A Review on Self-Compacting Concrete

Aparna Ramadas[1], K. Shobana[2], Samuel Thanaraj. M [3]
Department of Civil Engineering
[1] PG Student, Construction Engineering & Management, Nehru Institite of Technology, Coimbatore.
[2]Assistant Professor, Nehru Institute of Technology, Coimbatore.
[3] Assistant Professor, Nehru Institute of Technology, Coimbatore.

Abstract- *Concrete is one of the most widely used construction materials throughout the world. In recent years, there is an increasing research in the concrete construction using self-compacting concrete. Self-compacting concrete (SCC) is an innovative concrete which in fresh state flows under its own weight and does not require external vibration for undergoing compaction. It is used in the construction where it is hard to use vibrators for compaction of concrete and the areas where vibrations are restricted. Filling ability, passing ability and segregation resistance are the properties of self-compacting concrete. There is a misconception that the cost of SCC is much higher than that of conventional concrete but the cost of materials for SCC is about 10-15% higher than normal concrete. When other factors such as cost of vibrators, compaction and finishing is considered the SCC is certainly not a costly concrete for comparable strength. Recent research has shown that the addition of fillers or partial replacement of cement or aggregate or sand or the combination of these helps to make the SCC more economical with increased mechanical properties.*

Keywords- admixtures, compressive strength, flexural strength, flow ability, self-compacting concrete, split tensile strength, super plasticizer, viscosity modifying agent.

I. INTRODUCTION

Concrete is a worldwide essential building material which is an absolutely vital compound of public infrastructure. Self-compacting concrete (SCC) was developed in Japan in early nineties and first developed to overcome the deficiency of the skilled man power and later on formed as an innovative high performance concrete. SCC is a concrete with high workability and it is gained through the use of super plasticizers and viscosity modifying agents which increases the bond between the aggregate and cement matrix. SCC contains high fine content (cement and fine aggregate) that provides a homogeneous mix with less chance to segregation and lower coarse aggregate and water content which reduces the chances for bleeding. The compressive strength of concrete greatly depends upon amount of compaction and homogeneity and placing of concrete requires skilled labours using heavy, energy-consuming, noisy, expensive and sometimes dangerous mechanical vibrators for proper compaction and the properties of SSC helps for mitigating those issues. It also helps in the reduction of dust in the air, saving energy, reduction of voids etc. Workability of the concrete is one of the major attractions regarding SCC. The tests that are usually carried out for finding the workability of Self-compacting concrete are Slump flow test which is used to assess the horizontal flow of the concrete without obstructions, V-Funnel test is used for assessing the flowability, L-Box test also assesses the flow of SCC also the extent to which it is subjected to blocking by reinforcement. U-box test and Fill box tests are the other methods for testing the workability of SCC. In Japan, Sweden, UK etc, the invention of SCC has moved from research level to application level. The Japanese way of preparing the optimum mixture composition of SCC contains a number of steps. First of all the optimum ratio of water to powder is determined. Then there are some criteria that have to be met. The most important of which are that the volume of coarse aggregate should not be more than 50% of the solid volume of the concrete without air, and the volume of fine aggregate should be 40% of the mortar volume, and the particles finer than 0.09mm are not considered as aggregate, but as powder. This calculation leads to a little bit of “excess paste” concrete composition which helps to fill all the holes between the particles which forms like a “lubricating” by which the friction between the particles in the fluid mixture is greatly reduced compared to that of conventional mixtures.

II. REVIEW OF LITERATURES

Divya chopra et al (2015) have studied the strength, permeability and micro structure of self-compacting concrete with replacement of cement by Rise Husk Ash(RHA) as supplementary cementitious material. Tests were carried out for fresh and hardened state for four different mixes. Varying percentages of RHA, from 0, 10, 15 and 20 is added to the concrete as replacement of cement. Workability is increased by incorporating high range water reducer super plasticizer up to 25%. The test result shows that the replacement of 15% RHA shows better workability and up to 33% of strength increased. The strength gradually decreased when RHS increased to 20% but 20% RHA mix showed increase in porosity, but it is still less than the control mix. The study also shows that the porosity decreases with increase in age. The reason is due to the large formation of C-S-H gel, which forms as dense structure and it is showed by XRD and SEM analysis. The replacement of RHA at 15% shows an increase in compressive strength[1].

Burak Felekog lu et al (2006) conducted a study on the effect of water/cement ratio on the fresh and hardened properties of self-compacting concrete. The adjustment of the water/cement ratio and super plasticizer dosage is one of the main key properties in proportioning of SCC mixtures. Several tests such as slump flow, V-funnel, L-box were carried out to determine optimum parameters for the self-compactibility of mixtures. Compressive strength development, modulus of elasticity and splitting tensile strength of mixtures were also studied. Optimum w/c ratio is in the range of 0.84–1.07. Below or above opt level cause blocking or segregation. It has been found that it shows higher splitting tensile strength and lower modulus of elasticity [2].

P.L. Domone et al (2005) conducted an analysis of 11 years of case study about SCC and found a clear majority of 70% of cases used aggregate with a maximum size between 16 and 20 mm and crushed rock or gravel aggregates seemed to depend upon local availability. Nearly about all cases used either a binary blend or ternary blend of Portland cement with additions of all the types used in conventional concrete. Limestone was the most common addition of about 41% of the cases. Approximately half of the cases used a viscosity-modifying agent (VMA) additional to superplasticizer. The case studies have confirmed about the mix proportions that SCC is a wide family of mixes, and there is no unique mix for a given application or set of requirements. This welcomes a considerable scope for the optimisation of mixes to achieve greater efficiency and economy [3].

S. M. Dumne et al (2014) studied about the effect of superplasticizer in fiber-reinforced self-compacting concrete. The result shows that there is an increase in workability with the addition of fly ash (10% fly ash) and also there is a positive increase in the compressive strength with the optimum quantity of fly ash [4].

Kennouche et al (2013) have done a research on formulation and characterization of self-compacting concrete with silica fume. The optimum quantity of silica fume is found to be 15% of the cement and the dosage of the superplasticizer used is chosen after experimental results of fresh concrete tests executed, as L-box and segregation resistance are on concordance with the values recommended by the French association of Civil Engineering. The compressive strength results shows more than 25 MPa for all compositions with a very low porosity. The reason is because of the filler effect of silica fume which is equal to 0.42 less than the normal concrete. The results of rheological test shows the effect of superplasticizers on cement grout flow. The viscosity of the cement pastes is inversely proportional to the percentage of superplasticizer used [5].

Esraa Emam Ali et al (2012) made an experiment on the effect of recycled glass waste, as a partial replacement of fine aggregate and studied the fresh and hardened properties of Self-Compacting Concrete. About 18 concrete mixes were produced with different cement contents such as 350, 400 and 450 kg/m3 with W/C ratio kept as constant as 0.4. Recycled glass used with the proportions of 0%, 10%, 20%, 30%, 40%, and 50%. They have found that the compressive strength, splitting tensile strength, flexural strength and static modulus of elasticity of self-compacting concrete with recycled glass mixtures were decreased with the increase in the recycled glass content. On the other hand, the slump flow increased with the increase of recycled glass content [6].

A. Rajathi et al (2014) have done a research on the experimental study on SCC using glass powder. The study aims to incorporate recycling waste material- glass power as an innovative concrete and used different percentage of glass powder as a partial replacement of cement. They could arrive at conclusions that the addition of glass powder has an inverse impact on the compressive strength and found the average reduction in compressive strength as 6%, 5% and 20% with the addition of glass powder contents of 5%, 10%, and 15% respectively. It also reduces the characteristics such as filling ability, segregation resistance and passing ability [7].

Sakthi Ganesh. G has carried out an investigation on the mechanical and durability properties of SCC. In order to reduce the cement content in the concrete he has introduced fly ash- 15%, 20% and 25% as a partial replacement of cement. Superplasticizer and VMA is used so as to increase the workability of the concrete and the SCC with fly ash is compared with that of conventional concrete for its mechanical properties. Compressive strength, split tensile strength, flexural strength and rapid chloride penetration test have been carried out and found the optimum quantity of fly ash as 15% for the increased mechanical property compared to the other two proportions for SCC [8].

B. H. V. Pai et al (2014) conducted a comparative study of SCC mixes containing fly ash and rice husk ash as supplementary cementing materials in terms of compressive strength split tensile strength and flexural strength. The fresh properties of the concrete is tested as per the EFNARC and got satisfactory results. They have also checked the hardened properties like compressive strength split tensile strength and flexural strength and all the mixes were not satisfactory. They have found that the SCC containing fly ash showed better mechanical properties in the hardened state than that of rice husk ash [9].

Gergely A. Sik et al (2012) emphasised on production scheduling for producing a huge quantity of self-compacting concrete. Therefore scheduling was required so as to mitigate the problem of settlement of the concrete if it is not placed at site before time. The authors would like to optimise the relationship between the production scheduling and the delivery of prefabricated specimens using ALVI software [10].

Gupta A. K. et al (2010) conducted an experiment on the application of foundry sand in self-compacting concrete by replacement of natural sand with foundry sand. This research was done for finding a solution for mitigating the scarcity of natural sand for construction works. Foundry sand was partially replaced from 5% to 60% for natural sand. They have conducted tests for fresh properties as well as hardened properties of concrete. The partial replacement of 20% to 60% shows a magical increase in the compressive strength and found that the strength started reducing with replacement percentage increases more than 60%. The foundry sand contained silica more than 90%. [11]

Yakhlafl et al (2016) conducted a case study of mechanical properties of carbon fibre on reinforced self-compacting concrete. The experimental result shows that the fresh properties like filling ability, passing ability and segregation resistance increases with the addition of carbon fibre and the hardened properties such as split tensile strength and flexural strength also increases with the w/b ratio equal to 0.35. But the compressive strength decreases with the addition of carbon fibre for self-compacting concrete [12].

Belaidi et al (2012) done a research on the effect of substitution of cement with marble powder and natural pozzolana on the rheological and mechanical properties of self-compacting concrete. OPC was partially replaced with different percentages of the marble powder and pozzolana ranging from 10% to 40%. V- flow test, j-ring test, Sieve stability test, and L-box tests were carried out to find out the workability of the fresh concrete and the result shows an increase in workability with the replaced materials. Compression test were carried out at 7, 28, 56 and 90 days and found that the compressive strength of binary and ternary SCC has inverse proportion to the increase in the substitution materials but there found increase in the compressive strength even at 40% at 28 and 90 days with the substitution of marble powder and pozzolana [13].

Dinesh. A et al (2017) conducted an experimental investigation on self-compacting concrete with the partial replacement of cement with silica fume and fly ash. 2.5%, 5%, 7.5%, 10% and 12.5% of silica fume is used and 5%, 10%, 15%, 20% and 25% of fly ash is used as partial replacement. It is found that there is an increase in the workability and hardened properties like split tensile strength and compressive strength for replacement of silica fume and increase in the workability for replacement of fly ash. The workability of concrete when replaced with 5%, 10%, 15%, 20% and 25% of fly ash is increased by 50%, 43.75, 37.5%, 31.25% and 25% respectively and the workability of concrete when replaced with 2.5%, 5%, 7.5%, 10% and 12.5% of silica fume is increased by 12.5%, 18.75, 25%, 43.75% and 50% respectively. The compressive strength of concrete is reduced by 4.55%, 7.44%, 10%, 11.71% and 13.61%, when the cement is replaced with 5%, 10%, 15%, 20% and 25% respectively with the fly ash. The compressive strength is increased by 3.95%, 5.9%, 7.56%, 9.15% and 14.05% when the cement is replaced with 2.5%, 5%, 7.5%, 10% and 12.5% respectively with the silica fume. When the cement is replaced with 5%, 10%, 15%, 20% and 25% of fly ash, the tensile strength of concrete is reduced by 3.65%, 10.48, 16.58%, 26.58% and 31.70% respectively and the cement replacement with 2.5%, 5%, 7.5%, 10% and 12.5% of silica fume increased the tensile strength by 3.65%, 5.12%, 10%, 13.90 and 19.5% respectively [14].

Abbas Al Ameeri (2013) has investigated the effect of self- compacting concrete with the partial replacement by steel fibre. Fresh properties of SCC is found out and obtained that there is a reduction in the workability of fresh concrete. Hardened properties such as compressive strength, split tensile strength and flexural strength increased with the optimum amount of replacement by steel fibre and the optimum percentage ranges from 0.75% to 1% [15].

Dhiyaneshwaran et al (2013) has done a research on durability characteristics of self-compacting concrete with fly ash using VMA and class F fly ash. Glenium B233 was used as super plasticizer and Glenium Stream2 was used as viscosity modifying agent (VMA) for the self-compacting concrete. The water-powder ratio of 0.45 is used throughout the research. He has studied the workability and durability of concrete and concluded that the dosage of super plasticizer and workability has a linear relation. From his results, compressive strength of concrete was decreased when the amount of fly ash is increased and it also showed that with increase in fly ash, water absorption percentage decreases [16].

Selvamony. C et al (2009) conducted a study on Development of high strength Self-compacted Self-curing with mineral admixtures and found out the effect of replacement of the cement by limestone powder with silica fume, coarse aggregate by quarry dust and fine aggregate by clinkers and various proportions on the properties of SCC was compared. It was found that silica fume improved the mechanical properties of SCC, but lime stone powder with quarry dust affected mechanical properties of SCC adversely. As a conclusion for the test result a maximum of 8% of lime stone powder with silica fume, 30% of quarry dust and 14 % of clinkers was able to be used as a mineral admixture without affecting the self-compactability of the concrete [17].

Ahmed Fathi et al (2013) done research on the effectiveness of the different pozzolanic material such as fly ash , silica fume and microwave incinerated Fly Ash as cement replacement material on self-compacting concrete and studied the effect of the mechanical and fresh properties of self-compacting Concrete (SCC). The result showed that the microwave incinerated Fly Ash required more water comparing to silica fume to achieve the same fresh properties, similarly concrete with 5% silica fume showed 9.70% higher compressive strength after 90 days, which is 5.10 MPa high tensile strength and 10.12 MPa high flexural strength while comparing to other mixes. 5% silica fume and 30% Fly Ash mixes showed highest compressive strength as compare to the control mix. Silica fume needs less water demand comparing to microwave incinerated Fly Ash for achieving the same fresh properties [18].

III. CONCLUSION

The concept of SCC has established itself as an innovative concrete and also confirmed itself as a revolutionary step forward in concrete technology. Generally SCC has a positive effect on the mechanical properties especially with the addition or partial replacement of cement or fine aggregate by the admixtures. In the case of using two or more admixtures in SCC, experimental mixtures is used to find out the optimum proportion of the components. Most of the cases used superplasticizer and viscosity modifying agent for increasing the workability of the concrete in the fresh state. The maximum size of coarse aggregate ranges from16-20mm. Result from the reviews show that the industrial by-products and waste products can be utilized for increasing the properties of the concrete both in fresh state as well as in the hardened state. It also helps in increasing the durability of the concrete.

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