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An Experimental Study on the Properties of Self Compacting Concrete with Incorporation of Industrial Waste

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ABSTRACT

Self-compacting concrete (SCC) 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. Due to industrialization there is huge amount of red mud and foundry waste sand created. Aluminium is now consume during manufacture red mud which is used Red Mud and Foundry waste Sand are industrial waste and causing threat to environment so the reduce the cost of the construction also to make structure more durable, reduce problem of this material the project has been undertaken so that it can be used for construction fashion following points attempted.

1) To study the properties of foundry waste sand.
2) To blend to mix or to replace cement by different % by foundry waste sand.
3) To study properties of Red mud
4) To prepare the concrete by blending or by replacing the cement by Red mud
5) To study the comparativeness.

Keywords: Compaction, Foundry waste, Self-compacting, Vibration

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 becomes 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 thePerformance 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. Self-compacting concrete is highly engineered concrete with much higher fluidity without segregation and is capable of filling every corner of form work under its self-weight only (Okamura 1997). Thus SCC eliminates the needs of vibration either external or internal for the compaction of the concrete without compromising its engineering properties. This concrete was first developed in Japan in late 80's to combat the deterioration of concrete quality due to lack of skilled labours, along with problems at the corners regarding the homogeneity and compaction of cast in place concrete mainly with intricate structures so as to improve the durability of concrete and structures. After the development of SCC in Japan 1988, whole Europe started working on this unique noise free revolution in the field of construction industry. The last half of decade 1991-2000 has remained very active in the field of research in SCC in Europe. That is why, Europe has gone ahead of USA in publishing specifications and guidelines for self-compacting concrete (EFNARC 2002).

II. NEED FOR 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. Which is going to cater in two ways Help in getting better quality of concrete?

For several years, the problem of the durability of concrete structures has been a major problem posed to engineers. To make durable concrete structures, sufficient compaction is required. Compaction for conventional concrete is done by vibrating. Over vibration can easily cause segregation. In conventional concrete, it is difficult to ensure uniform material quality and good density in heavily reinforced locations. If steel is not properly surrounded by concrete it leads to durability problems. This is the problem mainly with heavily reinforced sections where a very high congestion of reinforcement is seen. In this case, it becomes extremely difficult to compact the concrete. Then what can be done to avoid honeycombing?

The answer to the problem may be a type of concrete which can get compacted into every corner of form work and gap between steel, purely by means of its own weight and without the need for compaction. The SCC concept was required to overcome these difficulties.

ADVANTAGES OF SCC:

1. Improved Concrete Quality:

SCC yields homogeneous concrete in situations where the castings are difficult due to congested reinforcement, difficult access etc. SCC shows a good filling ability especially around reinforcement.

SCC is very well suited for special and technically demanding structures such as tunnel linings, as the possibility to compact the concrete is limited in the closed space between formwork and rock shows narrow variation in properties on site.

Most suitable for concrete filled tubes (CFT) technology construction for high rise buildings.

2. Environmental & Human Health Protection:

Reduces noise at sites, the pre-cast factory, and neighbourhood, hence, it is a silent concrete. Eliminates problems with blood circulation leading to "white fingers" caused by compacting equipment, hence called a healthy concrete. SCC gives noise protection in precast industry, by introducing no restrictive measures like ear protection, marked areas, and safety instructions are necessary. Shortens the construction time by accelerating construction process, especially in pre-cast industry.

3. Economy & Time Reducing:

Its ease of placement improves the productivity and the cost saving through reduced equipment and labor equipment. Reduction in wear and tear of forms, therefore, it extends the service life of forms. Reduction in the number of worker. Normally one cum requires 1.5 man-hours; with SCC this is reduced to 0.35 man-hours.

It reduces the consumption of resources and cost, even considering a higher price per cubic meter for the concrete. Okamura has reported that it is possible to reduce the overall bridge cost by 5-15%. Because of its high fluidity, this concrete does not need any vibrations so that it allows to save energy and ensure suitable cost in place. Reduction of expenses and manpower needed for patching finished precast elements. It can enable the concrete supplier to provide better consistency in delivering concrete, which reduces the interventions at the plants or job sites.

III. INGREDIENTS 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:

Cement: Generally Portland cement is used for SCC.

Aggregates: The maximum size of aggregate is generally limited to 20mm. Aggregate of size 10mm is desirable for structures having congested reinforcement. Where ever 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.

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

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.

The admixture consist chiefly of those which accelerate and those which retard hydration or setting of the cement, finely divided materials which improves workability, water proofers, pigments, wetting, dispersing and air-entraining agents and pozzolanas. Admixtures ranging from additions of chemicals to waste materials have been used to improve certain properties of concrete. The admixture is generally added in a relatively minute quantity. The degree of control must be higher to ensure that over dosages are unlikely to occur. Excess quantity of admixture may be detrimental to the properties of concrete. It may be mentioned here that concrete of poor quantity will not be converted to the good quality concrete by adding admixture.

IV. PROPERTIES OF SCC

Fresh SCC Properties

The 3 main properties of SCC in plastic state are:

1. Filling ability (excellent deformability)

2. Passing ability (ability to pass reinforcement without blocking)
3. High resistance to segregation.

1. Filling ability

Self-compacting concrete must be able to flow into all the spaces within the formwork under its own weight. This is related to workability, as measured by slump flow or Orimet test. The filling ability or flow ability is the property that characterizes the ability of the SCC of flowing into formwork and filling all space under its own weight, guaranteeing total covering of the reinforcement. The mechanisms that govern this property are high fluidity and cohesion of the mixture.

2. Passing ability

Self-compacting concrete must flow through tight openings such as spaces between steel reinforcing bars under its own weight. The mix must not 'block' during placement. The passing ability is the property that characterizes the ability of the SCC to pass between obstacles- gaps between reinforcement, holes, and narrow sections, without blocking. The mechanisms that govern this property are moderate viscosity of the paste and mortar, and the properties of the aggregates, principally, maximum size of the coarse aggregate. Stability or resistance to the segregation is the property that characterizes the ability of the SCC to avoid the segregation of its components, such as the coarse aggregates. Such a property provides uniformity of the mixture during transport, placement and consolidation. The mechanisms that govern this property are the viscosity and cohesion of the mixture.

3. High Resistance to Segregation

Self-compacting concrete must meet the requirements of 1 and 2 while its original composition remains uniform. The key properties must be maintained at adequate levels for the required period of time (e.g.20 min) after completion of mixing. It is property 2 the passing ability and property 3 resistance to segregation that constitute the major advance, form a merely super plasticized fresh mix which may be more fluid than self-compacting concrete mix.

RED MUD

Red mud is one of the major solid wastes coming from Bayer process of alumina production. At present about 3 million tons of red mud is generated annually, which is not being disposed or recycled satisfactorily. The conventional method of disposal of red mud in ponds has often adverse environmental impact and during monsoon, the wastes may be carried by runoff to the surface waters course and a result of leaching may cause contamination of ground water; further disposal of large quantities of red mud dumped, poses increasing problems of storage occupying a lot of space. Inspire of the fact that the aluminium production plant produces a great quantity of red mud; such plants are producing aluminium at an increasing rate of 1% per annum since last decade. Red mud is predominantly, a finely powdered mud. It adversely effects the air, land & water environment of surrounding area. With this reference it is desired and greatly needed to utilize the red mud in some way, or recycled, which otherwise is dumped in huge amounts anywhere in nearby vicinity of the plant.

EFFECT OF RED MUD ON ENVIRONMENT

In the last decade, the production of aluminium in spite of some stagnancy and even set back periods has shown a steady rise of about 1%. The ecological consequences of aluminium production are well known; land devastation by bauxite exploitation usurpation of big land areas by erection of disposal sites for red mud, threatening of surface & underground water & air pollution by waste gases from aluminium electrolysis plant & rolling mills. The degree of damage inflicted to ground water & air during the single production stages from bauxite to aluminium depends on a couple of tacts of which those connected with the alumina winning & red mud disposal.

RED MUD AS CONCRETE MATERIAL

Red mud has been used to produce synthetic dense aggregate in U.S.A & Japan (U.K. patent 1976) by pelletizing firing at temperature of 1200-1316°C. The compressive, tensile and bending strengths of concrete made with red mud aggregate have been found to be considerably higher than those of concrete made with river gravel. Light weight aggregates have been manufactured from mixture of red mud and various other materials like fly ash, blast furnace slag etc. Lightweight aggregate is used with cement to make a lightweight strong concrete.

EXPERIMENTATION

Self compacting concrete is a high performance concrete that can flow under its own weight to completely fill the formwork without segregation and self consolidate without any mechanical vibrations, even in the presence of congested reinforcements. Such concrete can accelerate placement and reduce labour required for consolidation and finishing. In other words, "Self compacting concrete is a highly flowable, yet stable concrete that can spread readily into place and fill the formwork without any consolidation and without undergoing any significance separation". Self compacting concrete offers a rapid rate of concrete placement, with faster construction times and ease of flow around congested reinforcement. The fluidity and segregation resistance of self compacting concrete ensures a high level of homogeneity, minimum concrete voids and uniform concrete strength, providing the potential for a superior level of finish and durability to the structure. In addition following are some more points, which makes self compacting concrete more reliable in concreting works-Improved compaction around congested reinforcement. The field of concrete technology has seen miraculous changes due to the invention of various admixtures. The admixtures modify the properties of fresh concrete and offer many advantages to the user. The main aim of this experimentation is to find out the effect of addition of red mud, which is a waste product from the aluminium industries, and foundry waste sand, which is a waste product from foundry, on the properties of self-compacting concrete containing two admixtures. In this experimentation combinations of admixtures which is taken. The flow characteristics and strength characteristics of self-compacting concrete produced from different waste material and different percentages of that material are found. The different percentages of red mud used in experimentation are 0%, 1%, 2%, 3%, 4%, 5%, 6%, 7% and 8% and the different percentages foundry waste used in experimentation are 2%, 4%, 6%, 8%.

Compressive strength test results of self compacting concrete containing the combination of admixtures (SP+VMA) with various percentages of red mud-

Table 1. Compressive strength of SCC with 0% red mud and with combination of admixtures (SP+VMA)

Specimen identific	Weight of speci	Density (N/cu	Average densit	Failure Load	Compressive strength	Average compressive
A1	82.4	24414.8	24079.0	900	40.00	40.59
A2	81.8	24237.0		930	41.33	
A3	79.6	23585.2		910	40.44	

Table 2. Compressive strength of SCC with 1% red mud and with combination of admixtures (SP+VMA)

Specimen identific ation	Weight of specimen	Density (N/cum)	Average densit y	Failure Load (KN)	Compressive strength (MPa)	Average compressive strength
B1	86.0	25481		960	42.67	
B2	80.0	23703		920	40.88	

B3	83.6	24770	24651	900	40.00	41.18

Table 3. Compressive strength of SCC with 2% red mud and with Combination of admixtures (SP+VMA)

Specimen identific	Weight of speci	Density (N/cu	Average densit	Failure Load	Compressive strength	Average compressive
C1	82.2	24355	24177.7	1020	45.33	44.29
C2	83.8	24829		990	44.00	
C3	78.8	23348		980	43.55	

Table 4. Compressive strength of SCC with 3% red mud and with combination of admixtures (SP+VMA)

Specimen identification	Weight of specim	Density (N/cu	Average densit	Failure Load	Compressive strength	Average comp
D1	84.0	24888.	24533.0	970	43.11	42.66
D2	81.2	24059.		930	41.33	
D3	83.4	24711.		980	43.55	

OVERALL RESULTS OF COMPRESSIVE STRENGTH

The following table no.8.10 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.

Table 5. Overall Result of Compressive Strength

Compressive strength (MPa) Percentage increase or decrease of compressive

percentage addition of red mud		Strength w.r.t. ref mix
0(Ref)	40.59	-
1	41.18	+1.45
2	44.29	+9.11
3	42.66	+5.10
4	40.29	-0.74
5	37.62	-7.32
6	35.11	-13.50
7	34.51	-14.98
8	33.62	-17.17

V. CONCLUSIONS

In present scenario there is a greater need for self compacting concrete due to sickness of member and architectural requirement, also to improve durability of the structure. Now the world is going to facing greater need of high performance concrete, durability point of view and SCC where the conventional way of compacting may not be always useful under different site condition. 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 +9.11. 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% foundry waste sand which is a waste material of ferrous industry (foundry).

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