DEVELOPMENT OF HIGH STRENGTH SELF-COMPACTING CONCRETE INCORPORATING RED MUD

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ABSTRACT

Concrete is very strong and versatile mouldable construction material. It consist of cement, sand and aggregates mixed with water. The aim of the present work is conducted for investigating about the effects of various percentages of Red Mud and the GGBS as the substitute for cement in order to reach this high strength SCC (HSSCC). The mix is designed for M60 grade. The cost of cement is higher than the Red mud while using as Building Construction material. It is suited as an Additive-Alkali Activated material. The PH of Red mud helps the setting time in the chemical reaction. The red mud is replaced at different percentages like 10%, 15%, 20%, 25%, 30% and the optimum content is found by conducting laboratory tests like Compressive strength, Flexural Strength and Split tensile Strength. Fresh properties such as Slump Flow, V-Funnel tests & the Mechanical properties test which are mentioned above are carried out. It is found that the slump flow has been decreased with increasing in the percentage of RedMud due to more absorption of water of red mud.

Keywords: Cement, Aggregates, GGBS, Red Mud, Super Plasticizer, SCC

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1. INTRODUCTION

The demand for the concrete is increasing everyday and there by leading to the increase in cement production. Several alternatives such as use of cementitious materials are in practice so as to decrease the effect of production of cement on environment. SCC is used in

construction for sustainable benefits for both qualitatively and quantitatively. And the main of this Red mud is used as the partial substitute for cement. Red mud, generally a wastes generated in industries and obtained from alumina production. It is derived from the caustic soda for the bauxite ore. Red Mud contains almost 65% to 70% Solids with the remaining as the moisture as a thixotropic substance which exhibits Shear thinning nature i.e., when this rate of shear is high, this apparent viscosity will decrease. It consists of Al_2O_3 (20-22%), Fe_2O_3 (40-45%) SiO_2 (12-15%), TiO_2 (1.8-2%) CaO (1-2%), Na_2O (4-5%). The presence of iron oxide will impart colour to the cement. At greater temperatures, Iron oxide forms tri calcium alumino ferrite by reacting with Al and Ca. This results increase in hardness and strength properties to the cement.

2. REASEARCH SIGNIFICANCE

Comparing Conventional vibrated concrete with self compacting concrete (SCC), SCC usually results a better performance. By incorporating Red Mud in SCC these properties can be improved resulting High Strength RedMud Self Compacting Concrete (HSRMSCC).

Characteristics such as Compressive strength, Split tensile strength, Flexural strength can be improved. Effect of Red Mud have great impact on structures and based on mechanical characteristics of High Strength Self Compacting Concrete have been worked widely.

3. MATERIALS USED

3.1. Cement

OPC 53grade confirming to IS 12269-1987 used as Binder content. The specific gravity is found out to be 3.15.

3.2. Ground Granulated Blast Furnace Slag(GGBS)

GGBS acquired by an quenching molten iron slag from a blast furnace, granular product, which is then dried, grounded into very fine powder. It is used as the binder to impart the flow in SCC and has the advantage of less heat of hydration.

3.3. Red Mud

Red Mud, used as a replacement for cementitious material. This is the waste product obtained in this industrial production of alumina (aluminium oxide, the principal raw material which is used in the manufacturing of aluminium metal and also widely used in the manufacturing of ceramics, abrasives and refractories). It is composed of iron oxide as a major one. Generally fineness of Red mud varies between $1000\text{-}3000\text{ cm}^2/\text{gm}$. Its PH varies in between 10.5 to 12.5 hence it is alkaline in nature and also the Specific gravity of red mud is found to be 2.51.

3.4. Aggregates

Fine Aggregate confirming to IS 2386-1963 are used. The Specific gravity of natural river sand is 2.6. The Fineness modulus is found out to be in zone-II.

Coarse Aggregates confirming to IS 2386-1963 is used. The maximum size of aggregate used is 10mm. The Specific gravity is found out to be 2.62.

4. DEVELOPMENT OF MIX PROPORTIONS OF HIGH STRENGTH SCC

4.1. Mix Proportions

The design Mix for SCC is obtained by conducting various trial mixes. The table1 represents the SCC mixes prepared with Red mud varrying percentages from 10% to 30% as the partial replacement of Cement and GGBS.

Table 1 Mix proportions of red mud SCC

Mix Designation	HSSCC	HSRMSC C1	HSRMS CC2	HSRMSC C3	HSRMS CC4	HSRMSC C5
Cement (Kg/m^3)	400	360	340	320	300	280
GGBS (Kg/m^3)	150	135	127.5	120	112.5	105
Red Mud (Kg/m^3)	0	55	82.5	110	137.5	165
Fine Aggregate (Kg/m^3)	810	810	810	810	810	810
Coarse Aggregate (Kg/m^3)	775	775	775	775	775	775
Super Plasticizer(SP)	0.63	0.63	0.63	0.63	0.63	0.63
Water/binder	0.34	0.34	0.34	0.34	0.34	0.34

4.2. Fresh Properties

The Fresh properties of SCC like Slump flow and V-Funnel values are shown in the table-2 are checked as per EFNARC guidelines. Fig 1,2 represents Slumpflow and V-funnel tests.

Figure 1 Slump Flow test

Figure 2 V-Funnel test

Table 2 Fresh Properties

Mix Designation	Flow Table		V Funnel	
	Diameter (mm)	T ₅₀ (seconds)	T _f (seconds)	T _{5 min} (seconds)
HSSCC	630	2.1	3	4
HSRMSCC1	600	3.6	4	5
HSRMSCC2	590	4.2	4.5	7
HSRMSCC3	590	4.5	5	7
HSRMSCC4	580	5.1	6	8
HSRMSCC5	560	5.8	6	8

Fig 3, 4 shown the variation of Slump flow and V-funnel for different mix designations NSCC-30HSSCC. Fig 5 shows, the variation of T50 cm, V-funnel and V-funnel T5 min.

Figure 3 Variation of slump Flow

Figure 4 Variation of V-funnel

Figure 5 Variation of T50 cm, V-Funnel, V-Funnel T5 min

5. HARDENED PROPERTIES

5.1. Compressive Strength

The hardened properties such as the Split tensile strength, Compressive strength test and Flexural strength are found. The values obtained for Compressive Strength conducted on 150 mm×150mm×150mm cube specimens for 7 & 28 days are shown in the Table 3. Fig 6, 7 shows the strength variations. Fig 8 shows the cube test.

Table 3 Compressive Strength

Mix designation	7days(N/mm ²)	28 days(N/mm ²)
HSSCC	48	54
HSRMSCC1	54.22	62.81
HSRMSCC2	59.82	68.79
HSRMSCC3	62.34	72.93
HSRMSCC4	57.12	67.40
HSRMSCC5	49.13	58.46

Figure 6 Values of compressive strength

Figure 7 Variation of Compressive Strength

Figure 8 Cube strength Test

5.2. Split Tensile Strength

The results of this test is carried out for 300mm height, 150mm diameter cylinder is shown in Table 4. Fig 8, 9 shows the values representation and the variation of SplitTensile strength. Fig 11 shows the cylinder testing.

Table 4 Split Tensile Strength

Mix designation	7days(N/mm2)	28 days(N/mm2)
HSSCC	2.27	3.37
HSRMSCC1	2.86	3.64
HSRMSCC2	4.62	4.83
HSRMSCC3	5.12	6.12
HSRMSCC4	3.4	4.86
HSRMSCC5	3.1	4.2

Figure 9 Values of Split Tensile Strength

Figure 10 Variation of Split tensile strength

Figure 11 Split tensile Strength Test

5.3. Flexural Strength

The values of test results are mentioned in the table 5 for 7 and 28 days strength. Fig 11, 12 shows the variation of Flexural strength. The prism dimensions are 100mm width, 100mm height, 500mm length. Fig 13 shows the beam testing.

Table 5 Flexural strength

Mix designation	7days(N/mm2)	28 days(N/mm2)
HSSCC	6.20	7.59
HSRMSCC1	6.87	7.86
HSRMSCC2	7.08	8.13
HSRMSCC3	7.42	8.78
HSRMSCC4	7.03	7.92
HSRMSCC5	6.18	6.82

Figure 12 Values of Flexural strength

Figure 13 Variation of Flexural strength

Figure 14 Flexural Strength Test

6. DISCUSSION FOR TEST RESULTS

The results that obtained from the study of Red mud Self - Compacting Concrete (SCC) mixes gives an idea on the optimization of this mix proportions.

6.1. Fresh Properties of HSSCC

The values for this mixes are shown in the above Table 1 and its fresh concrete properties are given in Table 2. Fig 1 to Fig 5 shown the graphs of variations of the fresh properties for different dosages of the replacement of red mud.

Slump flow is conducted to know flowability of fresh concrete mix. V- Funnel is conducted to know about filling ability. This can be observed that Slump flow has been reducing as there is rise in the red mud percentage. This occurred due to the more water absorption capacity of the Red mud. However, all the mix proportions are satisfying through the EFNARC guidelines.

6.2. Compressive Strength

The initial strength gain is high in all mixes and it is above 65% of the target mean strength. This indicates that the red mud contributes to the initial strength. The initial strength gain is helpful in removing the formwork at an early ages. The Compressive strength is noted to be decreased with the increase in percentage of the red mud. This is because of less strength of (Interfacial Transition Zone)ITZ formed as it is also an important factor in achieving the strength. With percentage of red mud increases, cement content will be decreased as a result of ITZ formed will have lesser strength as compared with the Conventional concrete.

6.3. Split Tensile Strength

This plays important role for the analysis of the concrete structures. Some factors that might influence tensile strength capacity that includes the type of the aggregates, and the distribution of size of the aggregates. As the percentage of red mud increased the split tensile strength test is found to be decreased. From fig 9 this can be noted that the decrease in this strength is almost linear beyond 20% replacement of red mud. With increased dosage of red mud, structural concrete seems to get more brittle in nature.

6.4. Flexural Strength

As mentioned earlier from the table 5, observes that there is decrease in Flexural strength for all mixes till HSSCC 2 and for HSSCC 3 highest value of flexural strength is achieved.

7. CONCLUSIONS

The fresh properties are affected with increase in percentage of Redmud but it can be controlled with the addition of super plasticizer. The values obtained for fresh properties are found to be in the limits according to EFNARC guidelines. The Compressive Strength of the red mud concrete has increased with increase in percentage of red mud upto 20%, beyond that it has been decreased. The increase in compressive strength is about 9.07% and 5.84% upto 20% replacement of red mud and beyond that there is decrease in compressive strength and it is about 7.88% and 14.2%. It can be concluded that the mix with 20% red mud replacement is compatible with the conventional concrete and hence it is taken for durability studies. The Split tensile strength test of the red mud concrete also increasing by increase in the red mud percentage, beyond that the decreased in strength is observed. Split Tensile strength increase is about 28% and 23.56% upto 20% replacement & beyond that the decrease in strength is about 23% and 14.56%. The mix with 20% replacement of Redmud has achieved the highest FlexuralStrength and beyond that there is decrease in strength.

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