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A Review on Self Compacting Concrete

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Abstract : This paper gives a review on Self Compacting Concrete (SCC) to be made using various Mineral Admixtures and Fibers. In current scenario of construction industries due to demand in the construction of large and complex structures, which often leads to difficult concreting conditions. When large quantity of heavy reinforcement is to be placed in a reinforced concrete (RC) member, it is difficult to ensure fully compacted without voids or honeycombs. Compaction by manual or by mechanical vibraators is very difficult in this situation. That leads to the invention of new type of concrete named as self-compacting concrete (SCC). This type of concrete flows easily around the reinforcement and into all corners of the formwork. Self- compacting concrete describes a concerete with the ability to compact itself only by means of its own weight without the requirement of vibration. Self – copacting concrete also known as Self-consolidating Concrete or Self Compacting High Performance Concrete. It is very fluid and can pass around abstructions and fill all the nooks and corners without the risk of either mortar or other ingredients of concrete separating out, at the same time there are no entrapped air or rock pockets. This type of concrete mixture does not require any compaction and is saves time, labour and energy. This review paper explains the utilizationof fibers and various mineral admixtures in the properties of Self Compacting Compacting Concrete.
Keywords : Self Compacting Concrete, Mix design, Mineral Admixtures, Fibers, Durability, Workability.

Introduction:

History of SCC:

The introduction of the “modern” self-compacting concrete (SCC) is associated with the drive towards better quality of concrete pursued in Japan in late 1980’s, where the lack of uniform and complete compaction had been identified as the primary factor responsible for poor performance of concrete structures. There were no practical means by which full compaction of concrete on a site was ever to be fully guaranteed, instead, the focus therefore turned onto the elimination of the need to compact, by vibration or any other means. This led to the development of the first practicable SCC by researchers Okamura & Ouchi [1] at the University of Tokyo. The SCC, as the name suggests, does not require to be vibrated to achieve full compaction. 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. The composition of SCC mixes includes substantial proportions of fine-grained inorganic materials; this offers possibilities for utilization of “dusts”, which are currently waste products demanding with no practical applications and which are costly to dispose of.

Current Indian scenario in construction shows increased construction of large and complex structures, which often leads to difficult concreting conditions. Vibrating concrete in congested locations may cause some risk to labour in addition to noise stress. There are always doubts about the strength and durability placed in such locations. So it is worthwhile to eliminate vibration in practice, if possible. In countries like Japan, Sweden, Thailand, UK etc., the knowledge of SCC has moved from domain of research to application. But in India, this knowledge is to be widespread.

Literature Review:

Dr. Mrs. S.A. Bhalchandra et.al

[8] studied the performance of steel fiber reinforced self compacting concrete as plain self compacting concrete is studied in depth but the fiber reinforced self compacting concrete is not studied to that extent.

Prof. Aijaz Ahmad Zende et.al

[2] studied on Self Compacting Concrete (SCC) and compares it with Normal Concrete (NC). Almost all countries in the world are facing an acute decline in the availability of skilled labor in the construction industry, and hence the need of Special Concretes becomes very essential in this world where the use of concrete is just next to the water. The word “Special Concrete” refers to the concrete which meets the special performance and requirements which may not be possible by using conventional materials and normal methods of concreting. Self Compacting Concrete is one of the type of a special concrete which flows and consolidates under its own weight thereby eliminates the problems of placing concrete in difficult conditions and also reduces the time in placing large sections and at the same time giving high strength and better durability characteristics as compared to the Normal Concrete. This paper discusses the various aspects of SCC including the materials and mix design, different test methods such as V-funnel test, L- Box test etc., and also its performance characteristics and properties in the fresh and hardened state.

Paratibha Aggarwal et.al

[9] prepared an experimental procedure for the design of self-compacting concrete mixes. The test results for acceptance characteristics of self-compacting concrete such as slump flow; J-ring, V-funnel and L-Box are presented. Further, compressive strength at the ages of 7, 28, and 90 days was also determined and results are included here.

Esraa Emam Ali et.al

[10] has studied the effect of using recycled glass waste, as a partial replacement of fine aggregate, on the fresh and hardened properties of Self-Compacting Concrete (SCC). A total of 18 concrete mixes were produced with different cement contents (350, 400 and 450 kg/m3) at W/C ratio of 0.4. Recycled glass was used to replace fine aggregate in proportions of 0%, 10%, 20%, 30%, 40%, and 50%. The experimental results showed that the slump flow increased with the increase of recycled glass content. On the other hand, the compressive strength, splitting tensile strength, flexural strength and static modulus of elasticity of recycled glass (SCC) mixtures were decreased with the increase in the recycled glass content. The results showed that recycled glass aggregate can successfully be used for producing self-compacting concrete.

Mounir m. Kamal et.al

[11] studied the optimum content of fibers (steel and polypropylene Fibers) used in scc. The effect of different fibers on the fresh and hardened properties was studied. An experimental investigation on the mechanical properties, including compressive strength, flexural Strength and impact strength of fiber reinforced self-compacting concrete was performed. The results of the investigation showed that: the optimum dosage of steel and polypropylene fiber was 0.75% and 1.0% of the cement content, respectively. The impact performance was also improved due to the use of fibers. The control mix specimen failed suddenly in flexure and impact, the counterpart specimens contain fibers failed in a ductile manner, and failure was accompanied by several cracks.

M. Valcuende et.al

[12] studied the porosity in self-compacting concrete (scc) made without adding limestone filler, comparing the results with other scc and with normally-vibrated concrete (nvc). Several types of concrete were made, keeping the w/c ratio constant. The results show that the air content in scc depends on the flowability and viscosity of the material, putting a forward an Expression to estimate the air content in accordance with these two parameters. Scc shows a finer and more tortuous porous structure than nvc, leading to lower permeability to water under pressure. Nevertheless, in the absence of pressure, when water penetrates by capillary action, the results obtained from the different types of concrete were very similar, with differences below 3.5%. This is due to the fact That the content of pores over 0.5 lm is practically the same in scc and nvc, but for smaller pore sizes, which are therefore only accessed when water under pressure is applied, the differences in porosity between the different samples is more pronounced. On the other hand, it was observed that the use of more fluid mixtures permitted more impermeable concrete to be obtained. The use of viscosity-modifying admixture on scc as a replacement for limestone filler does not affect the total volume of pores, but generates a slightly more coarse porous microstructure, thereby leading to concretes in which water penetration depth under pressure is a little higher (around 4 mm).

A.S.E. Belaidi et.al

[13] has studied the effect of substitution of cement with natural pozzolana and marble powder on the rheological and mechanical properties of self-compacting mortar (scm) and self compacting concrete (scc). Ordinary portland cement (opc) was partially replaced by different percentages of pozzolana and marble powder (10–40%). The workability of fresh scc was measured using slump test, v-funnel flow Time test, j-ring, l-box and sieve stability tests. Compressive strength was determined on prisms at the ages of 7, 28, 56 and 90 days. The results indicate an improvement in the workability of scc with the use of pozzolana and marble powder. Compressive strength of binary and ternary SCC decreased with the increase in natural pozzolana and marble dust content, but strength at 28 and 90 days indicate that even with 40% (natural pozzolana + marble powder), suitable strength could be achieved.

Rahmat madandoust et.al

[14] studied the fresh and hardened properties of self-compacting concrete (scc) containing Metakaolin (MK). Totally, fifteen mixes including different mk contents (0–20% by weight of cement) With three water/binder (w/b) ratios of 0.32, 0.38 and 0.45 were designed. The fresh properties were investigated by slump flow, visual stability index, t50, v-funnel and l-box. The slump flow changes with Hauling time were also considered. The hardened properties were tested for compressive strength, splitting Tensile strength, ultrasonic pulse velocity (upv), initial and final absorption and electrical resistivity. The fresh concrete test results revealed that by substituting optimum levels of MK in scc, satisfactory workability and rheological properties can be achieved, even though no viscosity modifying agent was Needed. MK inclusion significantly enhanced the compressive strength of scc within the first 14 days up to 27%. Moreover, the compressive strength of scc with mk can be predicted in terms of upv by using multiple regression analysis. The tensile strength and electrical resistivity of the scc containing mk were higher than those of the control scc by maximum of 11.1% and 26%, respectively. A low absorption (below 3% at 30 min) can be achieved for MK mixes classified as ‘‘good’’ concrete quality. In general, it seems that 10% MK can be considered as a suitable replacement regarding to the economic efficiency, fresh and hardened properties of MK concrete.

Materials Used:

The Materials used in SCC are the same as in conventional concrete except that an excess of fine material and chemical admixtures are used. Also, a viscosity-modifying agent (VMA) will be required because slight variations in the amount of water or in the proportions of aggregate and sand will make the SCC unstable, that is, water or slurry may separate from the remaining material. The powdered materials are fly ash, silica fume, lime stone powder, glass filler and quartzite filler. The use of pozzolanic materials helps the SCC to flow better.

The factors which dominates the selection of materials are-

i. Aggregates amount used.

ii. Type of superplastizer & VMA used.
iii. Percentage of powder content in concrete mix.
iv. Water/Cement ratio.

Cement:

Ordinary Portland Cement (OPC) conforming to IS: 12269 to be used. The physical and chemical property of cement is to be identified.

Fine Aggregate:

Locally available river sand is used as fine aggregate. The sand was dried before use to avoid the problem of bulking.

Coarse Aggregate:

Locally available granite with a size ranges from 20 mm to 8 mm and down was used as coarse aggregate.

Water:

Potable water is used for mixing and curing of concrete.

Mineral Admixtures:

Mineral admixtures are used to improve the fresh and hardened properties of concrete and at the same time reduce the cost of concrete materials. In order to achieve the necessary viscosity to avoid segregation, additional fine materials are used. Various fine materials such as fly ash, silica fume, lime stone powder, rice husk ash, glass filler and quartzite filler etc. can be used .

Chemical Admixtures:

The various types of chemical admixtures are used in the production of SCC viz., superplasticizers and Viscosity Modifying Agents (VMA).

Mix Design:

Designing an approximate mix proportion to suit the needs of standard and high strength SCC with different types of aggregates is to be developed. The strength of SCC is provided by the aggregate binding the paste in the hardened state, while the workability of SCC is provided by the binding paste at fresh state. Mix design selection and adjustment can be made according to the procedure shown in Figure 1.

Flow-chart describing the procedure for design of SCC mix

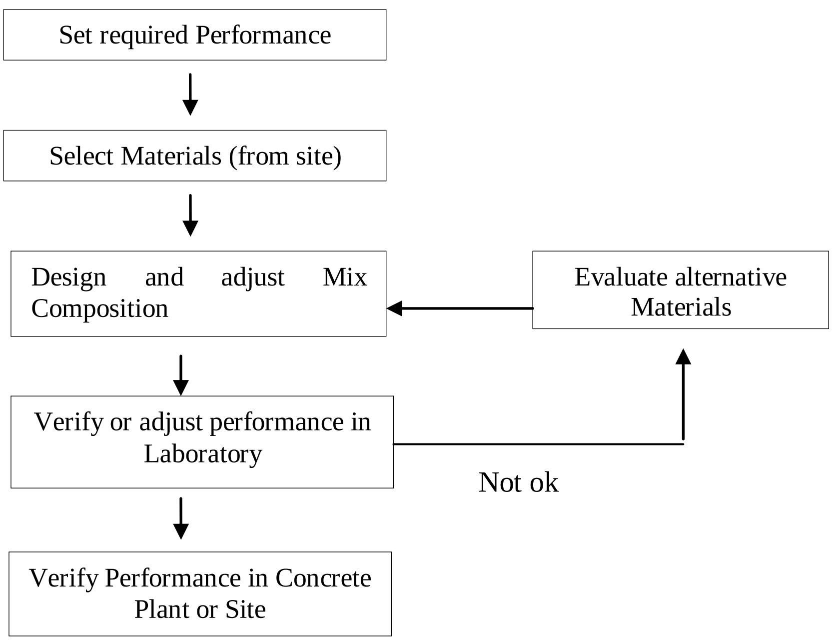

Figure 1: SCC Mix Design Procedure (EFNARC, 2005) [3].

Properties of Fresh Scc:

[4] Fresh SCC must possess the key properties including filling ability, passing ability and resistance to segregation at required levels. The filling ability is the ability of the SCC to flow into all spaces within the formwork under its own weight. Without vibrating the concrete, SCC has to fill any space within the formwork and it has to flow in horizontal and vertical directions without keeping air entrapped inside the concrete or at the surface. Passing ability is the ability of the SCC to flow through tight openings such as spaces between steel reinforcing bars, under its own weight. Passing ability is required to guarantee a homogenous distribution of the components of SCC in the vicinity of obstacles. The resistance to segregation is the resistance of the components of SCC to migration or separation and remains uniform throughout the process of transport and placing. To satisfy these conditions, The European Federation of Specialist Construction Chemicals and Concrete Systems. (EFNARC) has formulated certain test procedures.

Table 1. List of test methods for workability properties of SCC by EFNARC [3]

S.No	Methods	Property
1	Slump-flow by Abrams cone	Filling ability
2	T50cmslumpflow	Filling ability
3	J-ring	Passing ability
4	V-funnel	Filling ability
5	V-funnel at T 5 minutes	Segregation resistance
6	L-box	Passing ability
7	U-box	Passing ability
8	Fill-box	Passing ability
9	GTM screen stability test	Segregation resistance
10	Orimet	Filling ability

Workability criteria for the Fresh SCC:

These requirements are to be fulfilled at the time of placing. Likely changes in workability during transport should be taken into account in production. Typical acceptance criteria for Self-compacting Concrete with a maximum aggregate size up to 20 mm are shown in Table 2.

Table 2: Acceptance criteria for Self-compacting Concrete.

S. No	Method	Unit	Typical range of values	
			Minimum	Maximum
1	Slump flow by Abrams cone	mm	650	800
2	T50cmslumpflow	sec	2	5
3	J-ring	mm	0	10
4	V-funnel	mm	6	12
5	Time increase, V-funnel at T5minutes	sec	0	+3
6	L-box	h2/h1	0,8	1,0
7	U-box (h2-h1)	(h2-h1) mm	0	30
8	Fill-box	%	90	100
9	GTM Screen stability test	%	0	15
10	Orimet	sec	0	5

Hardened Concrete Properties of Scc:

The hardened properties of SCC such as Compressive strength, Split tensile strength, Flexural strength, Durability etc. can be studied according the use of admixtures in the SCC.

Conclusions:

Particularly in India, the use of Self-compacting concrete for routine construction is not much because of the lack of awareness while in countries like Canada, Denmark, Sweden, Thailand, UK etc., apart from Japan, SCC is used for the routine construction and with research data available, awareness can be spread in order to utilize the various benefits of this material. It is not fully clear whether existing design codes for structural concrete can be practical in case of self-compacting concrete. Use of viscosity modifying agents along with high-range water reducing agent is very essential for flowability and segregation control. A better understanding of the rheology of SCC has made it easier to know the functions of fines, super plasticizers, and VMA in SCC, and the compatibility between these and gives the designers a clear understanding of the mechanical properties including stress strain characteristics of SCC in its hardened state. No standard codes are available for the mix design of self compacting concrete apart from few methods developed by the researchers and many institutions, RMC; companies are using their own methods with one or other limitations. Thus some generalized method can be developed taking into the consideration all the aspects.

Self Compacting Concrete (SCC) can save time, cost, enhance quality, durability and moreover it is a green concept.

1. Due to its ability to guide itself into every nook and cranny in the form, SCC can produce nearly nil defects concrete. Number of pouring points can be reduced, thus eliminating the cumbersome activity of pipe laying over the pour.
2. About 40 to 50% of cement content can be replaced by materials like fibers; cost of the concrete is greatly reduced. The number of skilled supervisors, engineers, vibrator operators and pipe fitters can drastically be reduced. Formwork can be used for more number of times. Cost of repairing the structure is reduced as the numbers of defects are reduced to a great extent.
3. Since the concrete is capable of self-consolidating and reaching the difficult areas in moulds, manual variables in terms of placing and compacting concrete is nil. This factor ultimately yields defect less, better-quality concrete structures.

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