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Manufacturing of Self Compacting Concrete using Red Mud-an industrial waste

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***Abstract**: - Self-compacting concrete is an innovative concrete that does not require vibration for placing and compaction. It is able to flow under its own weight, completely filling formwork and achieving full compaction, even in the presence of congested reinforcement. The hardened concrete is dense, homogeneous and has the same engineering properties and durability as traditional vibrated concrete.*
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 using red mud as partial replacement for cementitious material along with used foundry sand as partial replacement for fine aggregate is also evaluated.
Red mud is an undisposed industrial waste in Bayer's process during extraction of alumina from Bauxite. Accumulation of undisposed dry/wet red mud wastes of variant mineralogy pollutes air, soil, surface/ ground water and vegetation. Deterioration of the environment and its ecology has caused concern to the environment of the surroundings of Alumina industry. Efficacy of use of the red mud by partial replacement of cement and coarse aggregates in construction industry has brought revolution in research and development for last ten years.
The main aim of this thesis is to study the effect on properties of self-compacting concrete and determining their mechanical strengths (Compressive, tensile and flexural) by replacing cement with red mud in the laboratory by using Compression Testing Machine and the Universal Testing Machine (UTM) at various mixed proportions. The flow characteristics of self-compacting concrete using red mud is measured from J-ring test, V-funnel test, U-box test, L- box test, J-Ring test. Also the strength properties of self-compacting concrete using red mud like compressive strength and these properties are compared with ordinary concrete strength and normal self-compacting concrete and attempt has been made to study the effect of replacement of cement with Red Mud and performance of concrete using it.
KEYWORDS: -Self compacting, Compressive Strength, Split tensile Strength, Red Mud, Vibrated concrete

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I. INTRODUCTION

The development of new technology in the material science is progressing rapidly. In last three decades, a lot of research was carried out throughout globe to improve the performance of concrete in terms of strength and durability qualities. Consequently, concrete has no longer remained a construction material consisting of cement, aggregate, and water only, but has become an engineered custom tailored material with several new constituents to meet the specific needs of construction industry. The growing use of concrete in special architectural configurations and closely spaced reinforcing bars have made it very important to produce concrete that ensures proper filling ability, good structural performance and adequate durability. In recent years, a lot of research was carried out throughout the world to improve the performance of concrete in terms of its most important properties, i.e. strength and durability. Concrete technology has under gone from macro to micro level study in the enhancement of strength and durability properties from 1980's onwards. Till 1980 the research study was focused only to flow ability of concrete, so as to enhance the strength however durability did not draw lot of attention of the concrete technologists. This type of study has resulted in the development of self-compacting concrete (SCC), a much needed revolution in concrete industry.

There is no standard self-compacting concrete. Therefore, each self-compacting concrete has to be designed for the particular structure to be constructed. However, working on the parameters which affect the basic properties of self-compacting concrete such as plastic viscosity, deformability, flow ability and resistance to segregation, self-compacting concrete may be proportioned for almost any type of concrete structure. To establish an appropriate mixture proportion for a self-compacting concrete the performance requirements must be defined taking into account the structural conditions such as shape, dimensions, reinforcement density and construction conditions. The construction conditions include methods of transporting, placing, finishing and curing. The specific requirement of self-compacting concrete is its capacity for self-compaction, without vibration, in the fresh state. Other performances such as strength and durability should be established as for normal concrete.

To meet the concrete performance requirements, the following three types of self-compacting concretes are available.

a) Powder type of self-compacting concrete: This is proportioned to give the required self-compatibility by reducing the water-powder (material<0.1mm) ratio and provide adequate segregation resistance. Super plasticizer and air entraining admixtures give the required deformability.

b) Viscosity agent type self-compacting concrete: This type is proportioned to provide self-compaction by the use of viscosity modifying admixture to provide segregation resistance. Super plasticizers and air entraining admixtures are used for obtaining the desired deformability.

c) Combination type self-compacting concrete: This type is proportioned so as to obtain self-compact ability mainly by reducing the water powder ratio, as in the powder type, and a viscosity modifying admixture is added to reduce the quality fluctuations of the fresh concrete due to the variation of the surface moisture content of the aggregates and their gradations during the production. This facilitates the production control of the concrete.

OBJECTIVE OF THE STUDY

Now having a look over history of SCC, question arises that what is needed to go for SCC? So, here are some of the important aspects to go with SCC:

Foundry sand and red mud has pozzolanic properties hence increasing the binding properties and gives the better strength at the same time it reduces the cost problems. And also reduces the following problems.

1. Foundry waste dumping
2. Red mud dumping.

In dumping land become useless. It starts polluting the groundwater. So it should be used in some constructive fashion.

II. LITERATURE REVIEW

1.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.

2.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.

3.Singh et al (2011) reported that partial replacement of UFS i.e. up to 15% will increase the strength properties of concrete.

4.Singh et al. (2011), have reported that waste foundry sand can be suitably used in making structural grade concrete.

4.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.

5.Yahia et al. 1999, Bouzoubaa, and Lachemi 2001, Persson 2002, Naik and Kumar 2003 have reported that SCC gives wide opportunity for the use of high-volumes of byproduct materials such as fly ash, lime stone powder, quarry dust etc, since a higher volume of powder material is required for enhancing the cohesiveness and reducing the amount of superplasticizer and viscosity modifying agents.

6.Case study: effective utilization of red mud as alternate raw material - dalmia cement (bharat) limited. Project Implemented by: Dalmia Cement (Bharat) Limited in 2009

III. MATERIALS AND METHODOLGY

The SCC concept can be stated as the concrete that meets special performance and uniformity requirements that cannot always be obtained by using conventional ingredients, normal mixing procedure and curing practices. The SCC is an engineered material consisting of cement, aggregates, water and admixtures with several new constituents like colloidal silica, pozzolanic materials, chemical admixtures to take care of specific requirements, such as, high-flow ability, compressive strength, high workability, enhanced resistances to chemical or mechanical stresses, lower permeability, durability, resistance against segregation, and possibility under dense reinforcement conditions.

The properties, such as, fluidity and high resistance to segregation enables the placement of concrete without vibrations and with reduced labor, noise and much less wear and tear of equipment.

Use of SCC overcomes the problem of concrete placement in heavily reinforced sections and it helps to shorten construction period.

Self-compacting concrete is growing rapidly, especially in the precast market where its advantages are rapidly understood and utilized.

Super plasticizer enhances deformability and with the reduction of water/powder segregation resistance is increased.

High deformability and high segregation resistance is obtained by limiting the amount of coarse aggregate.

However, the high dosage of super-plasticizer used for reduction of the liquid limit and for better workability, the high powder content as 'lubricant' for the coarse aggregates, as well as the use of viscosity-agents to, as well as the use of viscosity-agents to increase the viscosity of the concrete have to be taken into account.

Now in this thesis I have used replacement of cement by volume by red mud and foundry waste.

Also conventional method of waste red mud in ponds has often adverse environmental impact and during monsoon waste may be carried by runoff to the surface water course and a result of leaching may cause contamination of ground water, for further disposal of large quantities of red mud dumped, produces problems of storage occupying of a lot of space at present about 60 million tons of red mud is generated annually worldwide which is not being recycled satisfactorily.

IV. INGRADIENTS OF SCC

SCC is something different than the conventional concrete or modification of conventional concrete. It has similar ingredients such as aggregate binder, however there blending is changed so as to get the advantage of self-compactness.

4.1.1 Cement: - Generally Portland cement is used for SCC.

4.1.2 Aggregates: - The maximum size of aggregate is generally limited to 20mm. Aggregate of size 10 mm is desirable for structures having congested reinforcement. Wherever possible, size of aggregate higher than 20 mm could also be used. Well graded cubical or rounded aggregate are desirable. Aggregates should be of uniform quality with respect to shape and grading.

Fine aggregate can be natural or manufactured. The grading must be uniform throughout the work. The moisture content or absorption characteristics must be closely monitored as quality of SCC will be sensitive to such changes. Particles smaller than 0.125mm i.e. 125-micron size are considered as FINES which contribute to the powder content.

4.1.3 Mixing water: - Ordinary potable water of normally pH 7 is used for mixing and curing the concrete specimen.

4.1.4 Admixtures for SCC: - An admixture is a material other than water, aggregates and cement and is added to the batch immediately before or during its mixing. Admixtures are used to improve or give special properties to concrete. The use of admixture should offer an improvement not economically attainable by adjusting the proportions of cement and aggregates and should not adversely affect any properties of the concrete.

V. SCC AND MEASUREMENT OF IT'S FLOW PROPERTIES

It is important to appreciate that none of the test methods for SCC has yet been standardized and the tests described are not yet perfected or standardized. The methods presented here are descriptions rather than fully detailed procedures. They are mainly ad-hoc methods, which have

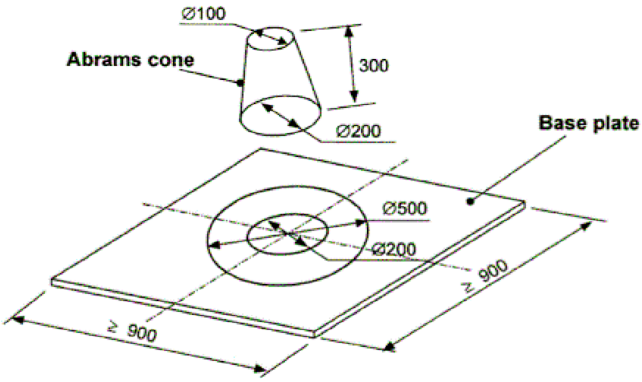
5.2. TEST METHODS

5.2.1 SLUMP FLOW TEST.

The slump flow is used to assess the horizontal free flow of SCC in the absence of obstructions. It was first developed in Japan for use in assessment of underwater concrete. The test method is based on the test method for determining the slump. The diameter of the concrete circle is a measure for the filling ability of the concrete.

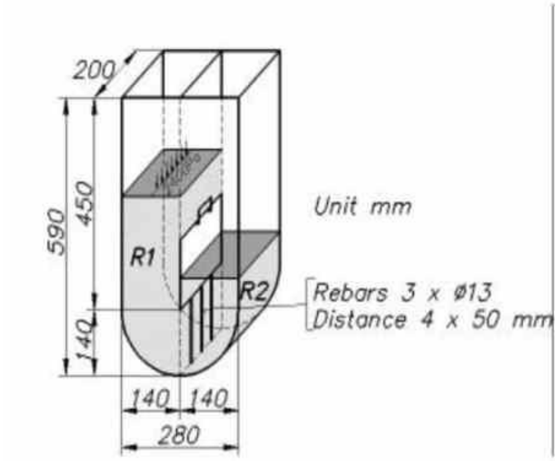
Equipment used

The apparatus is shown in figure.



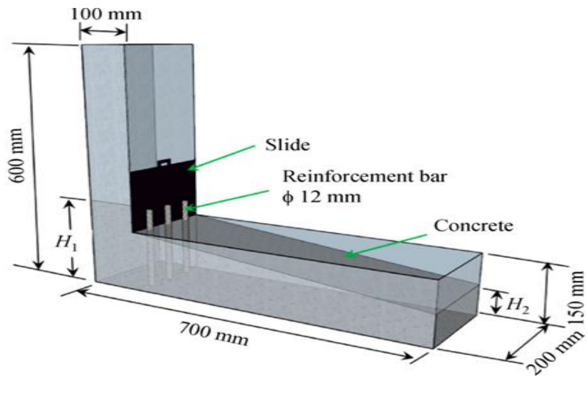
5.2.2 U box test method

The test was developed by the Technology Research Centre of the Taisei Corporation in Japan. Sometimes the apparatus is called a "box shaped" test. The test is used to measure the filling ability of self-compacting concrete. The apparatus consists of a vessel divided by a middle wall into two compartments, shown by R1 and R2 in **Fig.**



5.2.3 L box test method

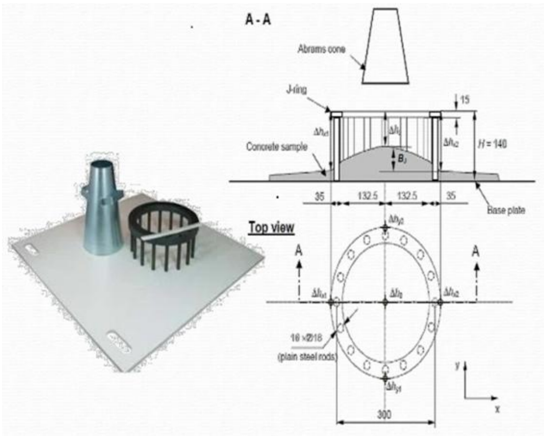
This test, based on a Japanese design for underwater concrete, has been described by Peterson. The test assesses the flow of the concrete, and also the extent to which it is subjected to blocking by reinforcement. The apparatus is shown in figure.



5.2.4 Orimet Test

The Orimet was developed at the University of Paisley as a method for assessment of highly workable, flowing fresh concrete mixes on construction sites. The equipment is shown in figure.

5.2.5. J-RING TEST
The principle of J Ring test may be Japanese, but no references are known. The J Ring test itself has been developed at the University of Paisley. The test is used to determine the passing ability of the concrete.



5.5.6.Suggested value of acceptance for different test methods of SCC

Sl No.	Method	Unit	Typical Range of values	
			Maximum	Minimum
1.	Slump flow by Abrams cone	Mm	600	800
2.	T50cm slump flow	Sec	2	5
3.	J-ring	Mm	0	10
4.	V-funnel	Sec	6	12
5.	Time increase, V-funnel at T5minutes	Sec	0	3
6.	L-box	h_2/h_1	0.8	1.0
7.	U-box	h_2-h_1	0	30
8.	Fill-box	%	90	100
9.	GTM screen stability test	%	0	15

VI. RED MUD TEST RESULTS OF SELF COMPACTING CONCRETE CONTAINING THE COMBINATION OF ADMIXTURES (SP+VMA)

6.1 Compressive Strength Test Results
The following tables give the test results of effect of addition of red mud in various percentages on the properties of self-compacting concrete containing an admixture combination (SP+VMA) Compressive strength test results of self-compacting concrete containing the combination of admixtures (SP+VMA) with various percentages of red mud

The following table below gives the overall results of compressive strength of self-compacting concrete containing the combination of admixtures (SP+VMA) for various percentage addition of red mud

Percentage addition of red mud	Compressive strength (MPa)	Percentage increase or decrease of compressive strength w.r.t ref. mix
0 (Ref.)	40.87	-
1	41.53	+1.61
2	44.40	+8.63
3	42.87	+4.89
4	40.54	-0.80
5	37.53	-8.17
6	35.30	-13.62
7	34.45	-15.7
8	33.45	-18.15

6.2 OVERALL RESULTS OF TENSILE STRENGTH

The following table below gives the overall results of tensile strength of self-compacting concrete containing the combination of admixtures (SP+VMA) for various percentage addition of red mud.

Percentage addition of red mud	Tensile strength (MPa)	Percentage increase or decrease of tensile strength w.r.t. ref mix
0 (Ref.)	**3.34**	**-**
1	**4.00**	**+19.76**
2	**4.62**	**+38.32**
3	**3.34**	**0**
4	**3.25**	**-2.69**
5	**3.10**	**-7.19**
6	**2.87**	**-14.07**
7	**2.50**	**-25.15**
8	**2.16**	**-35.33**

6.3 OVERALL RESULTS OF FLEXURAL STRENGTH

The following table below gives the overall results of flexural strength of self-compacting concrete containing the combination of admixtures (SP+VMA) for various percentage addition of red mud.

Percentage addition of red mud	Tensile strength (MPa)	Percentage increase or decrease of tensile strength w.r.t. ref mix
0 (Ref.)	**5.12**	**-**
1	**5.36**	**+4.69**
2	**5.60**	**+8.32**
3	**5.50**	**+7.12**
4	**5.26**	**+2.73**
5	**5.15**	**+0.59**
6	**4.90**	**-3.91**
7	**4.85**	**-5.66**
8	**4.40**	**-14.06**

6.4 FLOW TEST RESULTS

The following tables give the flow test results of effect of addition of red mud in various percentages on the properties of self-compacting concrete containing an admixtures combination of (SP+VMA).

Percentage of red mud	Slump flow (mm)	Time in sec T50
0	685	4.9

1	700	4.7
2	715	4.3
3	710	4.6
4	690	5.2
5	655	5.8
6	640	8.7
7	600	12.2
8	580	13.1

6.5 Funnel Test Results

Percentage of red mud	**Flow Time in sec**
0	**33.0**
1	**24.7**
2	**28.8**
3	**32.8**
4	**34.5**
5	**36.9**
6	**41.9**
7	**52.5**
8	**66.0**

VII. CONCLUSIONS

- It has been observed that the compressive strength of self-compacting concrete produced with the combination of admixtures such as (SP+VMA) goes on increasing up to 2% addition of red mud.
- After 2% addition of red mud, the compressive strength starts decreasing, i.e. the compressive strength of self-compacting concrete produced with (SP+VMA) is maximum when 2% red mud is added.
- The percentage increase in the compressive strength at 2% addition of red mud is +8.63. Thus, it can be concluded that maximum compressive strength of self-compacting concrete with the combination of admixtures (SP+VMA) may be obtained by adding 2% red mud which is a waste material from aluminum industry.
- The partial replacement of cement by red mud resulted in producing Self Compacting Concrete, less permeable, anticorrosive, ecofriendly and cost-effective concrete. At each replacement level of cement with red mud an increase in strength and self-compacting properties was observed up to 20% because of higher percentage of finer material.
- The concrete obtained is highly compact with smaller quantity of voids leading to higher strength, increased flowage and self-compacting.
- In higher percentage of red mud, the concrete possesses a very good early strength (7 days) but the rate of growth slows down as replacement in red mud increases.
- Increase in flexural strength of red mud concrete is relatively more than the compressive strength. Although the optimum replacement for achieving desired compressive strength is 20%, it can be even more than 40% for the flexural strength.
- This is the cutting edge in the direction of achieving strength of concrete by utilizing the environment alarming waste red mud to convert as ecofriendly self-compacting concrete.

VIII. SCOPE FOR FURTHER STUDY

➢ The effect of addition of red mud on the durability characteristics of self-compacting concrete containing more than three admixtures.

➢ The effect of high temperature on the properties of self-compacting concrete containing more than three admixtures with red mud.

➢ The effect of addition of red mud on the shrinkage and the creep properties of self-compacting concrete containing more than two admixtures.

➢ Similarly, there are lot more mineral admixtures which are the wastage of the industry. The other type of ingredient's wastages used for manufacturer of concrete to reduce the problems of environmental attack.

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