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An Experimental Investigation on the Mechanical Properties of Self Compacting Concrete using Powder & Viscosity Modifying Agent

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Abstract **-- Self Compacting Concrete, a new kind of high performance concrete have been first developed in Japan in 1986. The development of SCC has made casting of dense reinforcement and mass concrete conveniently. Fresh self compacting concrete flows into formwork and around obstructions under its own weight to fill it completely without any segregation and blocking. Concrete performance is commonly evaluated with respect to mechanical properties such as compressive strength, tensile strength and modulus of elasticity. This study investigates the mechanical properties of self compacting concrete. The ingredients used for SCC are 53 grade ordinary Portland cement, river sand, coarse aggregate, superplasticizer, class-F fly ash from thermal power plant, viscosity modifying agent. Cement is replaced by fly ash at 20% level by weight of cement. Various tests such as slump flow test, U-tube test, V-funnel test and L-box test are conducted to study the characteristics of fresh concrete. The basic tests were conducted for all ingredients of SCC. In this study, we use 8 different mixes to find the mechanical properties of SCC. The super plasticizer mix ratios are 1%, 1.5%, 2% and 2.5% like that VMA also mix at 1%, 1.5%, 2% and 2.5%. For each mix 6 numbers of cube and 12 numbers of cylinder are cast. The cube used to find the compressive strength and the cylinder used to find compressive strength and split tensile strength.**

Keywords **-- Self-Compacting Concrete, Fly Ash, Fresh properties, Super plasticizer, Viscosity Modifying Agent, Hardened properties**

I. Introduction

The concrete technology has made tremendous studies in past decade. Concrete is now no longer a material consisting of cement, aggregates, water and admixtures but it is an engineered material with several new constituents. The concrete today can take care of any specific requirements under most of different exposure conditions. The self compacting concrete is a flowable Concrete mixture that is able to consolidate under its own weight. It does not require any external vibration for compaction. The highly fluid nature of SCC makes it suitable for placing in difficult condition and in sections with congested reinforcement SCC does not show segregation and bleeding. Much more is demanded of SCC in its fresh state than of conventional vibrated concrete, and it became clear that the remaining fundamental obstacle to the wider use of SCC in Europe was the absence of suitable test methods to identify and specify its three key fresh properties are passing ability, filling ability and resistance to segregation. Although there were a number of test methods, these had often been developed for specific applications with little or no attempt to ensure that they were more generally applicable, and there was no immediate prospect, anywhere, of a standardised test. This was hindering the increased use of SCC since it was difficult to validate mix designs except by full-scale trials, and confidence in the material was therefore undermined.

A. Objective of the project

- To identify the three key properties of SCC i.e. filling ability, passing ability and segregation resistance
- To determine the workability of SCC using Slump Cone Test, U Tube Test, L Box Test and V Funnel Test.

- To study the Strength and behavior of SCC with Fly ash.
- The main objective of this study is to find the mechanical properties of SCC.

B. Scope of the project

- To improve filling capacity through highly congested reinforcement by using the Self Compacting concrete.
- To reduce the construction time in the project.
- To get good surface finishing.

C. Advantages of SCC

Advantages of SCC over Normal Concrete are as follows:

- Faster construction
- Reduction in site man power
- Better surface finishes
- Easier placing
- Reduced noise levels in work site
- Economical construction
- Improved filling capacity through highly congested reinforcement

D. Application areas of SCC

SCC may be used in pre-cast applications or for concrete placed on site. It can be manufactured in a site batching plant or in a ready mix concrete plant and delivered to site by truck. It can then be placed either by pumping or pouring into horizontal or vertical structures. In designing the mix, the size and the form of the structure, the dimension and density of reinforcement and cover should be taken in consideration. These aspects will all influence the specific requirements for the SCC. Due to the flowing characteristics of SCC it may be difficult to cast to a fall unless contained in a form. SCC has made it possible to cast concrete structures of a quality that was not possible with the existing concrete technology.

E. Fresh properties of SCC

Filling ability: The ability of SCC to flow through tight openings such as spaces between steel reinforcing bars without segregation or blocking

Passing ability: This property of fresh concrete is related entirely to the mobility of the concrete.

Resistance to segregation: The mix has to maintain its stability under high flow conditions i.e. it should not segregate and should remain homogenous in composition during transport and homogeneity.

F. Hardened properties of SCC

In normal concrete, during vibration, water tends to migrate to the surface of the coarser particles causing porous and weak interfacial zones to develop. In case of well designed SCC the homogeneity, mobility, cohesiveness helps placing concrete in formwork without compaction. This helps in better interface between coarse aggregate and mortar paste as minimal interfacial zone develops. The microstructure of SCC can be therefore expected to be superior, promoting strength, impermeability, durability and ultimately longer service life of concrete. The performance of hardened concrete of SCC and normally vibrated concrete does not show much of a difference. Variation in strength across depth of structure, between creeps and drying shrinkage, strength and statistic modulus is also the same. Durability is better for SCC while early age shrinkage and cracking is higher for SCC.

II. Materials

A. Cement

53 grade Ordinary Portland cement is used for the study Programme. The properties of this cement have been tested and given below:

Specific gravity of Cement = 3.14

Fineness modulus cement = 1.75

Consistency = 36 %

Initial Setting Time = 32 minutes

B. Fine Aggregate

River sand was used in preparing the concrete as it was locally available in sand quarry. The properties of this fine aggregate have been tested and given below:

Specific gravity of fine aggregate = 2.60

Fineness modulus of fine aggregate = 2.85

Water absorption = 2.5%

C. Coarse Aggregate

Aggregate must be equal to or better than the hardened cement to withstand the designed loads and the effects of weathering. The properties of this coarse aggregate have been tested and given below:

Specific gravity CA = 2.66

Bulk density of coarse aggregate = 1487.6 Kg/m^3

Fineness modulus = 3.15

Water absorption = 1.0%

D. Water

Potable water available in laboratory with pH value of 7.0 ± 1 and confirming to the requirement of IS: 456-

2000 was used for mixing concrete and curing the specimens as well.

E. Fly Ash

Fly ash consists of fine, powdery particles that are predominantly spherical in shape, either solid or hollow, and mostly glassy in nature. The carbonaceous material in fly ash is composed of angular particles. The particle size distribution of most bituminous coal fly ashes is generally similar to that of silt. Although sub bituminous coal fly ashes are also silt-sized, they are generally slightly coarser than bituminous coal fly ashes.

F. Superplasticizers

Superplasticizers, also known as high range water reducers, are chemicals used as admixtures where well-dispersed particle suspension are required. These polymers are used as dispersants to avoid particle aggregation, and to improve the flow characteristics of suspensions such as in concrete applications. Their addition to concrete or mortar allows the reduction of the water to cement ratio, not affecting the workability of the mixture, and enables the production of self-consolidating concrete and high performance concrete.

G. Viscosity Modifying Agent

Cement paste serves as the basis for the workability properties of self compacting concrete and these properties could be assessed by self consolidating cementitious materials. SCC have to be sufficiently fluid to ensure the fluidity of the SCC itself and sufficiently viscous to support the coarse aggregates. Viscosity modifying admixtures are water-soluble polymers that increase the viscosity of mixing water and enhance the ability of cement paste to retain its constituents in suspension.

III. MIX PROPORTION

Class C Fly Ash (MTPS) is used as a mineral admixture @ 10% replacement cement. Super plasticizer (Glenium B233) was used @ 1%, 1.5%, 2%, 2.5% by weight of cement and Viscosity Modifying Agent (Glenium Stream 2) was used @ 1%, 1.5%, 2%, 2.5% by weight of cement.

TABLE-1 MIX PROPORTION FOR VARIOUS GRADES OF SCC

S.No	Trial Mix	Cement	F.A	C.A	Fly Ash	Water	S.P	VMA
1	SCC-1	1	2.45	1.80	20%	0.40	1.0%	1.0%
2	SCC-2	1	2.45	1.80	20%	0.40	1.5%	1.0%
3	SCC-3	1	2.45	1.80	20%	0.40	2.0%	1.0%
4	SCC-4	1	2.45	1.80	20%	0.40	2.5%	1.0%
5	SCC-5	1	2.45	1.80	20%	0.40	1.0%	1.0%
6	SCC-6	1	2.45	1.80	20%	0.40	1.0%	1.5%
7	SCC-7	1	2.45	1.80	20%	0.40	1.0%	2.0%
8	SCC-8	1	2.45	1.80	20%	0.40	1.0%	2.5%

IV. TEST ON FRESH PROPERTIES OF SCC

A. 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.

Fig.1. Slump flow test

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.

B. L-Box test

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 subject to blocking by reinforcement.

Fig.2. L-box test

C. V-Funnel test

The test was developed in Japan and used by Ozawa et al. The equipment consists of a V-shaped funnel, shown in Fig. An alternative type of V-funnel, the O funnel, with a circular section is also used in Japan. The described V-funnel test is used to determine the filling ability of the concrete with a maximum aggregate size of 20mm. The funnel is filled with about 12 liters of concrete and the time taken for it to flow through the apparatus measured. After this the funnel can be refilled concrete and left for 5 minutes to settle. If the concrete shows segregation then the flow time will increase significantly.

Fig.3. V-funnel test

D. U-Box test

U - box test is used to measure the filling ability and segregation properties of the SCC. In this test, the degree of compatibility can be indicated by the height that the concrete reaches the other part of box after flowing through an obstacle. The test measures filling and segregation properties of Self Compacting Concrete.

Fig.4. U-box test

V. Tests on Hardened Concrete

A. Cube Compressive Strength

One of the important properties of concrete is its strength in compression. The strength in compression has definite relationship with all other properties of concrete i.e. these properties are improved with the improvement in compression strength. The aim of this experimental test is to determine the maximum load carrying capacity of test specimens. The compression test specimens were tested on a compression testing machine of capacity 2000 kN. The specimen was placed on machine in such a way that its position is at right angles to its own position which it had at the time of casting. Load is applied gradually as the rate of 14 N/mm^2/min or 320 kN/min.

S.No	Trail Mix	7 Day Compressive Strength (N/mm^2)	28 Day Compressive Strength (N/mm^2)
1	SCC 1	27.51	41.41
2.	SCC 2	28.22	44.33
3.	SCC 3	30.45	46.75
4.	SCC 4	27.87	44.56
5.	SCC 5	27.77	41.69
6.	SCC 6	29.02	44.59
7.	SCC 7	30.59	46.98
8.	SCC 8	28.32	44.69

Fig.5. Test setup for Cube Compressive Strength

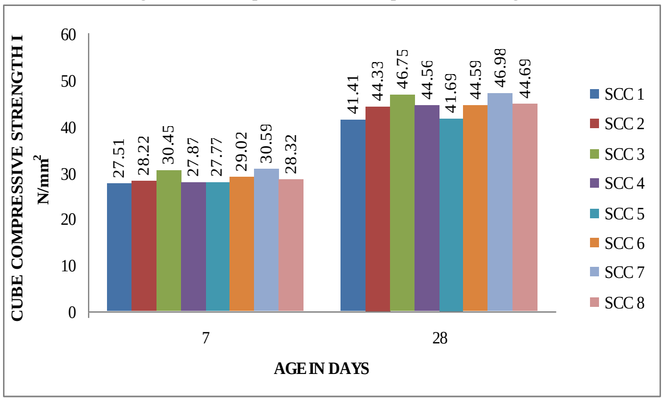

Table-2 Cube Compressive Strength at 7 Days and 28 Days

Fig 6 Comparison of cube compressive strength at 7 days & 28 days

B. *Split Tensile Strength*

The tensile strength is one of the basic and important properties of the concrete. The concrete is not usually expected to resist, the direct tension because of its low tensile and brittle in nature. However the determination of tensile strength of concrete is necessary to determine the load at which the concrete members crack. The cracking is a form a tensile failure. The main of this experimental test is to determine the maximum load carrying capacity of test specimens. Cylinders of size 150 mm in diameter and 300 mm height were cast for split tensile test. Two numbers of specimens were tested 28days.The splitting tests are well known as indirect tests used for determining the tensile strength of concrete. They are sometimes referred as split tensile strength of concrete.

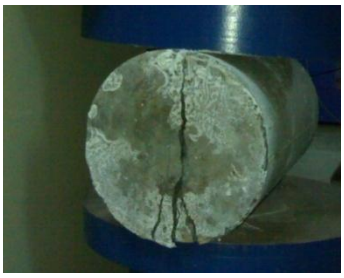

Fig.7. Test setup for Split Tensile Strength

TABLE-3 SPLIT-TENSILE STRENGTH AT 7 DAYS AND 28 DAYS

S.No	Trail Mix	7 Day Split Tensile Strength (N/mm^2)	28 Day Split Tensile Strength (N/mm^2)
1	SCC 1	2.70	3.95
2	SCC 2	2.85	4.25
3	SCC 3	3.0	4.47
4	SCC 4	2.79	4.30
5	SCC 5	2.88	4.08
6	SCC 6	2.93	4.30
7	SCC 7	3.12	4.50
8	SCC 8	2.90	4.40

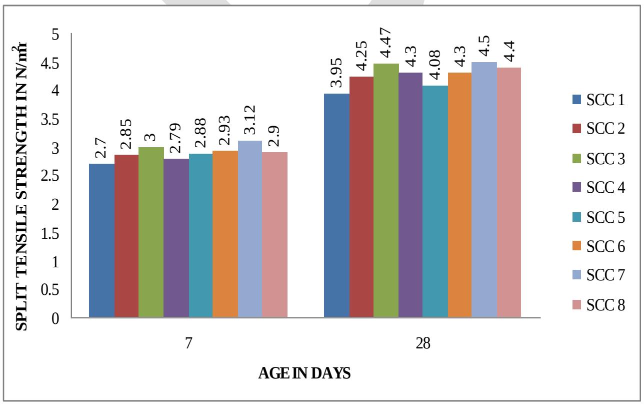

Fig 8 Comparison of Split Tensile Strength at 7 days & 28 days

C. *Cylinder Compressive Strength*

The cylinder are cast and tested in the same position the standard size of cylinder is 15 cm diameter and 30 cm height in actual structures in the field the casting and loading is similar to that of the cylinder and not like the cube therefore the use of cylinder is more popular particularly in the research laboratories.

Fig. 9 Cylinder Compressive test

TABLE. 4. CYLINDER COMPRESSIVE STRENGTH AT 7 DAYS AND 28 DAYS

S.No	Trail Mix	7 Day Compressive Strength (N/mm^2)	28 Day Compressive Strength (N/mm^2)
1	SCC 1	23.68	41.06
2.	SCC 2	25.12	42.53
3.	SCC 3	28.62	44.25
4.	SCC 4	24.35	45.85
5.	SCC 5	24.57	41.36
6.	SCC 6	25.82	43.53
7.	SCC 7	29.55	46.28
8.	SCC 8	24.87	45.87

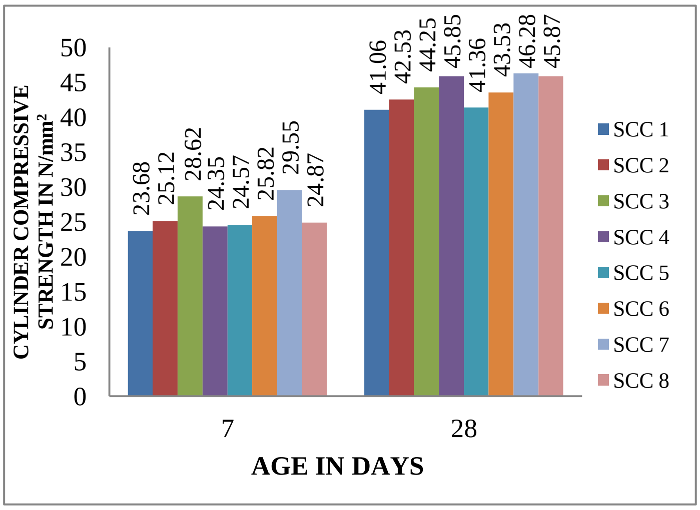

Fig 10 Comparison of Cylinder Compressive Strength at 7 days and 28 days

VI RESULTS AND DISCUSSION

- All the trials of SCC are showing satisfactory results. Table 1, 2 and 3 shows the compressive strength, Split tensile strength and Cylinder compressive strength of SCC at 7 days and 28 days.
- The trail mix 7 shows the higher cube compressive strength, split tensile strength and cylinder compressive strength with 46.98 N/mm^2, 4.50 N/mm^2 and 46.28 N/mm^2 for 28 days respectively.
- The trail mix 7 containing 20% fly ash, 1% super plasticizers and 2% VMA. It gave good results.

VII CONCLUSION

- Basic tests for cement, coarse aggregate and fine aggregate were conducted and results were Listed.
- The mix design for the self compacting concrete is founded out with using L box, V funnel, U tube and slump flow test.
- The acquired mix design is used for casting cylinder and cube with replacement of cement with use of fly ash about 20%.
- Test result for 7 days and 28 days mechanical properties of M40 grade self compacting concrete were shown in graph.
- The compressive and split tensile strength of SCC containing 20% of fly ash, 1% of super plasticizers and 2% of VMA could be useful in most structural applications.

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