SELF COMPACTING CONCRETE USING RED MUD AND USED FOUNDRY SAND

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Abstract

The protection of the environment is a basic factor, which is directly connected with the survival of the human race. Parameters like environmental consciousness, protection of natural resources, sustainable development play an important role in modern requirements for construction. Keeping this in mind, in this study the fresh and hardened properties of self compacting concrete (SCC) using red mud as partial replacement for cementitious material along with used foundry sand as partial replacement for fine aggregate were evaluated. Cementitious material in the mixture was replaced with red mud at 1%, 2%, 3% and 4%. For each red mud replacement level, 10% of fine aggregate (regular sand) was replaced with used foundry sand (UFS).

Keywords: *Red mud, self compacting concrete and used foundry sand*

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1. INTRODUCTION

The search for newer material and newer technology, especially in the construction industry is on in view of growing awareness on protection of environment and conservation of natural resources. Together with this, the problem of waste disposal has become a major concern for planners and engineers in the developing countries. With the enormous increase in the quantity of waste materials from industries, the continuing shortage of dumping sites, sharp increase in the transportation and disposal cost and above all the stringent antipollution and environment regulations enforced in a number of countries, the waste disposal problem is assuming serious and at times even alarming proportions. It is therefore no wonder that the concept of recycling the waste material and using it again in some form or the other has gathered momentum.

Kushwaha et al. (2013), have reported that the use of red mud as an admixture up to 2% will improve the compressive strength and if over 2% of red mud is added then the strength stars decreasing [1]. Siddique et al. (2008) have reported that compressive strength, split tensile strength, flexural strength and modulus of elasticity of concrete mixtures increased with the increase in addition of used foundry sand (UFS) and also with age. Increase in compressive strength varied between 8% and 19% depending upon UFS percentage and testing age, whereas it was between 6.5% and 14.5% for splitting-tensile strength, 7% and 12% for flexural strength, and 5% and 12% for modulus of elasticity. Singh et al (2011) reported that partial replacement of UFS i.e. up to 15% will increase the strength properties of concrete [2]. Singh et al. (2011), have reported that waste foundry sand can be suitably used in making structural grade concrete [3]. Basar et al. (2012), have reported that waste foundry sand can be used as replacement of 20% of regular sand without compromising the mechanical and physical properties [4].

In this paper we prepared self compacting concrete by partially replacing cementitious material by red mud (RM) and in the same mix we have also partially replaced sand by used foundry sand. Cementitious material in the mixture was replaced with red mud at 1%, 2%, 3% and 4%. For each red mud replacement level, 10% of fine aggregate (regular sand) was replaced with UFS.

Red mud is the insoluble product after bauxite 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 forms or introduced during bayer cycle. 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. The disposal of red mud is not easy. In most countries where red mud is produced, it is pumped into holding ponds. Red mud presents a problem since it takes up land area and can neither be on nor farmed, when it is dry. The HINDALCO plant at Belgaum, India has adopted dry disposal mode. Here the mud after clarification passes through six stage counter current washing and after filtration (65% solids), it is disposed off by dumpers at the pond site. Used foundry sands (UFS) are generated by metal casting industries. Foundries purchase new, virgin sand to make casting moulds, and the sand is reused many times within the foundry. However heat and mechanical abrasion eventually render the sand unsuitable for use in casting moulds, and a portion of the sand is continuously removed and replaced with virgin sand. The used foundry sand, that is, the sand that is removed, is either recycled in a non-foundry application or landfilled. Estimates are that less than 15% of the 6-10 million tons of UFS generated are recycled.

2. EXPERIMENTAL PROGRAM

2.1 Materials Used

2.1.1 Cement

Ordinary Portland cement (43 grade) was used in this study. The cement was tested according to IS: 8112-1989 [5]. The specific gravity was found to be 3.1.

2.1.2 Fly Ash

The fly ash used in this study was obtained from Raichur Thermal Power Plant Station (RTPS). As the fly ash produced by Raichur Thermal Power Plant Station (RTPS) contain less carbon content and are extremely finer than any other source. This enable to study the SCC mixes containing fly ash incorporation. The specific gravity was found to be 2.23.

2.1.3 Red Mud

Red mud is a waste material generated by the bayer process widely used to produce alumina from bauxite. In the bayer process, the insoluble product generated after bauxite digestion with sodium hydroxide at elevated temperature and pressure to produce alumina is known as red mud or bauxite residue. The waste product derives its colour and name from its iron oxide content. The red mud used in this study was obtained from Hindalco Industries Limited, Belgaum, Karnataka. The red mud used in this study was sieved through 600µ sieve. The specific gravity was found to be 2.807.

2.1.4 Fine Aggregate

Natural river sand with maximum size of 4.75mm was used in this study. The specific gravity was found to be 2.64.

2.1.5 Used Foundry Sand

Foundry sand is a byproduct of ferrous and non-ferrous metal casting industries. Foundries successfully recycle and reuse the sand many times in the foundry. When the sand can no longer be reused in the foundry, it is removed from the foundry and is termed as used foundry sand. Classification of foundry sands depends upon the type of binder systems used in metal casting. Generally two types of binder systems are used, and based on that foundry sands are classified as clay bonded systems (green sand) and chemically bonded systems. Green foundry sand was used in this study. Its specific gravity was found to be 2.406.

2.1.6 Coarse Aggregate

SCC can be made from most normal concreting aggregates. Coarse aggregates differ in nature and shape depending on their extraction and production. SCC has been produced successfully with coarse aggregates up to 40 mm, however these trials are made keeping maximum aggregate size of 12 mm. The coarse aggregates, obtained from a local source, had a specific gravity of 2.65. The size fraction of the coarse aggregate used is extremely important for determining the optimum amount of paste content to obtain all the necessary characteristics of a flowing concrete. The fine and coarse aggregates were tested according to IS: 383-1970 [6].

2.1.7 Admixture

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. The admixture used in the current program was Algihyperplast N supplied by ALGI. ALGIHYPERPLAST-N is powerful Naphthalene based super plasticiser recommended of site mixed concrete or for concrete which requires high early strength or where concrete is placed within half an hour of mixing.

2.2 Concrete Mix Proportions

In this study five concrete mix proportions were made. The first mix was a controlled mix (without red mud and UFS) and the remaining four mixtures contained red mud and UFS. The controlled SCC mix was designed for M25 grade.

EFNARC [7] guidelines were followed to design the SCC mix. Cementitious material in the mixture was replaced with red mud at 1%, 2%, 3% and 4%. For each red mud replacement level, 10% of fine aggregate (regular sand) was replaced with used foundry sand (UFS).

2.3 Preparation and Casting of Specimens

150 × 150 × 150 mm cubes were cast for compressive strength. For split tensile strength 150 × 300 mm cylinders were cast. For the flexural strength beams of 100 × 100 × 500 mm were cast. After casting, all the test specimens were kept at room temperature for 24 hours and then demoulded. These were then placed in the water curing tank.

2.4 Properties of Fresh Concrete

The properties of fresh concrete such as slump, passing ability, filling ability and segregation resistance were determined according to EFNARC specifications. The tests carried out to determine these properties were slump flow test, T – 500 test, L – box test, V – funnel test and U – box test.

2.5. Properties of Hardened Concrete

The compressive strength tests on the cubes were performed at ages 7 and 28 days. The split tensile tests on cylinders and the flexural strength tests on beams were performed at 28 days. All tests were performed in accordance with the provisions of IS: 516-1959 [8]

3. RESULTS AND DICUSSIONS

3.1 Compressive Strength

The concrete mixtures were made with the controlled mix as well as with red mud and UFS to check the compressive strength for 28 days of curing. The results are shown in fig.1. At 28-day, the control mixture NSCC (0% RM, 0% UFS) achieved a compressive strength of 34.4 MPa. The mixtures RM-1(1% RM, 10% UFS), RM-2 (2% RM, 10% UFS), RM-3(3% RM, 10% UFS) and RM-4(4% RM, 10% UFS) achieved compressive strengths of 36.624 MPa, 39.719 MPa, 37.583 MPa and 34.269 MPa respectively. The compressive strength reached an optimum value at RM-2 and then decreased for RM-3 and RM-4. An increase in strength of 6.4%, 15.4% and 9.2% was observed for RM-1, RM-2 and RM-3 respectively with respect to NSCC. A decrease of 0.38% was observed for RM-4.

3.2 Splitting-Tensile strength

The split tensile strength is shown in fig.2. At 28-day, the control mixture NSCC achieved a split-tensile strength of 3.538 MPa. The mixtures RM-1, RM-2, RM-3 and RM-4 achieved splitting-tensile strengths of 3.035 MPa, 3.146 MPa, 2.763 MPa and 3.295 MPa respectively. Among the four mixes RM-4 mix shows less loss in strength.

3.3 Flexural Strength

The flexural strength is shown in fig.3. At 28-day, the control mixture NSCC achieved a flexural strength of 6.278 MPa. The mixtures RM-1, RM-2, RM-3 and RM-4 achieved flexural strengths of 6.905 MPa, 6.756 MPa, 6.747 MPa and 6.886 MPa respectively. The maximum flexural strength was achieved at 1% red mud with 10% UFS. After this the flexural strengths reduced marginally and then remained almost constant. The flexural strength achieved for all the mix is more than the control mix and all these values are more than IS specified values. An increase of 9.9%, 7.6%, 7.4% and 9.6% was observed for RM-1, RM-2, RM-3 and RM -4 respectively with respect to NSCC.

Table – 1: Concrete mixture proportions

Mixture No.	NSCC	RM-1	RM-2	RM-3	RM-4
Cement (kg/m^3)	367.5	363.85	360.15	356.475	352.8
Fly ash (kg/m^3)	332.5	329.175	325.85	322.525	319.2
Red mud (%)	0	1	2	3	4
Red mud (kg/m^3)	0	7	14	21	28
Used foundry sand (%)	0	10	10	10	10
Used foundry sand (kg/m^3)	0	63.235	63.235	63.235	63.235
Water (kg/m^3)	212.8	212.8	212.8	212.8	212.8
W/C	0.304	0.304	0.304	0.304	0.304
Sand (kg/m^3)	632.35	569.115	569.115	569.115	569.115
Coarse aggregate (kg/m^3)	689.05	683.05	683.85	684.33	684.82
Superplasticizer (l/m^3)	3.59	3.59	3.59	3.59	3.59

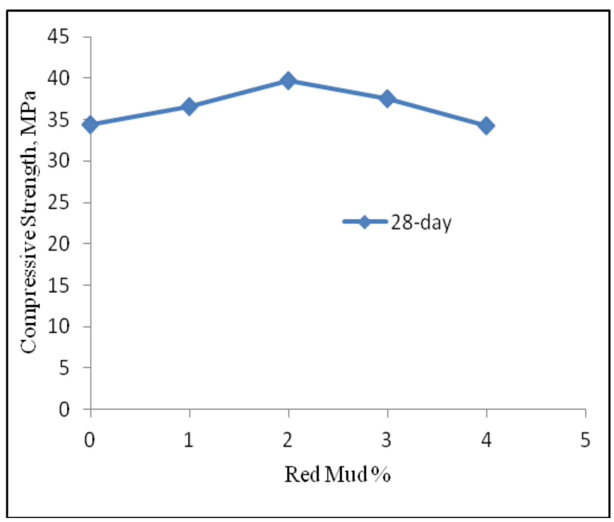

Chart – 1: Compressive strength in relation to red mud content and curing age

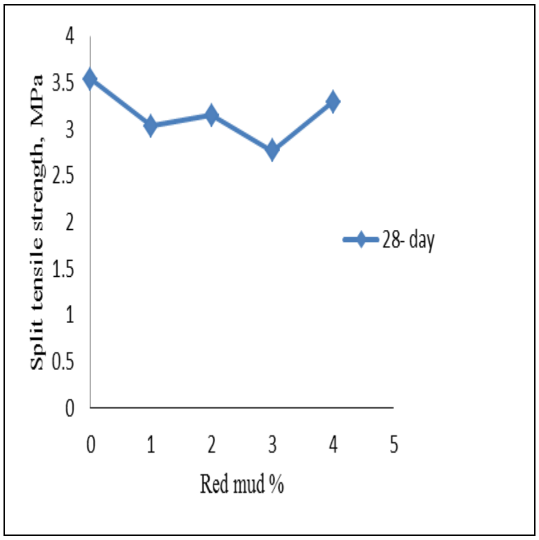

Chart – 2: Split tensile strength in relation to red mud content and curing age

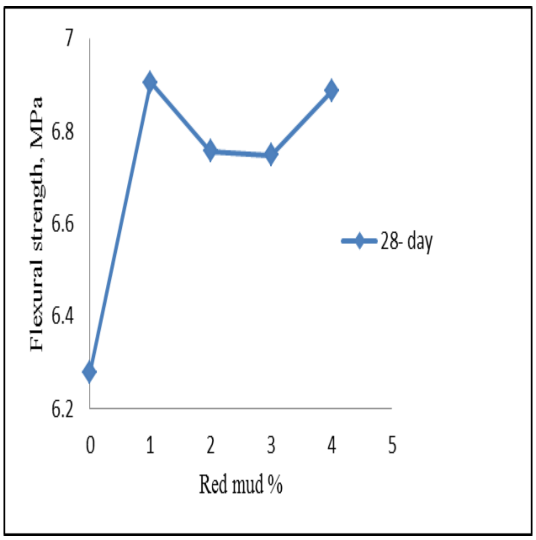

Chart – 3: Flexural strength in relation to red mud and curing age

4. CONCLUSIONS

Following conclusions were drawn from the experimental results of this study:

1. The maximum compressive strength was achieved at 2% red mud with 10% UFS. The compressive strength increased by 15.4% for this mix.
2. The flexural strength achieved for all the mix is more than the control mix and all these values are more than IS specified values.
3. The maximum flexural strength was achieved at 1% red mud with 10% UFS. The flexural strength increased by 9.9% at for this mix

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