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Powder Type Self Compacting Concrete for Infrastructure Projects

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Abstract*: Self-compacting concrete is defined as a concrete which is capable of self- consolidating without any external efforts like vibration, floating, poking etc. under its own weight. The mix is therefore required to have ability of passing, ability of filling and ability of being stable.*

Keywords: *Self-compacting concrete*

I. INTRODUCTION

Self-compacting concrete is defined as a concrete which is capable of self- consolidating without any external efforts like vibration, floating, poking etc. under its own weight. The mix is therefore required to have ability of passing, ability of filling and ability of being stable.

SCC developed by Prof. Okamura and his team in Japan in the early nineties, has evolved as an innovative technology, capable of achieving the status of being an outstanding advancement in the sphere of concrete technology. Though the concept of self-compacting concrete was evolved initially in Japan around 1988, since then several research efforts have been made in developed countries such as Western Europe, Canada, Sweden and Netherlands. Self-Compacting Concrete has been described as "The most revolutionary development in concrete construction for several decades".

Essential Properties of Self Compacting Concrete

Filling Ability

It is the property of Self Compacting Concrete to flow into and fill all spaces within the formwork completely under its own weight without any honeycombing. If Self Compacting Concrete is satisfying this test, that means one can be sure about its property to fill the form completely and can believe on 'Pour and forget.'

Passing Ability

It is the property of the Self Compacting Concrete to pass through congested reinforcement without blocking. As one of the distinct advantages of Self Compacting Concrete is that it can use in the situation of congested reinforcement, it has to satisfy the test of passing ability.

Segregation Resistance (Stability)

It is the ability of Self Compacting Concrete to remain stable in composition. SCC being flowing in nature, it must satisfy this property

Need of SCC

Need of Self Compacting Concrete through reinforcement and fill all the space in the form for meeting strength and durability requirement. If compaction is not complete, it will lead to loss of strength and affect performance of the structure. The compaction becomes difficult when percentage of reinforcement is high which does not allow insertion of vibrator at some places. In addition, the vibration increases noise level in and around construction site. There was also a concern about lack of skilled labor. Self- compacting concrete (SCC) may provide remedies to these problems.

Self-Compacting Concrete is a newly evolved technique with excellent Concrete is being used over 150 years. It is mixed, placed into the form and then compacted. It is essential to compact the concrete so that it should completely pass

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through formwork. Deformability and segregation resistance, SCC as the name signifies should be able to fill, occupy and compact itself without any additional means of vibrating equipment. No vibration is necessary for SCC, which can flow around obstructions, encapsulate the reinforcement, and fill up the formwork completely under gravity. It also improves the durability and speed of construction in mass concrete. SCC should be able to assume any complicated formwork shapes without cavities and entrapment of air.

The key to successful use of SCC is the availability of a cheaper filler, to make up demand for higher powder content. In India, good quality fly ash is now available and therefore this should not pose a problem.

Benefits and Advantages of Self Compacting Concrete

- Improved filling capacity of highly congested structural member without honey combing.
- Increases speed of construction.
- Reduced formwork and equipment cost.
- Reduction in site manpower.
- The surface finish produced by SCC is exceptionally good and no patching is required.
- Placing of concrete becomes easier.
- It improves durability of concrete

Disadvantages of self-compacting concrete

SCC requires higher powder and admixture contents than NVC and so the material cost is higher. It was reported that in most cases, the cost increase ranged from 20% to 60% compared to similar grade NVC. However in very large structures, increased material cost by using SCC was outweighed by savings in labor costs and construction time.

The benefits of SCC were fully displayed in a composite sandwich system, which involves casting SCC and NVC in layers within the same structural elements.

The increased content of powder and admixture also leads to higher sensitivity of SCC to material variation than that of NVC; thus greater care with quality control is required.

Applications of Self Compacting Concrete

SCC is a very dense, homogenous and durable concrete. It is readily used in precast and on site construction.

Applications of SCC in Precast/Prestress Industry

SCC is also advantageously and effectively used in precast industry.

The renovation work being proposed for Soldier Field in Chicago will feature precast concrete tubes using SCC. The material will provide a flawless concrete that eliminates the need for patching, speeding the work considerably.

Precast panels using SCC are poured at the Fin fork industries plant in Orlando, Fla. The material flows quickly to fill every nook & cranny, leaving no voids and flowing around densely packed reinforcements.

Applications of SCC in India:

Nuclear Power Corporation of India (NPCIL) intended to use SCC at two Nuclear Power Plants of India

Nuclear Power Plant at Kaiga in Karnataka.

Nuclear Power Plant at Tarapur Atomic Power Research Plant for its 3rd and 4th stages

SCC was used in the construction of a pre-cast slab element used in a Gujarat school project.

It was used as a backpack concrete in tunnel for Khopoli New Water Conductor system. A total 10,000 m3 of SCC was placed in a tunnel length of 1.48 km.

Variable in proportion with the given material four variable factor to be considered in connection with specifying are

(a) Water -cement ratio.

(b) Cement content or cement- aggregate ratio

(c) Gradation of the aggregates

(d) Consistency

In general all four of these inter related variable cannot choosen or manipulated arbitrarily two or three factors are specified and other are adjusted to give minimum workability and economy. We use arbitrary proportion method with variable cementacious material content.

Self compacting concrete as Eco-friendly material

The major environmental impact of concrete is caused by CO2-emissions during cement production. Great potential for reducing the impact is seen especially for concretes with normal strength. The use of Superplasticizer and highly reactive cements as well as optimization of particle-size distribution and reduction in water content allows a significant reduction in Portland cement clinker in the concrete. Essential is the addition of mineral fillers (e.g. limestone powder) to provide an optimal paste volume. In addition, the already practicable substitution of secondary raw materials like fly-ash or furnace-slag for cement clinker is an appropriate option which is however limited by the availability of these resources.

In several test series the fresh and hardened concrete properties of concretes with reduced water and cement contents were investigated, especially their workability, strength development, design-relevant mechanical properties as well as durability aspects such as carbonation. It was shown that concretes with cement clinker and slag contents as low as 150 kg/m3 were able to meet the usual requirements of workability, compressive strength (approx. 40 N/mm2) and mechanical properties. The carbonation depth of concretes with 150-175 kg/m3 clinker and slag was equal or lower than the depth of conventional reference concretes for exterior structures. The ecological advantages were identified, using environmental performance evaluation. A reduction of up to 35% in environmental impact was calculated compared with conventional concrete and of more than 60% with granulated blast-furnace slag. Practical application was verified by means of full-scale tests in a precast and ready-mix concrete plant.

Objective of the study

The uses of SCC in the construction of rigid pavements are now seen in major areas. However, problems arise from the consideration that the infrastructures susceptible to cracking and structural defects. This can be overcome by use of powder type SCC in Infrastructure.

The fly ash added in appropriate quantity as replacement. The addition of fly ash imparts properties. Hence property impartation can be used for concreting in infrastructure works. Current problems associated with on site concrete manufacturing, specific properties, compaction equipments and vibration machineries and their costings is a big concern. For comparison properties like compressivestrength, Flexural Strength and tensile strength are being considered.

II. LITERATURE REVIEW

Large no. of research papers have been published till date related to Self Compacting concrete. Researchers used different mixes for analysis. Very few researchers went for high powder content.

Bertil Persson 2000[2], This is an experimental and numerical study on mechanical properties, such as strength, elastic modulus, creep and shrinkage, of self-compacting concrete (SCC) and the corresponding properties of normal compacting concrete (NC) is outlined in this article. The study included eight mix proportions of sealed or air- cured specimens with water ± binder ratio (w/b) varying between 0.24 and 0.80. Half of the mixes studied were based on NC. The age at loading of the concretes in the creep studies varied between 2 and 90 days. Four different stresses to strength levels were studied. Parallel studies were performed on strength (fc) and relative humidity (RH). The results show that elastic modulus, creep and shrinkage of SCC did not differ significantly from the corresponding properties of NC. The ongoing study was started in 1997.

Saradhi Babu, K. Ganesh babu and T. H. Wee (2004)[3] showed that Lightweight concretes can be produced by replacing the normal aggregates in concrete or mortar either partially or fully, depending upon the requirements of density and strength levels. The present study covers the use of expanded polystyrene (EPS) beads as lightweight aggregate, both in concrete and mortar. The main aim of this programme is to study the mechanical properties of EPS concretes containing fly ash and compare the results with these in literature on concretes containing OPC alone as the binder. The effects ofEPS aggregate on the green and hardened state characteristics of concretes containing fly ash were

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evaluated. The compressive strength of the EPS concretes containing fly ash show a continuous gain even up to 90 days, unlike that reported for OPC in literature. It was also found that the failure of these concretes both in compression and split tension was gradual as was observed earlier for the concretes containing plastic shredded aggregates. The stress–strain relations and the corresponding elastic moduluswere also investigated.

J.M. Khatib 2007[4], the influence of including fly ash (FA) on the properties of self- compacting concrete (SCC) is investigated. Portland cement (PC) was partially replaced with 0–80% FA. The water to binder ratio was maintained at 0.36 for all mixes. Properties included workability, compressive strength, ultrasonic pulse velocity(V), absorption and shrinkage. The results indicate that high volume FA can be used inSCC to produce high strength and low shrinkage. Replacing 40% of PC with FA resulted in strength of more than 65 N/mm2at 56 days. High absorption values are obtained with increasing amount of F.A., however, all FA concrete exhibits absorptionof less than 2%. There is a systematic reduction in shrinkage as the FA content increases and at 80% FA content, the shrinkage at 56 days reduced by two third compared with the control. A linear relationship exists between the 56 day shrinkage and FA content. Increasing the admixture content beyond a certain level leads to a reduction in strength and increase in absorption. The correlation between strength and absorption indicates that there is sharp decrease in strength as absorption increases from 1 to 2%. After 2% absorption, the strength reduces at a much slower rate.

C. M. Tam, Vivian W. Y. Tam and K. M. Ng 2011[5], focused on RPC. Reactive powder concrete (RPC) is coarse aggregate-free which differs from that of the ordinary concrete. Instead, fine powders such as quartz sand and crushed quartz, with particle sizes ranging from 45 to 600 lm are used. In fact, it is rather a mortar than a concrete mixture because of the lack of coarse aggregate. The mechanical property performance of RPC has been investigated by the previous researchers. However, the performance on drying shrinkage and water permeability is of paucity in the literatures. This paper examines the influences of water-to-binder ratio and Superplasticizer dosage on the drying shrinkage and water permeability of RPC. Recommendations for reducing drying shrinkage and water permeability of RPC are also discussed.

Lino Maia and Joaquim Figueiras (2012)[6],The age of loading and the stress level are important parameters in the precast/pre-stress industry as they are related to the time of each production cycle, as well as to the concrete deformation. For this reason, astudy about the influence of the age of loading and the stress level on the deformation of a self-compacting concrete with a mix composition typically used in the prefabrication of pre-stressed bridge girders was performed. This concrete develops 60MPa within 24

h. Its deformation was evaluated at the stress-to strength ratio of 30% for six stages of loading at the ages of 12, 16, 20, 24, 48 and 72 h. At the age of12 and24 h, deformation was also evaluated at the stress-to-strength ratios of 20% and 40%. Loaded specimens were kept under constant stress during at least 600 days in a climatic chamber with a temperature and a relative humidity of 20˚C and 50%, respectively. Deformation in non-loaded specimens was also measured to determine shrinkage and calculate creep deformation. Results are compared with the predictions provided by the Eurocode 2.

Antonios Kanellopoulos, Michael F. Petrrou and Ioannis Ioannou 2012[7] although self-compacting concrete (SCC) is currently used in many countries, there is a fundamental lack of the intrinsic durability of the material itself. This article presents the outcomes from a research program on principal indicators that define the durability of SCC (porosity and chloride ion permeability) and compares these indicators with the corresponding parameters of conventional concrete. The results show, for the first time, that there is a correlation between the various durability indicators for the specific filler additives used in the mix designs incorporated in this paper. Such a correlation maybe used to assess the durability of SCC without the need to rely on timeconsuming artificial weathering experimental procedures.

Petr Hunka (2013)[10],This article is summarizing technological and test influences on modulus of elasticity of concrete and presents in more detail results of experimental measuring of following test influences: shape and dimension of test piece, method of finishing of pressing surface, level of load. Not just its durability but also deformative characteristics of concrete have been coming to fore of experts' interest during last few years. One of deformable characteristics of each concrete type is modulus of elasticity of concrete. Modulus of elasticity is part of many static calculations and has close relation to other physical and mechanical characteristics of concrete as are creeping, shrinking, frost resistance etc. Final value of modulus of elasticity of concrete depends on many influences. These influences can be basically classified as test influences and technological influences.

Her-Yung Wang and Chih-Chung Lin (2013)[11], This study examined the properties of freshly poured self-compacting concrete with a fixed water–cement ratioof 0.37 in which a portion of the cement was replaced by furnace slag in weight ratios of 0%, 15% and 30%. The fresh and various engineering properties are discussed. The results showed that the slump flow varied with the replacement ratio of furnace slag for Portland cement. The slump flow for the 15% furnace slag sample was within the design value of 550–700 mm. The compressive strength of the 15% furnace slag replacement sample was higher than that of the control group. The shrinkage increasedas the amount of slag added increased. The cores were drilled from upper, middle and lower layers of the field MOCK-UP model specimen, and the appearance was noted. It was obvious that the SCHSC specimen had no bleeding pores or aggregate segregation. When concrete containing furnace slag is used in self-compacting concrete structures, the fresh and engineering properties can be improved, and the waste resource can be reused. The results of laboratory test are comparable with mock-up tests.

Abhijeet A. Ulagadde, P. D Kumbhar (2013)[12], in this experimental work, SCC of M60 grade is tried to be developed by using Nan Su method of mix design and by incorporating different mineral admixtures of FA, SF and GGBFS with appropriate dosage of Superplasticizer (SP) at different replacement levels of FA and GGBFS at 15%, 20% and 25% and SF at 5%, 10% and 15% (by weight of cement) in the form of quaternary blends to study workability and 28 days compressive strength properties. 45% of total replacement (i.e. FA15%, SF15% & GGBFS15%) gave good results for both fresh and hardened properties.

Batham Geeta, Bhadauria S. S., Akhtar Saleem (2013)[13], Present paper explores the recent innovations in self-compacting concrete containing agro-industrial waste materials. Various research studies have been conducted on the use of agro-industrial waste as an innovative material to produce good quality of concrete whether it is plain concrete or self-compacting concrete. The use of agro-industrial waste materials in concrete is common solution for waste disposal as well as economy purpose. The paper also reviewed latest application of admixtures and their performance on SCC quality. Application of various innovative materials as ingredients in SCC and their effect on the fresh and hardened properties are discussed here. SCC is a special type ofhighly flowable concrete that does not require vibration for placing and compaction. Innovative materials are generally used for partial replacement of cement or sand or aggregate or combination of two or more. They may be used as additional filler to enhance the physical and mechanical properties of the SCC. The goal that expected from the paper is to compile the recent innovations in SCC, study their effect on the properties of SCC and establish an international benchmarking for further research work in this regard.

Dhruvkumar H. Patel, Dixitkumar D. Patel, Dhaval P. Patel [14] Suggests concrete is a family of binding material, fine aggregate, coarse aggregate and water. Concrete is normally used in the frame structure. But there is some limitation like self compaction, surface finishes, maintains strength at congested area. Due to this limitation we are trying to make self- compacting concrete with the use of mineral admixture. SCC is concrete that can be placed and compacted under its own weight without any vibration effort, assuring complete filling of formwork even when access is hindered by narrow gaps between reinforcement bars. The primary objective of this study is to make use of Ground granulated blast furnace slag (GGBS) as a replacement of cement and understand its effects on the fresh properties, compressive strength weathering. The study also intended to quantify the amount of Ground granulated blast furnace slag (GGBS) to be added to the concrete according to the value of concrete properties Measured. The workability of self-compacted concrete is increased as content of GGBS increased. Compressive strength of SCC with GGBS is increased up to 10% replacement of cement with GGBS.

Subhan Ahmad1, Arshad Umar2, Amjad Masood3 (2016)[15], their research comprises of comparison between hardened properties of normal concrete (NC) and Self compacting concrete (SCC) and experimental study on influence of glass fibres on fresh and hardened properties of SCC is investigated. They suggest that the compressive strength and split tensile strength of SCC were found to be slightly higherthan NC.

Research Gap

1. Though large no. of research papers have been published till date related to Self Compacting concrete. Very few researchers went for high powder content.
2. Considering imparting cementacious substances like Fly ash can enhance the properties of SCC which can overcome problems associated with infrastructure works.
3. It is expected Study suggests a powder type SCC for Infrastructure works.

III. EXPERIMENTAL PROGRAMME / METHODOLOGY

Self-compacting concrete with varying proportion of powder content 600kg/m3 and 650 kg/m³ are considered along with normal (vibrated) concrete.

Tests on Green Concrete

Workability of SCC is higher than highest class of any normal concrete. Being of flowing nature, normal workability measurement methods are not suitable for SCC.

The concrete is classified as Self Compacting Concrete only if it satisfies the following requirement

- Filling ability
- Passing ability
- Segregation resistance

Various test methods have been developed in attempts to characterize the properties of SCC. So far, no single method or combination of methods has achieved universal approval and most of them have their adherents. Similarly, no single method has been found which characterizes all the relevant workability aspects of Self Compacting Concrete, so each mix design should be tested by more than one test method for the different workability parameters. Alternative test methods for the different parameters are listed in table 3.1

Table 3.1 Tests on Fresh Concrete

Sr. No.	Method	Property
1	Slump-flow by Abrams cone	Filling ability
2	T50cm slump flow	Filling ability
3	V-funnel	Filling ability
4	V-funnel at T5minutes	Segregation resistance
5	L-box	Passing ability

Workability Criteria for the Fresh SCC

These requirements are to be fulfilled at the time of placing. Typical acceptance criteria for Self Compacting Concrete with a maximum aggregate size up to 20 mm is presented in Table No. 3.2

Table 3.2 Ideal Results for workability

Sr. No.	Method	Unit	Typical range of values	
			Minimum	Maximum
1	Slump-flow by Abrams cone	mm	650	800
2	T50cm slump flow	Sec	2	5
3	V-funnel	Sec	6	12
4	V-funnel at T5minutes	Sec	0	+3
5	L-box	(H_2/H_1)	0.8	1.0

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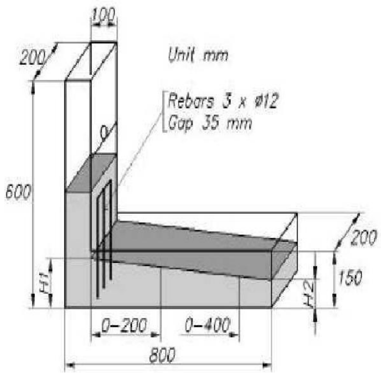

Fig. 3.1(a) L – Box Apparatus

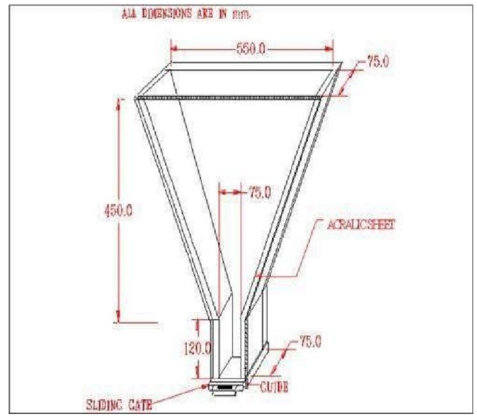

Fig. 3.1(b) V - funnel test apparatus

Selection Criteria for the Hardened SCC

To find strength of hardened concrete there are lot of tests to be performed on samples. These test results helps to workout different properties of concrete. These tests are listed below in the table 3.3

Table 3.3 Test on Hardened Concrete

Sr. No.	Method	Property
1	Compression Test on cubes	Characteristics Compressive Strength
2	Split Tension Test on Cylinders	Tensile strength of concrete
3	Flexural Test on beams	Flexural Strength of concrete

Specimen Samples Details

Numbers of samples and their sizes prepared for tests to be performed to work out their properties are listed below in the table 3.4

Table 3.4 No. of Samples

TEST NAME	Normal Concrete			600 kg/m^3			650 kg/m^3			No. of sample
CURING PERIOD (DAYS)	7	28	56	7	28	56	7	28	56	
COMPRESSION TEST ON CUBE (150X150X150)	3	3	3	3	3	3	3	3	3	27
FLEXURAL TEST ON BEAMS (500X100X100)	0	3	3	0	3	3	0	3	3	18
SPLIT TENSION TEST ON CYLINDERS (300X150Φ)	3	3	3	3	3	3	3	3	3	27

All Dimensions are in mm.

Methodology & Equipment

Instruments used

Vernier Caliper

A Vernier caliper consists of a high quality metal ruler with a special vernier scale attached which allows the ruler to be read with greater precision than would otherwise be possible. The vernier scale provides a means of making measurements of distance (or length) to an accuracy of a tenth of a millimeter or better. Although this section will be devoted to the use of the vernier caliper, it should be noted that vernier scales can be used to make accurate measurements of many different quantities

MIX DESIGN

Referance Mix Design

A Reference mix design from "Tarapur atomic power plant". Based on EFNARC guidelines, extensive trials were conducted to select the ingredients for SCC. The following are the mix proportions adopted based on laboratory trials for 40 Mpa SCC. Table 3.5 Reference Mix Design

MATERIALS	**Wt. Per Cu.m. (Kg)**
Cement	300
Fly ash	200
Micro Silica	25
Coarse aggregate	664
Fine aggregate	976
Superplasticizer	12.60 (2.4%By wt. Of powder)
VMA (Powder)	52.5 g (0.03% By wt. Of water
Water	175 Kg

For preparing mix design with variable powder content, percentage of different materials per cubic meter quantity of concrete is used and same percentage for different powder content from following calculations.

Weight of concrete excluding cement =

(Density of concrete) – (Wt. Of cementations material content) 2165 – 525 = 1640

% of Fine aggregate = 976 / 1640 x100 =59.52

% of Coarse aggregate = 664 / 1640 x100 =40.49

Super plasticizer = as per manufacturers specification

Water = 32% by wt. of cementations material content

Mix design for Trial Mix

Following table shows a sample trial mix for powder content 600 kg/m^3.

Table 3.6 Trial Mix Design

MATERIALS	**Wt. Per Cu.m. (Kg)**
Cement	360
Fly ash	240
Natural sand	1095.5
Coarse aggregate	459.5
Coarse Agg.(10mm)	187.8
Coarse Agg.(20mm)	281.76
Water	192
Super Plasticizer	8.10 (1.1%)

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Tests conducted on above trial mix and their results are listed below in the table 3.7 Table 3.7 Test Results of Trial Mix for powder content 600

Sr. No.	Method	Unit	Results
1	Slump-flow by Abrams cone	mm	650
2	V-funnel	Sec	15
3	V-funnel at T5minutes	Sec	17
4	T50cm slump flow	Sec	6
5	L-box	(H2/H1)	0.895

Mix Design for Actual Mix

Now days we are facing problem for disposal of fly ash, so considering environmental aspect it is beneficial to use fly ash in concrete as replacement with cement. In present investigation, we replaced 40% fly ash by weight cementacious material content

Table 3.8 Design mixes for Actual Mix for SCC (600, 650)

Materials	600 kg/m^3	650 kg/m^3
Cement	360	390
Fly Ash	240	250
Natural Sand	1095.5	1060.50
Coarse Aggregate	459.5	454.50
Coarse Agg.(10mm)	187.80	250
Coarse Agg.(20mm)	281.76	204.50
Water	192 (32%)	208 (32%)
Super Plasticizer	8.10 (1.1%)	7.15 (1%)

Weight of concrete excluding cement = (Density of concrete) – (Wt. Of cementations material content)

2165 – 550 =1615

% of Fine aggregate = 1130.5/ 1615 x100 =70.00

% of Coarse aggregate = 484.5 / 1640 x100 =30.00

Super plasticizer = As per manufacturers specification

Water = 32% By Wt. of cementacious material content

Table 3.9 Test Results of Actual Mix PC 600 and 650

Method	Unit	600 kg/m^3	650 kg/m^3
Slump-flow by Abrams cone	Mm	750	780
V-funnel	sec	11	10
V-funnel at T5minutes	sec	13	12

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T50cm slump flow	sec	4	3
L-box	(H2/H1)	0.945	0.893

IV. TESTS AND RESULTS

Tests on material

Tests on cement:

Laboratory Test:

Ordinary Portland cement of 53 grade from the local market was used and tested for physical and chemical properties as per IS: 4031 – 1988 and found to be conforming to various specifications as per IS: 12269-1987.

1. Fineness Test : 2%
2. Normal consistency : 30%
3. Initial setting time : 35 min
4. Final setting time : 217 min
5. Standard Consistency : 35%
6. Specific gravity : 3.09

Tests on Aggregate

Fine aggregate: In the present investigation fine aggregate is natural sand from local market is used. The physical properties of fine aggregate like specific gravity, bulk density, gradation and fineness modulus are tested in accordance with IS : 2386.

Table 4.1 Fine Aggregate Test Results

Property	**Result**
Fineness modulus	5.065
Specific gravity	2.73
Silt Content	0.002
Water Absorption	3.09%

Coarse aggregate : The physical properties of coarse aggregate like specific gravity, bulk density, gradation and fineness modulus are tested in accordance with IS : 2386

Table No. 4.2 Coarse Aggregate Test Results

Property	**Result**	
	10 mm	**20 mm**
Fineness modulus	2.9	3.0
Specific gravity	2.67	2.7
Water Absorption (%)	2.28	2.28

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Fly Ash: In the present investigation work, the fly ash used is obtained from Eklahara thermal power station in Nashik (Maharashtra). The specific surface of fly ash is found to be 359.143m^2/kg. By blains permeability apparatus and its specific gravity is 2.3 and product P-60.

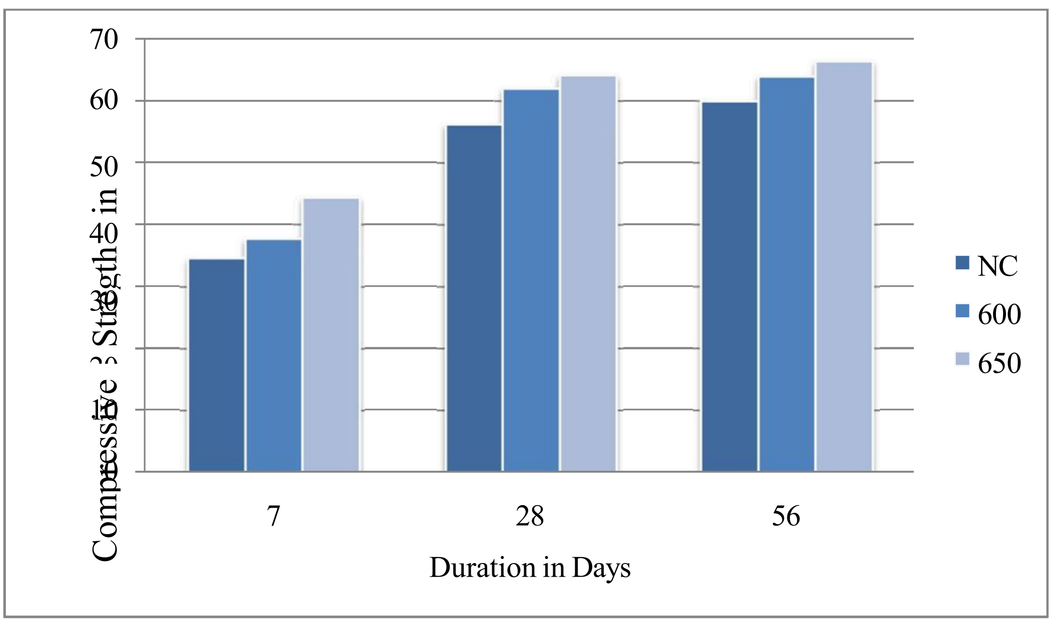
Super plasticizer: The super plasticizer used in concrete mix makes it highly workable for more time with much lesser water quantity. It is observed that with the use of large quantities of finer material (fine aggregate + cement + fly ash) the concrete is much stiff and requires more water for required workability hence, in the present investigation SP430 is used as water reducing admixture. Super plasticizer is essential for the creation of SCC. The job of SP is to impart a high degree of flow ability and deformability, however the high dosages generally associate with SCC canlead to a high degree of segregation. SP 430 to be utilized in this project, is a product of FOSROC Company having a specific gravity of 1.222

TESTS AND RESULTS ON SCC SPECIMEN

4.2.1. Compressive strength of concrete: Compressive strength of concrete is defined as the load, which causes the failure of a standard specimen (150 mm cube according to ISI) divided by the area of cross section in uniaxial compression under a given rate of loading. The test of compressive strength should be made on 150 mm size cubes

Table 4.3 Compressive Strengths results for NC and SCC

Curing Period (Days)	Powder Content (kg/m^3)		
	NC	600	650
7	34.67 N/mm²	37.78 N/mm²	44.44 N/mm²
28	56.30 N/mm²	62.07 N/mm²	64.18 N/mm²
56	60.07 N/mm²	64.00 N/mm²	66.43 N/mm²



Graph 4.1 Comparison of Compressive Strength of NC and SCC (600,650)

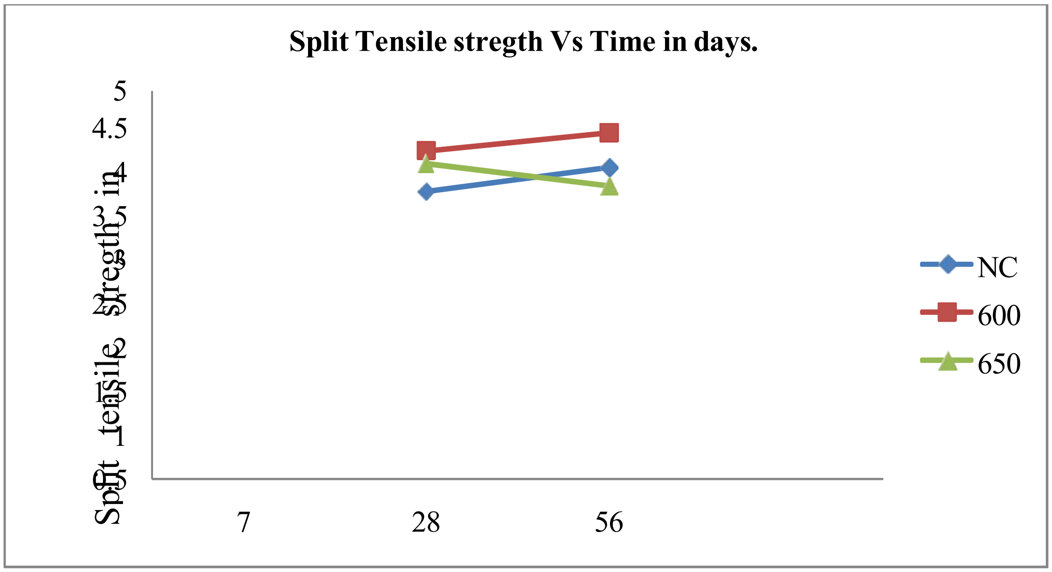
From above results it is observed that compressive strength of concrete increases with increase in powder content. As compared to normal vibrated concrete, compressive strength of powder type SCC is slightly more.

Tensile strength of concrete.

Split tension strength: A concrete cylinder of size 150 mm dia × 300 mm height is subjected to the action of the compressive force along two opposite edges, by applying the force in this manner. The cylinder is subjected to compression nearthe loaded region and the length of the cylinder is subjected to uniform tensile stress

Table 4.4 Splitting tensile strength of concrete

Days	Split tensile strength in N/mm²		
	NC	600	650
28	3.71	4.23	4.07
56	4.02	4.46	3.78



Graph 4.2 Split Tensile Strength Vs Time

Standard beam test

Standard beam test or modulus of rupture carried out on the beams of size (100mm×100mm×500mm), by considering the material to be homogeneous. The beam should be tested on a span of 400 mm for 100mm specimen by applying one equal loads placed at third points .To get these loads, a central point load is applied ona beam supported on steel rollers placed at third point. The rate of loading shall be 1.8 KN/minute for 100 mm specimens the load should be increased until the beam failed.

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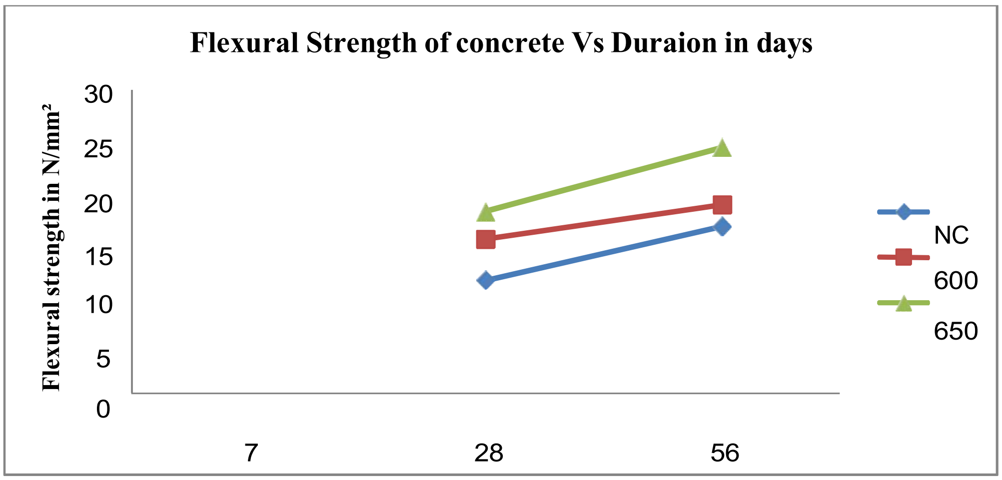
Table 4.5 Flexural Strength of Concrete for NC and SCC (600,650)

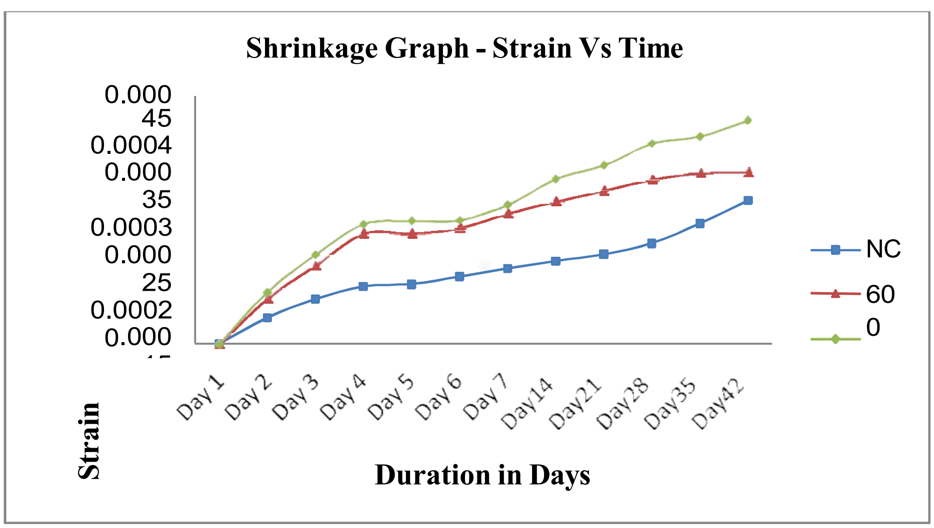
Days	**Flexural Strength of concrete in N/mm²**		
	NC	**600**	**650**
28	11.178	15.24	18
56	16.5	18.63	24.33



Graph 4.3 Flexural Strength Vs Duration in days

Shrinkage Test

The shrinkage represents a time dependent deformation which reduces the volume of Concrete, without the impact of external forces. The time flow and the final values of shrinkage are influenced by numerous factors: temperature and humidity, dimensions of elements, the type and quantity of cement, w/c factor, granulometric and mineralogical composition of aggregates, concrete strength, method of workability and curing, concrete age at the end of curing and many other factors.



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Graph 4.4 Shrinkage Vs Time in days

From above results, it is clear that as shrinkage for SCC is more than the normal (vibrated) concrete. Again, shrinkage of PC 650 seems slightly more than PC 600. Hence, increase in powder content results in increase in shrinkage. Considering Infrastructure works, Powder Content can be limited up to 600 kg/m^3

V. CONCLUSION

From the current investigation, we can say that as compared to traditional concrete SCC have improved properties. Compressive strength of SCC with GGBS, fly ash or other filling materials can be increased. These properties of concrete at hardened state are important considering infrastructure projects. Hence, rather than traditional concrete SCC can be used to achieve economy in structures where no special load conditions are susceptible with large variation and huge demand. Now a day, efforts are made to succeed in creating durable and reliable structures with less maintenance so that SCC will change from Special to standard concrete.

Concluding Remarks

- From the literature review, it is seen that fly ash in appropriate quantity improves the fresh as well as hardened properties of SCC. From results, it is seen that addition of fly ash increases strength of concrete.
- As compared to normal (vibrated) concrete, strength results shown by powder type SCC are slightly on higher side. Also, compressive strength results of 650 kg/m³ were more than 600 kg/m³ powder content. Hence, Powder content plays important role in increasing Characteristics Compressive strength of SCC mix.
- Flexural strength concrete examined for beams with 28 days curing, powder type SCC beams shown higher flexural strength than Normal concrete.
- Indirect Tensile strength of concrete calculated by Split tensile strength test. The tensile strength of 600 PC was slightly more than 650 PC i.e., for 650 PC the split tensile strength decreased. Hence we can conclude powder content should be less than 650 kg/m3.
- Shrinkage analysis is done to understand shrinkage behavior of Powder type SCC. Shrinkage for SCC is more than the normal (vibrated) concrete. Again, shrinkage of PC 650 seems slightly more than PC 600. Hence, increase in powder content results in increase in shrinkage. Considering Infrastructure works, Powder Content can be limited up to 600 kg/m3.

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