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A COMPREHENSIVE STUDY ON SELF COMPACTING CONCRETE AND ITS IMPACT ON ENVIRONMNET – A MODEL STUDY

Engineering

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ABSTRACT

A mixture of cement, sand, coarse aggregates and water which dries hard and strong and is used as a material for building is termed as concrete. Heavy vibration of concrete has to be done for flowing into very intricate form or forms that have a lot of reinforcing bars. Hence to overcome the difficulties of normal cement concrete that can tend to cause honeycombs in spite of careful compaction process through vibration of fresh concrete in designed moulds, the SCC has made steady inroads into critical constructions. Self-compacting concrete is a flowing concrete mixture which can consolidate under its own weight without any external compaction. Without being heavily vibrated the self-compacting concrete flows easily at suitable speed into formwork without blocking through the reinforcement. A study comprising of Self- compacting concrete where the cement is partially replaced with fly-ash is presented in this study.

KEYWORDS

SCC, Sand, Reinforcing bars, Compaction, Reinforcement, Fly-ash

2. INTRODUCTION

The development of new technology in the material science is progressing rapidly. A lot of research was carried out throughout globe in last three decades to improve the performance of concrete in terms of strength and durability. Therefore to meet the specific needs of construction industry 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. The growing use of concrete became very important to produce concrete that ensures proper filling ability, good structural performance and adequate durability for special architectural configurations and closely spaced reinforcing bars. 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 study has resulted in the much needed revolution in concrete industry in the development of self compacting concrete (SCC). Self compacting concrete, which has excellent deformability and resistance to segregation and can be filled in heavily reinforced formwork without vibrators, was developed in few decades ago. Development of self-compacting concrete was the social problem on durability of concrete structures that arose around 1983, to overcome this problem is the present motive

3. METHODOLOGY

The present investigations are aimed to design the M30 grade SCC mix by using ordinary Portland cement of 53 grade, fly ash from Vijayawada Thermal Power Station (VTPS), with locally available 20mm, 16mm, 12.5mm and 10mm size of well graded coarse aggregates, fine aggregate and commercially available self-compatibility of fresh concrete mixes was evaluated by slump-flow, V-funnel and L-box tests.

3.1 PROCEDURE FOR MIX DESIGN

3.1.1. Calculation of coarse and fine aggregate:

The content of coarse aggregates and fine aggregates can be calculated as :
(Eqs. (1) and (2)):
$Wg = PF \times WgL\,(1 - s/a)$--------- (1)
$Ws = PF \times WsL \times s/a$ --------- (2)

Where
Wg: Content of coarse aggregates in SCC (kg/m3);
Ws: Content of fine aggregates in SCC (kg/m3);
WgL: Unit volume mass of the loosely piled saturated surface- dry coarse aggregates in the air (kg/m3);
WsL: Unit volume mass of the loosely piled saturated surface-dry fine aggregates in the air (kg/m3);
PF: Packing factor, the ratio of mass of aggregates of tightly packed state in SCC to that of loosely packed state in air;
s/a: Volume ratio of fine aggregate to total aggregates, which ranges from 50% to 57%.

3.1.2. Calculation of cement content

The cement content which is to be used is (Eq. (3)):
$C = f'c/20$ ------------ (3)
Where C: cement content (kg/m3);
$f'c$: designed compressive strength (psi).

3.1.3. Calculation of mixing water content required by the cement :

The Content of mixing water required by cement can then be obtained using (Eq. 4):
$Wwc = (w/c) \times C$ --------- (4)

Where
Wwc: content of mixing water content required by the cement (kg/m3);
w/c: the water/cement ratio by weight, can be determined by compressive strength.

3.1.4. Calculation of the fly ash (FA) and ground granulated blast-furnace slag (GGBS) contents:

To obtain the required properties such as segregation resistance and to increase the content of binders, FA and GGBS are used. When the flow values of the FA and GGBS pastes are equal to that of the cement paste and let W/F and W/S be the ratios of water/FA and water/GGBS by weight.

Then the volume of FA paste (VPf) and the GGBS paste (VPB) can be calculated as follows:
$VPf + VPB = 1 - (Wg/1000 \times Gg) - (Ws/1000 \times Gs) - (C/1000 \times Gc) - (Wwc/1000 \times Gw) - Va$ ----------------- (5)

Where
Gg : specific gravity of coarse aggregates;
Gs: specific gravity of fine aggregates;
Gc : specific gravity of cement;
Gw : specific gravity of water;
Va : air content in SCC (%).

If the total amount of Pozzolonic materials (GGBS and FA) in SCC is Wpm (kg/m3), where the percentage of FA is A% and the percentage of GGBS is B% by weight, the adequate ratio of these two materials can be set according to the properties of local materials and previous engineering experience.

$Vpf + Vpb = (1 + W/F) \times A\,\% \times Wpm/(1000 \times Gf) + (1 + W/S) \times B\,\% \times Wpm/(1000 \times Gb)$ -------------- (6)

Where
Gf : Specific gravity of fly ash,

Gb : Specific gravity of GGBS,
Gf, Gb, Gc, W/F and W/S can be obtained from tests, A% and B% are given, and VPf + VPB can be obtained from Eq. (5). Hence, Wpm can be calculated using Eq. (6).

Also, Wf (FA content in SCC, Kg/m3) and WB (GGBS content in SCC, Kg/m3) can be calculated (Eqs. (7) And (8)),

Wf = A% x Wpm ---------------- (7)
WB = B% x Wpm ---------------- (8)

Water content mixing required by FA paste is (Eq. (9)):
Wwf = (W/F) x Wf -------------------- (9)

Water content mixing required by for GGBS paste is (Eq. (10)):
WwB = (W/S) x WB ------------------- (10)

3.1.5: Calculation of mixing the water content needed in SCC:

Ww = Wwc + Wwf + WwB

3.1.6. Calculation of SP dosage

If dosage of SP used is equal to n% of the amount of binders and its solid content of SP is m%, then the dosage can be obtained as follows (Eq. (12) and (13)):

Dosage of SP used WSP = n% x (C + Wf + WB) ----------- (12)
Water content in SP WwSP = (1-m %) x WSP ------------ (13)

3.1.7. Adjustment of the mixing water content needed in SCC:

According to the moisture content of the aggregates at the ready-mixed concrete plant or at the construction site, the actual amount of water used for mixing should be adjusted.

3.1.8. Trial mixes and the tests on SCC properties:

The quality control tests for SCC should be performed to ensure that the following requirements are met.

Results of slump flow, U-Box, L-flow and V-funnel tests should comply with the specifications of the JAS.

The segregation phenomenon of the materials must be satisfactory.

Water–binder's ratio should satisfy the requirements of durability and strength.

Air content should meet the requirements of mix design.

3.1.9. Adjustment of mix proportion

Adjustments should be made until all properties of SCC satisfy the requirements specified in the design if the results of the quality control tests mentioned above fail to meet the performance required for the fresh concrete. For example, the PF value is reduced to increase the binder volume and to improve the workability, when the fresh SCC shows poor flow ability.

3.2 TESTS ON SCC

Slump flow & T50 test789-*
L-box test
V-funnel test & V-funnel at T5minuts

Table 1: List of test methods for workability properties of SCC

S. No	Method	Property
1	Slump Flow Test	Filling Ability
2	T50cm Slump Flow	Filling Ability
3	V-Funnel Test	Filling Ability
4	V-Funnel at T5minuts	Segregation Resistance
5	L-Box Test	Passing Ability

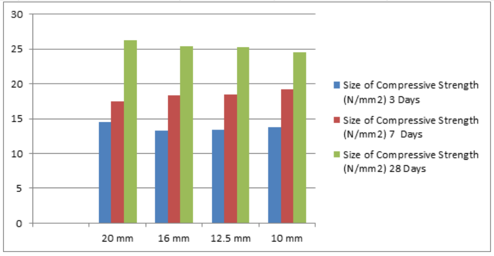
4 RESULTS AND DISCUSSIONS

TABLE 2: List of workability Values

S.No	Size of Aggregate	Slump value	T50	V-Funnel	V-Funnel at T5 Minutes	L-Box H2/H1
1.	20 mm	650 mm	3 Sec	4 Sec	5 Sec	0.79
2.	16 mm	640 mm	4 Sec	4 Sec	5 Sec	0.805
3.	12.5 mm	660 mm	3 Sec	4 Sec	4 Sec	0.82
4.	10 mm	660 mm	4 Sec	3 Sec	4 Sec	0.81

TABLE 3: Test Results of Cubes

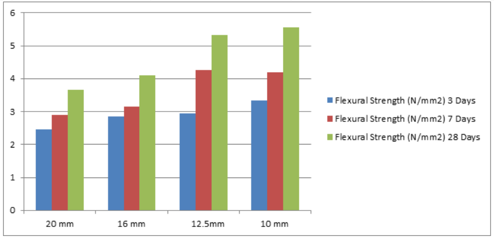
S.No	Size of Aggregate	Compressive Strength (N/mm2)		
		3 Days	7 Days	28 \Days
1.	20 mm	14.46	17.47	26.27
2.	16 mm	13.22	18.36	25.42
3.	12.5 mm	13.45	18.46	25.31
4.	10 mm	13.75	19.25	24.52



Graph: 1 Test Results of Cubes

TABLE 4: Test Results of beams

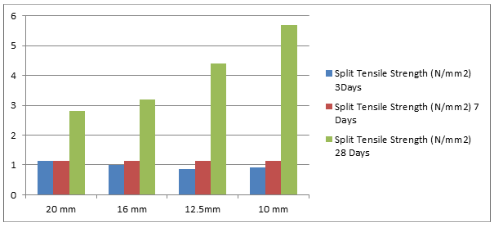
S.No	Size of Aggregate	Flexural Strength (N/mm2)		
		3 Days	7 Days	28 Days
1.	20 mm	2.46	2.90	3.65
2.	16 mm	2.84	3.16	4.09
3.	12.5mm	2.95	4.25	5.32
4.	10 mm	3.33	4.20	5.56



Graph: 2 Test Results of beams

TABLE 5: Test Results of Cylinders

S No	Size of Aggregate	Split Tensile Strength (N/mm2)		
		3Days	7 Days	28 Days
1.	20 mm	1.13	1.125	2.8
2.	16 mm	0.99	1.125	3.2
3.	12.5mm	0.85	1.132	4.4
4.	10 mm	0.92	1.132	5.7



Graph: 3 Test Results of cylinders

5. CONCLUSIONS

Replacing cement with high volumes of fly ash in self-compacting concrete production can achieve many economical and environmental advantages. The fresh concrete tests like L box, V funnel, U box and slump flow tests were conducted and results tabulated. For the prepared cube, cylinder and beam, the mechanical properties are found, such as compressive strength, spilt tensile strength and flexural strength on both conventional concrete and self compacting concrete at 3 days, 7days and 28days.The test result are compared by using chart for 3 days , 7days and 28 days. And also chart is used to compare the conventional concrete and Self compacting concrete, the test results showed that the compressive strength, the split tensile and the flexural strength were good for self compacting concrete when compared to conventional concrete. With increasing fly ash content there is a significant decrease in the emissions of CO2, NOx and SOx, consumption of raw materials and consumption of heat energy.

However, Self Compacting Concrete (SCC) by itself is an environmentally friendly material because it represents a sustainable construction material using significant quantities of secondary cementatious materials which help to reduce the CO2 footprint. Therefore the results obtained are universal, but it presents an approach for the direction which is possible for reducing the environmental impact through the structural and material optimization in the construction sector, which may also lead to sustainable development in the field of civil engineering.

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