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Effect of Size of Aggregate on Self Compacting Concrete of M70 Grade

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***Abstract*:** *Concrete is a versatile used construction material and concrete has been accepted as a material for construction, researchers trying to improve its quality and enhance its performance. Recent changes in construction industry demand improved durability of structures. There is a methodological shift in the concrete design from a strength based concept to a performance based design. At present there is a large emphasis on performance aspect of concrete. One such thought has lead to the development of Self Compacting Concrete (SCC). SCC is a new kind of High Performance Concrete (HPC) with excellent deformability and segregation resistance. It can flow through self gravity and fill the gaps between reinforcement and corners of moulds without any need for vibration and compaction during the placing process. certain guidelines for fresh properties of SCC comes by The European Federation of Producers and Applicators of Specialist Products for Structures (EFNARC). The present investigation is aimed at developing high strength Self Compacting Concrete of M70 Grade. The parameters of study include grade of concrete and effect of size of aggregate.*
***Keywords*:** *CRRI, NPCIL, EFNARC, PCI, IS 456-2000.*

I. Introduction

The concept of self-compacting concrete was proposed in 1986 by Professor Hajime Okamura, but it was first developed in 1988 in Japan by Professor Ozawa (1989) at the University of Tokyo. Self-compacting concrete (SCC) does not require any vibration and compaction for placing. It is able to flow under self-weight and achieving full compaction between congested steel reinforcement. as comparable to conventional concrete SCC has a strength and durability. the use of self-compacting concrete (SCC) has gained wide acceptance in the precast industry as well as in-situ constructions on account of reduction in the time of construction, noise of construction by eliminating vibration and good possibility of usage of complex formworks and members with highly congested reinforcement etc leading to achievement of a better final product in terms of finish and durability. As per IS: 456–2000 [Code of Practice for Plain and Reinforced Concrete], concretes ranging 25 – 55 MPa are called standard concretes and above 55 MPa called high strength concrete and above 120/150 MPa are called ultra high strength concrete. The applications of High strength concrete has numerous in buildings, bridges with long span and buildings in aggressive environments. Building elements made of high strength concrete are usually densely reinforced. At concreting time congested reinforcement creates a problems in placing the concrete. Densely reinforced concrete problems can be solved by using concrete that can be easily placed and spread in between the congested reinforced concrete elements. A highly homogeneous and well spread and dense concrete can be ensured using such a type of concrete. Usually range of compressive strengths of SCC is 60-100 N/mm2. However, as per requirements grades of concrete can be used. SCC was developed at the University of Tokyo in Japan in 1980 for used of congested reinforcement structures in an highly Earthquake regions. Durability of the structures is a very important lesson in Japan and skilled labor required for the compaction of concrete for durability of the structures. The SCC first reported in 1989. This requirement led to the development of SCC. The development of SCC was first reported in 1989. SCC is a new kind of High Performance Concrete (HPC) which has an excellent deformability and segregation resistance and flow through self weight in a congested reinforcement.

II. Self- Compacting Concrete

SCC is a very desirable achievement in the construction industry for overcoming the problems associated with cast-in place concrete. It is not affected by the skill labors, shape and arrangement of reinforcement bars. It can be pumped for longer distance because there are no segregation .it can be use for more types of construction. The use of SCC not only shortens the construction period but also ensures quality and durability of concrete.. Some of the advantages of Self Compacting Concrete are as follows:

1. Less noise from vibrators and reduced danger from Hand arm Vibration Syndrome.
2. Safe working environment.
3. Speed of placement, resulting in increased production efficiency.

4. Ease of placement, requiring fewer workers for a particular pour.
5. Better assurances of adequate uniform consolidation.
6. Reduced wear and tear on forms from vibrator.
7. Reduced wear on mixers due to reduced shearing action.
8. Improved surface quality and fewer bug holes, requiring fewer patching.
9. Improved durability.
10. Increased bond strength.
11. Reduced energy consumption from vibration equipment.
12. Greater freedom in design.

III. Materials

(3.1) Cement

Ordinary Portland cement of 53 grade [IS: 12269-1987, Specifications for 53 Grade Ordinary Portland cement] has been used in the study. It can stored as per IS: 4032 – 1977. throughout the investigation used the same cement and same grade of concrete.. The cement tested for physical properties as per IS: 12269 – 1987 shows by Table (A)

Table (A)

Sr. No	Property	Test Method	Test Results	IS Standard
1	Normal Consistency	vicat Apparatus (IS: 4031 Part - 4)	30%	
2	Specific gravity	Sp. Gr bottle (IS: 4031 Part - 4)	3	
3	Initial setting time Final setting time	Vicat Apparatus (IS: 4031 Part - 4)	95 minutes 210 minutes	Not less than 30 minutes Not less than 10 hours
4	Soundness	Le-Chatlier method (IS: 4031 Part – 3)	3 mm	Not more than 10 mm
5	Fineness	Sieve test on sieve	1.7 %	10 %

(3.2) Aggregates

(3.2.1) Fine Aggregate

Fine aggregate used from the river with out impourities and as per IS: 383 – 1970 [Methods of physical tests for hydraulic cement]. The fine aggregate was tested for its physical requirements such as gradation, fineness modulus, specific gravity and bulk density in accordance with IS: 2386 – 1963 [Methods of test for aggregate for concrete]. The surface of sand dried before use.

(3.2.2) Coarse Aggregate

The coarse aggregate chosen for SCC used between 10 mm to 16 mm round in shape, well graded and smaller in maximum size than that used for conventional concrete because rounde smaller aggregate gives flowability and deformability and segregation. Graded aggregate is also important particularly to cast concrete in highly congested reinforcement or formwork having small dimensions. Crushed granite metal of sizes 16 mm to 10 mm graded obtained from the locally available quarries was used in the present investigation. These were tested as per IS 383-1970 [Methods of physical tests for hydraulic cement].

(3.3) Water

Water used for mixing and curing was potable water, which is free from any amounts of oils, acids, alkalis, salts, organic materials or other substances as per IS : 3025 – 1964 part22, part 23 and IS : 456 – 2000 [Code of practice for plain and reinforced concrete]. The pH value should not be less than 6. The solids present were within the permissible limits as per clause 5.4 of IS: 456 – 2000.

(3.4) Chemical admixtures:

In a Self Compacting Concrete chemicals used as ingredients which can be added to the concrete mixture immediately before or during mixing. The use of chemical admixtures such as water reducers, retarders, high-range water reducers or Super Plasticizers (SP), and Viscosity Modifying Admixtures (VMA) is necessary in order to improve the fundamental characteristics of fresh and hardened concrete.

(3.5) Super Plasticizer:

More water reducing admixture and it is called as super plasticizers, used for improving the flow and workability for lower water-cement ratios without sacrifice in the compressive strength. These admixtures when they disperse in cement agglomerates significantly decrease the viscosity of the paste by forming a thin film around the cement particles. In the present work, water-reducing admixture Glenium conforming to IS 9103: 1999 [Specification for admixtures for concrete], ASTM C – 494 [Standard Specification for Chemical Admixtures for Concrete] . The details of the super plasticizer used are given in Table (B).

Table (B)

Sr. No	Property	Result
1	Form or state	Liquid (sulphonated naphthalene based formaldehyde
2	Colour	Brown
3	Specific Gravity	1.25 to 1.27 at 30°C
4	Choloride Content	IS 456
5	Air Enterentment	Approx. 1% additional air is entrained
6	Compatability	Can be used with all types of cements except high alumina cement..
7	Workability	Can be used to produce flowing concrete that requires no compaction
8	Cohesion	Cohesion is improved due to dispersion of cement particles thus minimizing segregation and improving surface finish.
9	Compresive Strength	Early strength is increased upto 22%. Generally, there is improvement in strength upto 24% depending upon W/C ratio and other mix parameters.
10	Durability	Reduction in w/c ratio enables increase in density and impermeability thus enhancing durability of concrete
11	Dosage	The rate of addition is generally in the range of 0.5 - 2.0 litres /100 kg cement

(3.6). Viscosity Modifying Agent:

VMA is a neutral, biodegradable, liquid chemical additive designed to reduce the bleeding, segregation, shrinkage and cracking that occur in high water/cement ratio concrete mixes. VMA also contribute to stabilization for SCC mixes that are susceptible to segregation at high slump ranges. Table (C)

Table (C)

Sr. No	Property	Result
1	Aspect	Colourless free flowing liquid
2	Relative Density	1.01
3	pH	>6
4	Choloride ion Content	< 0.2
5	Compatibility	Can be used with all types of cements
6	Incompatible	use with naphthalene sulphonate based superplasticiser admixtures
7	Mechanism of action	It consists of a mixture of water soluble copolymers
8	Dosage	50 to 500 ml/100 kg of cementitious material

(3.7) New Generation Plasticizers

To use poly-carboxylate based super plasticizer(pc).this next generation super plasticizer or sometimes called hyper plasticizer is more is more efficient than naphthalene or melamine based super plasticizer with respect to plasticizing property and slump retention property. They cause dispersion of fine particles more by steric hindrance of many side long chain of pc than only zeta potential of naphthalene based or melamine based plasticizers. Such polycarboxylatebased(PC), multi carboxylatehers(MCE) or carboxylic acrylic ester (CAE)etc,are available in India.shown by Table (D)

Table (D)

Sr.No	Manufacturing Companies	NEW GENERATION SUPERPLASTICIZERS FOR SCC	VMA FOR SCC
1	MC bauchemie india pvt.ltd	Muraplast FK 63 FK 61	Centramentstabi 510 (non-organic base)
2	BASF	Glenium 51 Glanium B 233	Glanium Stream – 2
3	SIKA	VISCO crete-1	Sika stabilizer 230
4	Burgin and leonsagenturenpvt.ltd	-	Kelco-crete 201 (containing diutan gum)

IV. World-Wide Utility Of Self Compacting Concrete:

Various countries used Self compacting concrete. In Japan, SCC is used in major construction projects in the late 1990s. Today, SCC is considered as a special concrete and efforts are made to integrate in the day-to-day concrete industry production. Currently, the percentage of self-compacting concrete in the annual production of Ready Mixed Concrete (RMC), as well as Precast Concrete (PC), in Japan is around 1.3% and 0.6% of concrete products.

In United States, the precast industry is also implementing SCC technology through the Precast/Prestressed Concrete Institute (PCI) which has done some research on the use of SCC in precast/prestressed concretes. There is a wide application of SCC in Precast/Prestressed industries in United States. There is an estimated 8000 m3 of SCC used just in the first quarter of 2003, almost 1% of the annual ready-mix concrete. Several state departments of transportation in the United States are involved in the study of SCC.

V. Development Of Self-Compacting Concrete In India

The development of Self Compacting Concrete (SCC) is considered as the most sought development in construction industry due to its numerous inherited benefits. In India, this technology is yet to realize its full potential. Central Road Research Institute (CRRI) [2005] New Delhi, has been working on SCC technology since the year 2000 and carried out significant research work on various aspects of SCC starting from selection of suitable ingredients including superplasticizer, viscosity modifying agent. Self Compacting Concrete (SCC) technology is a boon when Nuclear Power Corporation of India Limited (NPCIL) is planning for vast expansion of power generation within a short period of time. SCC is being considered in large scale for the construction work of Kaiga Power project (India) [Bapat S G et al,2004]. When Department of Atomic Energy (DAE) is celebrating its 50th year of glorious existence, the use of SCC in its building is a step forward towards green technology.

VI. Mix Design And Proportion

Step (6.1).

Grade	M-70
Quantity	1 m3
Type of cement	OPC 53 grade
Max size of aggregate	10 mm
Exposure condition	severe
workability	100mm (slump)
Min. cement content	320 kg/m3
Max. cement content	450 kg/m3
Max. w/c ratio	0.42
Type of aggregate	Crushed angular aggregate
Specific gravity of C.A.	2.80
Specific gravity of F.A.	2.70
Specific gravity of cement	3.15
Water absorption of F.A.	1%
Water absorption of F.A.	0.5%

Step (6.2). Target mean strength: F_{ck}=70

F_t=F_{ck}+1.65 S (s=6)

F_t=70+1.65x6

F_t=79.9 N/mm^2

W/C ratio: w/c ratio=0.42

Step (6.3). **Calculation of water content**:

Maximum water content as 10mm coarse aggregate size is 208 liter.
3% increase for every 25mm slump over and above 50mm slump.
Estimate water content for 100mm slump= 208x6/100+208 = 221 liter
As plasticizer is proposed we can reduce water content by 20 to 25% (normally 20%).
Assume used 20%
Actual water to be used = 221x0.8
Water = 177.00 liter

Step (6.4). Calculation of cement content:

W/c ratio = 0.42
Water used = 177 liter
W/c ratio = weight of water/weight of cement
0.4 = 177/ weight of cement
Weight of cement = 177/0.42
Weight of cement = 422 kg/m3

Step (6.5) Calculation of coarse aggregate and fine aggregate:

Volume of concrete = 1m3
Volume of cement = 422/ specific gravityx1000 = 422/3.15x1000
Volume of cement = 0.1339 m3
Volume of water = 177/ specific gravityx100 = 177/1x1000
Volume of water = 0.1770 m3
Admixture weight = 1.2 % by weight of cement = 1.2x422/100
Admixture weight = 5kg

Assume specific gravity of admixture = 1.1
Volume of admixture = 5/specific gravityx1000 = 5/1.1x1000
Volume of admixture = 0.00454 m3
Total volume of materials except = volume of cement + volume of water +volume of admixture = 0.1339+0.1770+0.00454
Total volume of materials = 0.3154 m3
Volume of C.A. & F.A. = 1-0.3154
Volume of C.A. & F.A. =0.6846 m3
Assuming 33% by volume of total aggregate
Volume of fine aggregate = 0.6846x0.3
Volume of fine aggregate = 0.2259 m3
Volume of coarse aggregate = volume of C.A. &F.A. – volume of fine aggregate = 0.6846-0.2259
Volume of coarse aggregate = 0.4587 m3
Weight of fine aggregate = volume of fine aggregate x specific gravity of F.A. x1000 = 0.2259x2.70x1000
Weight of fine aggregate = 609.93 kg/m3

Weight of C.A. = volume of C.A. x specific gravity of C.A.x1000
= 0.4587x2.80x1000
Weight of C.A. = 1284.36 kg/m3

Water : cement : F.A. : C.A.
0.42 : 1 : 1.445 : 3.043

VII. Test Method

None of the test methods for SCC has been standardized and the tests mentioned below are not perfected. These are only adhoc method which have been devised for SCC. These are the following. T_{50} CM Slump Flow Test, Slump Test, J- Ring Test, V- Funnel Test, L- Box

VIII. Results

This test is done to determine the cube strength of concrete mix prepared. The test is conducted on the 3rd, 7th, and the 28th day and its observation are listed below**.**shown by Table (E)

Table (E)

Size of Aggregate	3 days MPa	7 days MPa	28 days MPa
20 mm	31.8	46.5	74.6
12.5 mm	36.05	49.1	77.8
10 mm	38.2	49.8	79.2

IX. Conclusion

Based on experimental study conducted on SCC mixes with an aim to develop performance mixes, the following are the conclusions arrived.
1. The mixes designed using the lower size of aggregate yielded better fresh properties than higher size of aggregates.
2. As the strength of concrete increases, the effective size of aggregate has decreased.

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