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Significance of Red Mud and Foundary Sand in Self Compacting Concrete

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Abstract— **Maintenance, repair and rehabilitation of existing cement concrete structures involve a lot of problem leading to significant expenditure. In the recent past, there has been considerable attention for improving the properties of concrete with respect to strength and durability, especially in aggressive environments.Self-compacting concrete (SCC) appears to be better choice for a strong and durable structure. Suitable addition of mineral admixtures such as Red mud (RM) and Foundry Sand (FS) in concrete improves the strength and durability of concrete due to considerable improvement in the microstructure of concrete composites, especially at the transition zone. Very few studies have been reported on the use of RM and FS for development of Self compacting concrete and also durability characteristics of these mixes have not been reported. In order to make a quantitative assessment of different cement replacement levels with RM and FS on the strength and durability properties for M50 grades of SCC trial mixes and to arrive at the maximum levels of replacement of cement with RM and FS, investigations were taken. Requirement of proper curing is essential otherwise micro cracks will appear on the surface of concrete.**

This work reports on the performance of SCC trial mixes having different replacement levels of cement with RM and FS. The strength and durability characteristics of these mixes are compared with the mixes without SF and RHA. Compressive strengths of concrete at7day, 28 days and 90days were obtained by using various replacement of cement with RM and FS.

Index Terms—- **Self-compacting concrete (SCC), strength and durability, Red mud(RM), Foundry sand (FS), replacement of cement, Super plasticizer**

Sub Area: Concrete Technology
Broad Area: Construction Technology & Mgmt.

I. INTRODUCTION

Self-compacting concrete represents one of the most significant advances in concrete technology for decades. This concrete is able to flow and to fill the most restricted places of the framework without vibration. An idea of self-compacting concrete, a material that flows, that is placed into framework and compacted under influence of self-weight only, without vibration and additional processing emerged. As the durability of concrete structures became an important issue in japan, an adequate compaction by skilled labours was required to obtain durable concrete structures.

The concept of self-compacting concrete was purposed in 1986 by Professor Hajime Okamura (1997) and the prototype of self-compacting concrete was first completed in 1988 at university of Tokyo, so that durability of concrete structure can be improved. Since then various investigations have been carried out and the concrete has been used in practical structures in japan, mainly by large construction companies. Investigations for establishing a mix design method and self-compatibility testing method s have been carried out.

Red mud is a waste or a by-product generated after bauxite digestion with sodium hydroxide at elevated temperature and pressure by the Bayer process in the aluminium industry and mainly composed of coarse sand and fine particle. It is disposed as slurry having a solid concentration in the range of 10 – 30%, pH in the range of 13 and high iconic strength.

Depending on the raw material processed, 1–2.5 tons of red mud is generated per ton of alumina produced. In India, about 4.71 million tons/annum of red mud is produced which is 6.25% of world's total digestion with sodium hydroxide at elevated temperature and pressure.It is a mixture of compounds originally present in the parent mineral bauxite and of compounds formed or introduced during the Bayer cycle. It is disposed as slurry having a solid concentration in the range of 10-30%, pH in the range of 10-13 and high ionic strength.Red mud is a serious pollutant of the environment both by its chemical composition and it is classified for its complex character into the waste unsuitable for treatment and disposal. Red mud have the possibility of large scale application in the production of cement mixture.

Foundry sand is high quality silica sand that is a by-product from the production of both ferrous and nonferrous metal castings. The physical and chemical characteristics of foundry sand will depend in great part on the type of casting process and the industry sector from which it originates. Metal foundries use large amounts of sand as part of the metal casting process. Foundries successfully recycle and reuse the sand many times in a foundry. When sand can no longer be reused in the foundry, it is removed from the foundry and is termed "foundry sand." Foundry sand production is nearly 6 to 10 million tons annually. Like many waste products, foundry sand has beneficial applications to other industries. Foundries purchase high quality size-specific silica sands for use in their molding and casting operations. The raw sand is normally of a higher quality than the typical bank run or natural sands used in fill construction sites. The sands form the outer shape of the mold cavity. These sands normally rely upon a small amount of betonies clay to act as the binder

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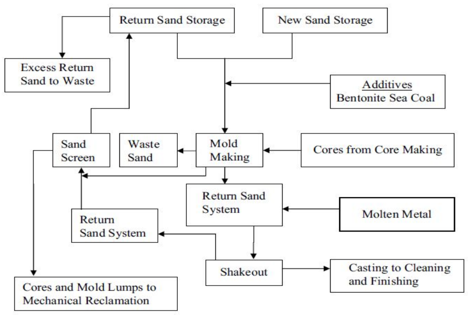
material. There are two basic types of foundry sand available, green sand (often referred to as molding sand) that uses clay as the binder material, and chemically bonded sand that uses polymers to bind the sand grains together. Green sand consists of 85-95% silica, 0-12% clay, 2-10% carbonaceous additives, such as sea coal, and 2-5% water. Green sand is the most commonly used molding media by foundries. The silica sand is the bulk medium that resists high temperatures while the coating of clay binds the sand together. The water adds plasticity.

Self-compacting concrete was first used by japan in bridge, building, tunnel construction since the early 1990s and the number of SSC bridges have been constructed in Europe. SSC has high potential for wider structural applications in highway bridge construction.



Objectives of the study

Even though extensive work is reported on SSC, not much work is reported on the behaviour of SSC with red mud and foundry sand as admixtures. Keeping this in view, the present experimental investigation is taken up to study the behaviour of replacement of cement with the red mud and replacement of sand with the foundry sand in different proportion of concrete mixes. The main aim is to obtain specific experimental data, to understand fresh and hardened properties of self-compacting concrete with red mud and foundry sand. Further it is also aimed to study durability aspects of admixtures. Broadly the main aim of the present investigation of SSC with red mud and foundry sand are:

1. To study fresh properties of SSC in addition with red mud and foundry sand.
2. To study the compressive strength and split tensile strength of SSC.
3. Software analysis of the study

Experimental programme

The selection of mix materials and their required proportion is done through a process called mix design. There are number of methods for determining concrete mix design. The methods used in India are in compliance with the BIS (Bureau of Indian Standards). The objective of concrete mix design is to find the proportion in which concrete ingredients-cement, water, fine aggregate and coarse aggregate should be combined in order to provide the specified strength, workability and durability and possibly meet other requirements as listed in standards such as IS: 456-2000. The specification of a concrete mix must therefore define the materials and strength, workability and durability to be attained. IS: 10262-1982 gives the guidelines for concrete mix designs. In this study, six batches of mixes were determined. The mixes was taken with (1:1.52:2.8, w/c=0.48) .The cement was replaced by red mud in the ratio of 10% to 50% and sand was replaced by foundry sand in the ratio of 10% to 50%. The properties such as compressive strength, X rays test and scanning electron microscopy test was studied.

Physical properties of cement 43-grade

S. No.	Properties	Observed values	Values specified by IS:8112-1989
1.	Fineness % (90 µm I.S. Sieve)	4	Not more than 10
2.	Soundness (mm) (Le Chatelier Method)	1.0	Not more than 10
3.	Normal Consistency (%)	29	……………………
4.	Initial Setting Time (minutes)	220	>=30
5.	Final Setting Time (minutes)	300	<=600
6.	Compressive Strength (MPa) 3 days 7 days	 26.07 31.40	 >23 >33
7.	Specific gravity (Le-Chatelier's Method)	3.87	…………..

Sieve Analysis of Coarse Aggregate (20mm)

Weight of Sample Taken = 2000gm

IS Sieve Size (mm)	Weight Retained (gm)	Cumulative Weight Retained (gm)	Cumulative percentage of Weight Retained	Percentage Passing
25	0	0	0	100
20	72	72	3.6	96.4
16	740	812	40.6	59.4
12.5	577	1389	69.45	30.55
10	546	1935	96.75	3.25
4.75	54	1989	99.45	0.55
Pan	-	-	-	-

∑C=199.8

Fineness Modulus (F.M.)=6.99

Admixtures

Admixtures are essential in determining flow characteristics and workability retention. Ideally, they should also modify the viscosity to increase cohesion. Newly developed types of super plasticizer, known as Poly-Carboxylated Ethers (PCE), are particularly relevant to SCC. They reconcile the apparently conflicting requirements of flow and cohesion, avoiding potential problems and unwanted retardation and excessive air entrainment, particularly at higher workability if the mix design is correct. It also resist the segregation due aggregation of the polymer chains when the concrete is not moving. The trade name of the superplasticizer is GLENIUMTM SKY 784. It greatly improves the cement dispersion. It is manufactured by BASF Construction Chemicals (India) Pvt. Ltd., Pune. Optimum dosage of

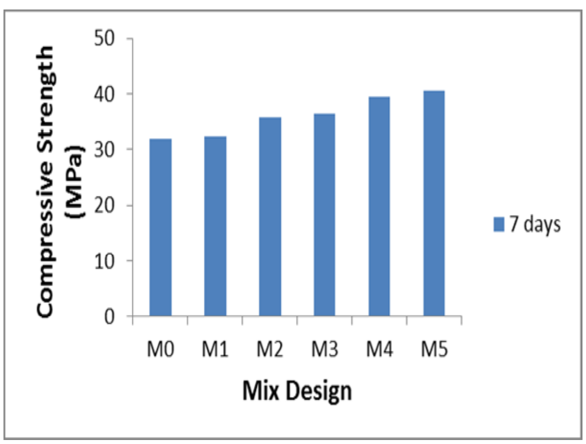
GLENIUMTM SKY 784 should be determined in trial mixes. As a guide a dosage range of 300ml to 1200ml per 100kg of cementitious material is normally recommended.

Testing Procedure
After the specified period of curing the specimens were taken out of the curing tank and their surfaces were wiped off. The various tests were performed as described below: Compressive Strength of Cubes at 7, 28 & 90 days.

Compressive Strength
The specimens were tested at the age of 7, 28 and 90 days. The cubes were tested on universal testing machine after drying at room temperature according to IS 516-1959. The load was applied continuously without impacts and uniformly @140N/$cm^{2/}$minute. Load was continued until the specimen failed and maximum load carried by the specimen was recorded. The cube compressive strength was obtained by considering the average of three specimens at each age.

Compressive Strength of 7 days for different proportion of foundry sand (W/C=0.48)

S. No.	Mix	W/C	Age (Days)	Compressive Strength (MPa)
1.	M0	0.48	7	31.98
2.	M1	0.48	7	32.35
3.	M2	0.48	7	35.83
4.	M3	0.48	7	36.37
5.	M4	0.48	7	39.36
6.	M5	0.48	7	40.55



Compressive Strength of 28 days for different proportion of foundry sand (W/C=0.48)

S. No.	Mix	W/C	Age (Days)	Compressive Strength (MPa)
1.	M0	0.48	28	39.83
2.	M1	0.48	28	40.05
3.	M2	0.48	28	43.4
4.	M3	0.48	28	45.55
5.	M4	0.48	28	48.48
6.	M5	0.48	28	50.12

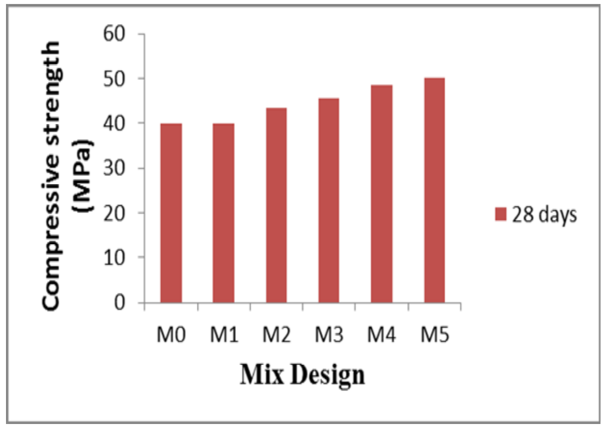


Figure :Compressive strength vs. Mix Design of replaced foundry sand for 28 days W/C=0.48

Compressive Strength of 90 days for different proportion of foundry sand (W/C=0.48)

S. No.	Mix	W/C	Age (Days)	Compressive Strength (MPa)
1.	M0	0.48	90	43.44
2.	M1	0.48	90	43.73
3.	M2	0.48	90	45.81
4.	M3	0.48	90	48.14
5.	M4	0.48	90	50.47
6.	M5	0.48	90	52.37

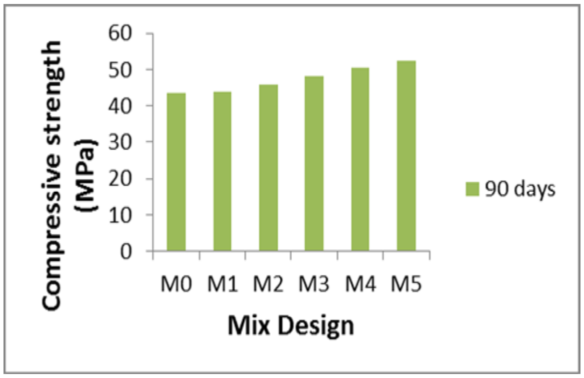


Figure : Compressive strength vs. Mix Design of replaced foundry sand for 90 days W/C=0.48

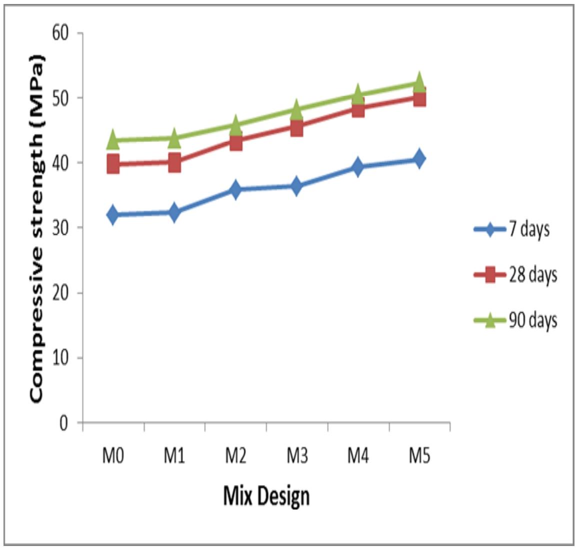


Figure :Compressive strength vs. Mix Design of replaced foundry sand for 7, 28 and 90 days W/C=0.48

Above Figure shows that compressive strength of foundry sand is higher than ordinary cement. 50 % replacement of sand by sand by foundry sand sample has compressive strength 40.55 MPa for 7 days curing , 50.12 MPa for 28 curing and 52.37 MPa for 90 curing samples whereas compressive strength of ordinary Portland concrete is 31.98 MPa,39.83 MPa and 43.44 MPa for 7, 28 and 90 days curing sample respectively. The maximum value of compressive strength was achieved by the sample of 50% (foundry sand) +50 % (natural sand) samples.

Variation of Splitting tensile Strength for different proportion of cement replaced by red mud and sand by foundry sand with Age

The specimens were tested at the age of 7, 28 and 90 days. The cylinder were tested on universal testing machine after drying at room temperature according to IS 516-1959. Three samples were tested for each proportion and find out the Splitting tensile Strength.

Table :Variation of splitting tensile Strength for replaced red mud and foundry sand of 7 days for W/C =0.48

S. No.	Mix	W/C	Age (Days)	Splitting tensile Strength(MPa)
1.	M0	0.48	7	3.81
2.	M11	0.48	7	3.91
3.	M12	0.48	7	4.3
4.	M13	0.48	7	4.26
5.	M14	0.48	7	4.17
6.	M15	0.48	7	4.03

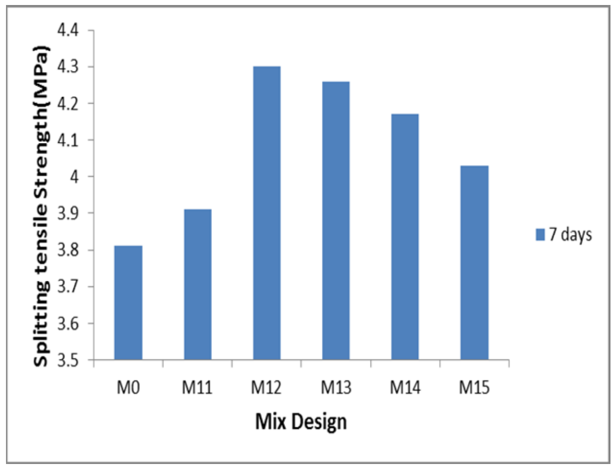


Figure : Splitting tensile Strength vs. Mix Design of replaced red mud and foundry sand for 7 days W/C=0.48

Table : Variation of splitting tensile Strength for replaced red mud and foundry sand of 28 days for W/C =0.48

S. No.	Mix	W/C	Age (Days)	Splitting tensile Strength(MPa)
1.	M0	0.48	28	4.38
2.	M11	0.48	28	4.72
3.	M12	0.48	28	5.81
4.	M13	0.48	28	5.36
5.	M14	0.48	28	5.14
6.	M15	0.48	28	4.93

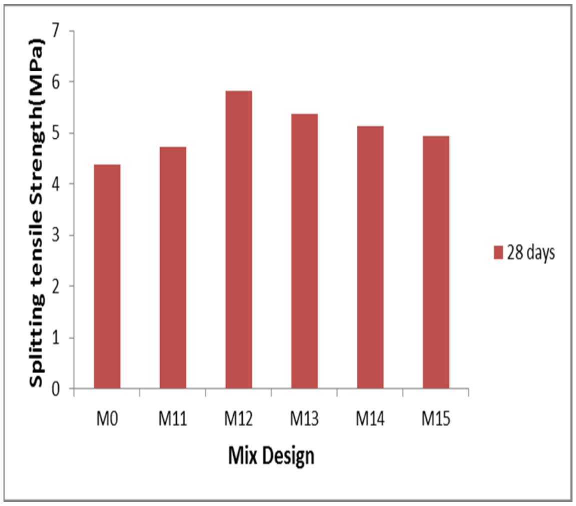


Figure : Splitting tensile Strength vs. Mix Design of replaced red mud and foundry sand for 28 days W/C=0.48

Table : Variation of splitting tensile Strength for replaced red mud and foundry sand of 90 days for W/C =0.48

S. No.	Mix	W/C	Age (Days)	Splitting tensile Strength(MPa)
1.	M0	0.48	90	4.82
2.	M11	0.48	90	4.89
3.	M12	0.48	90	5.93
4.	M13	0.48	90	5.57
5.	M14	0.48	90	5.28
6.	M15	0.48	90	5.16

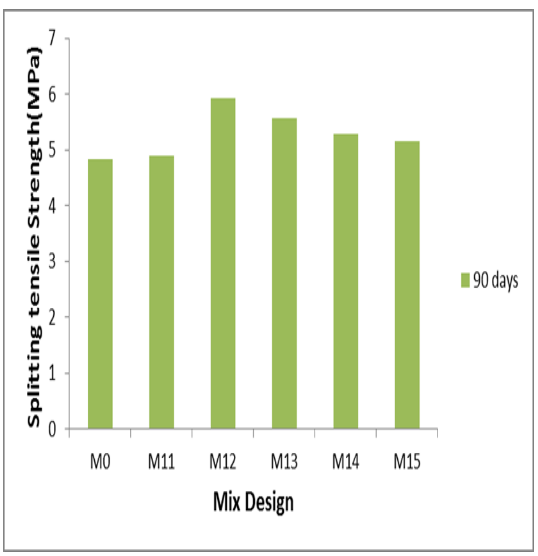


Figure : Splitting tensile Strength vs. Mix Design of replaced red mud and foundry sand for 90 days W/C=0.48

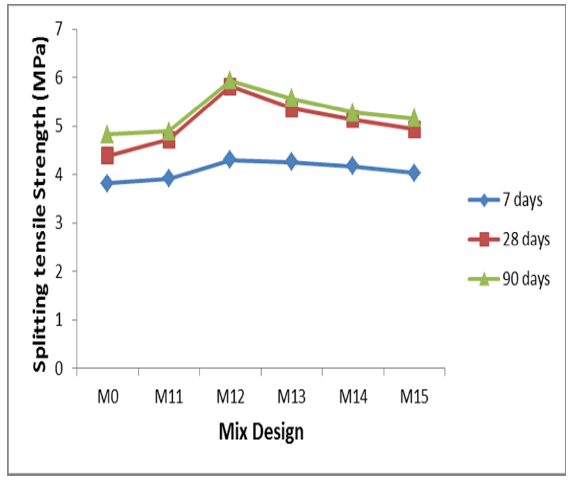


Figure :Splitting tensile Strength vs. Mix Design of replaced red mud and foundry sand for 7,28 and 90 days W/C=0.48

Figure shows that splitting tensile strength of red mud is higher than ordinary cement. 20 % replacement of cement by red mud and 20 % sand by foundry sand sample has splitting tensile strength 4.3 MPa for 7 days curing, 5.81 MPa for 28 days and 5.93 MPa for 90 days curing curing samples whereas splitting tensile strength of natural sand and cement is 3.81 MPa, 4.38 MPa and 4.82 MPa for 7, 28 and 90 days curing sample respectively.

CONCLUSION

Research on the usage of waste materials is very important because material waste is gradually increasing with the increase in population and increase in urban development. Red mud and foundry sand is easy to obtain and decrease the cost. The aim of present work is to determine the strength characteristics of red mud and foundry sand material such as compressive strength for potential application in the high concrete structural concrete. Following conclusions have been drawn based on the observations and discussion of test results:

Compressive strength of self-compacting concrete of 20 % replacement of cement by red mud is more than ordinary cement specimens. The compressive strength increases 16.13 % for 7 days curing and 20.88 % for 28 days curing and 17.84% for 90 days curing sample.

The compressive strength of foundry sand is higher than ordinary cement. 50% replacement of sand by foundry sand sample has compressive strength 40.55 MPa for 7 days curing , 50.12 MPa for 28 curing and 52.37 MPa for 90 curing samples

The splitting tensile strength of red mud (20%) is higher than ordinary cement. 20 % replacement of cement by red mud and 20 % sand by foundry sand sample has splitting tensile strength 4.3 MPa for 7 days curing, 5.81 MPa for 28 days and 5.93 MPa for 90 days curing curing samples whereas splitting tensile strength of natural sand and cement is 3.81 MPa, 4.38 MPa and 4.82 MPa for 7,28 and 90 days curing sample respectively.

Economical and environmental pressures justify consideration of this alternative material source i.e. red mud, foundry sand in places where there availability it decrease the cement and sand cost.

It can be said that it is a creative and environment friendly solution to usered mud and waste foundry sand.

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