity for water increases with increase in the proportions of red mud. V-funnel time and J-ring step height increases while the slump diameter and blocking ratio decreased as the red mud content increases in various mixes.
2. Utilization of red mud may also lead to improved waste management and energy savings in terms of carbon reduction.

6. REFERENCES

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