SELF-COMPACTING SELF-CURING CONCRETE: A REVIEW

Anisha Mariya Paul [1], Elba Helen George [2]

[1]PG student, Civil Engineering Department, Toc H Institute of Science and Technology, Kerala, India
[2]Assistant Professor, Civil Engineering Department, Toc H Institute of Science and Technology, Kerala, India

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Abstract - *Concrete is one of the most widely used materials in the construction industry due to its good compressive strength and durability. Present-days there is an endless prominence on performance aspect of concrete. One such thought has motivated the growth of Self Compacting Self Curing Concrete. It is reflected as "the most innovative development in concrete construction field". Self-Compacting Concrete has gained wide use for placement in congested reinforced concrete structures with difficult casting conditions while Self Curing Concrete absorb water from atmosphere to achieve better hydration of cement in concrete. Any negligence in compaction and curing will badly affect the strength and durability of concrete. This investigation is aimed at utilizing the combination of these two types together which provides a suitable solution for the curing and compacting processes. In this paper an overview on the literature on physical and mechanical behavior of Self Compacting Self Curing concrete is carried out based on recent research studies.*

Key Words: Self-Compacting concrete, Self-Curing concrete, Curing, Compaction, Physical and Mechanical behaviour.

1. INTRODUCTION

Concrete is a very strong and versatile construction material. It consists of cement, sand and aggregate (e.g., gravel or crushed rock) mixed with water. Since the time that concrete has been acknowledged as an asset for development of building, researchers have been attempting to help its strength and enhance its performance. Current advances in construction industry demand better quality strength of structures. There is a helpful modification in the design of concrete from strength oriented idea to a performance oriented design. Present-days there is a vast prominence on performance aspect of concrete. One such thought has prompted the change of Self Compacting Self Curing Concrete (SCCSC). It is reflected as “the most innovative development in concrete construction”.

A very limited work is reported from this area having the benefits of both self-curing as well as self-compaction. The future for this type of concrete is very bright due to scarcity of skilled man power, non-mechanization of construction industry, abundant availability of construction materials available at very low cost. The properties of this type of concrete, if found satisfactory would be a great step in concrete technology compiling the advantages of both internal curing as well as self-consolidation.

1.1 Self-compacting concrete

Self-compacting concrete (SCC) represents one of the most outstanding advancement in concrete technology during the last decade. SCC is another sort of concrete with huge deformability and segregation resistance. SCC was first developed in 1988 by professor Okamura intended to improve the durability properties of concrete structures. SCC is a flowing concrete mixture which is able to consolidate under its own weight. The highly fluid nature of SCC makes it suitable for placing in difficult conditions and in sections with congested reinforcement. the paper.

The method for achieving self-compactability involves not only high deformability of paste or mortar, but also resistance to segregation between coarse aggregate and mortar when the concrete flows through the confined zone of reinforcing bars. Okamura and Ozawa have employed the methods to achieve self-compactability such as limited aggregate content, low water-powder ratio and use of super plasticizer.

1.2 Self-curing concrete

A self-curing concrete is provided to absorb water from atmosphere to achieve better hydration of cement in concrete. It solves the problem that the degree of cement hydration is lowered due to no curing or improper curing and thus unsatisfactory properties of concrete. The self-curing agent can absorb moisture from atmosphere and then release it to concrete. The self-curing concrete means that no curing is required for concrete, or even there is no external supplied water is required after placing. The properties of this self-cured concrete of this invention are at least comparable to and even better than those of concrete with traditional curing. The internal water is maintained by incorporating the self-curing agent which reduces the evaporation of water from the concrete, thereby increasing the water retention capacity of concrete. In past decades, the effect of Self Curing Concrete possesses improved properties while comparing to identically cured controls. It was found that, initial surface absorption, chloride ingress, carbonation, corrosion potential and freeze and thaw resistance characteristics were comparatively better by air cured self-cure concrete than the air cured control.

2. REVIEW OF LITERATURE

In recent years, many studies were conducted by various researchers on self-compacting self -curing concrete. The goal that expected from the paper is to compile the recent innovations in Self-compacting Self-curing concrete, study their effect on the properties of concrete and establish an international benchmarking for further research work in this regard.

2.1 Studies on Self-compacting concrete

Narayanee et.al (2016) presented an experimental investigation on the strength characteristics of Self-compacting concrete with mineral admixture named Fly ash. The several series of tests involving various binder combinations, water-binder ratio and high range water reducing admixtures and set retarding admixtures were used to optimize the mix proportions of SCC at different grades (M30, M35, M40, M45, M50). Various tests were carried out to study the characteristics of fresh concrete such as Slump flow, U-tube, V-funnel and L-box tests. For hardened concrete, various tests such as compressive strength, split tensile strength, and flexural strength at 7, 14 and 28 days were also investigated. The test results showed that the workability characteristics of SCC are within the limiting constraints of SCC and better strength parameters were obtained. It was observed that the self-compacting concrete gives a homogeneous and cohesive mix with marginal decrease in workability.

Harini et.al (2015) conducted an experimental study on self-compacting concrete where the cement is partially replaced with fly-ash and silica fume. Here Ordinary Portland Cement is replaced with 5%, 10%, 15%, 20% and 25% of fly-ash and 2.5%, 5%, 7.5%, 10% and 12.5% of silica fume. Slump test, compressive strength test and flexural strength test were conducted to study the mechanical behavior of self-compacting concrete. From the experimental investigations, it was observed that there is an increase in the fresh properties and increase in the hardened properties for replacement of cement with silica fume. Similarly, there is an increase in the fresh properties and decrease in the hardened properties for replacement of cement with fly ash.

Karthick et.al (2016) conducted a study on Durability Properties of High Strength Self Compacting Concrete using Fly Ash and Quarry Dust. In this study cement was replaced with Fly Ash at 20% and fine aggregate were replaced with quarry dust at 20% in M60 grade equivalent SCC. Fresh properties of concrete such as slump flow test, L-box test, V funnel test and mechanical properties such as compressive strength, split tensile strength and flexural strength were evaluated. Durability tests such as alkalinity test, water absorption test, acid attack test and chloride attack test were also evaluated. From this study it was observed that when partially replacing cement with 20% of Fly Ash and 20% fine aggregate with quarry dust show very good resistance to alkaline attack, acid attack, sulphate attack and chloride attack than conventional concrete.

Ramanathan et.al (2013) investigated the workability and durability characteristics of self-compacting concrete with fly ash. In this study cement was replaced with fly ash at 10%, 20%, 30%, 40% and 50%. Fresh properties of concrete were evaluated by conducting various tests such as slump flow, V funnel, L box tests and U box tests. The durability of concrete was examined by conducting various tests such as acid resistance, sulphate attack and saturated water absorption at the age of 28, 56 and 90 days. It was observed that for 30% fly ash replacement, the fresh properties were good as compared to 10%, 20%, 40% and 50% fly ash replacements.

Oladipupo et al. (2015) compared the rheological properties and compressive strengths of Self Compacting Concrete (SCC) and conventional cement concrete. The flowability and segregation resistance of freshly mixed concrete specimens were examined by the V-funnel apparatus, while the characteristics of passing ability were investigated with the L-box apparatus. Cylindrical concrete specimens of 100 mm diameter × 200 mm length were investigated for compressive strength. The compressive strength results of hardened concrete showed that SCC gained strength slowly compared to the conventional cement concrete due to the presence of admixtures and its 28 days strength was lower than conventional cement concrete, but SCC eventually had potentials of higher strength beyond 90 days. Finally, the effect of water-cement ratio on the plastic properties of self-compacting concrete was quite negligible compared to conventional concrete.

Karamloo et.al (2016) had discussed the effects of water/cement ratio (w/c) on mechanical properties and fracture behavior of self-compacting lightweight concrete. For this purpose, four mix compositions with different w/c from 0.35 to 0.5 were prepared such that the nominal maximum aggregate size and weight of coarse and fine aggregates were kept constant. To determine the fracture parameters, twelve notched beam specimens were cast for each mix and the results were analyzed by means of the size effect method. The obtained results indicated that there is a remarkable relationship between the w/c, fracture behavior, and mechanical properties of the material.

2.2 Studies on Self-curing concrete

Mohanraj A et al. (2014) studied on self-curing concrete incorporated with polyethylene glycol. The compressive and split tensile strength for Self-cured concrete was higher than that of concrete cured by conventional curing method. Self-cured concrete was found to have less water absorption values and a fewer amounts of pores compared with concrete cured by other methods. It was found that concrete cast with Polyethylene Glycol as self-curing agent is stronger than that obtained by sprinkler curing as well as by immersion curing.

Shikha Tyagi (2015) studied the effect of curing compound on workability (slump and compaction factor) and compressive strength. In this study the percentage of Polyethylene-Glycol (PEG) by weight of cement from 0% to 2% as the dosage of internal curing compound was fixed. The test results were studied both for M25 and M40 mixes. It was found that PEG-400 helped in self curing by giving strength on par with that of the conventional curing method and improved workability. The optimum dosage of PEG-400 for maximum strength was found to be 1% for M25 and 0.5% for M40 grade. As percentage of PEG-400 increased slump increased for M25 and M40 grades of concrete.

Manoj Kumar (2013) studied super absorbent polymer (SAP) as self-curing agent. M40 grade of concrete was adopted for investigation. Water retention for the concrete mixes incorporating a self-curing agent was higher compared to conventional concrete mixes as found by the weight loss with time. The optimum dosage of 0.3% led to a significant increase of mechanical strength such as compressive strength, split tensile strength and flexural strength of self-cured concrete. There was a gradual increase in the strength for dosage from 0.2 to 0.3% and later gradually reduced. Self-cured concrete using SAP was more economical than conventional cured concrete. In the study, cubes were cast and kept for curing in room temperature to check practical feasibility of self-cured members.

Mousa et al. (2014) studied the physical properties of self-curing concrete incorporated with self-curing agents such as pre-soaked lightweight aggregate (Leca) and polyethylene-glycol (PEG), and the addition of silica fume on the properties of concrete was studied. The concrete used PEG as self-curing agent, improved its properties than concrete with saturated Leca. In all cases, either 2% PEG or 15% Leca was the optimum ratio compared with the other ratios. Results of their study demonstrated that a significant improvement took place in the physical properties studied for self-curing concrete with PEG as self-curing agent.

Mohammed et.al (2016) investigated the strength properties of concrete using water soluble Polyethylene Glycol as the self-curing agent. In this study, compressive strength and split tensile strength of concrete containing self-curing agent was investigated and compared with those of the conventionally cured concrete. The optimum dosage of PEG600 for maximum strength (compressive and tensile) was found to be 1% for both M20 and M25 grade. Strength of self-curing concrete was found to be equal with that of conventional concrete. Self-curing concrete is an alternative to conventional concrete in desert regions where scarcity of water is a major problem.

2.3 Studies on Self-compacting Self-curing concrete

Prakash et.al (2016) had discussed the effect of self-compacting self-curing concrete (SCSCC) using Polyethylene Glycols (PEG) and Glenium B233. The workability properties of SCSCC with partial replacement (20%) by weight of cement by Quartz powder and Fly-Ash were studied with 1% addition of PEG for all the tests. Workability studies such as Slump flow test, V– Funnel test and L– Box method were performed and strength related tests such as compressive test and split tensile test for 3, 7 and 28 days were performed in this study. For 20% replacement of cement by both Quartz Powder and Fly Ash, after 28 days of curing, self-compacting satisfying the target mean strength. The ultimate load for specimen replaced with Fly Ash was increased when compared to specimen replaced with Quartz Powder.

Dadaji et al. (2017) aimed to utilize the benefits of both self-curing as well as self-compacting by the use of self-curing agent viz., Polyethylene Glycol of molecular weight 400 (PEG 400) for dosages ranging between 0.1 to 1% by weight of cement added to mixing water. Two mixes with different w/c ratio were considered in the investigation. Workability tests such as slump flow, T50, V-funnel, J-ring, L-box were conducted on the fresh concrete whereas water retention and compressive strength were evaluated to determine the properties of hardened concrete. Comparative studies were carried out for water retention and compressive strength for conventional SCC and self-cured SCC. The compressive strength of self-cured SCC was comparable with traditional cured specimens at lower w/c ratio whereas does not provide satisfactory results at higher w/c ratio.

Mohan (2016) studied the strength parameters of self-compacting self-curing concrete (SCSCC) of M20 and M25 grade are compared with Conventional Concrete. The chemical admixtures used were conplast SP-430 for self-compacting concrete and polyethylene glycols (PEG) 400 as self-curing agents. Different percentage of 10%, 20%, and 30% of fly ash was investigated. SCSCC showed better results when compared to conventional self-curing and self-compacting concrete. The 20% replacement of fly ash in SCSCC gives optimum results while compared to conventional self-compacting concrete, self-curing concrete.

Yoganatham et.al (2014) presented the performance of Self Compacting Self Curing Concrete which consists of 30% of class C fly ash for the replacement of cement, 100 % of Manufactured Sand for river sand, water reducing admixture of Glenium B233 and self-curing compound of Polyethylene glycol (PEG 400). M25 concrete mix was designed with different proportions of PEG 400 from 0% to 2% by weight of cement. Fresh and hardened properties of Self-compacting and Self-curing concrete were studied in terms of flowability and workability, compressive strength and split tensile strength. The fresh properties of SCC are determined as per EFNARC and found satisfactory. It was observed that the addition of 1% of PEG 400 by weight of cement gives better compressive strength and it is taken as optimum dosage for making SCSCC. Glenium B233 of 0.6 % was added in SCSCC to improve the workability. The compressive strength and split tensile strength of SCSCC were found satisfactory as that of conventional concrete.

Gopi Rajamanickam et.al (2014) studied the self-compacting self-curing concrete made by partially replacing fine aggregate with the light expanded clay aggregate and fly ash aggregate is described in the paper. At that, maximum 25 % of fine aggregate (measured by volume) was replaced. Fresh concrete properties and mechanical properties of self-compacting self-curing concrete were analyzed. Test results indicate that all mixes satisfied the self-compacting properties of concrete. Furthermore, the concrete mix with 15% of expanded clay and the mix with 15% of fly ash exhibited greater strength under self-curing conditions, when compared to the control mix and other mixes.

3. CONCLUSIONS

Self-curing is done in order to fulfill the water requirements of concrete whereas self-compacting concrete is prepared so that it can be placed in difficult positions and congested reinforcements. The following conclusions were drawn from the literature study and discussion.

- Compressive strength and tensile strength of Self-Compacting Self-Curing Concrete was increased when compared with conventional concrete.
- The compressive strength of SCCSC are comparable with traditionally cured specimens at lower water cement ratio whereas does not provide satisfactory results at higher water-cement ratio.
- Overall better performance of concrete was obtained. SCSCC showed better results when compared to conventional, self-curing and self-compacting concrete.
- Replacing cement with Fly Ash showed promising results in Self-Compacting Self-Curing concrete and plays a significant role in reducing the environmental hazards.
- The 20% replacement of Fly Ash in SCSCC gave optimum results while compared to conventional self-compacting self-curing concrete.
- Lower dosage of Polyethylene Glycol were more efficient than higher dosage.
- The optimum dosage of PEG-400 for maximum strength was found to be 1% for different grades of concrete and the use of PEG as a self-curing agent resulted in better hydration of concrete. It gave strength on par with concrete with conventional curing methods.
- Good workability can be achieved with the use of PEG.
- Lower molecular weight PEG was more effective than higher molecular weight PEG.
- Normally large amount of water was required for curing purpose which can be saved by using Polyethylene Glycol.

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