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STUDY ON MECHANICAL AND CORROSION CHARACTERISTICS OF SELF COMPACTING CONCRETE (M30)

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Abstract- Self Compacting Concrete (SCC) is the only choice in construction industry because of its easy movement in highly congested reinforcement in the structural members without segregation and bleeding. Use of SCC is increasing day by day because of its technical advantages over Normally Vibrated Concrete (NVC) in different parameters like self consolidation, smooth finishing and labour reduction. Corrosion is one of the important factors influencing strength, durability and service life of Reinforced Concrete (RC) structures. This paper studies the mechanical properties of NVC and SCC of M30 grade and the extent of corrosion in NVC and SCC beams experimentally after 28 days when they are immersed in Nacl & $MgSo_4$ solutions to provide alkaline environment. The test results revealed that SCC shows better strength in compression and tension than that of NVC.

Keywords- Self Compacting Concrete (SCC), Normally Vibrated Concrete (NVC), Reinforced Concrete (RC), Super Plasticizer (SP), Viscosity Modifying Agent (VMA), Corrosion, Open Circuit Potential method (OCP).

I. INTRODUCTION

Self compacting concrete is a new innovative type of concrete, when properly designed and used, it is the most economical, environment friendly with high ease of use in practical construction sites. SCC can be cast easily without vibration in case of structural elements with congested reinforcement. The dosages of SP, VMA increases the segregation resistance and workability of SCC. For structural elements like slabs, beams, columns, footings etc high degree of compaction is necessary improper compaction either manual or mechanised means would effect in strength and durability of concrete structures. To avoid the above refered difficulties namely compaction, strength and durability, SCC could be an appropriate solution.

ASTM terminology defines corrosion as “the chemical or electrochemical reaction between a material, usually a metal and its environment that produces a deterioration of the material and its properties.” The word corrosion was derived from the latin word “corrosus” which means eaten away. Usually all materials achieves an equilibrium state of reaching back to its origin. As steel is an alloy it must obey this call of nature and must corrode. The major cause of corrosion is due to the depassivation of film formed on steel surface due to the high alkaline environment under chloride attack. Corrosion of steel reinforcement results in reduction of bond strength, cross section of steel, serviceability, beam’s shear capacity and anchorage capacity of longitudinal bar.

In this paper properties of both normally vibrated concrete and self compacting concrete of M30 grade in its fresh state and hardened state were studied. NVC and SCC prisms were casted with inserted bar to determine the corrosion levels. The experimental results shows the comparison of strength properties and corrosion characteristics of NVC & SCC after 28 days curing at aggressive environment.

II. MATERIALS AND METHODOLOGY

A. Materials

Cement: ordinary Portland cement (OPC) of 53 grade, ultratech brand has been used which satisfies all the physical properties as per IS 4031. It has a specific gravity of 3.13, fineness of 98%, consistency of 32%.

Aggregates: coarse aggregates used were of two sizes for SCC namely 12.5mm & 10mm and for NVC 20mm and 10mm nominal size were used. It has a specific gravity of 2.80. locally available fine aggregate of specific gravity of 2.63 conforming to grading zone II (IS 383-1970) was also used.

Ground granulated blast furnace slag (GGBS): GGBS is a by result of iron and steel making. For the present work GGBS was obtained from JSW cements ltd.

Steel: steel of Fe500 grade was used.

Super plasticizer: poly carboxylic ether based SP (glenium B233) was used to improve the workability of concrete.

Viscosity modifying agent (VMA): VMA based on cellulose ether was used only for SCC to modify its flow properties.

B. Mix proportions: Table 1 shows the mix proportions of normally vibrated concrete of M30 grade as per IS 10262-2009.

TABLE 1
MIX PROPORTIONS OF NVC

Materials	Mix proportions(kg/m^3)
Cement	216
GGBS	144
Fine aggregate	815
Coarse aggregate	1145
Water	156
Super plasticizer	5.4

Table 2 shows the mix proportions of self compacting concrete of M30 grade as per Nansu method (2011).

TABLE 2
MIX PROPORTIONS OF SCC

Materials	Mix proportions(kg/m^3)
Cement	275
GGBS	180
Fine aggregate	1015
Coarse aggregate	760
Water	180
Super plasticizer	9.1
VMA	3ml

Preparation of test specimens: As per IS 519-1959, cubes of size150mm X150mm X 150mm, beams of size 500mm X 100mm X 100mm were casted to determine the compressive strength and flexural strength respectively was determined. Based on IS 5816-1999, cylinders of height 300mm and diameter of 150mm were casted and split tensile strength was found. All these tests were conducted after 28 days of curing.

Fig1: casting and testing of specimen

Fig 2: Formwork of specimen for corrosion test

Table 3 shows the workability properties of normally vibrated concrete as per IS 1199.

TABLE 3
WORKABILITY PROPERTIES OF NVC (M30)

Tests	Obtained values	Degree of workability
Slump	70	Medium
Compaction factor	0.95	high

Table 4 shows the workability properties of self compacting concrete in accordance with EFNARC guidelines.

TABLE 4
WORKABILITY PROPERTIES OF SCC (M30)

Tests	Obtained values	Acceptance criteria based on EFNARC guidelines
Slump(mm)	570	550 - 650
V-funnel (seconds)	18	≥ 10 & ≤ 27
L-box	0.88	0.85-1
U- box (mm)	0	0-3

Fig3: slump cone and V-funnel tests

Fig 4: L-box and U-box tests

Table 5 shows the strength values of both NVC & SCC of M30 grade after 28 days.

TABLE 5
STRENGTH PROPERTIES OF NVC & SCC

Tests	NVC	SCC
Compressive strength (Mpa)	42.11	43.55
Flexural strength (Mpa)	4.095	4.365
Split tensile strength (Mpa)	3.183	2.97

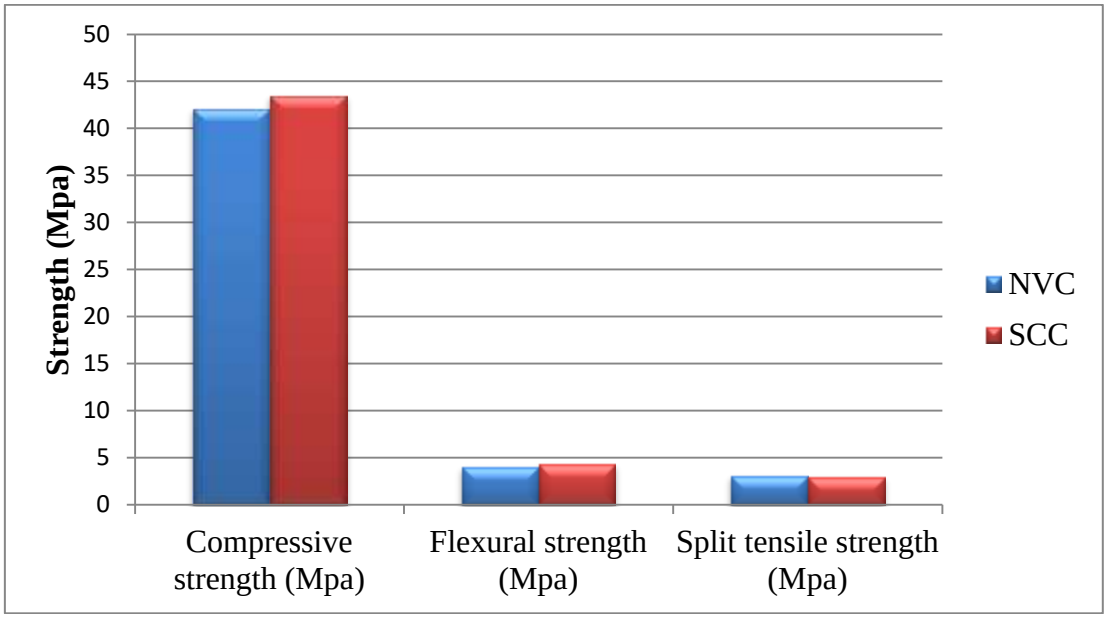

Fig 5: Variation in strength parameters between NVC & SCC after 28 days

C. Experimental programme

This experimental programme includes casting and testing of 8 specimens of size 100mm x 100mm x 350mm were cast of which four beams are self compacting concrete and four beams are normally vibrated concrete of M30 grade. The reinforcement of 16mm diameter and 500mm length were used. These beams were immersed in Nacl solution of 0.25M and Mgso_4 solution of 0.025M separately to create chemical environment and allowing the reinforcement to corrode.

III. TEST PROCEDURE

Determination of corrosion activity of reinforcing steel in the concrete beams of size 350mm x 100mm x 100mm by half cell potential method or open circuit potential (OCP) method was carried out in the present study.

Prediction of corrosion levels: OCP method is used to determine the corrosion activity levels. In this method silver chloride solution (Agcl) is used as a reference electrode. The positive terminal of voltmeter is connected to the end of reinforcing bar and the negative terminal is connected to the reference electrode. These two terminals are connected to the voltmeter which shows the potential difference in millivolts (mV) defining the extent of corrosion. ASTM has given some standard values for the prediction of corrosion activity levels by OCP method.

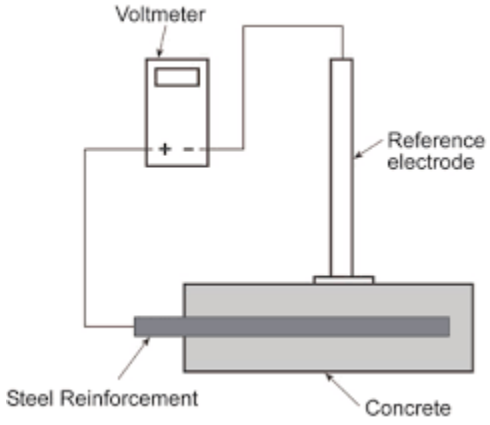

Fig 6: schematic diagram of half cell potential

Table 6 shows different levels of corrosion in accordance with the electrolyte used in reference electrode as per ASTM (876-1991).

TABLE 6
CORROSION LEVELS (ASTM 876-1991)

Cu/cuso_4 electrode (mV)	**Hg/Hg_2cl_2 electrode (mV)**	**Ag/Agcl electrode (mV)**	**Corrosion condition**
>- 200	>- 126	> - 106	Low
-200 to -350	-126 to -276	-106 to -256	Intermediate
< - 350	< - 276	< - 256	High
< - 500	< - 426	< -406	severe

Fig 7: testing of specimen by OCP method

Table 7 depicts the corrosion condition of both NVC & SCC specimens immersed in Nacl and Mgso_4solutions after 28 days.

TABLE 7
PREDICTION OF CORROION LEVELS IN NVC & SCC BY OPEN CIRCUIT POTENTIAL METHOD

S.No	**Concrete type**	**salts**	**OCP values (mV)**	**Corrosion condition**
1	NVC	Nacl	239	Intermediate
		Mgso_4	198	Intermediate
2	SCC	Nacl	169	Intermediate
		Mgso_4	154	intermediate

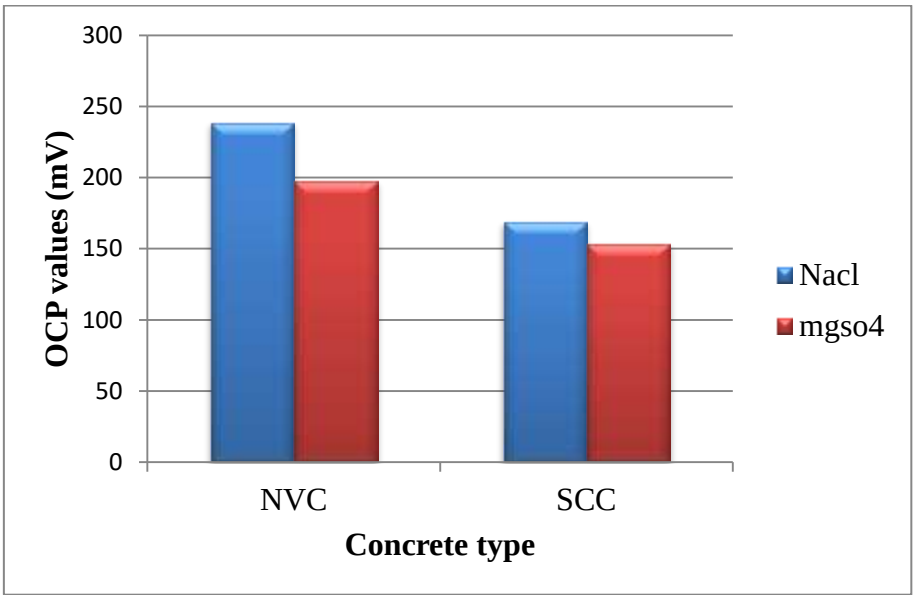

Fig 8: Variation in OCP values between NVC & SCC in Nacl and Mgso_4

IV. CONCLUSIONS

The following conclusions are drawn based on the experimental investigation:

- SCC exhibits better strength in compression and flexure than that of NVC.
- According to ASTM standards the level of corrosion for both NVC & SCC beams is approximately equal to intermediate.
- When tested by OCP equipment, SCC has got less corrosion values than NVC due to its self compactability.

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