FEASIBLE STUDY ON SELF COMPACTING CONCRETE

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Abstract - *Self-compacting concrete is a non-segregating concrete that is placed by means of its own weight. The importance of self-compacting concrete is that maintains all concrete's durability and characteristics, meeting expected performance requirements. In certain instances the addition of superplasticizers and viscosity modifier are added to the mix, reducing bleeding and segregation. Concrete that segregates loses strength and results in honeycombed areas next to the formwork. A well designed SCC mix does not segregate, has high deformability and excellent stability characteristics.*

The objective of present research work is to study the effect of incorporation of silica fume and fly ash in Self-compacting concrete. Self-compacting concrete has several advantages over Normally Vibrated Concrete. The addition of silica fume and fly ash improves behaviour of concrete under different conditions. Thus, SCC and cementitious materials can be combined to achieve more durable concrete. The effect of silica fume and fly ash was studied on fresh, strength and durability properties of SCC. Silica fume and fly ash in varying proportions of 4%, 8%, 12% and 15%, 25%, 35% respectively, by weight of concrete mix were added to SCC with tests carried out to evaluate the results regarding fresh, strength and durability properties.

***Key Words*: Self-Compacting Concrete, Normally Vibrated Concrete, Non-Segregating, Durability, Superplasticizers, Viscosity, Deformability.**

1. INTRODUCTION

Compared to normally vibrated concrete (NVC), self-compacting concrete (SCC) possesses enhanced qualities and improves productivity and working conditions due to the elimination of compaction. SCC generally has higher powder content than NVC and thus it is necessary to replace some of the cement by additions to achieve an economical and durable concrete. Japan has used self-compacting concrete (SCC) in bridge, building and tunnel construction since the early 1990's. In the last five years, a number of SCC bridges have been constructed in Europe. In the United States, the application of SCC in highway bridge construction is very limited at this time. However, the U.S. precast concrete industry is beginning to apply the technology to architectural concrete. SCC has high potential for wider structural applications in highway bridge construction.

1.1 Properties of Self Compacting Concrete

Self-compacting concrete produces resistance to segregation by using mineral fillers or fines and using special admixtures. Self-consolidating concrete is required to flow and fill special forms under its own weight, it shall be flowable enough to pass through highly reinforced areas, and must be able to avoid aggregate segregation. This type of concrete must meet special project requirements in terms of placement and flow.

Self-compacting concrete with a similar water cement or cement binder ratio will usually have a slightly higher strength compared with traditional vibrated concrete, due to the lack of vibration giving an improved interface between the aggregate and hardened paste. The concrete mix of SCC must be placed at a relatively higher velocity than that of regular concrete. Self-compacting concrete has been placed at heights taller than 5 meters without aggregate segregation. It can also be used in areas with normal and congested reinforcement, with aggregates as large as 2 inches.

1.2 Uses of Self Compacting Concrete

Self-compacting concrete has been used in bridges and even on pre-cast sections. One of the most remarkable projects built using self-compacting concrete is the Akashi-Kaikyo Suspension Bridge. In this project, the SCC was mixed on-site and pumped through a piping system to the specified point, located 200 meters away. On this particular project, the construction time was reduced from 2.5 years to 2 years. This type of concrete is ideal to be used in the following applications:

- Drilled shafts
- Columns
- Earth retaining systems
- Areas with high concentration of rebar and pipes/conduits

1.3 SELF COMPACTING CONCRETE BENEFITS

Using self-compacting concrete produce several benefits and advantages over regular concrete. Some of those benefits are:

- Improved constructability.
- Labor reduction.
- Bond to reinforcing steel.
- Improved structural Integrity.
- Accelerates project schedules.
- Reduces skilled labor.
- Flows into complex forms.
- Reduces equipment wear.
- Minimizes voids on highly reinforced areas.
- Produces superior surface finishes.
- Superior strength and durability.
- Allows for easier pumping procedure.
- Fast placement without vibration or mechanical consolidation.
- Lowering noise levels produced by mechanical vibrators.
- Produces a uniform surface.
- Allows for innovative architectural features.
- It is recommended for deep sections or long-span applications.
- Produces a wider variety of placement techniques.

1.4 FACTORS AFFECTING SELF COMPACTING CONCRETE

Using self-compacting concrete must not be used indiscriminately. These factors can affect the behavior and performance of self-compacting concrete:

- Hot weather
- Long haul distances can reduce flowability of self-compacting concrete.
- Delays on job site could affect the concrete mix design performance.
- Job site water addition to Self-Compacting Concrete may not always yield the expected increase in flowability and could cause stability problems.

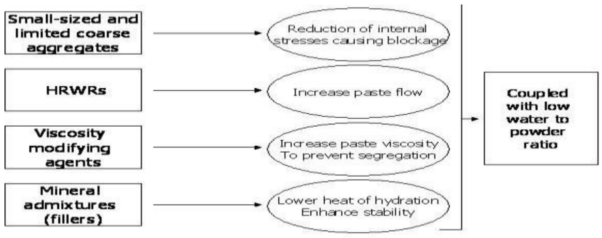

Fig -1: Principles of SCC Mixture Design

2. METHODOLOGY

The methodology adopted in this project is given below:

1. Determination of Compressive Strength of the concrete with and without Fly Ash and Silica Fume.
2. Determination of Split Tensile Strength of the concrete with and without Fly Ash and Silica Fume.
3. Determination of Flexural Strength of the concrete with and without Fly Ash and Silica Fume.
4. Determination of the properties of fresh concrete like slump test, V – Funnel etc.
5. Determination of the durability properties of concrete with and without Fly Ash and Silica Fume.

2.1 MATERIALS USED IN TESTING

1. Cement
2. Fine Aggregates
3. Coarse Aggregates
4. Water
5. Fly Ash
6. Silica Fume
7. Admixtures

Note:- Superplasticizer **STRUCTURO 100(M)** (Fosroc chemicals) was used as admixture. Structuro 100(M) combines the properties of water reduction and workability retention. Specifications of superplasticizer are shown in Table 1.

Table 1:- Specifications of Superplasticizer

Particulars	Properties
Appearance	Light yellow
Basis	Aqueous solution of Carboxylic ether polymer
pH	6.4
Density	1.04 kg/liter
Chloride content	Nil (IS:456)
Alkali content	Less than 1.6g Na_2O equivalent per liter of admixture
Optimum dosage	0.5 to 3.0 liters per 100kg of cementitious material

2.2 MIXTURE PROPORTIONING

The proportioning of mixture used in the study is as follows:-

SCC1 = Self-compacting Concrete with 15 % FA as cement replacement.

SCC2 = Self-compacting Concrete with 25 % FA as cement replacement.

SCC3 = Self-compacting Concrete with 35 % FA as cement replacement.

SCC A = Self-compacting Concrete with 4% SF as cement replacement.

SCC B = Self-compacting Concrete with 8% SF as cement replacement.

SCC C = Self-compacting Concrete with 12% SF as cement replacement.

Where,

CM = Control Mix, w/p= Water/ Powder (cement+ SCM)

FA = Fly ash,

SF = Silica fume,

CA = Coarse aggregates,

SP = Super plasticizer.

2.3 MIXING AND CASTING OF SPECIMEN

The mixing and casting of specimen for determination of various properties is done as follows:-

Mixing

The mixing of concrete was done to have a homogeneous mixture of all ingredients in concrete. The hand mixing was done for the ingredients. Batching of concrete was done by weight and the mixing process was as given below:

1. Firstly, coarse aggregate was weighed and put in mixing pan.
2. Fine aggregate was added to the coarse aggregate.
3. Fly ash, Silica Fume and cement were added to the aggregates. The mixture was thoroughly dry mixed so that the colour of the mixture was uniform and no concentration of any material was visible.
4. Fly ash and Silica Fume were added as per proportion or quantity recommended for the study.
5. The required quantity of superplasticizer was added to required quantity of water. To make solution, water was added and mixed thoroughly until uniform colored mixture was obtained.
6. The addition of Fly ash and Silica Fume to the mix required more time of mixing. After the mix starts flowing, the fresh properties were found. The mixing process was continued till the completion of all the tests.

Casting of specimens

The moulds of cubes, cylinders and beams were cleaned thoroughly. A thin layer of oil was applied to inner surface of the moulds to avoid the adhesion of concrete with the inner side of the moulds. Cubes of size 150mm x 150mm x 150mm were cast for compressive strength test and durability tests. Cylinders of size 300mm x 150mm were used for split tensile strength test. Beams of size 100mm x 100mm x 500mm were cast for flexural strength test. Tests were performed for compressive and split tensile at ages of 3, 7, 28, 56 days. But flexural strength was tested at 7 and 28 days and durability tests were carried out at 28 and 56 days.

3. RESULTS AND DISCUSSION

Self-compacting concrete in its fresh state is tested for fresh properties, tensile strength, flexural strength, durability etc.

Various different types of tests are done to study the feasibility of self compacting concrete. The test results are shown in the subsequent paragraphs.

3.1 FRESH PROPERTIES

The ability of SCC to remain homogeneous in composition during transport and placing. In the present study, Slump flow, T_{500} slump flow, V-funnel, L-box, U-box and V-funnel at T_{5min} tests were conducted to determine the filling ability, passing ability and segregation resistance of SCC reinforced with steel fibres and rice husk in different proportions.

Table 2:- Fresh Concrete Properties (Fly Ash)

Mixture ID	Slump (mm)	V-funnel (seconds)	L-Box (H2/H1)	U-box (H1-H2)
SCC1(15% FA)	687	9	0.9	30
SCC1(15% FA)	590	13	-	-
SCC2(25% FA)	704	11	-	35
SCC2(25% FA)	740	12	0.9	35
SCC2(25% FA)	720	9	1.0	-
SCC3(35% FA)	630	-	-	40
SCC3(35% FA)	680	13	-	-
SCC3(35% FA)	640	11	0.8	30

Table 3:- Fresh Concrete Properties (Silica Fume)

Mixture ID	Slump (mm)	V-funnel	L-Box	U-box(H1-
SCC A (4% SF)	600	11	0.9	34
SCC B (8% SF)	640	13	0.9	40
SCC C (12% SF)	670	9	0.9	35

3.2 STRENGTH PROPERTIES

The results of strength properties for SCC mixes containing different percentages of fibers are discussed below.

Compressive Strength

Table 4:- Compressive strength of Fly Ash mixes

Mix	7 Days	28 Days	56 Days
CM (MPa)	20.6	28.9	33

SCC1 (MPa)	18.5	27.2	38.5
SCC2 (MPa)	17.9	24.6	33
SCC3 (MPa)	15.2	23.5	29.5

Table 5:- Compressive strength of Silica Fume mixes

Mix	7 Days	28 Days	56 Days
CM (MPa)	22.5	30.6	35.4
SCCA (MPa)	25.0	32.8	40.5
SCCB (MPa)	21.4	28.2	35.8
SCCC (MPa)	20.5	26.6	32.2

Split Tensile Strength

Table 6:- Split Tensile Strength of Fly Ash Mixes

Mix	7 Days	28 Days	56 Days
CM (MPa)	0.87	1.03	1.18
SCC1(MPa)	1.01	1.25	1.50
SCC2(MPa)	1.07	1.27	1.56
SCC3(MPa)	1.16	1.34	1.62

Table 6:- Split Tensile Strength of Silica Fume Mixes

Mix	7 Days	28 Days	56 Days
CM (MPa)	1.16	1.32	1.48
SCC A(MPa)	1.41	1.56	1.90
SCC B(MPa)	1.43	1.60	1.95
SCC C(MPa)	1.47	1.65	2.01

3.3 DURABILITY

The results obtained for percentage of weight loss with ages with fly ash and silica fume are shown below:-

Table 7:- Percentage of weight loss with ages(Fly Ash)

	Percentage loss in weight			
MIX	3 days	7 days	14 days	21 days
SCC1 (15% FA)	-2.187	-2.335	-4.610	-6.804

SCC2 (25% FA)	-1.442	-1.620	-3.364	-5.467
SCC3 (35% FA)	-0.600	-0.437	-1.885	-3.913
CM	-2.700	-3.130	-5.200	-7.410

Table 7:- Percentage of weight loss with ages(Silica Fume)

	Percentage loss in weight			
MIX	**3 days**	**7 days**	**14 days**	**21 days**
SCC A (4% SF)	-0.88	-1.22	-1.86	-3.48
SCC B (8% SF)	-0.68	-0.86	-1.62	-2.87
SCC C (12% SF)	-0.50	-0.58	-1.50	-2.67
CM	-2.70	-3.13	-5.20	-7.41

4. CONCLUSION

The concept of Self Compacting Concrete has established itself as innovative material in the area of concrete technology. The general procedure of mix design can be adopted for self compacting concrete for various applications based on experiences in identification of suitable mix proportion. The increase in fine material increases the suitability of self compacting concrete. There is a remarkable difference in the various properties on various mix proportions with fly ash and silica fume.

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