Review Article Impact Factor: 4.226 ISSN: 2319-507X
Yamini J Patel, IJPRET, 2015; Volume 4 (2): 73-86 IJPRET

INTERNATIONAL JOURNAL OF PURE AND APPLIED RESEARCH IN ENGINEERING AND TECHNOLOGY

A PATH FOR HORIZING YOUR INNOVATIVE WORK

SELF COMPACTING CONCRETE: A REVIEW

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Accepted Date: 26/09/2015; Published Date: 01/10/2015

Abstract: - This paper presents a review on the sustainability in building construction, environmental protection with respect to construction industry. This paper gives an idea of Self-Compacting Concrete (SCC) and various industrial, Agricultural and demolition wastes materials for sustainability. SCC has significant environmental advantages in comparison to the normal vibrated concrete. Production of concrete without vibration reduces the noise pollution and provides a healthier working environment. This paper presents a review on the potential for usage of self-compacting concrete with different types of industry-agro waste materials and chemical admixtures as addition in concrete mix. As per the study a wide range of wastes and admixtures were used for production of SCC. Such Innovative waste materials are generally used for partial replacement of cement or sand or aggregate or combination of two or more. They may be used as additional filler to enhance the physical and mechanical properties of the SCC. The compressive strength is considered the most important factor on comparison with original mixes without any addition as well as the microstructure characterization. However, the production of SCC always contains powerful super plasticizer and viscosity-modifying admixture that were necessary. The paper also reviewed the application of admixture and their performance on quality and their effect on fresh and hardened properties. The results showed the feasibility of using industry-agro waste materials in SCC mixes and indicated the most influence on the workability and long-term performance. The aim of the paper is to compile the recent innovations in SCC, study their effect on the properties of SCC and establish an international benchmarking for further research work in this regard.

Keywords: Self Compacting Concrete, Rice Husk Ash, Super plasticizer, Deformer, Silica fume, Quarry Dust Powder

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Access Online On:

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How to Cite This Article:

Yamini J Patel, IJPRET, 2015; Volume 4 (2): 73-86

PAPER-QR CODE

INTRODUCTION

The demand of Self Compacting Concrete (SCC) is growing rapidly due to the shortage of skilled labors for which it was originally developed mainly due the work of Okamura [1]; it is also proved to be more economical, durable and termed as high performance concrete [2]. The advantages of SCC make this concrete more desirable all over the world which includes faster construction, reduces manpower, better finishes, easier placement, better durability, thinner concrete sections, lesser noise levels, no vibration, and safer working environment [3]. The Concept of SCC originates from Japan in 1980s and the early developed Super Plasticizers were the main reason which made it possible to flow and self consolidate. The use of SCC is rising steadily over the years because of their advantages and many scientists and organizations carried out research on properties of SCC [4]. Self-compacting concrete can be classified as an advanced construction material in current scenario. It does not require to be vibrated to achieve full compaction. SCC consists basically of the same constituents as a normally vibrated concrete. However, there is a clear difference in the concrete composition. It requires a higher proportion of ultra fine materials and the incorporation of chemical admixtures, particularly an effective high range water reducer [17].This offers many benefits and advantages over conventional concrete. These include an improved quality of concrete and reduction of on-site repairs, faster construction times, lower overall costs, facilitation of introduction of automation into concrete construction. An important improvement of health and safety is also achieved through elimination of handling of vibrators and a substantial reduction of environmental noise loading on and around a site. The composition of SCC mixes includes substantial proportions of fine-grained inorganic materials and this gives possibilities for utilization of mineral admixtures, which are currently waste products with no practical applications. [5]

SCC consists of almost same constituent materials as conventional concrete, which are cement, aggregates, water and with the addition of super- plasticizer and mineral admixtures in different proportions. Usually, the chemical admixtures used are high-range water reducers HRWR and viscosity-modifying agents VMA, which change the properties of concrete. Mineral admixtures are used as an extra fine material, besides cement, and in some cases, they replace cement. However, high volume of super-plasticizer for better workability, the high powder content as “lubricant” for the coarse aggregates, as well as the use of viscosity-agents to increase the viscosity of the concrete have to be taken into account. There is a no. of materials such as fly ash, silica fume, iron slag, plastic waste, tyre rubber waste, granite powder, marble powder, quarry dust powder, recycled concrete aggregates, super plasticizers and admixtures are recently used. The aim of this research paper is to review the latest innovations in the field of SCC containing innovative material and to compile them in such a way that it would be beneficial for selection of best material.

2.0 SELF COMPACTING CONCRETE USING DIFFERENT MINERAL ADMIXURES

2.1 SCC using fly ash, silica fume, slag: Many experiments have been carried out by the researcher on properties of self compacting concrete containing fly ash, slag and silica fume. Neelam Pathak et al. [6] conducted experimental study to study the properties of Self-Compacting-Concrete with (class F fly ash ranging from 30% to 50%) and without fly ash. The property investigated were compressive strength, splitting tensile strength, rapid chloride permeability, porosity, and mass loss when exposed to elevated temperatures. The variables were the temperature effects (20 LC, 100 LC, 200 LC, and 300 LC) using Ordinary Portland Cement. Test results showed little improvement in compressive strength within temperature range of 200–300 LC as com-pared to 20– 200 LC but there were little reduction in splitting tensile strength ranging from 20 to 300 LC and with the increase in percentage of fly ash. Heba A Mohamed [7] conducted experimental study on SCC under three curing conditions at 7 and 28 days curing under water and 28days curing in air with three types of mixes first with different % of fly ash, second with different % of silica fume and third with different % combinations of fly ash and silica fume. The experimental result showed that SCC with 15 % of silica fume shows high compressive strength than those with 30% of fly ash and water cured specimens for 28 days give higher compressive strength. The maximum compressive strength was found to be 5 MPa for SCC with 15 % SF. The maximum compressive strength was found to be 5 MPa for SCC with 15 % SF. Yuan Chen et al. [8] studied the effect of paste amount on the properties of SCC containing fly ash and slag. Results of SCC containing fly ash and slag under different water to binder material ratio and different cement paste were compared. Less the cement paste amount as well as the denser the blended aggregate, the lower the early age compressive strength and higher the long- term compressive strength becomes. For good quality concrete the amount of cement paste and water should be minimised for as low as possible to obtain the high ultrasonic pulse velocity. Krishna Murthy N et al. [9] designed a simple tool for SCC with high reactive metakaolin and fly ash as an admixture for cement replacement. They provide detailed steps for mix design with 29% of coarse aggregate with three cement replacement ratio 5-20%(by MK), 10-30% (by FA) and different % combination of MK+FA. Raharjo D et al. [10] experimented the composition of SCC containing fly ash, silica fume and iron slag. Using Optimal Composition SCC were prepared with silica fume (0-20% of fly ash weight) and super plasticizers of 0.5 -1.85 of cement weight and each composition tested by slump cone, L-box and V-funnel apparatus to meet the requirements of SCC. Hardened cylindrical specimens were prepared and tested at the age of 3, 7, 14, 28 and 56 days. Authors provide a formula for optimal composition. Ahmed Ibrahim et al. [11] studied relationship between high strength self compacting concrete and macroscopic internal structure. The maximum compressive strength was recorded 81.17 MPa that resulted from replacing the cement by 70 % slag. Mixes with high volume cement replacement up to 70% by slag, fly ash and silica fume were used. Image of internal structure of high strengths self compacting concrete cylindrical specimen of a flat bed digital scanner were analysed by iPas software. The result showed good correlation between HSSCC macroscopic structure and compressive strength. For hardened properties all mixes showed superior performance as compared to the control mix (basic mix with 0 % replacement). The maximum compressive strength was recorded 81.17 MPa that resulted from replacing the cement by 70 % slag. Rafat Siddque et al. [12] investigated the compressive strength of SCC containing bottom ash using Artificial Neural Network. Two models developed with input parameters as material and output parameters as compressive strength. First (ANN-I) to predict 28 days compressive strength through ANN technique using data from literature and second (ANN-II) developed experimentally for SCC containing bottom ash as partial replacement of sand. Result showed that model developed from literature data could be easily extended to the experimental data with some modifications. P. Ramanathan et al. [13] investigated compressive, flexural and split tensile strength of self compacting concrete by replacing Silica fume, Fly ash, and Blast furnace slag by 30%, 40% and 50% for Portland cement. The Blast furnace slag series had a good workability properties compared to Fly ash and Silica fume series. The use of mineral admixtures improved the performance of self-compacting concrete in fresh state and also avoided the use of viscosity modifying admixtures. Higher compressive strength has been obtained for Silica fume series. In the case of fly ash and blast furnace slag, filling of the voids between the larger cement particles, and increasing production of secondary hydrates by pozzolanic reactions with the lime resulting from the primary hydration enhances compressive strength.

2.2 SCC using different types of admixtures and super plasticizers

Ali Mardani-Aghabaglou et al. [14] experimented the effect of four different types of Superplasticizer with same main chain and same polymer structure but different molecular weight and different side chain groups on fresh, rheological and strength properties of SCC. The result showed that V-funnel flow time, plastic viscosity and slump retention of SCC mixtures were affected by the side chains density of polymer considerably. All the mix satisfied the desired slump (730+ 10 mm). V-funnel time decreases with increase in SP dosage. All the mix satisfied the desired slump (730+ 10 mm). V-funnel time decreases with increase in SP dosage. Minimum time V- funnel time was found 27 seconds for mix D with 1.67 % dosage of SP. The mix with 1.33% SP and with 1.67% did not satisfy the lower limit 0.80 by EFNARC guidelines. It was also concluded that SCC mixtures also influenced by the type super plasticizers at early ages. Mary Barfield et al. [15] investigated effect of three slump flows (559mm, 635mm and 711mm) and four admixture on the fresh properties of air entrained SCC. Various mixes were prepared by varying dosage of admixtures like HRWR (high range water reducing admixture), VMA (viscosity modifying agent) and AEA (air entraining admixtures). Result showed significance difference between admixtures with similar chemical composition, it was found that the slump flow of SCC decreased stability and air void characteristic. MA Baoguo1 et al.[16] experimented the rheological properties of SCC cement paste containing chemical admixtures (CA) such as polycarboxylate-based superplasticizer (PCE), air-entraining agent (AE) and deformer (DF) were investigated. For PCE paste, as the dosage of superplasticizer increases, the yield stress and the plastic viscosity improve in the range up to 0.12wt% PCE. For two components systems, the yield stress and the plastic viscosity are decreased and increased respectively in accordance with an increase of AE in the PCE-AE system. In the PCE-DF system, the yield stress is slightly decreased compared with the sample without DF. For the three components systems, the rheological properties were improved compared with the two components system. In the PCE-AE-DF system, the AE did not influence so significantly for increasing the yield stress and the plastic viscosity. The higher components system showed better rheological parameters than the lower components system.

2.3. SCC using different filler additives

H. A. F. Dehwah et al. [17] experimented mechanical properties of SCC containing fly ash, silica fume and quarry dust powder. Trial mixes were prepared with only fly ash, only quarry dust powder (QDP) and combination of silica fume and quarry dust powder. Tests were conducted for compressive strength, split tensile strength, flexural strength and homogeneity by ultra-sonic pulse velocity test. SCC incorporating QDP (8-10%) showed better performance as compared to other two categories of trial mixes. At 8% QDP shows highest tensile strength. Compressive strength and sound velocity increased linearly with age up to 28 days. The maximum value of compressive strength and sound velocity was noted in 8% QDP while the minimum value of these two properties was noted in 8% ODP+5% SF. Muceteba Uysal [18] experimented to evaluate the performance of SCC at elevated temperature 200^0 C, 400^0 C, 600^0 C and 800^0 C at the age of 56 days. Portland cement is replaced by lime stone powder (LP) basalt powder (BP) and marble dust powder (MP) in various proportions. Severe strength loss for all SCC mixture after exposure to 600 ^{0}C. Lower residual strength was observed at higher level replacement. It was observed that at higher replacement ratio of LP, BP and MP the weight loss were also high. Lime stone powder (LP) showed higher weight loss as compared two BP and MP. For 200 to 400 C decrease in compressive strength was observed 16-23 % of original strength. At 400 to 600 C strength loss was within range of 47-53 %. At 400 to 600 C strength loss was within range of 47-53 %. BP series performed better as compared to other two series. At 600 to 800 C the average loss was 78 %. At this temperature all series experienced extensive cracking and spalling and their residual strength was less as compared to control mix. Mayur B. Vanjare et al. [19] used glass powder (GP) in different percentage for partial replacement of cement for production of SCC. The paper presents the ingredient of these mixtures (Glass powder, fly ash, super plasticizer, cement) by examining their specific role in SCC. Various properties of the glass powder integrated SCC mixes such as self compactability, compressive strength, and flexural strength were evaluated and compared with those of conventional SCC. As per result the addition of glass powder in SCC mixes reduces the self compactability characteristics like filling ability, passing ability and segregation resistance. The compressive strength and flexural strength of SCC with the glass powder also decreases. L. García et al. [20] carried out experiment of the robustness of a SCC made with VMAs and with high limestone filler content and less cement. Mechanical Properties were compared with commercial SCC, Three types of SCCs were prepared with water/cement (w/c) = 0.6 produced with water contents varying between −7.5% and 7.5%.

A linear regression model from the experimental data for calculating water-content variation in concrete that satisfies certain robustness requirements was prepared. The results show that variations in flow ability and compressive strength due to changes in water content were very similar in the three concrete types. When filler was replaced by VMA, the material's cohesive properties like viscosity and segregation resistance showed improvement. It was also concluded that segregation resistance and compressive strength do not play a significant role in the robustness of SCC under consideration. M. Nepomuceno et al. [21] experimented comparative performance for lime stone powder, fly ash, granite filler and micro silica in different % with binary and ternary blends of powder materials. V Corinaldesi et al. [22] investigated several concrete mixtures using lime-stone powder , fly ash and recycled aggregate powder as mineral addition in the presence of an acrylic based super plasticizer with a dosage ranging from 1% to 2% by weight of very fine material fraction (maximum 150 lm). The fresh properties were evaluated through slump flow, L-box test and segregation resistance. Compressive strength of concrete was determined at 1, 3, 7 and 28 days of wet curing. Results showed that an optimization of SCC mixture seems to be achievable by the simultaneous use of rubble powder and coarse recycled aggregate with improved fresh concrete performance and unchanged concrete mechanical strength.

2.4. SCC using plastic waste

Utilization of plastic waste to mortar and concrete is very common and a lot of investigation has been conducted to evaluate the performance characteristic of the plastic concrete. Choi et al. [23] experimented to study the effect of plastic waste in the form of PTE bottle as aggregate on proper- ties of concrete. Bacharach et al. [24] used plastic waste as partial replacement of sand in concrete. It is concluded that 20% substitution of sand can reduce compressive strength up to 70% as compared to normal concrete. [25, 26, 27 and 28] used consumed plastic bottle for sand substitution within composite materials for building application. Brahim Safi et al. [29] used plastic waste 0 to 50% for sand replacement in self compacting rubberized mortar and investigated that the effect on physical and mechanical properties. Porosity and water absorption decreases up to 30 % sand replacement by plastic waste after that slight increase was observed. The mortar with 50 % of plastic waste gives better results than other proportion of the waste. Reduction in compressive strength was observed 15% and 33 % at 30 % and 50 % sand replacement respectively. Slight increase in flexural strength was observed after age of 28 days.

2.5. SCC using fibers

R Deeb et al. [30] Experiment was carried to study to develop Self Compacting Concrete with high ultra performance concrete with and without steel fibers. Ten deferent mixes were prepared and tested to meet the SCC requirements. As per Results 30 mm long 0.55 mm diameter steel fibers with crimped ends increases the viscosity of SCC mixes with fibers. Mixes with fibers meet the flow ability criteria and resistance to segregation. Significant improvement in the performance with addition of fibres. However practically it was observed that mixes 0% and 0.5 % fibers satisfied the flowability criteria and no signs of segregation to ensure that they were able to pass through narrow gaps between reinforcing bars. In M-4 some blocking was found. The bulk of fibers and coarse aggregate lumped in the centre of flow spread. M. Pajak et al. [31] concluded the flexural behavior of SCC reinforced with straight and hooked end steel fibers at levels of 0.5 %, 1.0 % and 1.5 %. All mixes satisfy the T-50 time. Highest slump flow was found at 0.5 % addition of fibres (both straight and hooked end). SCC reinforced with hooked end fiber showed higher strength and maximum compressive strength found was 98.20 MPa at 0.5 % addition of hooked end steel fibers. The flexural strength also increases with increase in fiber content. The maximum flexural strength found was 8.31 MPa at 1.5 % addition of hooked end steel fibres. Results were compared with NVC. On the basis of result obtained they proposed equation to predict the deflection- CMOD relationship of SCC and NVC. SCC achieves the maximum crack mouth displacement for lower deflection than NVC. Also developed a formula to describe fracture energy of SCC. Valeria Corinaldesi et al. [32] prepared self-compacting concretes mixes using three different types of fibers made of steel, high toughness polypropylene (PPHT) and poly-vinyl-alcohol (PVA) and two different types of mineral addition, limestone powder and powder from recycled concrete. As per Result, the use of recycled-concrete powder instead of limestone powder for producing SCC seems to be promising, particularly for fresh concrete flow ability. The mixture containing PVA fibers and recycled concrete powder showed best performance. SCC with steel fibres showed superior performance for flexural strength and SCC with PPHT and PVA fibres showed reduced strength compared to steel fibers.

2.6 SCC using recycled concrete aggregate

Christos G. Fakitsas et al. [33] carried out experimental study on SCC using natural rock aggregate (NR-SCC) and recycled concrete aggregate (RC-SCC). All mixes were found to be highly flowable and stable. The result showed superior compressive and frictional characteristics of RC-SCC, indicating the beneficial effects of internal curing. The unconfined shear strength of NR-SCC was found to be superior to that of the RC-SCC. The higher shear strength of the natural rock aggregate responsible for superior unconfined shear strength of the NRSCC. K C Panda et al. [34] investigated properties of self compacting concrete using recycled concrete aggregate for M-25 grade of concrete. NA was replaced by RCA in various 10%, 20%, 30%, and 40%. Result showed that compressive strength, flexural strength and split tensile strength of SCC containing RCA is less than NVC and these strengths decreases with increase in the amount of RCA. Mix with 30 % of RCA in SCC gives desirable characteristic strength. RCA show higher water absorption compared to conventional NVC. Kou et al. [35] and Grdic et al. [36] investigated Mechanical properties of SCC prepared with recycled concrete aggregates. Fonseca et al [37] investigated the influence of curing conditions on the mechanical properties of concrete using recycled concrete wastes. Uysal et al [38] investigated effect of mineral admixtures on properties of SCC. Zhao et al [39] and Uysal [40] investigated the effect of coarse aggregate gradation and type on the properties of SCC.[S.C. Kou et al. [41] investigated the fresh and hardened properties of self-compacting concrete (SCC) using recycled concrete aggregate as both coarse and fine aggregates. 100% coarse RCA was used and rivers sand was replaced by 0, 25, 50, 75, 100 % with fine RCA. Two mixes were prepared with 0.53 and 0.44 W/B ratio. Also mix was prepared using 100% Coarse and Fine Aggregates with 0.44, 0.40, 0.35 W/B ratio. Class F-Fly ash was used as binder and R-Fly ash was used as filler. It was concluded that, Slump flow and blocking ratio increases with increse in fine RA with the f-fly ash.The maximum compressive and tensile splitting strength were achieved by using 25–50% fine RA. (iii) Resistance to chloride ion penetration increases with Increase in RA and with decrease in the W/B ratio from 0.44 to 0.35.Drying shrinkage increases with increase in RA.H.A.F. Dehwah conducted to evaluate the mechanical properties of self-compacting

Concrete (SCC) prepared using quarry dust powder (QDP), silica fume (SF) plus QDP or only fly ash (FA). Mix were prepared with 8% QDP and w/cm ratio of 0.40, 0.38, 10% QDP and w/cm ratio of 0.40., 8% QDP plus 5% SF and w/cm of 0.40, mix with 8% QDP and w/cm ratio of 0.38.0.Results shows that The compressive strength and pulse velocity of SCC specimens prepared with only QDP were more than those incorporating SF plus QDP or FA alone. The maximum compressive strength and maximum pulse velocity, split tensile and flexural strength were noted in 8% QDP and w/cm ratio of 0.38 specimens while the minimum was noted in mix with 8% QDP and w/cm ratio of 0.38.

3.0. DISCUSSION

With respect to the fresh and hardheaded properties studied, the use of tyre rubber waste and plastic waste for sand replacement has positive effect on fresh SCC. Hardened property such as compressive strength and flexural strength reduces with increase in percentage of replacement. Use of fly ash, silica fumes and iron slag has positive effect on both fresh and hardened properties. SCC prepared with fly ash, silica fume and iron slag in various combinations satisfies the requirement of SCC. Addition of the material results in increase in compressive strength. Addition of steel fibers results in reduced slump flow which can be increased by increasing the amount of super plasticizers. Using steel fibers it is possible to produce high strength and ultra high strength SCC. Regarding shape of fibers hooked fibers performed well. In relation to the use of various admixtures and super plasticizers the performance of SCC depends on the physical properties of SP and SP dosage. Addition of QDP (Quarry Dust Powder) as filler in SCC improves the fresh properties. Glass powder decreases the fresh properties as well as hardened properties. The use of RCA (Recycled Concrete Aggregate) in SCC had also negative effect on compressive strength, flexural strength and split tensile strength.

4 CONCLUSIONS:

IN this paper recent innovation in Self Compacting Concrete using various agro-industrial wastes and their effect on fresh and hardened properties have been reviewed. It is concluded that the use of various agro-industrial wastes in Self Compacting Concrete has positive effect on fresh and hardened properties. Use of agro- industrial wastes in Self Compacting Concrete also solves the current issues related to CO_2 emission in the atmosphere by decreasing the cement content. It also solves the problem of dumping of such agro-industrial wastes on the valuable land and thus restricts the land pollution. It is possible to produce SCC of medium strength, high strength and even ultra high strength good quality using the wastes.

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