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A Review on Self Compacting Concrete

P.Kannan[1], C.F.Jerin[2], Dr.K.Murali[3]
[1](P.G. Student CE&M, Sri Ramakrishna Institute of Technology, Coimbatore, India)
[2](Assistant Professor, Department of Civil Engineering, Sri Ramakrishna Institute of Technology, Coimbatore, India)
[3](Professor, Department of Civil Engineering,Sri Ramakrishna Institute of Technology, Coimbatore, India)

ABSTRACT: Self compacting concrete was first developed by Okamura in Japan in 1980. Significant research on self compacting concrete with regard to identification of mix proportions and properties for different applications was carried out around the world. The paper mainly focuses on the mix proportions by partial replacement of cement and fine aggregate by various eco friendly materials and to critically review the mechanical properties of self compacting concrete. It was observed that fine materials improve the properties of self compacting concrete at low water binder ratio and addition of super plasticizer.
Keywords: Durability, Filler material, SCC, Strength, Viscosity modifying agent.

I. INTRODUCTION

Concrete is an artificial conglomerate stone made essentially of Portland cement, water, fine aggregate and coarse aggregates. The mixture of the materials results in a chemical reaction called hydration and a change in the mixture from plastic to a solid state occurs over a period of time. Currently India has taken a major initiative on developing the infrastructures such as express highways, power projects, industrial structures, metro rail systems, etc., to meet the requirements of globalization, in the construction of buildings and other structures concrete plays a vital role and a large quantum of concrete is being utilized. The durability of concrete plays a vital role in the infra structure development. To construct durable concrete structures, satisfactory compaction by experienced workers is required. Nowadays, the quality of construction work has a drastic change due to gradual reduction of skilled workers in construction industry. The solution to attain durable concrete is the employment of self compacting concrete, which can be compacted into every corner of a formwork, purely by means of its own weight and without the need for vibrating compaction [1]. The necessity of this type of concrete was proposed by Okamura in 1986. Studies to develop selfcompacting concrete (SCC), including a fundamental study on the workability of concrete, were carried out by Ozawa and Maekawa at the University of Tokyo [1].Therefore, the objective of this paper is to review the study of Self Compacting Concrete containing innovative material and to compile them in such a way that it would be beneficial for selection of best material.

II. REVIEW OF LITERATURE

Kosmas et al (2015) replaced ladle furnace slag, a byproduct of steel making process as filler material for the production of self compacting concrete mixtures of different classes. Seven different self-compacting concrete mixtures SCC 25-30 LF, SCC 25-30 LFS 15%, SCC 25-30 LFS 25%, SCC 30-37 LF, SCC 30-37 LFS 15%, SCC 30-37 LFS 25% and SCC 35-45 were produced. Ladle furnace slag was used as an alternative filler material replacing aggregates in four SCC mixtures at percentages of 15% and 25% per weight of cement. Ladle furnace slag is a fine material with 100% passing the 96 μm sieve and 95% passing the 45 μm sieve. High range water reducing carboxylic ether polymer admixture was added at different dosages in order to achieve self compactibility in the case of SCCs. It was observed that addition of LFS improved the fresh properties of SCC mixtures resulting this way to reduction of the super plasticizer amount needed in C25/30 SCC mixtures, compressive strength of SCC25/30 mixtures was slightly increased at later ages when LFS was used. The effect on strength increase was more significant in SCC30/37 mixtures where higher dosages of LFS were added. Durability properties of LFS SCCs were improved especially in mixtures produced with higher amount of LFS and lower w/c ratio. Both carbonation and chloride resistance were increased. This increase was more essential in SCC30/37 mixture produced with 25%LFS where both durability indicators found to be equal with the values measured on SCC35/45 mixture[2].

Mohamed et al (2010)carried out an experiment of self compacting concrete with the addition of micro-cellulose fibres in SCC. It is obtained from the recycled paperboard. It is used in the production of SCC with six different fibre volumes V_f 14%, 21%, 28%, 41%, 83% and 138% and a normal SCC is designed and tested. Limestone is used as a filler material and to improve the fresh state of concrete super plasticizer are added in it. The packing factor of solid component mixture is prepared without fiber and with fiber is tested. The compressive strength increases due to addition of fiber content by volume of about 21%, due to homogeneity and high compaction between the fibers and the cement matrix. If fiber content exceeds to 41% the compressive strength and the density are remarkably reduced. Concrete Equivalent Mortar (CEM) method of design is induced and addition of fibre content of about 21% by volume of cement shows good result in compressive strength up to 25%. At the addition of 41% fiber content showed a reduction of about 5% compressive strength compare to the non-fibered one. Incorporation of cellulose micro fibre decreases super plasticizer dosage reduce the density of the concrete[3].

Divya chopra et al (2015) carried out a study on strength, permeability and micro structure of self compacting concrete containing Rise Husk Ash. The cement is replaced by Rice husk ash (RHA) as supplementary cementitious material. SCCwas tested for fresh and hardened state for four different mixes. The rice husk ash is replaced by cement by varying percentages from 0, 10, 15 and 20. To improve the workability high range water reducer super plasticizer is used up to 25% without loss of workability. By the replacement of 15% RHA shows good workability and up to 33% of strength increased. The replacement increased to 20% the strength decreased but 20% RHA mix shows increase in porosity, but it is still less than the control mix. In this study porosity decreased with increases in age. This is basically due to large formation of C-S-H gel, dense structure is formed, so porosity decreased. From XRD and SEM analysis shows the formation of C-S-H gel at the replacement of 15% RHA concrete helps increase in compressive strength. Pores and cracking were at maximum for the control mix. The most dense structure was observed for 15% replacement with RHA which resulted in the highest compressive strength for the mix [4].

Andreas Leemann et al (2007) carried out a study on the effect of viscosity modifying agent (VMA) on mortar and concrete used to obtain the flow properties and the rheology is studied. Mainly VMA is used in the SCC to obtain the free flow without any segregation. Inorganic VMA micro silica (MS) and nano silica slurry (NA) and organic VMA high molecular ethylenoxide derivate (EO), Natural Polysaccharide (PS), starch derivate (ST) are used. These are combined with Super plasticizer (SP) for varying water binder ratios (w/b) are tested. While addition of VMA and SP shows the marginal difference in flow properties and rheology. The organic VMA MS and NS and the organic VMA to show a bigger gradient and VMA PS (0.4% and 0.8%) and ST a smaller gradient than the mix without VMA. PS causes the strongest increase of yield stress and MS the lowest. Combination of VMA and SP shows the improvement in compressive strength at the age of 28 days. Variation of w/b, the addition of SP and VMA all change flow properties and rheological properties in a different way. The in organic VMA cause an acceleration of hydration and higher compressive strength[5].

Erdogan Ozbay et al (2008) carried out an investigating mix proportion of high strength self compacting concrete (HSSCC) by using Taguchi Method. The experiment shows the HSSCC by replacing the cement by fly ash in various stage by15%, 30% and 45%. It is used as a filler material and coarse aggregate is replaced by crushed lime stone and crushed sand. To improve the fresh property super plasticizer is used. For this experiment Eighteen (18) different mixeswere designed and tested for fresh and hardened properties of concrete. HSSCC is analysed by using the Taguchi's experiment design. In this method level of mix proportions are determined by Ultra Pulse Velocity (UPV).Various test are carried out for fresh and hardened concrete were Slump flow and V funnel test; UPV, compressive strength and split tensile tests. It was observed that design mix M10 (1:1.5:1.9)shows better improvement in compressive strength and M18 (1:2.1:1.8)in split tensile strength. The design mix confirming to M10 and M18 satisfies the high strength self compaction concrete [6].

Ali Abd-Elhakam Aliabdo et al (2012) carried out an experimental study on polymer modified concrete self compacting concrete (PMSCC). Two different polymers,styrene butadiene rubber (SBR) and polyvinyl acetate (PVC) are used in this experiment in different dosage from 0%, 5%, 10% and 15% in the production PMSCC and was compared with traditional concrete and self compacting concrete. The filler material used in this experiment is Lime powder and Silica fume. To increase the flow properties super plasticizer namely, naphthalene and modified polycarboxylic ether were used for the production of SCC. The flow test is conducted on a constant 70 cm diameter of concrete for 12 different mix designs. The comparison is tested between SBR and PVC in PMSCC and SCC. From the results it was observed that, at 90 days compressive strength of PMSCC is 25% higher than the self compacting concrete. Lime powder and Naphthalene based chemical admixture shows amarginal improvement in compressive strength, mechanical properties and bond strength. The use of polymer decrease the degree of hydration of cement [7].

Kannan et al (2013) carried out an experiment of chloride and chemical resistance of self compacting concrete using Rice Husk Ash (RHA) and Metakaolin (MK) as filler materials and replacement of cement. Seventeen different mixes for various proportions were designed including ordinary SCC and tested for suitability. The percentage replacement of RHA and MK adopted in this study were 5%, 10% 15%, 20%, 25% and 30% in separate and combined percentage replacement of RHA and MK were 5%, 10%, 15% and 20% with the addition of super plasticizer (SP). The fresh state is tested for all mix and the flow properties are observed. From the results it was observed that compressive strength increased at a replacement of 15% (RHA), 20% and 30% (MK) in combination of both. The durability test to determine the acid resistance is carried out by immersing the cube in H_2SO_4 solution, the result shows that there is a better improvement during individual replacement of RHA and MK at 25% and 5% respectively and 40% of combination of RHA and MK.The SEM analysis clearly states that there were no pores while RHA and MK are combined together [8].

Edwin Fernando et al (2014) carried out an experimental investigation on self compacting concrete by replacing the fly ash as a filler material and copper slag as fine aggregate at a percentage of 5%, 10%, 15%, 20% and 25%. Mix design is done as per EFNARC specification by keeping water cement ratio of 0.40 all mix and super plasticizer was used to increase the flow properties. The fresh and hardened properties of concrete was tested as per the standards and compared for normal SCC and SCC with partial replacement of fly ash and copper slag. The result shows a marginal improvement in the replacement of cement by fly ash up to 40% [9].

Nileena et al (2014) replaced the Ground Granulated Blast Furnace Slagand Granulated Blast Furnace Slag as filler material by the water cement ratio of 0.45. Six different mix proportions were prepared with a partial replacement of cement by GGBS at 30%, 40% and 50% and GBS at 30%, 40% and 50% as partial replacement of fine aggregate. . Super plasticizer is used to achieve the selfcompactibility. The standard tests for fresh and hardened concrete was carried out and it was observed that only a small increase in compressive strength was achieved for 20% partial replacement of GGBS and GBS. But, ultrasonic pulse velocity shows an excellent result that there is no crack or undulations inside the specimen [10].

Nageswararao et al (2015) replaced the fine aggregate by crushed stone dust (CSD) and marble sludge powder (MSP) in various proportions in combination. Six mix deignswere prepared by partial replacement of CSD and MSP at 0%, 20%, 40%, 60%, 80% and 100%. Super plasticizer is added in various ratios 0.35, 0.3 and 0.25 to obtain the flow properties. The fresh and hardened concrete (Compressive strength, Split tensile strength and Flexural strength) properties show good results at a partial replacement of MSP (60%) and CSD (40%) with lower water content. However, the durability results are not comparable with normal self compacting concrete. Self compacting concrete can be achieved by low water cement ratio with addition of super plasticizer [11].

Shriram et al (2013) carried out an experiment on mineral admixture and hardened properties of self compacting concrete by partial replacement of cement by cement kiln dust (CKD). CKD is the waste product from the production of cement. Four mix designsare prepared by varying percentage (10%, 20% and 30%) of replacement including normal SCC along with addition of super plasticizer in order to obtain the flow properties and workability. Flow properties are determined as per EFNARC guidelines, to fix the water powder ratio. Flow properties show a better improvement up to 20% partial replacement of cement by CKD and decreased above 20% replacement. An increase of 2% was observed in compressive strength at a partial replacement of CKD at 20%, whereas the split tensile strength and flexural strength shows a slight marginal increase of 3% compared to normal SSC [12].

Srivastava et al (2012) carried an experiment of addition of silica fume as a filler material to concrete in various stages. Cement is partially replaced by silica fume in varying proportions as per the mix design. The addition of silica fume increases workability, strength and durability, as well as resistance to cracks are improved. It was observed that there is an increase in compressive strength from 6% to 57% during partial replacement of cement by silica fume. Addition of silica fume improves the bond strength of concrete; however, modulus of elasticity of silica fume in concrete shows a similar result to that of conventional self compacting concrete [13].

Attar et al(2010) carried out an experiment on replacement of natural sand by foundry sand in self compacting concrete. The scarcity of natural sand diverted the researchers for a better alternative; in this view foundry sand is replaced as fine aggregate. Foundry sand is partially replaced from 5% to 60% for natural sand and tested for various fresh and hardened properties of concrete. The silica content in the foundry sand was observed to be more than 90%. The compressive strength result shows a marginal increase at partial replacement of 20% to 60%, however, the strength decreases if replacement percentage exceeds 60% [14].

Siddique et al (2013) carried an experiment of foundry sand in SCC by the partial replacement of natural sand. To identify various mix proportions of SCC by partial replacement of fine aggregate by foundry sand at 0%, 10%, 15% and 20% is calculated using mix design by considering water powder ratio as 0.47 and that of 0.8% of super plasticizer. From the results it was observed that, compressive strength increases by 35.14% (28 days) and 24.94% (56 days) for a partial replacement of 15% when compared to control mix. Rapid chloride permeability result shows 15% replacement of foundry sand gives better effect to internal pore structure of concrete as filler material [15].

Bertil et al (2001) carried out an experimental and numerical study on mechanical properties such as strength, elastic modulus, creep and shrinkage of SCC and the corresponding properties of normal compacting concrete. The study includes eight mix proportions of sealed or air-cured specimens with water binder ratio (w/b) varying between 0.24 and 0.80. Fifty percent of mixes were self compacting concrete and rest were normal cement concrete. The result indicates that elastic modulus, creep and shrinkage of SCC did not differ significantly from the corresponding properties of normal cement concrete [16].

III. CONCLUSION

- The concept of self-compacting concrete has established itself as innovative material in the area of concrete technology.
- The general procedure of mix design can be adopted for self compacting concrete for various applications based on experiences in identification of suitable mix proportion. The increase in fine material increases the suitability of self compacting concrete.
- The partial replacement of cement and fine aggregate with finer material exhibit self compacting concrete with low segregation potential.
- Self compacting concrete with mineral admixtures shows satisfactory results.
- The research focus on viscosity agent and the interaction with super plasticizer is worthwhile in self compacting concrete.

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