International Journal of ChemTech Research
CODEN (USA): IJCRGG, ISSN: 0974-4290, ISSN(Online):2455-9555
Vol.10 No.11, pp 39-44, 2017

Study on Strength and Behaviour of Self Compacting Concrete Incorporating Corrosion Inhibitor

R.Dharmaraj*[1], R.Malathy[2]

[1]Department of Civil Engineering, University College of Engineering Panruti, Panruti – 607 106, India.
[2]Department of Civil Engineering, Sona College of Technology, Salem – 636 005.

Abstract : Self compacting concrete (SCC) never needs to vibration, for placing and consolidation of concrete. It can achieve complete compaction in formworks by its self weight, even in heavy reinforcement structures. Corrosion of steel reinforcement is the most important cause of premature failure on reinforced concrete. Prevention of corrosion is primarily achieved in the design phase by using high quality concrete and adequate cover. Additional anticipation techniques are adopted when severe environmental conditions occur or on structures requiring very long service life. In this work the effect of corrosion inhibitor deals with the strength properties of self compacting concrete with the addition of hexamine as organic corrosion inhibitor in concrete were studied. The inhibitor is added in different percentages of 0%, 1%, 2%, 3%, 4% and 5% by weight of cement. Mix design for M25 grade of concrete according to BIS method (IS 10262:2009).Then the standard concrete mix proportions were modified into SCC properties as per EFNARC specifications and different trail mixes were done. The feature of the fresh concrete (slump flow, V-funnel, L-Box, and J Ring)and hardened concrete and durability (Water absorption, and Sorptivity is review. From experimental results, it has been observed that addition of Hexamine as corrosion inhibitor (CI) increasing the compressive strength up to H2% at all ages i.e. 3, 7, 14, 28, 56 and 90 days, while an decreases trend is observed for addition of CI in H3%, H4% & H5%. After the strength tests were carried out and the results were compared with reference self compacting concrete.

Keywords : Self-compacting concrete, Mix design, Hexamine (Corrosion inhibitor), Super plasticizer, fresh and hardened concrete properties, Durability studies.

Introduction

In recent years there are number of papers published about self compacting concrete has been increased. In the year nineties and eighties SCC was used in Skyscrapers, before it was developed in Japan[1]. For an efficient and quality Construction SSC was required due to its major advanced technology. Using SCC lead to made complicated, interesting shapes, and construction of slender building elements. Due to its self weight it is very ease to pumping the concrete at a greater height through congested reinforcing bars without any compaction [2]. Due to the character of SCC it's reduced the construction time, labour cost and the level of noise on the construction site.

To increase the workability and reduce segregation, it is necessary to add chemical admixtures in production of SCC. Comparing to conventional concrete the coarse aggregate and water are low in SCC [3].

Therefore large amounts of fine particles such as, blast-furnace slag, fly ash and lime powder were in SCC to avoid gravity segregation of large particles in the fresh mix of concrete.

The strength and drying shrinkage of SCC is similar tothose of conventional concrete at the same water to cementratio [4]. Compared with traditional concrete, SCC showsa lower permeability and absorption by capillary action,which might be attributed to the less porous zone andrefinement of pore structure. From the studies, it is depicted that the wield of fly ash in concrete amplifies the workability thereby partakes the long-term strength. The demand of super plasticiser which is indispensable to achieve an alike slump flow in harmony with the concrete grasping solely concrete as binder is got reduced by the impulsion of fly ash [5]. It is found that the strength and shrinkage of SCC domesticating high volume of fly ash is similar to that of habitual concrete [6]. Moreover the shrinkage was imperceptibly different from that of traditional concrete. The differing water to binder ratios plays a crucial role at the extremities.

Corrosion of reinforcing steel in concrete, also known as rebar corrosion, is a serious and significant problem both from the structural integrity and economic points of view [7]. The steel reinforcements in concrete structures are in passive condition that is they are protected by a thin oxide layer promoted by the concrete alkalinity (pH between 12 to 13). When this protective passivity is breached due to either chloride attack or carbonation, corrosion takes place [8]. This results in the formation of rust which has two to four times the volume of original steel and none of its good mechanical qualities. When reinforcement corrodes, the formation of rust leads, to loss of bond between concrete and steel and subsequent delamination, cracking and spalling.

Among the available methods to prevent corrosion, the use of corrosion inhibitors is most attractive from the view point of economy and ease of application [9]. There are many investigations on use of inhibitors for corrosion of steel. Most of the commercial inhibitors are either toxic or show adverse effect on concrete properties.

The present work investigates the effect of Hexamine as organic corrosion inhibitor in SCC mixes can be determined. The water to cement ratioof 0.40.The addition of corrosion inhibitor to concrete can increase the protection of the steel [10]. A corrosion inhibitor is a chemical compound added to concrete, to delay corrosion of the steel. This study performance of the commercially available organic inhibitor on its corrosion control ability and its influence on concrete strength properties. To improve the strength and prevent sulphate attack and chloride ingress to concrete is most appropriate and desirable.

Experimental Programme

Material Used:

Ingredients used in mix design: the mix contains Cement, fine aggregate, coarse aggregate, fly ash, super- plasticizer, corrosion inhibitor, and water were used in experimental work.

a. Cement:

Ordinary Portland cement of available in local market is used in the investigation. The Cement used has been tested for various proportions as per IS: 4031 and found to be confirming to various specifications of I.S-8112- 1989. The specific gravity was 3.15 and fineness was 5.0% and standard consistency 29 %.

b. Fine Aggregate:

In this study, the use of fine aggregate was instrumented about the whole work comprising natural river sand of maximum size 4.75mm. By IS 383-1970, it is ratified to grading zone-II against specific gravity of 2.60 and fineness modulus of 2.25 was applied in this investigation.

c. Coarse Aggregate:

Coarse aggregate obtained from nearby granite quarry has been used for this study. it consisted of machine crushed stone angular in shape and the maximum size of aggregate is 12.5 mm with specific gravity 2.80, and fineness modulus 6.23 was used.

d. Fly Ash:

Class F fly ash from Mettur Thermal Power Station, Tamil Nadu was used as cement replacement material. The properties fly ash are confirming to I.S. 3812 – 2003 of Indian Standard Specification for Fly Ash for use as Pozzolanic and Admixture. The specific gravity of 2.15.

e. Admixture:

Sulphonated Naphthalene Polymers (Conplast SP430) based super plasticizer which is brown colour and free flowing and having relative density 1.20 super plasticizer confirming to IS: 9103-1999.To give high water reduction up to 25% without loss of workability or to produce high quality of concrete that reduces permeability it is formulated Conplast SP430.

f. Corrosion Inhibitor (Hexamine):

Hexamineis Hexamethylenetetramine which is a heterocyclic organic compound with the molecular formula $(CH_2)_6N_4$. The main use of Hexamine is in the production of powdery or liquid preparations of phenolic (phenolic formaldehyde) resins and phenolic resin molding compound, where it is added as a hardening component [11]. These products are used as binders, e.g., in brake and clutch linings, abrasive products, fire proof materials. Phenolic formaldehyde resins include synthetic thermosetting resins got by the reaction of phenol (an organic compound) and formaldehyde.

g. Mixing water:

For casting the concrete specimen potable water has been used. Also the water has been had a water-soluble Chloride content of 140 mg/lit. The permissible limit for chloride is 500 mg/lit as per IS 456 – 2000. Therefore the amount of chloride present is very less than the permissible limit.

Mix Proportions:

The concrete mix design was proposed by using IS 10262:2009. The grade of concrete used was M-25 with water to cement ratio of 0.40. The standard concrete mix proportions were modified as per EFNARC specifications and different trial mixture proportions used in laboratory.

In favour of examining the fresh and hardened properties of SCC a number of mixes about 6 were hired. With contradicting CI, the quantity of sand, coarse aggregate, water/binder ratio and SP dosage were maintained constant for all the mixes [12]. The reference mix H0 does not gets added in CI, meanwhile the mixes H1, H2, H3, H4 & H5 were added about 1 to 5%(by weight) in CI accordingly [13]. The water/binder ratio of all mixes was maintained constant at 0.40.

Casting, curing and testing

The IS mix design of M25 grade concrete is evaluated. With reference to the guidelines of EFNARC [15], the assessed mix design was modified. Based on the modified mix design the workability properties of SCC such as filling ability, passing ability and viscosity were accessed with the help of following tests viz., Slump flow, V Funnel, L Box, J Ring and Marsh cone tests [14]. The various tests are conducted, while the test results and their acceptance criteria as per EFNARC are listed in Table 1 and the marsh cone results for fresh properties of SCC mix is shown in figure 1. The study on compressive strength was practiced on cube moulds of size 100 x 100 x 100 mm and cylindrical moulds of size 100 x 200 mm which is used for the determination of split tensile strength. Whereas the flexural strength studies were carried out in prisms of size 100 x 100 x 500 mm. The strength studies were carried out at 3, 7, 14, 28, 56 and 90 days for these mix proportions.

Table 1: Fresh SCC properties of reference mix

S.No	Test Method	Unit	Typical range of values as per EFNARC		Results of Tests
			Min.	Max.	Mix M25
1	Slump flow	mm	650	800	700
2	V - funnel	Sec	6	12	7
3	L - Box	(H2/H1)	0	1.0	0.89
4	J-Ring	mm	0	30	8

Results and Discussion

The inquiry on fresh and hardened properties of SCC was made with the help of CI in this study. The EFNARC committee serves as serviceable criteria for these studies. The results achieved from the study satisfy the EFNARC's guidelines. Noticeably the marsh cone test yields the value of about 2% of hexamine which is the optimum value.

Mechanical Properties:

The compressive, split and flexural strength studies at different ages are shown in the figures (1, 2, 3,and 4).When compared to that of the standard mixture increasing amounts of Hexamine generally decrease the strength. Hexamine has shown better performance in all the mixes. This is due to the physical nature of better packing and fineness of it. In general there occurs in strength towards higher addition of corrosion inhibitors (Hexamine). The mechanical strength obtained for different percentage of Hexamine mixes.

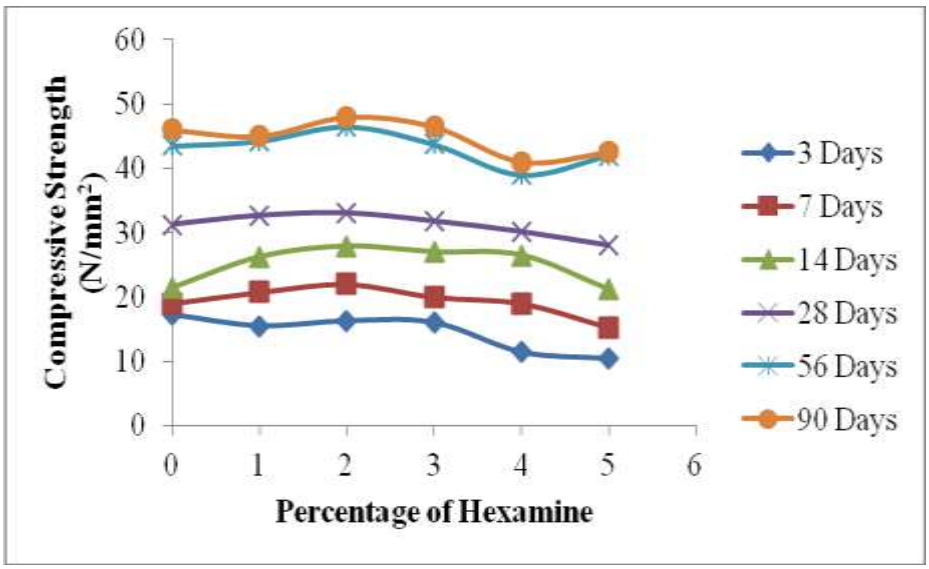

Fig.1 Compressive Strength vs % of Corrosion Inhibitor

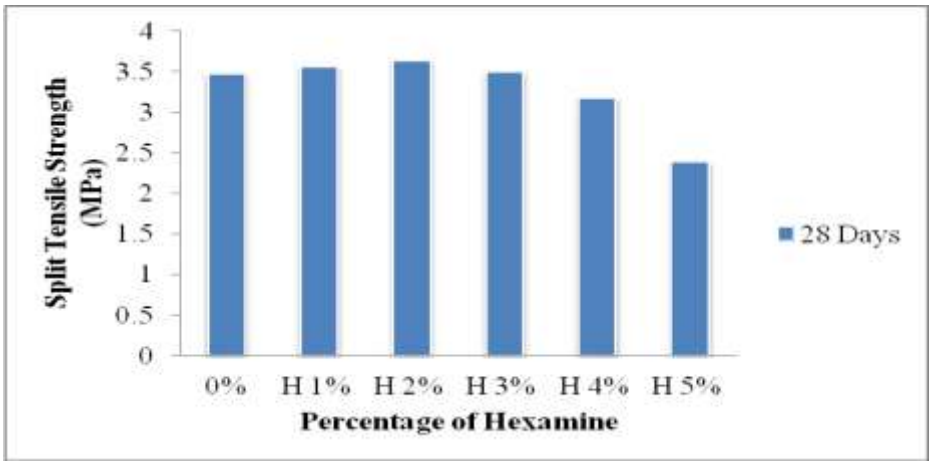

Fig.2 Split Tensile Strength vs % of Corosion Inhibitor

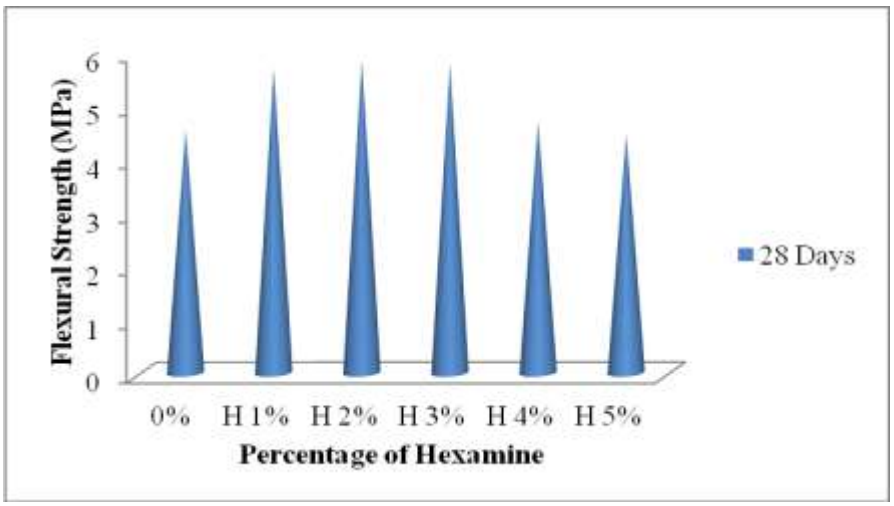

Fig.3 Flexural Strength vs % of Corrosion Inhibitor

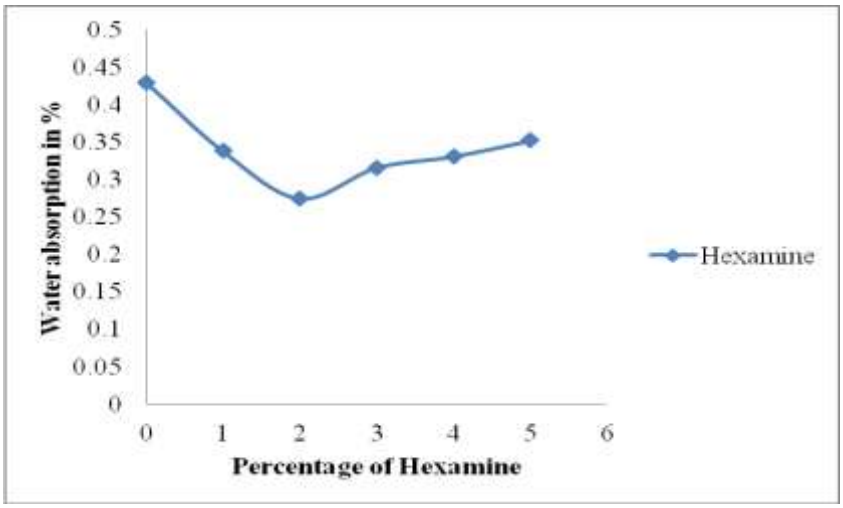

Fig.4 Water absorption vs % of Corrosion Inhibitor

Conclusion

The subsequence is the extremity of the tests which were done to examine the fresh and hardened properties of SCC.

- In general the use of mineral and chemical admixture improved the performance of SCC in the state.
- The specimens were cast with fly ash percentage of 40% by weight of cement and for the optimal percentage Hexamine inhibitor of varying percentage of 0%, 1%, 2%, 3%, 4% and 5% weight of cement are added.
- As the outcome of mechanical and durability properties (Compressive, Split, Flexural, Workability), it is evident that the remarkable performance differences and higher compressive strength was achieved for the mix H2. Meanwhile it is apparent that the further increment of hexamine results in the decrease of strength.
- The compressive, split tensile strength of the concrete specimen cast with 40% fly ash attained the maximum values. It was observed that there was 5.6 % increase in compressive strength, 0.57% increase in split tensile strength,and 28% in flexural strength.
- Inhibitors additions to chloride contaminate concrete have no harmful effects to the compressive strength. But up to 2% inhibitors additions to high chloride contaminate concrete was strongly recommended as Hexamine corrosion inhibitor showed superior strength over standard self compacting concrete.

References

1. W. Zhu, C.J. Gibbs, and P.J.M. Bartos, Uniformity of In Situ Properties of Self Compacting Concrete in Full-scaleStructural Elements, Cement & Concrete Composites, 2001, 23; 57–64.
2. K.H. Khayat, J. Assaad, and J. Daczko, Comparison of Field-Oriented Test Methods to Assess Dynamic Stability of Self-Consolidated Concrete, ACI Materials Journal, 2004, 101; 168–176.
3. H. Okamura and K. Ozawa, Mix Design for Self-Compacting Concrete, ConcreteLibrary of JSCE, 1995, 25; 107–120.
4. H. Okamura and M. Ouchi, "Self-Compacting Concrete", Journal of Advanced Concrete Technology, 2003, 1; 5–15.
5. K. Audenaert, V. Boel, and G.D. Schutter, "Carbonation of Self Compacting Concrete", 6th International Symposiumon High Strength/High Performance Concrete, Leipzig, 2002; 853–862.
6. N. Su, K.C. Hsu, and H.W. Chai, "A Simple Mix Design Method for Self-Compacting Concrete", Cement andConcrete Research, 2001, 31; 1799–1807.
7. R.D. Browne, M.P. Geoghegan and A.F. Baker. In: A.P. Crane, Editor. Corrosion of reinforcement in concrete construction. London, UK, 1983; 193. Transportation Association of Canada.
8. Ha-Won Song and VeluSaraswathy. Corrosion monitoring of reinforced Concrete structures - A review. International journal of electrochemical science. 2007, 2; 1-28.
9. Videm. Corrosion of Reinforcement in concrete. Monitoring, prevention and Rehabilitation. EFC No: 25. London.1998; 104-121.
10. R. Vedalakshmi and N.S. Rengasamy. Quality assurance tests for corrosion resistance of steel reinforcement. The Indian concrete journal. 2000.
11. Michael C. Brown, Richard E. Weyers and Michael M. Sprinkel. 2001. Effect of corrosion - Inhibiting admixtures on material properties of concrete. ACI Material journal. 2001, 98.
12. De. Schutter G. LuoL.. Effect of corrosion inhibiting admixtures on concrete properties. Construction and building Materials. 2004; 483-489.
13. R. Dharmaraj, R.Malathy, Performance Evaluation of Sodium Nitrite Corrosion Inhibitor in Self Compacting Concrete, Indian Journal of Science and Technology, 2015, 8; 1-6.
14. R. Dharmaraj, R.Malathy, An Experimental Study on Self Compacting Concrete by using Corrosion Inhibitor, International Journal of Applied Engineering Research, 2015, 10; 14285-14291.
15. EFNARC, "Specifications and Guidelines for Self-Compacting Concrete," EFNARC, UK(www.efnarc.org), February, 2002 ;1–32.

*****