

TO STUDY THE FLEXURAL BEHAVIOUR OF NON-PRISMATIC BEAMS USING SELF COMPACTING CONCRETE

Imran Sharik M.¹, Joshua Daniel A.²

^{1,2}SRM University, Kattankulathur, Kancheepuram, India. imransharik@gmail.com

²Kancheepuram.joshuadaniel.a@ktr.srmuniv.ac.in

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ABSTRACT

Self-compacting concrete (SCC) is a type of concrete that consolidates under its own weight without external compaction. The extremely fluid nature of SCC makes it appropriate to use in difficult conditions and in sections with congested reinforcement. Non prismatic beams have non uniform cross section and so congestion arises due to closely spaced stirrups and bars. Compaction by vibrator is difficult, to overcome this beam are studied with self-compacting concrete. The present paper focuses on investigating the characteristics of M50 grade of self-compacting concrete where cement is replaced with ground granulated blast furnace slag (GGBS) and Micro Silica (MS) with six different proportions. Fresh concrete properties of the concrete were studied. Cubes and prisms were casted and tested to obtain the optimum proportion. This is further used in fabrication of non-prismatic beams. Flexural behavior of these beams are tested and compared with that of the conventional beam

Keywords-GGBS, Microsilica, CERA hyperplast XRW40, Non-prismatic beams, Self-compacting concrete (SCC), Crack pattern, Flexure test, Two point loading, Mix 1(M1), Mix 2(M2), Mix 3(M3), Mix 4(M4), Mix 5 (Mix 5), Mix 6(M6).

I. INTRODUCTION

Concrete is the most utilized development material in the world with in regard to six billion tones being made per annum. It's exclusively by water as far according to per capita utilization. Materials known as pozzalons such as Flyash, Silica Fume, Meta-kaolin, Ground Granulated Blast Furnace Slag (GGBS) and Micro Silica (MS) when combined with calcium hydroxide exhibits cementitious properties. There are various methods to improve the durability of concrete and also to achieve high performance concrete by using pozzolons [Pai. et al., 2014] or admixtures. Plasticizer is a substance added to promote plasticity and flexibility and to reduce segregation in concrete. These admixtures are used to reduce the water requirement of concrete and also to improve its workability. Self-compacting concrete (SCC) is a concrete which has fluidic nature, high deformability and modern viscosity important to guarantee uniform suspension of solid particles during transportation, placing concrete without external compaction methods [Nan, et al., 2001]. It is also a flowing concrete mixture that is able to consolidate under its own self weight by using pozzalons and admixtures. The pozzalons and admixtures helps the SCC to attain its workability properties like flow ability, passing ability etc. Non-prismatic beams are of non-uniform cross section. They are used bridges, haunched beams etc [Rita and Vyawahare, 2015]. Since these beams have non-uniform cross section the reinforcement in these beams arises congestion. And hence these beams are analyzed with Self compacting concrete.

II. MATERIAL USED IN THE PROJECT

A. CEMENT: Ordinary Portland cement 53 grade brand conforming to Indian Standard is used in the present investigation.

B. FINE AGGREGATE: The fine aggregate utilized in this experimentation conforms IS: 383-1970 specifications and was found to be Zone II.

C. COARSE AGGREGATE: The coarse aggregate utilized in this experimentation were about 10 mm size and tested as per IS: 383-1970 specifications.

D. ADMIXTURES

1. GROUND GRANULATED BLAST FURNACE SLAG (GGBS): Ground Granulated Blast Furnace is a by-product discharged in large quantities by the iron and steel industry. The most ingredient of slag is lime (CaO) and silica (SiO₂).

2. MICRO SILICA (MS): Micro silica is a mineral admixture collected as by-product of the mechanic fabricate [Yalcinkaya, 2010] of ferrosilicon and metallic silicon in high temperature electric circular segment heaters. The main field of application is that it gives better performance to concrete when blended with cement.

3. SUPER PLASTICIZER: The plasticizer used in this project is CERA HYPERPLAST XRW40. It is a High range water reducing agent and this admixture has specific gravity 1.09-1.11. It is a Modified polycarboxylate based brown colour liquid.

III. EXPERIMENTAL STUDY

E. PRELIMINARY TESTS

TABLE I: PRELIMINARY TEST RESULTS

Material Properties	Test results
Cement	
Specific Gravity	3.12
Coarse aggregate	
Specific Gravity	2.80
Fine aggregate	
Specific Gravity	2.65
Sieve Analysis	Zone II
Ground Granulated Blast Furnace Slag	
Specific Gravity	2.82
Micro Silica	
Specific Gravity	2.2

F.MIX DESIGN

The mix design of Self compacting concrete is carried out by using Nan et al., [2001] method. The design procedure followed is

Design strength = 50Mpa (M50)

Specific gravity of coarse aggregate = 2.80

Bulk density of coarse aggregate = 1500kg/m³

Specific gravity of fine aggregate = 2.65

Bulk density of fine aggregate = 1404kg/m³

Specific gravity of cement = 3.12

Volume ratio of fine aggregate = 58%

Volume ratio of coarse aggregate = 42%

Packing factor = 1.12

Amount of fine aggregate = 912kg

Amount of coarse aggregate = 705.6kg

Determination of cement content

Assume each kg of cement provide 10Mpa strength of 20Psi, 28days

$$C = f^c/20$$

$$f^c = 58.5 \times 145.038 = 8484.7$$

$$C = 8484.7/20 = 425\text{kg/m}^3$$

W/C ratio for M50 = 0.43

Amount of mixing water content needed for cement = 0.43 x 425

Amount of mixing water content needed for cement = 182.75 liters (kg/m³)

Determination of S.P dosage

(1.5% of cement)

$$\text{S.P dosage} = (1.5/100) \times 425$$

$$\text{S.P dosage} = 6.375\text{kg/m}^3$$

Mix proportion

C : F.A : C.A : W/C

1 : 2.14 : 1.66 : 0.43

G.MIX DETAILS**TABLE II: MIX PROPORTION DETAILS**

Designation Id	GGBS content(%)	MS content(%)
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M1	10	3
M2	10	6
M3	10	9
M4	20	3
M5	20	6
M6	20	9

H. WORKABILITY TESTS**TABLE III:WORKABILITY TEST VALUES FOR SCC**

Mix	M1	M2	M3	M4	M5	M6
Slump flow (mm)	684	680	670	672	665	660
Slump T50 (secs)	4	4	5	6	5	6
V funnel (secs)	8	9	9	9	10	11
V funnel T50 (secs)	11	11	12	15	13	15

I.COMPRESSIVE STRENGTH AND FLEXURAL STRENGTH:

Cubes & prisms are casted for six different proportions to obtain their compression and flexure strength.

Cubes of 150x150x150mm are casted for six different proportions and cured for 28 days and then tested to get the optimum percentage.

TABLE IV: COMPRESSIVE STRENGTH OF M50 GRADE SCC

Mix	7 th day strength (N/mm ²)	14 th day strength (N/mm ²)	28 th day strength (N/mm ²)
M1	16.04	29.15	42.26
M2	24.79	36.79	52.43
M3	17.55	18.44	25.56
M4	24.71	35.12	52.12
M5	11.55	14.35	22.16
M6	22.75	30.79	40.45



Fig. 1. Compressive failure for Six proportions Prisms of 500x100x100mm are casted for six different proportions and cured for 28 days, then tested to obtain optimum percentage for SCC



Fig. 2. Flexural failure of M2 proportion

TABLE V: FLEXURAL STRENGTH OF M50 GRADE SCC

Mix	7 th day strength (N/mm ²)	14 th day strength (N/mm ²)
M1	3	4
M2	5.5	7
M3	4.5	6.5
M4	4	6
M5	4	5
M6	3.5	4.5

J. NON PRISMATIC BEAMS

1. BEAM CROSS SECTION

Non prismatic beams are been casted for three different shapes with SCC. And one conventional beam is casted. All dimensions are in millimeters below

Type 1

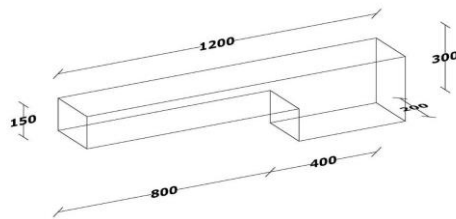


Fig. 3(a). Type 1 cross section

Type 2

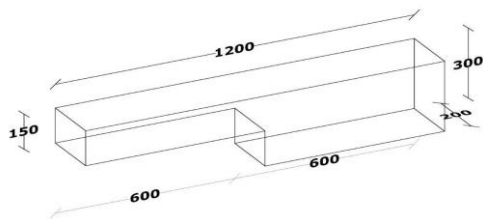


Fig. 3(b). Type 2 cross section

Type 3

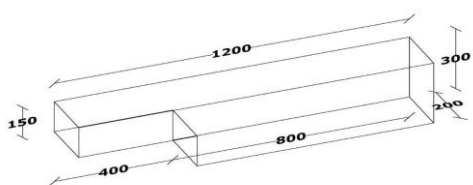


Fig. 3(c): Type 3 cross section

Conventional beam

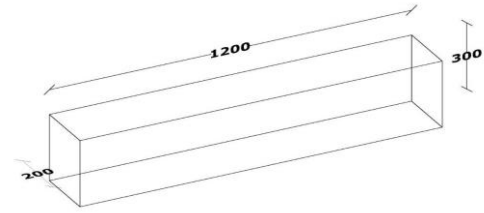


Fig. 3(d). Conventional beam cross section

K. BEAM REINFORCEMENT: Since the cross section is non-uniform, designing of reinforcement is complex. The structure has critical points. So, reinforcement is designed with development length and also considering shear resistance.

Type 1

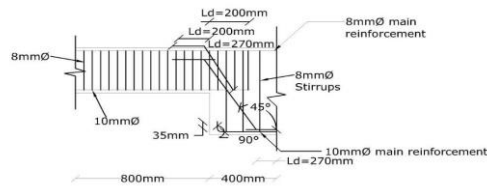


Fig. 4(a). Reinforcement detailing for Type 1

Type 2

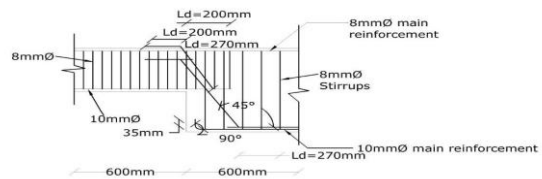


Fig.4(b). Reinforcement detailing for Type 2

Type 3

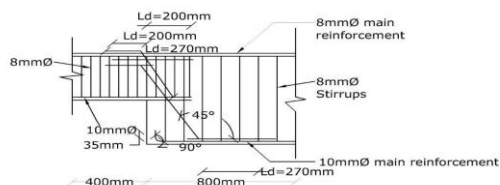


Fig. 4(c). Reinforcement detailing for Type 3

Conventional beam

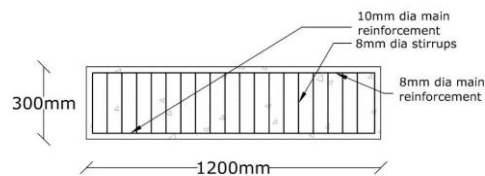
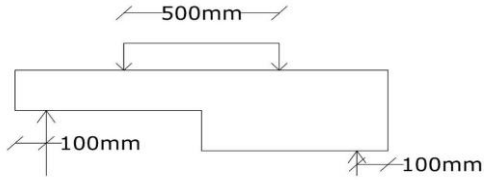


Fig. 4(d): Reinforcement detailing for Conventional beam

L. FLEXURE TEST FOR NON-PRISMATIC BEAMS & CONVENTIONAL BEAM:

These beams are tested for flexural strength with two point loading pattern. The loading pattern for two points is 500mm distance between them for all beams. 1st point lies in

larger cross-sectional area and 2nd point lies in smaller cross-sectional area for non-prismatic beams. The beams are simply supported at two ends 100mm from corner of two ends. Three deflecto-meters have been set at 1st point, 2nd point and mid-point to determine deflection values.



The Loading pattern is same for all the remaining beams.

Type 1



Fig. 5(a). Type 1 SCC beam



Fig.5(b). Loading pattern for Type 1 SCC beam

Type 2



Fig. 5(c). Type 2 SCC beam



Fig. 5(d). Loading pattern for Type 2 SCC beam

Type 3



Fig. 5(e). Type 3 SCC beam

Conventional beam



Fig. 5(f). Conventional beam

M.CRACK PATTERN

The crack pattern is observed only in lesser cross-sectional area whereas the larger cross-sectional area is free from cracks. Shear failure is a brittle type of failure in experimental. But in this experimental testing, flexural crack is observed. Thereby catastrophic failure of beam is completely eliminated. The crank rod provided in Type 1, Type 2, Type 3 prevents the formation of shear crack.

Type 1

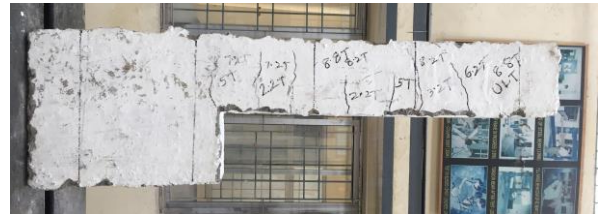


Fig. 6(a).crack pattern for Type 1 SCC

Type 2



Fig. 6(b). Crack pattern for Type 2 SCC

Type 3



Fig.6(c). Crack pattern for Type 3 SCC

Conventional Beam



Fig. 6(d). Crack pattern for Conventional Beam

N. LOAD VS DEFLECTION GRAPHS

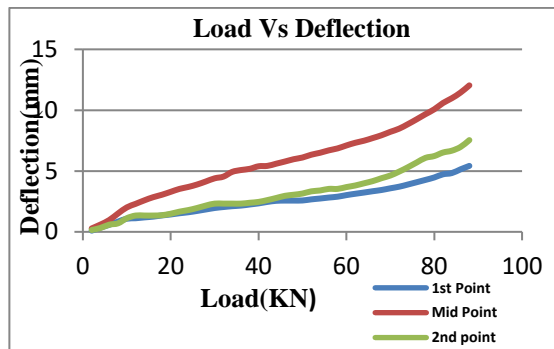


Fig. 7(a). Load Vs Deflection curve for Type 1 SCC

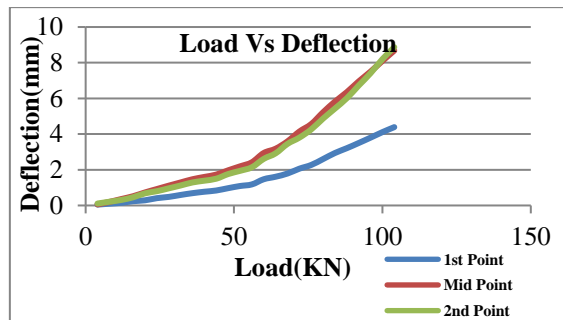


Fig. 7(b). Load Vs Deflection curve for Type 2 SCC

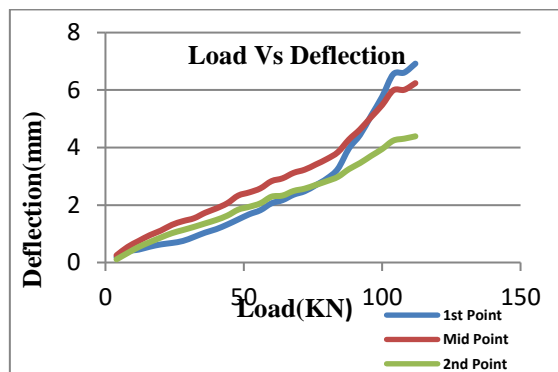


Fig. 7(c). Load Vs Deflection curve for Type 3 SCC

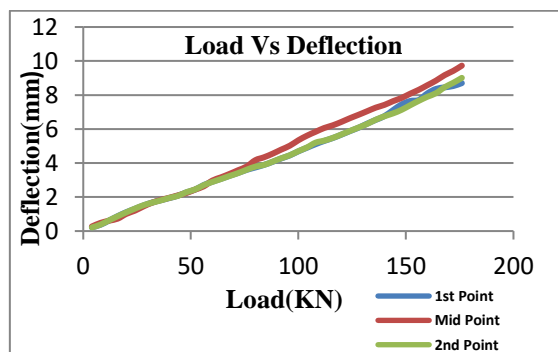


Fig. 7(d). Load Vs Deflection curve for Conventional beam

IV.RESULTS & DISCUSSION

- It shows that replacement of cement with 10% GGBS and 6% MICRO SILICA helps in attaining M50 grade strength of concrete
- More the proportion of GGBS and MS increased lesser the strength obtained but these materials shows better performance in workability tests
- The optimum percentage of GGBS&MS is 10% & 6%.
- By replacing cement with GGBS and MS increases durability.
- The load carrying capacity of conventional beam is higher than the non-prismatic beams
- In non-prismatic beam, the load carrying capacity of Type 3 is higher than the corresponding beam.
- The crankrod provided in the region of varying cross section prevents the formation of Shear crack.

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