Load-Deflection Characteristics Of SCC Beams Casted With Quarry Rock Dust Using Different Percentage Of Tensile Reinforcement And Superplasticizers

S. Kavipriya, C.Kannan, S. Ramkumar

Abstract: Self Compacting Concrete is different from Conventional Concrete; it requires no internal or external vibration for its consolidation but readily deforms and flows without blockages through congested reinforcement and complicated structural forms, fills the entire volume of the mould and gets compacted under its own self-weight. In SCC, characteristics such as high fluidity, adequate viscosity and high resistance to segregation should exist. Fluidity of the paste can be increased by increasing the water-powder ratio and by addition of superplasticizers. Segregation and blockages can be avoided by reducing the size and content of coarse aggregate. At this present situation where availability, source of river sand is really challenge.QRD is used as one of the desirable useful product in this SCC concrete mix which also aim to reduce the cost of construction.SCC can be used for several applications such as high-rise buildings, precast industry, cooling towers, and marine structures, highly congested and complicated sections or even for general constructions. To utilize them in any structural application, the structural behavior of SCC also needs to be evaluated since in the fresh stage, SCC is quite different from CVC. This aspect is considered in this study. Reinforced Concrete (RC) beam of size 150mmx250mmx2500mm were casted using SCC and CVC and tested for static flexure using two point loading system and the flexural behavior of these beams are examined by casting SCC beams with three different bases of superplasticizers such as polycarboxyl, naphthalene and melamine bases. And each set of these different bases of specimens are also moulded with various tensile reinforcement such as 1.04%,1.23% and 1.37%.

Index Terms: CVC-Conventional Concrete, HRWRA-High Range Water Reducing Agent, NMS-Nominal Maximum Size, OPC-Ordinary Portland Cement, QRD-Quarry Rock Dust, RC-Reinforced Concrete, SCC-Self Compacting Concrete, VMA-Viscosity Modifying Agent.

1. INTRODUCTION

SCC is one of the concrete that is able to flow under its own weight and completely fill the formwork, even in the presence of dense reinforcement without the need of any vibration. [1]The use of pozzolanic material is one of the art of concrete construction. The pozzolanic materials used in olden days are nowadays designated as mineral admixture. These admixtures when used in appropriate amount, modify certain properties of fresh and hardened mortar and concrete. The pozzolanic materials can be divided into two groups namely natural and artificial pozzolana. In this study artificial pozzolana, fly ash is used. The use of chemical admixtures have become a universal practice to reduce w/c ratio for the given workability, which increases the strength. Moreover, the reduction in w/c ratio improves the durability of concrete. Sometimes chemical admixtures are employed to reduce the cement content and heat of hydration in mass concrete.[2] In this study three different admixtures have been used for evaluating hardened properties. The use of Viscosity Modifying Admixture (VMA) gives more possibilities of controlling segregation when the amount of powder content is limited.[3] This admixture helps to provide very good homogeneity and reduces the tendency to segregation. Different types of superplasticizers and VMA are shown in Table 1.

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TABLE 1

Different bases of Superplasticizers and VMA

SI.No	Type of base	Superplasticizer	VMA
1	Polycarboxyl	Glenium Superplasticizer	Glenium VMA
2	Melamine	R550 MC	Stabilizer 4R
3	Napthalene	Conplast SP337	Diutan gum

CHARACTERISTICS OF SCC

The workability of SCC can be characterized by the standards of EFNARC code with the basic characteristics such as filling ability, passing ability and segregation resistance.[4] For the initial mix design of SCC all the three workability parameters need to be assessed by trial and error method to ensure that basic characteristics of SCC get satisfied as per EFNARC code.

TABLE 2

Properties of Fe 415 Grade Bars

RTS Bar	Diameter (mm)	Area (mm^2)	Yield Strength (N/mm^2)	Ultimate Strength N/mm^2	Elongation Percent
8mm dia	8.03	50.64	445.55	658.65	24.5
10mm dia	10.00	78.53	449.71	612.11	21.6
12mm dia	11.99	113.097	485.74	598.50	21.0
16mm dia	16.01	201.06	434.24	531.82	20.1

MIX DESIGN

IS method is followed to design the mix for M35 grade using w/c ratio 0.45 for normal vibrated concrete. Since there is no standard code for self compacting concrete yet,

EFNARC code and IS code are referred to calculate the design mix using w/c ratio 0.5 to satisfy various characteristics of SCC.Mix proportions of CC and SCC are mentioned in Table 3. Number of trial mixes are conducted to achieve fresh workability properties of Self Consolidating Concrete by replacing 20% of coarse aggregate with flyash. Fine aggregate have been entirely replaced with Quarry Rock Dust.[4]

TABLE 3

Mix Proportion of CC and SCC Mix

Ingredients	Quantity (per cubic metre)	Ingredients	Quantity (per cubic metre)
Water	200 litres	Water	220 litres
Cement	444kg	Cement	440kg
Flyash	-	Flyash	168.29kg
Fine Aggregate	742kg	Quarry Rock Dust	794.27kg
Coarse Aggregate	946kg	Coarse Aggregate	673.19kg
CC Mix- 1:1.67:2.13		SCCMix- 1:1.80:1.52:0.38	

2. METHODOLOGY

1. Details of the beam specimens

The mean compressive strength of both SCC and CVC beams are used for casting the beams. Three series of beams, three SCC beams of different admixtures and one of CVC in each series were casted and tested at the end of 28 days. All the beams have a cross- sectional area of 150 x 250 mm and a length of 2500mm.Both SCC and CVC beams have similar dimensions and different reinforcement content of Fe 415 grade RTS bar. The properties of Fe415 grade bars are tabulated in Table 2. The beams were designed as singly under reinforced section beams. Three set of beams are casted with 1.04%,1.23% and 1.37% of tensile reinforcement. First set of CVC and SCC beams with different superplasticizers were casted with 3-10mm dia main bars. Second set of CVC and SCC beams were casted with 2-12mm dia and 1-10mm dia main bars with different superplasticizers. Third set of CVC and SCC beams were casted with 2-10mm dia and 1-16mm dia bars. All the beams were hanged with 2-10mm dia hanger bars. The shear reinforcement was calculated for the entire shear force and shear stirrups 8mm dia were provided equidistant throughout the beam. Properties of RTS bar was found by using UTM machine and details were shown below in Table 4

TABLE 4

Reinforcement Details of CVC and SCC Beams

Beam reference ID	Tensile Reinforcement	Hanger Bars	Shear Reinforcement	Tensile Reinforcement (%)
CVC 1.04	3-10mm φ	2-10mmφ	8mmφMS@ 150mm	1.04
SCC 1.04PS	3-10mm φ	2-10mmφ	8mmφMS@ 150mm	1.04
SCC 1.04NS	3-10mm φ	2-10mmφ	8mmφMS@ 150mm	1.04
SCC 1.04MS	3-10mm φ	2-10mmφ	8mmφMS@ 150mm	1.04
CVC 1.23	2-12mm & 1-10mmφ	2-10mmφ	8mmφMS@ 150mm	1.23
SCC 1.23PS	2-12mm & 1-10mmφ	2-10mmφ	8mmφMS@ 150mm	1.23
SCC 1.23NS	2-12mm & 1-10mmφ	2-10mmφ	8mmφMS@ 150mm	1.23
SCC 1.23MS	2-12mm & 1-10mmφ	2-10mmφ	8mmφMS@ 150mm	1.23
CVC 1.37	2-10mm & 1-16mmφ	2-10mmφ	8mmφMS@ 150mm	1.37
SCC 1.37PS	2-10mm & 1-16mmφ	2-10mmφ	8mmφMS@ 150mm	1.37
SCC 1.37NS	2-10mm & 1-16mmφ	2-10mmφ	8mmφMS@ 150mm	1.37
SCC 1.37MS	2-10mm & 1-16mmφ	2-10mmφ	8mmφMS@ 150mm	1.37

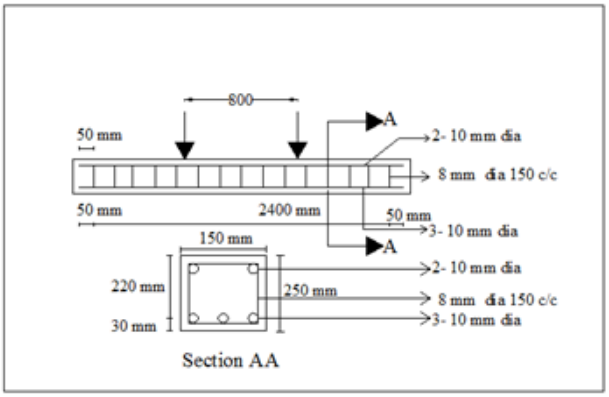

Fig. 1*. Plan and Cross-Section of Reinforcement Details of SCC Beam*

3. TEST SETUP PROCEDURE

Reinforcement details are shown in Fig 1. The effective span of the beam was 2400mm.A hydraulic jack of 100KN capacity was used to apply the load.[5] The beams were simply supported and subjected to two point loading. The dial gauges were fixed at the centre of the beam and under load points to record the deflection of the beam during the test. The deflection of the beams at mid span and under the load points were measured at every 2.5KN intervals of loading. Pellets were fixed at gauge length 250mm on the surface of the beam and strains were measured at ever 2.5KN intervals of loading using strain gauge. [6]At every loading stage, cracks appearing on the surfaces were marked. The beam was loaded up to

ultimate failure[7]. It was concluded that Conventional Vibrated Concrete (CVC) and Self Compacting Concrete (SCC) are designed to have different characteristics when the concrete is fresh.[8] To utilize them in any structural behavior of these two concrete in hardened stage, Reinforced Concrete (RC) beams of size 150x250x2500mm with similar concrete strength and different reinforcement casted with quarry rock dust and three different bases of super plasticizers and tested in flexure[9]. The structural behavior and load-deflection characteristics of all three set of beams with different superplasticizers and various tensile reinforcement are calculated and plotted in graph.

LOAD- DEFLECTION CHARACTERISTICS OF CVC AND SCC BEAMS

The Fig.2 shows the load- deflection curve for 1.04% steel reinforcement with three different types of superplasticizers. Fig.3 shows load-deflection curve for 1.23% tensile reinforcement using all superplasticizers.Fig.4 represents load-deflection curve for 1.37% steel reinforcement with all bases.Deflection was taken up to yield load point, beyond that point load was applied till failure breaking point. Finally the load Vs deformation curves were plotted up to the failure stage for all set of beams.

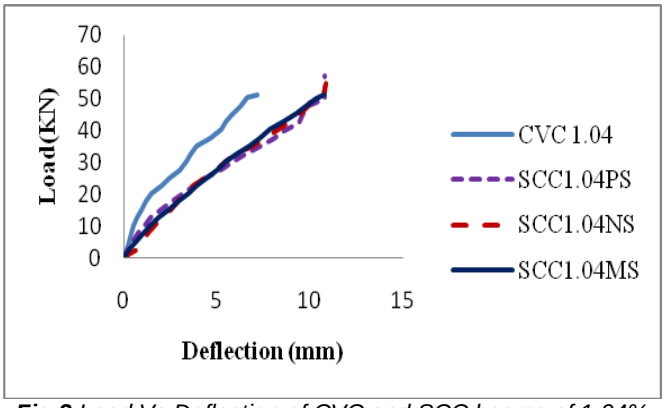

Fig.2 *Load Vs Deflection of CVC and SCC beams of 1.04% steel reinforcement*

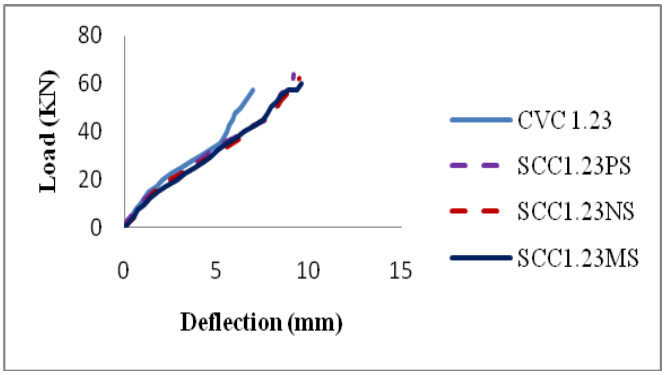

Fig.3 *Load Vs Deflection of CVC and SCC beams of 1.23% steel reinforcement*

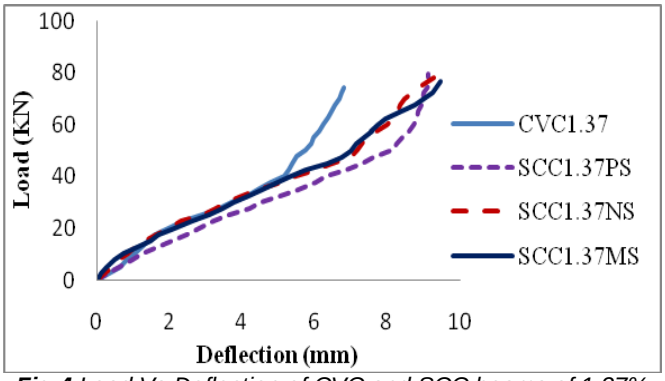

Fig.4 *Load Vs Deflection of CVC and SCC beams of 1.37% steel reinforcement*

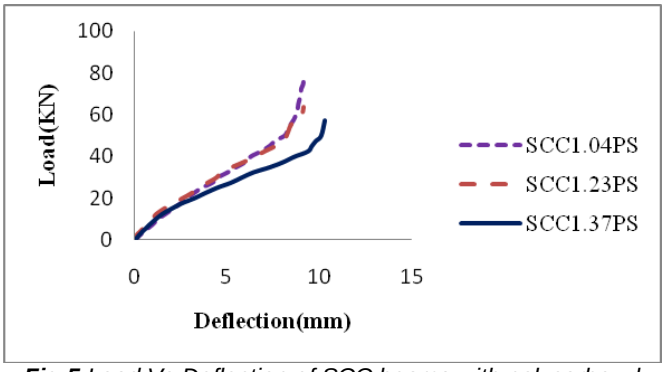

Fig.5 *Load Vs Deflection of SCC beams with polycarboxyl base superplasticizer*

In the first set of series of beams casted with 1.04% of tensile reinforcement the P_U of self compacting concrete with polycarboxyl base resists more load with 57.36KN compared to SCC beams casted with naphthalene base and melamine base[10]. But naphthalene based SCC beam resists more load P_U compared to conventional concrete beam. Melamine based SCC beams almost carry equal load compared with control beam. Hence compared to CC beam SCC1.04PS shows more than 11.08% of P_U. And SCC1.04NS possess more than 6.81% P_U compared to control beam. The P_U %of CC and SCC1.04MS almost resembles the same. Yield load and ultimate load details of all specimens are tabulated in table.5 and yield deflection and ultimate deflection are tabulated in table.6

TABLE 5

Yield Load and Ultimate Load Details of CVC and SCC Beams

Beam reference ID	Yield Load P_y (KN)	Ultimate Load Pu (KN)	Pu / P_y
CVC1.04	20	51	2.55
SCC1.04PS	27.5	57.36	2.09
SCC1.04NS	20	54.73	2.73
SCC1.04MS	22.5	51.02	2.26
CVC1.23	25	57.36	2.21
SCC1.23PS	25	63.75	2.55
SCC1.23NS	25	62.47	2.49
SCC1.23MS	20	60	3.0
CVC1.37	22.5	74.21	2.28
SCC1.37PS	27.5	79.66	2.89
SCC1.37NS	20	78.25	3.91
SCC1.37MS	20	76.84	3.84

TABLE 6
Yield Deflection and Ultimate Deflection Details of CVC and SCC Beams

Beam reference ID	Yield Deflection Δy (mm)	Ultimate Deflection Δu (mm)	Δu/ Δy
CVC1.04	1.52	7.21	4.74
SCC1.04PS	5.21	10.32	1.98
SCC1.04NS	3.12	10.51	3.37
SCC1.04MS	3.95	1.74	0.44
CVC1.23	3.08	6.97	2.26
SCC1.23PS	3.52	9.48	2.69
SCC1.23NS	3.63	9.47	2.61
SCC1.23MS	2.86	9.59	3.35
CVC1.37	2.37	6.80	2.87
SCC1.37PS	4.2	9.12	2.17
SCC1.37NS	1.97	9.27	4.71
SCC1.37MS	2.11	9.46	4.48

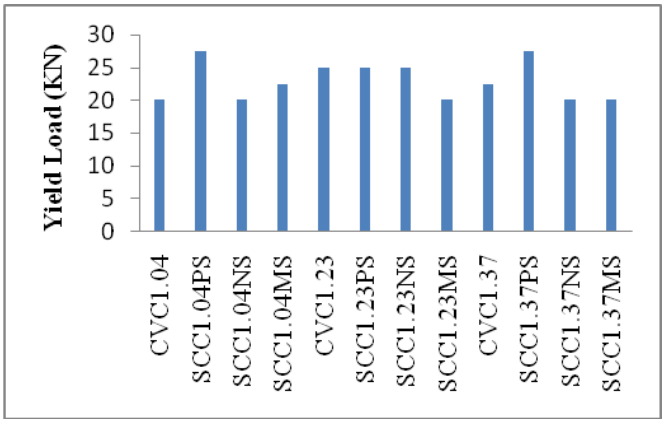

Fig.6 *Yield load of all specimens*

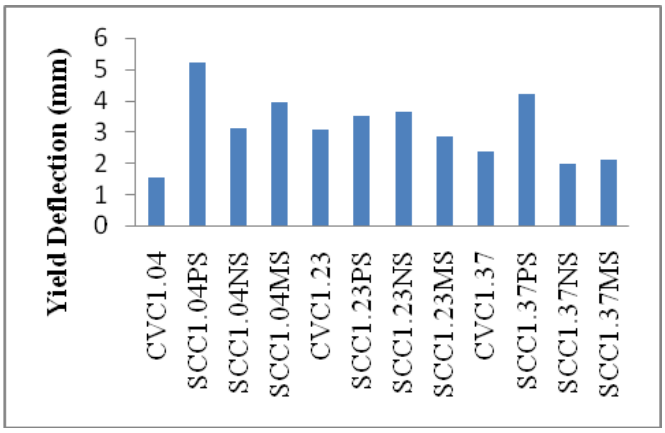

Fig.7 *Yield deflection of all specimens*

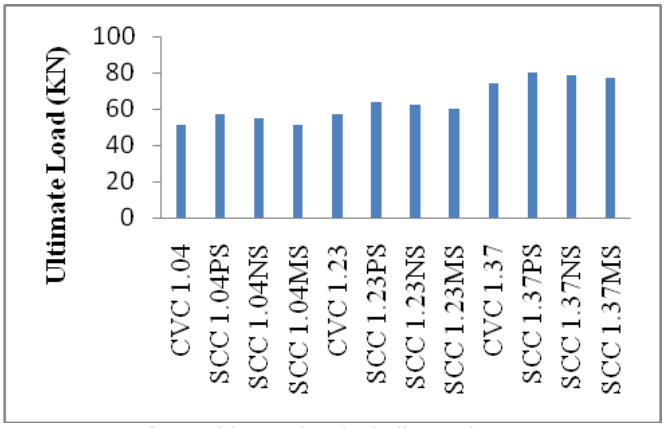

Fig.8 *Ultimate load of all specimens*

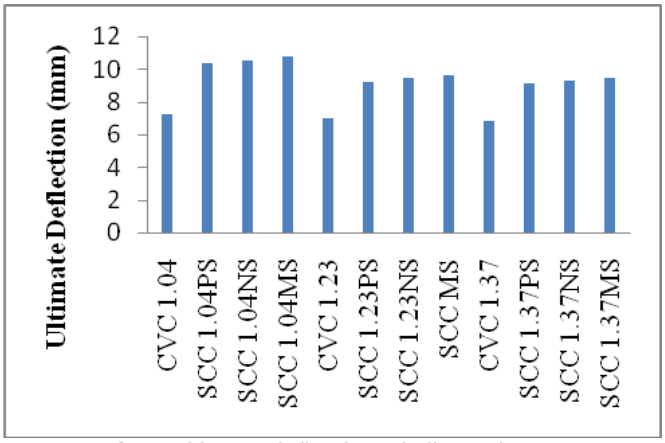

Fig.9 *Ultimate deflection of all specimens*

In the second set of series of beams casted with 1.23% of tensile reinforcement the P_U of beams increases to a good percentage compared to beams casted with 1.04%.Here also SCC beam casted with polycarboxyl base shows enhanced results compared to other SCC and CC beams.SCC 1.23PS resists more than 10.02% P_U compared to CC beam. Also SCC 1.23NS shows more than 8.17% of P_U compared to control beam. And SCC1.23MS produce more than 4.4% of P_U compared to normal beam. In the third set of series of beam with 1.37% of tensile reinforcement the percentage of P_U increases twice compared to first set of series. Here also SCC1.37PS shows an excellent results compared to all other beams. It carries more than 6.84% of P_U compared to control beam.SCC 1.37NS produce more than 5.16% of P_U compared to CC beam.SCC1.37MS shows more than 3.42% of P_U compared to control beam. Thus SCC beam casted with polycarboxyl base with 1.37% of tensile reinforcement produce excellent P_U compared to 1.04% and 1.23% of reinforcement and all the yield load details of all specimens are plotted in Fig.6 and yield deflection are plotted in Fig.7. The P_U shows 79.66KN with polycarboxyl base in SCC beam, whereas the P_U of SCC beam with polycarboxyl base casted with 1.23% produce 63.75KN as P_U and SCC beam with polycarboxyl base under 1.04% of reinforcement resists 57.36KN P_U.Since polycarboxyl base superplasticizer produce better results all the SCC beams load-deflection curve using polycarboxyl base are plotted in Fig.5 The Δ_U of beams get reduced when the percentage of tensile reinforcement gets increased[11]..All

the ultimate load details are shown in Fig.8 and ultimate deflection are plotted in Fig.9. The control concrete beams shows less Δ_u values compared to SCC beams with different superplasticizers. Compared to SCC beams Δ_u values of polycarboxyl base shows less values compared to naphthalene and melamine base superplasticizers [12].Deflection pattern of all SCC beams resembles almost similar compared to CC beams.

4. CONCLUSION

- Load carrying capacity of SCC beams casted with polycarboxyl base shows enhanced results compared to naphthalene and melamine base superplasticizers.
- Compared to CVC beam SCC1.04PS shows more than 11.08% of load carrying capacity casted with 1.04% of tensile reinforcement.
- SCC 1.23PS resists more than 10.02% load carrying capacity compared to CVC beam casted with 1.23% of tensile reinforcement.
- SCC 1.37PS carries more than 6.84% ultimate load compared to control beam casted with 1.37% of tensile reinforcement.
- The ultimate load shows 79.66KN with polycarboxyl base in SCC 1.04PS with 1.04% of tensile reinforcement.
- The ultimate load of SCC beam with polycarboxyl base casted with 1.23% produce 63.75KN.
- SCC beam with polycarboxyl base under 1.04% of reinforcement resists 57.36KN ultimate load.
- The control concrete beams shows less deflection values compared to SCC beams with different superplasticizers.
- Compared to all SCC beams, beams casted with polycarboxyl base shows less deflection values compared to other two bases.
- When the percentage of tensile reinforcement increases, the rate of deflection gets reduced.

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