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SELF-COMPACTING CONCRETE

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ABSTRACT

Concrete occupies unique position among the modern construction materials, Concrete is a material used in building construction, consisting of a hard, chemically inert particulate substance, known as a aggregate (usually made for different types of sand and gravel), that is bond by cement and water.
Self – compacting concrete (SCC) is a high – performance concrete that can flow under its own weight to completely fill the form work and self consolidates without any mechanical vibration. Such concrete an accelerate the placement, reduce the labor requirements needed for consolidation, finishing and eliminate environmental pollution. The so called first generation SCC is used mainly for repair application and for casting concrete in restricted areas, including sections that present limited access to vibrate. Such value added construction material has been used in applications justifying the higher material and quality control cost when considering the simplified placement and handling requirements of the concrete.

The successful production of self – compacting concrete (SCC) for use, is depended on arriving at an appropriate balance between the yield stress and the viscosity of the paste. Specially formulated high range water reducers are used to reduce the yield stress to point to allow the designed free flowing characteristics of the concrete. However, this alone may result in segregation if the viscosity of the paste is not sufficient to support the aggregate particles in suspension.

The process of selecting suitable ingredients of concrete and determining their relative amounts with an objective of producing a concrete of required strength, durability, and workability as economically as possible is termed as concrete mix design.

The Mix Design for concrete M30 grade is being done as per the Indian Standard Code IS: 10262-1982.

CHAPTER - 1
INTRODUCTION

1.1 GENERAL

Self – compacting concrete (SCC) is a fluid mixture, which is suitable for placing difficult conditions and also in congested reinforcement, without vibration. In principle, a self – compacting or self – consolidating concrete must:

- Have a fluidity that allows self – compaction without external energy
- Remain homogeneous in a form during and after the placing process and
- Flow easily through reinforcement

Self – consolidating concrete has recently been used in the pre – cast industry and in some commercial applications, however the relatively high material cost still hinders the wide spread use of such specialty concrete in various segments of the construction industry, including commercial and residential construction.

Compared with conventional concrete of similar mechanical properties, the material cost of SCC is more due to the relatively high demand of Cementation materials and chemical admixtures including high – range water reducing admixtures (HRWRA) and viscosity enhancing admixtures (VEA). Typically, the content in Cementation materials can vary between 450 and 525 Kg/m^3 for SCC targeted for the filling of highly restricted areas and for repair applications.

Such applications require low aggregate volume to facilitate flow among restricted spacing without blockage and ensure the filling of the formwork without consolidation. The incorporation of high volumes of finely ground powder materials is necessary to enhance cohesiveness and increase the paste volume required for successful casting of SCC.

Proper selection of finely ground materials can enhance the packing density of solid particles and enable the reduction of water or HRWRA demand required to achieve high deformability. It can also reduce viscosity for a given consistency; especially in the case of SCC made with relatively low Water – Binder ratio. Reducing the free water can decrease the VEA dosage necessary for stability. High binder content typically includes substitutions of cement with 20 to 40% fly ash or GGBS and, in some cases low contents of micro silica employed. The cost of SCC can be reduced through the selection of adequate concrete - making materials and admixture constituents, including partial substitutions of cement and supplementary Cementations materials by readily available fillers.

Regardless of its binder composition, SCC is characterised by its low yield value to secure high deformability, and moderate viscosity to provide uniform suspension of solid particles, both during casting and thereafter until setting. The mixture proportioning of SCC to simultaneously meet the various performance requirements at minimum cost involves the optimisation of several mixture constituents that have a marked influence on performance. This process is quite complex and can be simplified by understanding the relative significance of various mixture parameters on key properties of SCC. This includes deformability, passing ability, filling capacity and segregation resistance.

As with any new technology, there was clearly a learning curve to overcome, and refinement of the materials and mix proportions used took care to finally achieve optimum performance. In Japan, self – compacting concretes are divided into three different types according to the composition of the mortar:

- Powder type
- Viscosity – modifying agent (stabilizer) type
- Combination type

For the powder type, a high proportion of fines produce the necessary mortar volume, while in the stabilizer type, fines content can be in the range admissible for vibrated concrete. The viscosity required to inhibit segregation will then be adjusted by using a stabilizer (Kosmatka et al., 2002). The combination type is created by adding a small amount of stabilizer to the powder type to balance the moisture fluctuations in the manufacturing process.

The SCC essentially eliminates the need for vibration to consolidate the concrete. This results in an increase in productivity, a reduction in noise exposure and a finished product with few if any external blemishes such as “bug holes”. However, after completion of proper proportioning, mixing, placing, curing and consolidation, hardened concrete becomes a strong, durable, and practically impermeable building material that requires no maintenance.

1.2 BENEFITS AND ADVANTAGES

At present self – compacting concrete (SCC) can be classified as an advanced construction material. The SCC as the name suggests, does not require to be vibrated to achieve full compaction. This offers benefits and advantages over conventional concrete.

- Improved quality of concrete and reduction of onsite repairs.
- Faster construction times.
- Lower overall costs.
- Facilitation of introduction of automation into concrete construction.
- Improvement of health and safety is also achieved through elimination of handling of vibrators.
- Substantial reduction of environmental noise loading on and around a site.
- Possibilities for utilization of "dusts", which are currently waste products and which are costly to dispose of.
- Better surface finishes.
- Easier placing.
- Thinner concrete sections.
- Greater Freedom in Design.
- Improved durability, and reliability of concrete structures.
- Ease of placement results in cost savings through reduced equipment and labor requirement.
- SCC makes the level of durability and reliability of the structure independent from the existing on – site conditions relate to the quality of labor, casting and compacting systems available.
- The high resistance to external segregation and the mixture self – compacting ability allow the elimination of macro – defects, air bubbles, and honey combs responsible for penalizing mechanical performance and structure durability.

1.3 DEVELOPMENTS OF SELF – COMPACTING CONCRETE

For several years beginning in 1983, the problem of the durability of concrete structures was a major topic of interest in Japan. The creation of durable concrete structures requires adequate compaction by skilled workers. The designs of modern reinforced concrete structures become more advanced, the designed shapes of structures are becoming increasingly complicated and heavy reinforcing is no longer unusual. Furthermore, the gradual reduction in the number of skilled workers in Japan"s construction industry has led to a similar reduction in the quality of construction work. One solution for the achievement of durable concrete structure independent of the quality of construction work is the employment of self – compacting concrete, which can be compacted into every corner of a form work, purely by means of its own weight and without the need for vibrating compaction. Okamura proposed the necessity of this type of concrete in 1986. Studies to develop self – compacting concrete, including a fundamental study on the workability of concrete, have been carried out by "Ozawa and Maekawa" at the university of Tokyo.

The prototype of SCC was first completed in 1988 using materials already on the market. The proto type performed satisfactorily with regard to drying and hardening shrinkage, heat of hydration, denseness after hardening, and other properties. This concrete was named "High Performance Concrete" and was defined as follows at the three stages of concrete:

1. Fresh : Self – Compactable.
2. Early age : Avoidance of initial defects
3. After hardening: Protection against external factors.

"High Performance Concrete" was defined as a concrete with high durability due to a low water

– cement ratio by professor Aitcin et al (Gangneetal 1989). Since then, the term high performance concrete has been used around world to refer to high durability concrete. Therefore, H.Okamura and M.Ouchi, the authors, of an invited paper on SCC for JACT 2003 have changed the term for the proposed concrete, for their work, to "Self – compacting High performance Concrete".

1.4 MECHANICAL CHARACTERSTICS

- Characteristic compressive strength at 28 days shall be 25 – 60 Mpa.
- Early age compressive strength shall be 5 – 20 Mpa at 12 – 15 hours (Equivalent age at 20^{0} C
- "Normal" creep and shrinkage

1.5 HOW DOES IT WORK?

A self consolidating must:
Have a fluidity that allows self – consolidation without external energy. Remain homogenous in a form during and after the placing process and Flow easily through reinforcement

To achieve these performances, Okamura redesigned the concrete mix design process. His mix design procedure focused on three different aspects:

1. Reduction of the aggregate content in order to reduce the friction, or the frequency of collisions between them increasing the overall concrete fluidity
2. Increasing the paste content to further increase fluidity
3. Managing the paste viscosity to reduce the risk of aggregate blocking when the concrete flows through obstacles.

In rheological terms, even though a significant amount of research tends to show that SCC" s viscosity varies with the shear rate and acts as a pseudo plastic material, SCC is often described as Bingham fluid (visco elastic) where the stress/shear rate ratio is linear and characterized by two constants – viscosity and yield stress.

Back to the performance based definition of SCC, the self – consolidation is mainly governed by yield stress, while the viscosity will affect the homogeneity and the ability to flow through reinforcement. As the SCC viscosity can be adjusted depending on the application, the yield stress remains significantly lower than other types of concrete in order to achieve self – consolidation.

1.6 APPLICATIONS

Applications of Self Compacting Concrete in Japan.
Current conditions on application of self – compacting concrete in Japan.

After the development of the prototype of self – compacting concrete at the University of Tokyo, intensive research was begun in many places, especially in the research institutes of large construction companies. As a result, self – compacting concrete has been used in many practical structures. The first application of self – compacting concrete was in a building in June 1990. Self – compacting concrete was then used in the towers of a pre stressed concrete cable – stayed bridge in 1992. Since then, the use of self compacting concrete in actual structures has gradually increased. Currently, the main reasons for the employment of self – compacting concrete can be summarized as follows.

1. To shorten construction period

2. To assure compaction in the structure: especially in confined zones where vibrating compaction is difficult.

3. To eliminate noise due to vibration: especially at concrete products plants.

The production of self-compacting concrete as a percentage of Japanese ready mixed concrete, which accounts for 70% of total concrete production in Japan, is only 0.1%. The current status of self-compacting is „special concrete „rather than „standard concrete" .

- Other applications of self-compacting concrete are summarized below.
- Bridge (anchorage, arch, beam, girder, tower, pier, joint between beam and girder) Box culvert building
- concrete filled steel column
- tunnel (lining, immersed tunnel, fill of survey tunnel)
- dam(concrete around structure)
- concrete products (blocks, culvert, wall, water tank, slab and segment)
- diaphragm wall
- tank(side wall, joint between side wall and slab)

1.6.0. Large scale construction

Self-compacting concrete is currently being employed in various practical structures in order to shorten the construction period of large-scale constructions.

The anchorages of Akashi-Kalikyo (Akashi straits) Bridge opened in April 1998, a suspension bridge with the longest span in the world (1,991mts), is a typical example (Kashima 1999). Self- compacting concrete was used in the construction of the two anchorages of the bridge. A new construction system that makes full use of the performance of self-compacting concrete was introduced for the purpose. The concrete was mixed at the batcher plant next to the site, and was then pumped out of the plant. It was transported 200mts through pipe to the casting site, where the pipes were arranged in rows 3 to 5mts apart. The concrete was cast from gate valves located at 5mts intervals along the pipes. These valves were automatically controlled so that the surface level of the cast concrete could be maintained. The maximum size of the coarse aggregate in the self-compacting concrete used at this site was 40mm the concrete fell as much as 3mts, but segregation did not occur, despite the size of coarse aggregate. In the final analysis the use of self-compacting concrete shortened the anchorage construction period by 20% from 2.5 to2 years.

Self-compacting concrete was for the wall of a large LNG tank belonging to the Osaka gas company. The adoption of self-compacting concrete in this particular project had the following merits.

1. The number of lots decreased from 14 to 10 as the height of one lot of concrete was increased.
2. The number of concrete workers was reduced from 150 to 50.
3. The construction period of the structure decreased from 22 months to 18 months.

In addition, a rational acceptance test for self-compact ability at the job site was newly introduced. The concrete casting was complete in June 1998.

1.6.2. Concrete products

Self – compacting concrete is often employed in concrete products to eliminate vibration noise. This improves the working environment at plants and makes the location of concrete products plants in urban areas possible. In addition, the use of self – compacting concrete extends the lifetime of mould for concrete has been gradually increasing.

1.7. NECESSITY FOR NEW STRUCTURAL DESIGN AND CONSTRUCTION SYSTEMS

Self – compacting concrete saves the cost of vibrating compaction and ensures the compaction of the concrete in the structure. However, total construction cost cannot always be reduced, except in large – scale constructions. This is because conventional construction systems are essentially designed based on the assumption that vibrating compaction of concrete is necessary.

Self – compacting concrete can greatly improve construction systems previously based on conventional concrete that required vibrating compaction. This sort of compaction, which can easily cause segregation, has been an obstacle to the rationalization of construction work. Once this obstacle is eliminated, concrete construction can be rationalized and a new construction system including form work, reinforcement, support and structural design, can be developed.

One example of this is the so called sandwich structure, where concrete is filled into a steel shell. Such a structure has already been completed in Kobe, and could not have been achieved without the development of self – compacting concrete (Shishido et al, 1999).

CHAPTER - 2
MATERIALS OF SCC

2.0 INTRODUCTION

The materials used for SCC are selected from those by the conventional concrete industry. Typical materials used for SCC are coarse aggregate, fine aggregate, cement, mineral admixtures (fly ash, ground – granulated blast furnace slag), and chemical admixtures (super – plasticizer, viscosity – modifying agents). SCC can be designed and constructed using a broad range of normal concreting materials, and that this is essential for SCC to gain popularity.

2.1 MATERIALS

2.1.1. Aggregates

The coarse aggregate chosen for SCC is typically round in shape, is well graded, and smaller in maximum size than that used for conventional concrete typical conventional concrete could have a maximum aggregate size of 40 mm or more. In general, a rounded aggregate and smaller aggregate particles aid in the flow ability and deformability of the concrete as well as aiding in the prevention of segregation and deformability of the concrete as well as aiding in the prevention of segregation. Gradation is an important factor in choosing a coarse aggregate, especially in typical uses of SCC where reinforcement may be highly congested or the formwork has small dimensions. Gap – graded coarse aggregate promotes segregation to a greater degree than well-graded coarse aggregate. As with conventional concrete construction, the maximum size of the coarse aggregate for SCC depends upon the type of construction. Typically, the maximum size of coarse aggregate used in SCC ranges from approximately 10 mm to 20 mm.

Generally aggregates occupy 70% to 80% of the volume of concrete and have an natural rock (crushed stone, or natural gravels) and sands, although synthetic materials such as slag and expanded clay or shale are used to some extent, mostly in lightweight concretes (Miness et al., 2003). In addition to their use as economical filler, aggregates generally provide concrete with better dimensional stability and wear resistance. Although aggregate strength can play sometimes an important role, for example in high – strength concretes, for most applications the strength of concrete and mix design are essentially independent of the composition of aggregates.

However, in other instances, a certain kind of rock maybe required to attain certain concrete properties, e.g., high density or low coefficient of thermal expansion (Neville, 1993).

In order to obtain a good concrete quality, aggregates should be hard and strong, free of undesirable impurities, and chemically stable (GarberandHoel, 1998). Soft and porous rock can limit strength and wear resistance, and sometimes it may also break down during mixing and adversely affect workability by increasing the amount of fines. Rocks that tend to fracture easily along specific planes can also limit strength and wear resistance (Neville, 1993). Aggregates should also be free of impurities like silt, clay, dirt or organic matter. If these materials coat, the surfaces of the aggregate, they will isolate the aggregate particles from the surrounding concrete, causing reduction in strength. Silt, clay and other fine materials will increase the water requirements of the concrete, and the organic matter interfere with the cement hydration.

All normal concreting sands are suitable for SCC. Both crushed and rounded sands can be used. Siliceous or calcareous sands can be used. The amount of fines less than 0.125 mm is to be considered as powder and is very important for the rheology of the SCC. A minimum amount of fines (arising from the binders and the sand) must be achieved to avoid segregation.

2.1.2. Cement

The most common cement currently used in construction is type I/II Portland cement. This cement conforms to the strength requirement of a Type I and the C3A content restriction of a Type II. This type of cement is typically used in construction and is readily available from a variety of sources. The Blaine fineness is used to quantify the surface area of cement. The surface area provides a direct indication of the cement fineness. The typical fineness of cement ranges from 350 to 500m2/kg for Type I and Type III cements, respectively.

2.1.3. Fly ash

Fly ash (or) pulverized fly ash is a residue from the combustion of pulverized coal collected by mechanical separators, from the fuel gases of thermal plants. The composition varies with type of fuel burnt, load on the boiler and type of separation. The fly ash consists of spherical glassy particles ranging from 1 to 150 micron in diameter and also passes through a 45-micron sieve. The constituents of fly ash are mentioned below.

Silicon dioxide ----- SiO_2 --- 30 – 60 %

Aluminum oxide ----- Al_2O_3 --- 15 -30 %

Unburnt fuel ----- (Carbon) --- up to 30 %

Calcium oxide ----- CaO --- 1-7%

Magnesium oxide ---(MgO) --- small amounts

Sulfur trioxide -----(So_3) --- small amounts

Fly ash is one of the most extensively used by-product materials in the construction field resembling Portland cement (Pfeifer, 1969). It is an inorganic noncombustible, finely divided residue collected or precipitated from the exhaust gases of any industrial furnace (Halstead, 1986).

Many class C ashes when exposed to water will hydrate and harden in less than 45 minutes. In concrete, class Fly ash is often used at dosages of 15% to 25% by mass of cementitious material and class C fly ash is used at dosages of 15% to 40% (Halstead, 1986). Dosage varies with the reactivity of the ash and the desired effects on the concrete (Mindess et al., 2003). Because of their spherical morphology, when using fly ash admixtures as replacement for cement, workability and long-term strengths are achieved in concretes. In such cases, they act like small balls to reduce inter particle friction. Fly ashes are also used in concrete mixes in order to reduce the heat of hydration, permeability, and bleeding. The durability is improved by providing a better sulfate resistance, control of the alkali-silica reduction, decreased chloride diffusion and reduction in calcium hydroxide (which is the most of the hydration products) and changes in pore structure. However, there are some disadvantages related to the use of fly ash regarding the reduced air entraining ability and early strength due to the influence of residual carbon from the ash (Gebler and Klieger, 1986)

2.1.4. Ground Granulated Blast Furnace Slag (GGBS)

Ground granulated blast-furnace slag is a non metallic product consisting essentially of silicates and aluminates of calcium and other bases. The molten slag is rapidly chilled by quenching in water to form glassy sand like material. The granulated material when further ground to less than 45 micron will have specific surface about 400 to 600m2/kg. the chemical composition of blast furnace slag is similar to that of cement clinker.

Cao	-	30-45%
Sio2	-	17-38%
Al2o3	-	15-25%
Fe2o3 - 0.5-2.0%		
Mgo	-	4.0-17%
Mno2	-	1.0-5.0%
Glass	-	85-98%
Specific gravity - 2.9		

The performance of slag largely depends on the chemical composition. Glass content and fineness of grinding. The quality of slag is governed by IS 12089 of 1987.

2.1.5. Micro Silica

Silica fume also referred to as micro silica or condensed silica fume, is another material that is used as an artificial pozzolonic admixture. It is a product resulting from reduction of high purity quartz with coal in an electric and furnace in the manufacture of silicon or ferrosilicon alloy. Silica fume rises as oxidized vapors. It cools, condenses and is collected in cloth bags. It is further processed to remove impurities and to control particle size. Condensed silica fume is essentially silicon dioxide (more than 90%) in non crystalline form. Since it an airborne material like fly ash, it has spherical shape. It is extremely fine with particle size less than I micron and with an average diameter of about 0.1 micron, about 100 times smaller than average cement particles. Silica fume has specific surface area of about 20,000m2/kg, as against 230 to 300 m2/kg that of cement.

2.1.6. Super plasticizer

Super plasticizer is essential for the creation of SCC. The job of SP is to impart a high degree of flow ability and deformability, however the high dosages generally associate with SCC can lead to a high degree of segregation. Conplast SP 430 is utilized in this project, which is a product of FOSROC Company having a specific gravity of 1.222. Super plasticizer is a chemical compound used to increase the workability without adding more water i.e. spreads the given water in the concrete throughout the concrete mix resulting to form a uniform mix. SP improves better surface expose of aggregates to the cement gel. Super plasticizer acts as a lubricant among the materials. Generally in order to increase the workability the water content is to be increased provided a corresponding quantity of cement is also added to keep the water cement ratio constant, so that the strength remains the same.

Super plasticizers (high-range water-reducers) are low molecular-water-soluble polymers designed to achieve high amounts of water reduction (12.30%) in concrete mixture in order to attain a desired slump (Gagne et al., 2000). These admixtures are used frequently to produce high- strength concrete (>50 Mpa), since workable mixes with water-cement ratios well below 0.40 are possible (Whiting, 1979). They also can be used with water reduction to produce concretes with very high slumps, in the range of 150 to 250 mm (6 to 10 inches). At these high slumps, concrete flows like a liquid and can fill forms efficiently, requiring very little vibration. These highly workable mixtures are called flowing concretes and require slumps to be in excess of 190mm (8.5 inches).

Water-reducing admixtures are negatively charge organic molecules that adsorb primarily at the solid-water interface, whereas solid particles carry residual charges on their surfaces, which may be positive, negative, or both (Russell, 1983). In cement paste, opposing charges on adjacent particles of cement can exert considerable electrostatic attractions, causing the particles to flocculate. A considerable amount of water is tied up in these agglomerates and adsorbed on the solid surfaces, leaving less water available to reduce the viscosity of the paste and hence that of the concrete. Molecules of the water reducing admixtures interact to neutralize these surface charges and cause all surfaces to carry uniform charges of like sign (Mindess et al., 2003) Particles now repel each other, rather than attract, and remain fully dispersed in the paste, thus most of the water is available to reduce the viscosity of the paste and of the concrete. Because super plasticizers have air-determining properties, an air-entraining agent must be added to the concrete to get a stable air void system before a super plasticizer is added (Gagne et al., 1996).

Some high range water reducing admixtures can retard final set by one to four hours and if prolonged setting times are not convenient, the admixture can be combined with an accelerating admixture to counteract the retarding tendencies or even to provide some acceleration of setting. When water reducing admixtures are used in concrete mixtures, some increases in compressive strength can be anticipated and these increases can be observed in as early as one day if excessive retardation does not occur. It is generally agreed that increases in compressive strength are up to 25% greater than would be anticipated from the decrease in water content and cement dispersion (Ozyilirim, 2003). The reduction of the water cement ratio and the creation of a more uniform pore structure mean that the permeability of concrete can be reduced by the use of super plasticizers, along with a general improvement of durability.

2.1.6.1 Role of S.P in cement

We know that the main action of S.P is to fluidity the mix and improve the workability of concrete. Port land cement, being in fine state of division will have a tendency to flocculate in wet concrete. This flocculation‟ s entraps certain amount of water used in the mix and there by all the water is not freely available to fluidity the mix. When plasticizers are used, they get absorbed on cement particles. The absorption of charged polymer on cement particle creates particle to particle repulsive forces, which overcome the attractive forces. This repulsive force is called zeta potential, which depends on the base, solid contents and quality of super plasticizer used. The overall result is that the cement particles are deflocculated and the water trapped inside the flocks gets released and now available to fluidity the mix.

2.1.7. Water

Potable water is used for mixing and curing.

CHAPTER - 3
PROPERTIES OF SCC

3.0 INTRODUCTION

In this chapter, requirements of constituent materials and factors influencing SCC are furnished.

3.1 REQUIREMENTS FOR CONSTITUENT MATERIALS

3.1.1. Cement

All types of cement conforming to EN 197 are suitable. Selection of the type of cement will depend on the overall requirements for the concrete, such as strength, durability etc., C3A content higher than 10% may cause problems of poor workability retention.

The typical content of cement is 350-450Kg/m3

More than 500Kg/m3 cement can be dangerous and increase the shrinkage. Less than 350 Kg/m3 may only be suitable with the inclusion of other fine filler, such as fly ash, pozzolona, etc.,

3.1.2. Aggregates

3.1.2.1. Sand

All normal concreting sands are suitable for SCC. Either crushed or rounded sands can be used. Siliceous or calcareous sands can be used.

The amount of fines less than 0.125 mm is to be considered as powder and is very important for the rheology of the SCC. A minimum amount of fines (arising from the binders and the sand) must be achieved to avoid segregation.

3.1.2.2. Coarse aggregate

All types of aggregates are suitable. The normal maximum size is generally 16 – 20 mm. however particle size up to 40 mm more have been used in SCC. Consistency of grading is of vital importance.

Regarding the characteristics of different types of aggregate, crushed aggregates tend to improve the strength because of the interlocking of the angular particles, whilst rounded aggregates improve the flow because of lower internal friction. Gap graded aggregates are frequently better than those continuously graded, which might experience greater internal friction and give reduced flow.

3.1.3. Admixture

The most important admixtures are the super plasticizers (high range water reducers), used with a water reduction greater than 20%

The use of a Viscosity Modifying Agent (VMA) gives more possibilities of controlling segregation when the amount of powder is limited. This admixture helps to provide very good homogeneity and reduces the tendency to segregation.

3.2. PROPERTIES OF FRESH SCC

SCC differs from conventional concrete in that its fresh properties are vital in determining whether or not it can be placed satisfactorily. The various aspects of workability which control its filling ability, its passing ability and its Segregation resistance all need to be carefully controlled to ensure that its ability to be placed remains acceptable.

3.2.1. Workability

The level of fluidity of the SCC is governed chiefly by the dosing of the Super plasticizer. However overdosing may lead to the risk of segregation and blockage. Consequently the characteristics of the fresh SCC need to be carefully controlled using preferably two of the different types of test.

3.2.2 Segregation resistance

Due to the high fluidity of SCC, the risk of segregation and blocking is very high. Preventing segregation is therefore an important feature of the control regime. The tendency to segregation can be reduced by the use of a sufficient amount of fines (<0.125mm), or using a Viscosity Modifying Admixture (VMA).

3.2.3. Open time

The time during which the scc maintains its desired rheological properties is very important to obtain good results in the concrete placing. This time can be adjusted by choosing the right type of super plasticizers or the combined use of retarding admixtures. Different admixtures have different effects on open time and they can be used according to the type of cement and the timing of the transport and placing of the SCC.

3.3. PROPERTIES OF HARDENED SCC

3.3.1. Compressive strength

In all SCC mixes compressive strengths of standard cube specimens were comparable to those of traditional vibrated concrete made with similar water-cement ratios – if anything strengths were higher.

In-situ strengths of SCC are similar to those of traditional vibrated concrete, indeed somewhat higher when limestone powder is used as filler, probably because of a densifying mechanism and the observed lower susceptibility to imperfect curing, both attribute to this type of filler.

The in-situ strengths of both types of civil engineering concrete, SCC and traditional vibrated concrete were closer to standard cube strengths than those of the housing mixes again; this is typical of higher strength concrete.

In vertical element, in-situ strengths of both SCC and traditional vibrated concrete are higher at the bottom than at the top, vibration of in-situ strengths, for both types of concrete is much lower in horizontal elements, in this case the beams. These observations are characteristic of traditional vibrated concrete. The in-situ strengths of elements cast and cured outdoors in winter (the beams), whether SCC or conventional, were lower than those cast indoors at the same time (the columns).

Overall, we might conclude that the fresh self-compacting properties of the concrete have little effect on the in-situ strengths.

3.3.2. Tensile strength

Tensile strength was assessed indirectly by the splitting test on cylinders. For SCC, both the tensile strengths themselves, and the relationships between tensile and compressive strengths were of a similar order to those of traditional vibrated concrete.

3.3.3. Bond strength

The strength of the bond between concrete and reinforcement was assessed by pullout tests, using deformed reinforcing steel of two different diameters, embedded in concrete prisms. For both civil engineering and housing categories, the SCC bond strengths, related to the standard compressive strengths, were higher than those of the reference concrete were.

3.3.4. Modulus of elasticity

Results available indicate that the relationships between static modulus of elasticity and compressive strengths were similar for SCC and the reference mixes. A relationship in the form of E/ (fc) 0.5 has been widely reported, and all values of this ratio were close to the one recommended by ACT for structural calculations for normal weight traditional vibrated concrete.

3.3.5. Freeze/thaw resistance

This property was assessed by loss of ultrasonic pulse velocity (UPV) after daily cycles of 18 years at 30C and 66 hours at room temperature. No significant loss of UPV has been observed after 150 cycles for the SCC or reference higher strength concrete (the civil engineering mixtures).

3.3.6. Shrinkage and creep

None of the results obtained indicates that the shrinkage and the creep of the SCC mixes were significantly greater than those of traditional vibrated concrete.

3.3.7. Some aspects of durability

Elements of all types of concrete have been left exposed for future assessment of durability but some preliminary tests have been carried out.

The permeability of the concrete, a recognized indicator of likely durability, has been examined by measuring the water absorption of near surface concrete. The results suggest that in the SCC mixes, the near surface concrete was denser and more resistant to water ingress than in the reference mixes. Carbonation depths have been measured at one year. The civil mixes (both SCC and reference) show no carbonation. The evidence in hand and data from other source suggest that the durability performance of SCC is likely to be equal or better than that of traditional vibrated concrete.

3.3.8. Structural performance

The structural performance of the concrete was assessed by loading the full-size reinforced columns and beams to failure.

For the columns, the actual failure load exceeded the calculated failure load for both types of concrete (SCC and traditional vibrated concrete).

For the beams the only available comparison is between SCC and traditional vibrated concrete in the civil engineering category. Here the behavior of the two concretes in terms of cracking moment, crack width and load-deflection was similar.

3.4 FACTORS INFLUENCING SCC

3.4.1. Mortar

Mortar also plays a vital role as solid particle in SCC. This property is so called "pressure transferability" which can be apparent when the coarse aggregate particles approach each other and mortar is in between coarse aggregate particles. Here the mortar is subjected to normal stress. The degree of the decrease in shear deformability of mortar largely depends on the physical characteristics of the solid pattern in the mortar. It was found that the relation between the flow ability of mortar and concrete couldn" t always be same due to differences in the characteristics of the solid particles in the mortar.

3.4.2. Influence of coarse aggregate, shape and grading

The influence of coarse aggregate on self-compaction of fresh concrete is more. Proper care should be taken while grading the coarse aggregate, where as presence of more uneven size of aggregate may lead to the blockage of concrete due to the action of internal sources.

3.4.3. Water powder ratio and S.P dosage

The characteristics of powder and S.P largely affect the mortar property and so the proper water powder ratio and S.P dosage cannot be fixed without trail mixing. Therefore once the mix proportion is decided self-compatibility has to be formulated. So that we can establish a rational method for adjusting the water powder ratio and S.P dosage to achieve appropriate deformability and viscosity.

3.4.4. Workability

Workability is a measure of ease by which fresh concrete can be placed and compacted. It is a complex combination of aspects of fluidity, cohesiveness, transportability, compact ability and stickiness. A good SCC shall normally reach a slump flow value exceeding 60cm without segregation. Following are the requirements for good workability in SCC.

1. If required, SCC should remain flow able and self compactable for at least 90 minutes.
2. If required, SCC shall be able to with stand a slope of 3% in case of free horizontal surface.
3. If required, SCC shall be pump able for at least 90 minutes and through pipes with a length of at least 100 meters.

CHAPTER - 4
MIX PROPORTION

4.1 GENERAL

To produce SCC, the major work involves designing an appropriate mix proportion and evaluating the properties of the concrete thus obtained. In practice, SCC in its fresh state shows high fluidity, self-compacting ability and segregation resistance, all of which contribute to reducing the risk of honey combing of concrete. With these good properties, the SCC produced can greatly improve the reliability and durability of the reinforced concrete structures. In addition SCC shows good performance in compressive strength test and can fulfill other construction needs because its proportion has taken into consideration the requirements in the structural design.

The ingredients for SCC are similar to other plasticized concrete. It consists of cement, coarse aggregate, fine aggregate, water, and mineral and chemical admixtures.

No standard or all-encapsulating method for determining mixture proportions currently exists for SCC. However, many different proportion limits have been listed in various publications. Multiple guidelines and "rules of thumb" about mixture proportions for SCC were found. The table summarizes this information.

Table 4.1 Limits on SCC material proportions

	High fines	**VMA**	**Combination**
Cementations lb/yd3 (kg/m3)	750-1000 (450-600)	650-750 (385-450)	650-750 (385-450)
Water/Cementations material	0.28-0.45	0.28-0.45	0.28-0.45
Fine aggregate/Mortar (%)	35-45	40	40
Fine aggregate/Total Aggregate (%)	50-58	—	—
Coarse aggregate / Total mix (%)	28-48	45-48	28-48

For example,

1. Gibbs (1999) states that the following particle riles of thumb for the proportioning of SCC mixture exist.

- Coarse aggregate content should be limited to 700-800Kg/m3 (about 50%of the total volume)
- Paste not less than 40% of the volume of the mixture.
- Low stand content in the mortar (40-50%by volume).
- Water/power ratio nit more than 0.5(power being solids < 0.003 5 in, 0.09 mm).

2. Okamura and Ozawa (1995) have proposed a simple proportioning system assuming general supply from ready-mixed concrete plants.

- The coarse and fine aggregate contents are fixed so that self-compact ability can be a achieved easily by adjusting the water-power and super plasticizer dosage only.
- The coarse aggregate content in concrete is fixed at 50% of the solid volume. The fine aggregate content is fixed at 40% of the mortar volume.
- The water-powder ratio in volume assumed as 0.9 to 1.0, depending on the properties of the powder.
- The super plasticizer dosage and the final water powder ratio are determined so as to ensure self-compact ability.

3. The "Standardized mix design method of SSC" proposed by the JRMCA (1998) is a simplified version of Okamura‟ s method. This method can be employed to produce SCC with a large amount of powder materials, and water-binder ratio of < 0.30.

4. A visual Summary of the segregations as listed by Chattopadya (2002) is a follows.

Water : 13.5 to 15% of volume

Power : 15 to 16.5% of volume

Fine aggregate : 20% of volume

Coarse aggregate : 50% of volume

These numbers are based on SCC using a rounded gravel aggregate. Subramanian and Chattopadyay (2002) advise adjusting the proportions by incorporating more fines when using a crushed angular aggregate.

5. Several methods for determining mixture proportions of SCC exist, and two main philosophies of SCC mixture design contain these differing methods: mixture design based on SCC rheology and mixture design based on fresh SCC field tests. The rheological philosophy involves large, expensive immobile equipment suitable for the laboratory. The results are very helpful in determining the behavior of SCC as a fluid material. This method is described by Oh et al (1999) and Saak et al.(2001). The fresh SCC field test philosophy is much faster, very mobile, and suited to laboratory or field conditions. These are several proposed tests, and work is currently being done by several standardization organizations to create a unified set of tests. All of these tests can be performed in the field just prior to concrete placement.

6. the mixture design by Su et al. (2001) utilizes the High Fines Approach by using an appropriate amount of cement to achieve the design strength and incorporating additional fine material (in the form of fly ash and GGBFS) to obtain sufficient viscosity. The report states that testing in the fresh as well as hardened state was completed to examine the performance of SCC, and the results indicate that the proposed method could produce SCC of high quality. Su et al. (2001) State that the principal consideration of their method is to fill the paste of binders into voids of the loosely piled aggregate. The reports continues by pointing hardened state, while the workability of SCC is provided by the binding of paste at the fresh state, while the workability of SCC is provided by the binding of paste at the fresh state. Therefore, the contents of the coarse and fine aggregates, binders, mixing water and super-plasticizer will be the main factors influencing the properties of SCC. With Su‟ s (2001) proposed method, all that needs to be done is to select the approved materials, do the calculations, conduct mixing tests and make some minor adjustments, and SCC with good flow ability, deformability and segregation resistance can be obtained with as specified by the JSCE (Su 2001).

4.2 EFNARC-PROPOSALS

4.2.1. Initial mix composition

In designing the mix it is most useful to consider the relative proportions of the key components by volume rather than by mass.

Water / Powder ratio by volume of 0.80 to 1.10
Total powder content – 160 to 240 liters (400 – 600 Kg) per cubic meter. Coarse aggregate content normally 28 to 35 percent by volume of the mix.

Water cement ratio is selected based on requirements in EN 206. Typically water content does not exceed 200 liter/m^3.

The sand content balance the volume of the other constituents

Generally, it is advisable to design conservatively to ensure that the concrete is capable of maintaining its specific fresh properties despite anticipated variations in raw material quality. Some variation in aggregate moisture content should also be expected and allowed for at mix design stage. Normally viscosity-modifying admixtures are a useful tool for compensating for the fluctuations due to any variations of the sand grading and the moisture content of the aggregates.

4.3 GENERAL REQUIREMENTS IN THE MIX DESIGN

4.3.1. A high volume of paste

The friction between the aggregates limits the spreading and the filling ability of SCC. This is why SCC contains a high volume of paste (cement + additions + sufficient water + air), typically

330 to 400 $1/m^3$, the role of which is to maintain aggregate separation.

4.3.2. A high volume of the fine particles (<80 μm)

In order to ensure sufficient workability, while limiting the risk of segregation or bleeding. SCC contains a large amount of fine particles (around 500 kg/m3). Nevertheless, in order to avoid excessive heat generation, the Portland cement is generally partially replaced by mineral admixtures like limestone filler or fly ash or GGBS (Cement should not be used as a filler). The nature and the amount of filler added are chosen in order to comply with the strength and durability requirements.

4.3.3. A high dosage of plasticizer

Super plasticizers are introduced in SCC to obtain the fluidity. Nevertheless, a high dosage near the saturation amount can increase the proneness of the concrete to segregate.

4.3.4. The possible use of a viscosity agent (water retainer)

These products are generally cellulose derivatives, polysaccharides or colloidal suspensions. These products have the same role as the fine particles, minimizing bleeding and coarse aggregate segregation by thickening the paste and retaining the water in the skeleton. The introduction of such products in SCC seems to be justified in the case of SCC with high water to binder ratio. On the other hand, they may be less useful for high performance SCC (strength higher than 50Mpa) with low water to binder ratio. For intermediate SCC, the introduction of viscosity agent has to be studied for each case. Viscosity agents are assumed to make SCC less sensitive to water variations in water content of aggregate occurring in concrete plants. Because of the small quantities of viscosity agents required, however, it may be difficult to achieve accuracy of dosage.

4.3.5. A low volume coarse aggregate

It is possible to use natural rounded, semi-crushed or crushed aggregates to produce SCC. Nevertheless, as the coarse aggregate plays an important role on the passing ability of SCC in congested areas, the volume has to be limited. Generally speaking, the maximum aggregate size, D max, is between 10 and 20 mm. The passing ability decreases when D max increases, which leads to a decrease of the coarse aggregate content. The choice of a higher D max is thus leads to

a decrease of the coarse aggregate content. The choice of a higher D max is thus possible but is only justified with low reinforcement content.

Admixture added to SCC can have a resulting effect on strength and the temperature development in the fresh concrete, and this will have to be borne in mind in the construction process.

CHAPTER - 5
S.C.C.TESTS

5.1 GENERAL

It is important to appreciate that none of the test methods for SCC has yet been standardized and the test described are not yet perfected or definitive. The methods presented here test procedures are descriptions rather than fully detailed procedures. They are mainly ad-hoc methods, which have been devised specifically for SCC.

Existing rheological test procedures have not been considered here, through the relationship between the results of these tests and the rheological characteristics of concrete is likely to figure out highly in future work, including standardization work. Many of the comments made come from the experience of the partners in the EU-funded research project on SCC.A further EU project on test methods is about to o far destart.In considering these tests, there are number of points which should be taken in to account.

- One principal difficulty in devising such tests is that they have to assess three distinct, though related, properties of fresh SCC-its filling ability(flow ability),its passing ability(free from blocking at reinforcement),and its resistance to segregation(stability).No single test so fardevised can measure all three properties.
- There is no clear relation between test results and performance on site.
- There is little precise data, therefore no clear guidance on compliance a limits. Duplicate tests are advised.
- The test methods and values are started for maximum aggregate size of up to 20 mm; different test values and for different equipment dimensions may be appropriate for other aggregate sizes.
- Different test values may be appropriate for concrete being placed in vertical and horizontal elements. Similarly different test values may be appropriate for different reinforcement densities.
- In performing the tests, concrete should be sampled in accordance with EN 12350-1.It is wise tomix the concrete first with a scoop, unless the procedure indicates otherwise.

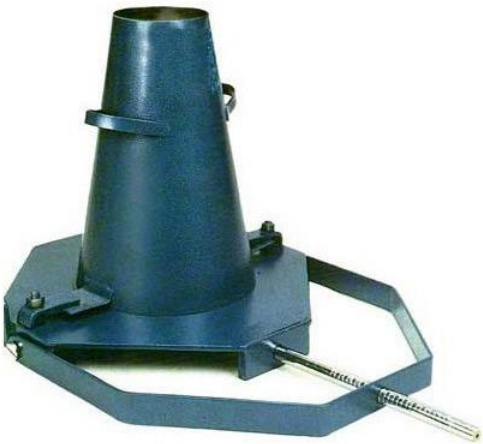
5.2 SLUMP FLOW &T50 TEST

Slump flow is one of the most commonly used SCC tests at the current time. This test involves the use of slump cone used with conventional concretes as described in ASTM C 143(2002).The main difference between the slump flow test and ASTM C 143 is that the slump flow test measures the “spread” or “flow” of the concrete sample once the cone is lifted rather than the traditional “slump” (drop in height) of the concrete sample. The T50 test is determined during the slump flow test. It is simply the amount of time the concrete takes to flow to a diameter of 50 centimeters .Typically, slump flow values of approximately 24 to 30 inches are within the acceptable range; acceptable T50 times range from 2 to 5sec.

5.2.1. Apparatus

1. Mould in the shape of a truncated cone with the internal dimensions 200mm diameter at the base,100mm diameter at the top and height of 300 mm, conforming to EN12350-2
2. Base plate of stiff non - absorbing material, at least 700mm square, marked with a circle marking the central location for the slump cone, and a further concentric circle of 500 mm diameter.
3. Trowel
4. Scoop
5. Ruler

6. Stopwatch



SLUMP FLOW Apparatus

5.2.2. Procedure

- Dampen slump flow table and slump cone.
- Level the slump flow table
- Place cone on the centre of the table that has a circle having a diameter of 50 centimeters drawn concentrically to the location for the slump cone.
- Using funnel and with one person holding cone down(as to avoid concrete pushing itself underneath the cone),continuously fill the cone with a representative sample concrete from bucket
- Screed and level the concrete from the top of the cone as to ensure the proper amount of concrete is within the cone.
- Immediately remove the funnel
- Immediately lift cone in an upward direction and begin to time the concrete(from the instant the lift started)for the T50 time(the cone should be raised at a rate of approximately one foot in two seconds).
- Stop the timing device when the concrete reaches the T50 line and record this time as the T50 value.
- Measure the final diameter of concrete in two perpendicular directions.
- Record the slump flow as the average of two measurements.

5.2.3. Interpretation of results

The higher the slump flow (SF) value, the greater its ability to fill formwork under its own weight. A value of at least 650 mm is required for SCC. There is no generally accepted advice on what are reasonable tolerances about a specified value, through ±50mm, as with the relative flow able test might be appropriate.

The T50 time is a secondary indication of flow. A lower time indicates greater flow ability. The BriteEuram research suggested that a time of 3-7 seconds is acceptable for civil engineering applications and 2-5 seconds for housing applications.

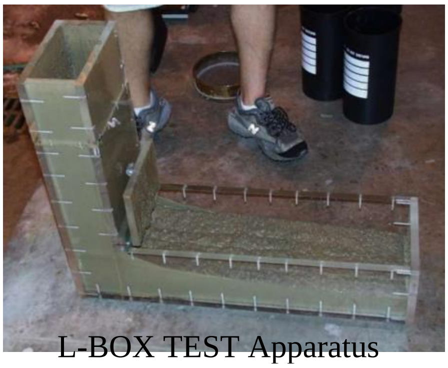
In case of severe segregation most coarse aggregate will remain in the centre of the pool of concrete and mortar and cement paste at the concrete periphery. In case of minor segregation border segregation a border of mortar without coarse aggregate can occur at the edge of the pool of concrete. If none of these phenomena appear it is no assurance that segregation will not occur since this is a time related aspect that can occur after a longer period.

5.3. L-BOX TEST

The L-box value is the ratio of levels of concrete at each end of the box after the test is complete at each end of the box after the test is complete. The L-box consists of a “chimney “section and a “trough “section after the test is complete, the level of concrete in the chimney is recorded as H1,the level of concrete in the trough is recorded as H2.The L-box value(also referred to as the “L-box ratio”, “blocking value”, or “blocking ratio”)is simply H2/H1.Typical acceptable values for the L-box value are in the range of 0.8 to 1.0.If the concrete was perfectly level after the test is complete, the L-box value would be equal to 1.0.Conversely,if the concrete was too stiff to flow to the end of the trough the L-box value would be equal to zero.

5.3.1. Apparatus

1. L-box of a stiff non-absorbing material.
2. Trowel
3. Scoop
4. Stop watch.



L-BOX TEST Apparatus

5.3.2. Procedure

- Dampen all surfaces of the L-box that will be in contact with concrete.
- Make sure that the gate is restrained as to avoid premature flow of concrete through the L- box.
- Continuously fill the upper portion of the L-box with a representative sample concrete from a bucket.
- Screed the concrete from the top of the box as to ensure the proper amount of concrete is within the apparatus.
- Promptly open/lift the gate to allow the flow of concrete through the L-box. Once the concrete has ceased to flow (not more than one minute from the opening/lifting the gate) measure the height of concrete at the “trough end”(record this as H2)and at the chimney end”(record this as H1)of the L-box to the nearest 1⁄2 inch.
- The L-box ratio is calculated as H2/H1.For a summarized visual display of the L-box sequence refers to figure 7.2

5.3.3 Interpretation of result

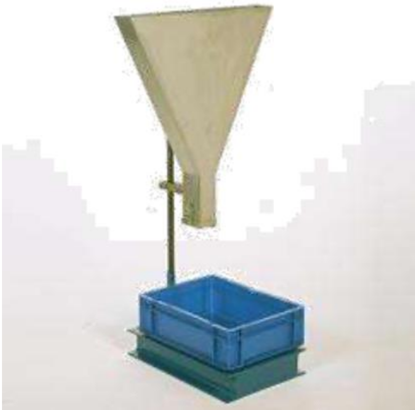
If the concrete flows as freely as water, at the rest it will be horizontal, so H2/H1=1.Therefore the nearer this test value, the “blocking ratio” is to unity, the better the flow of concrete. The EU research team suggested minimum acceptable values have been generally agreed. Obvious blocking of course aggregate behind the reinforcing bars can be detected visually.

5.4. V-FUNNEL TEST AND–FUNNEL TEST AT T 5 Minutes

V-funnel test is used to determine the filling ability (flow ability) of the concrete with a maximum aggregate size of 20 mm. The funnel is filled with about 12 liters of concrete and the time taken for it to flow through the apparatus is measured .After this the funnel can be refilled concrete and left for 5 minutes to settle .If the concrete shows segregation then the flow time will increase significantly.

5.4.1. Apparatus

1. V-funnel
2. Bucket(±12 liter)
3. Trowel
4. Scoop
5. Stopwatch


V-FUNNEL TEST Apparatus

5.4.2. Procedure

- About 12 liters of concrete is needed to perform the test, sampled normally.
- Set the V-funnel on firm ground. Moisten the inside surfaces of the funnel.
- Keep the trap door open to allow any surplus water to drain.
- Close the trap door and place a bucket underneath.
- Fill the apparatus completely with concrete without compacting or tamping; simply strike off the concrete level with the top with the trowel.
- Open within 10 sec after filling the trap door and allow the concrete to flow out under gravity.
- Start the stopwatch when the trap door is opened and record the time for the discharge to complete (the flow time).
- This is taken to be when light is seen from above through the funnel .The whole test has to be performed within 5 minutes.
- The Procedure for the flow time at T5 minutes
- Do not clean or moisten the inside surfaces of the funnel again.
- Close the trap door and refill the V-funnel immediately after measuring the flow time.
- Place a bucket underneath.
- Fill the apparatus completely with concrete without compacting or tapping, simply strike off the concrete.
- Level the top with the trowel.
- Open the trap door 5 minutes after the second fill of the funnel and allow the concrete to flow out under gravity.
- Simultaneously start the stopwatch when the trap door is opened and record the time for the discharge to complete (the flow time at T5 minutes).this is taken to be when light is seen from above through the funnel.

5.4.3. Interpretation of result

This test measures the ease of flow of the concrete; shorter flow time indicates greater flow ability .For SCC a flow time of 10 seconds is considered appropriate .The inverted cone shape restricts flow, and prolonged flow times may give some indication of the susceptibility of the mix to blocking.

After 5 minutes of settling, segregation of concrete will show a less continuous flow with an increase in flow time.

5.1 Acceptance criteria for SCC

Method	**Unit**	**Minimum**	**Maximum**
Slump flow test	Mm	650	800
T_{50}cm slump flow	Sec	2	5
V-funnel test	Sec	6	12
V-funnel at T_5minutes	Sec	6	15
L-Box test	H2/H1	0.8	1.0

5.5 J RING TEST

5.5.1. Introduction

The principle of the J ring test may be Japanese, but no references are known .The J ring test itself has been developed at the University of Paisley. The test is used to determine the passing ability of the concrete. The equipment consists of a rectangular section (30mm×25mm) open steel ring, drilled vertically with holes to accept threaded sections of reinforcement bar. These sections of bar can be of different diameters and spaced at different intervals; in accordance with normal reinforcement considerations,3x the maximum aggregate size must be appropriate .The diameter of ring in vertical bars is 300 mm and the height 100 mm.

The J ring can be used in conjunction with the slump flow, the Orimet test, or eventually even the V-funnel. These combinations test the flowing ability and (the contribution of the J ring) the passing ability of the concrete. The Orimet time and/or slump flow spread are measured as usual to assess flow characteristics .The J ring bars can principally be set at any spacing to impose a more or less severe test of the passing ability of the concrete . After the test, the difference in height between the concrete inside and that just outside the J ring is measured .This is an indication of passing ability, or the degree to which the passage of concrete through the bars is restricted.

5.5.2. Assessment of test

These combinations of tests are considered to have great potential, though there is no general view on exactly how results should be interpreted .There are a number of options-for instance it may be instructive to compare the slump –flow/J ring spread with the unrestricted slump flow, to what extent is it reduced?

Like the slump flow test, these combinations have the disadvantage of being unconfined ,and therefore do not reflect the way concrete is placed and moves in practice .The Orimet option has the advantage of being the dynamic test ,also reflecting placement in practice .Though it suffers from requiring two operations.

5.5.3. Apparatus

1. Mould without foot pieces in the shape of a truncated cone with the internal dimensions 200 mm diameter at the base, 100 mm diameter at the top and a height of 300 mm.
2. Base plate of a stiff non-absorbing material
3. Trowel
4. Scoop
5. Ruler

6. J ring a rectangular section(30mm×25mm) open steel ring , drilled vertically with holes .In the holes can be screwed threaded sections of reinforcement bar (length 100mm,diameter 10mm,spacing 48±2mm)

5.5.4. Procedure

- About 6 liter of concrete is needed to perform the test, sampled normally.
- Moisten the base plate and inside of slump cone.
- Place base-plate on level stable ground.
- Place the J-ring centrally on the base plate and the slump-cone centrally inside it and hold down firmly.
- Fill the cone with the scoop. Do not tamp, simply strike off the concrete level with the top of the cone with the trowel.
- Remove any surplus concrete from around the base of the cone.
- Raise the cone vertically and allow the concrete in two perpendicular directions.
- Calculate the average of the two measured diameters (in mm).
- Measure the difference in height between the concrete just inside the bars and that just outside the bars.
- Calculate the average of the difference in height at four locations (in mm).
- Note any border of mortar or cement paste without coarse aggregate at the edge of the proof of concrete.

5.6 J RING IN CONJUNCTION WITH THE ORIMET

5.6.1 Apparatus

1. Orimet device of a stiff non absorbing material.
2. Trowel
3. Scoop
4. Stopwatch
5. Ruler
6. J ring a rectangular section(30mm×25mm) open steel ring , drilled vertically with holes . In the holes can be screwed threaded sections of reinforcement bar (length 100mm,diameter 10mm,spacing 48±2mm);

5.6.2. Procedure

- About 8 liter of concrete is needed to perform the test , sampled normally. Set the Orimet on firm ground.
- Moisten the inside surfaces of the casting pipe and the orifice.
- Keep the trap door open to allow any surplus water to drain.
- Close the trap door place a bucket underneath.
- Fill the apparatus completely with concrete without compacting or tapping, simply strike off the concrete level with the top with the trowel.
- Open the trap door within 10 seconds after filling and allow the concrete to flow out under gravity.
- Simultaneously, start the stopwatch and record the time.
- Start the stopwatch when the trap door is opened and record the time for time for the discharge to complete(the flow time).this is taken to be when light is seen from above through the orifice section.
- Measure the final diameter of the concrete in two perpendicular directions. The whole test has to be performed within 5 minutes.
- Calculate the average of the two measured diameters (in mm).
- Measure the difference in height between the concrete just inside the bars and that just outside the bars.

- Calculate the average of the difference in height at four locations (in mm).
- Note any border of mortar or cement paste without coarse aggregate at the edge of the pool of concrete.

5.6.3 Interpretation of result

It should be appreciated that although these combinations of tests measure flow and passing ability ,the results are not independent .The measured flow is certainly affected by the degree to which the concrete movement is blocked by the reinforcing bars .The extent of blocking is much less affected by the flow characteristics ,and we can say that clearly ,the greater the difference in height ,the less the passing ability of the concrete, Blocking and/or segregation can also be detected visually ,often more reliably than by calculation.

Note: The results of the J ring are influenced by the combination method selected and resultsobtained with different combinations will not be comparable.

5.7. U BOX TEST

5.7.1 Introduction

The test was developed by the technology research center of the taisei corporation in Japan

.Sometimes the apparatus is called a “box-shaped” test .The test is used to measure the filling ability of self-compacting concrete .The apparatus consists of a vessel that is divided by a middle wall in to two compartments .An opening with a sliding gate is fitted between the two sections. Reinforcing bars with normal diameter of 13mm are installed at the gate with centre-to-centre spacing of 50mm .this creates a clear spacing of 35mm between the bars. The left hand section is filled with 20 liter of concrete then the gate lifted and concrete flows upwards in to the section. The height of the concrete in both the sections is measured.

5.7.2. Assessment of test

This is a simple test to conduct, but the equipment may be difficult to construct. It provides a good direct assessment of filling ability-this is literally what the concrete has to do modified by an unmeasured requirement for passing ability .The 35 mm gap between the sections of reinforcement may be considered too close. This question remains open of what filling height less than 30cm, is still acceptable.

5.7.3. Apparatus

1. U box of a stiff non-absorbing material trowel.
2. Scoop
3. Stopwatch

5.7.4. Procedure

- About 20 liter of concrete is needed to perform the test, sampled normally.
- Set the scoop level on firm ground, ensure that the sliding gate can open freely and then close it.
- Moisten the inside surface of the apparatus, remove any surplus water.
- Fill the one compartment of the apparatus with the concrete sample.
- Leave it to stand for 1 minute.
- Lift the sliding gate and allow the concrete to flow in to the other compartment.
- After the concrete has come to rest, measure the height of the concrete in the compartment that has been filled in two places and calculate the mean (H1)& the height in other compartment (H2).
- The whole test has to be performed within 5 minutes.

5.7.5. Interpretation of result

If the concrete flows as freely as water, at least it will be horizontal, so H1-H2=0.Therefore the nearer this test value, the filling height is zero, the better the flow and passing ability of concrete.

5.8. FILL BOX TEST

5.8.1. Introduction

This test is also known as the "Kajima test". The test is used to measure the filling ability of self-compacting concrete with maximum aggregate size of 20mm. The apparatus consists of container (transparent) with a flat and smooth surface. In the container are 35 obstacles made of PVC with a diameter of 20mm and a distance centre to centre of 50mm.At the top side put a filling pipe (diameter 100mm height 500mm) with a funnel (height 100mm).The container is filled with concrete through this filling pipe and the difference in height between two sides of a container is measure for filling ability.

5.8.2. Assessment of test

This is a test that is difficult to perform on site due to the complex structure of the apparatus and large weight of the concrete .It gives a good impression of the self-compacting characteristics of the concrete. Even a concrete mix with a high filling ability will perform poorly if the passing ability and segregation resistance are poor.

5.8.3. Apparatus

1. Fill box of a staff ,transparent non absorbing material
2. Scoop ca 1.5 to 2 liter
3. Ruler
4. Stopwatch

5.8.4. Procedure

- About 45 liter of concrete is needed to perform the test, sampled normally.
- Set the apparatus level on firm ground.
- Moisten the inside surfaces of the apparatus, remove any surplus water Fill the apparatus with the concrete sample.
- Fill the container by adding each 5 seconds one scoop with 1.5 to 2 liter of fresh concrete into the funnel until the concrete has just covered the first top obstacle.
- Measure after the concrete has come to rest, the height at the side at which the container is filled in two places and calculate the average (h1).
- Do this also on the opposite side (h2).
- Calculate the average filling percentage.
- Average filling %: F=((h1+h2)/2*h1)*100%
- The whole test has to be performed within 8 minutes.

5.8.5. Interpretation of result

If the concrete flows as freely as water, at rest it will be horizontal, so average filling percentage=100%, the better the self-compacting characteristics of the concrete.

5.9. PREPARATION OF SCC SPECIMENS

5.9.1. Proportioning

The quantity of cement, fine and coarse aggregates, fly ash, water and SP for each batch of proportion is prepared as mentioned in design of SCC.

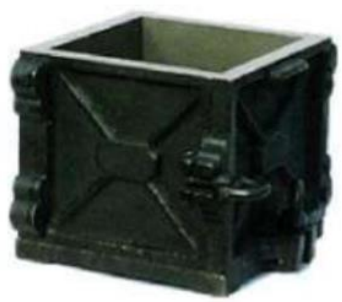
5.9.2. Mixing of concrete

Mixing of concrete was carried out by machine. Machine mixing is not only efficient but also economical. Before the materials are loaded in to drum about 25 percent of the total quantity of water required for mixing is poured in to the mixer drum and to prevent any sticking of cement on the bodies or at the bottom of the drum.

Then discharging all the materials i.e. coarse aggregate and cement in to the drum. Immediately after discharging the dry material in to the drum the remaining 75 percent of water is added to the drum .The time is counted from the moment all the materials are placed particularly the complete quantity of water is fed in to the drum.

5.9.3. Moulds

The concrete is casted in to cube moulds of size 100mm×100mm,beam moulds of size 100×100×500mm and cylindrical moulds of 200 mm height ×150 mm dia. The moulds used for the purpose are fabricated with steel seat. It is easy for assembling and removal of the mould specimen without damage. Moulds are provided with base plates, having smooth to support. The mould is filled without leakage .In assembling the moulds for use joints between the section of the mould are applied with a thin coat mould oil and similar coating of mould oil is applied between the contact faces of mould and the base plate to ensure that no water escape during filling .The interior surfaces of the assembled mould shall be thinly coated with mould oil to prevent adhesion of concrete.



Cube mould

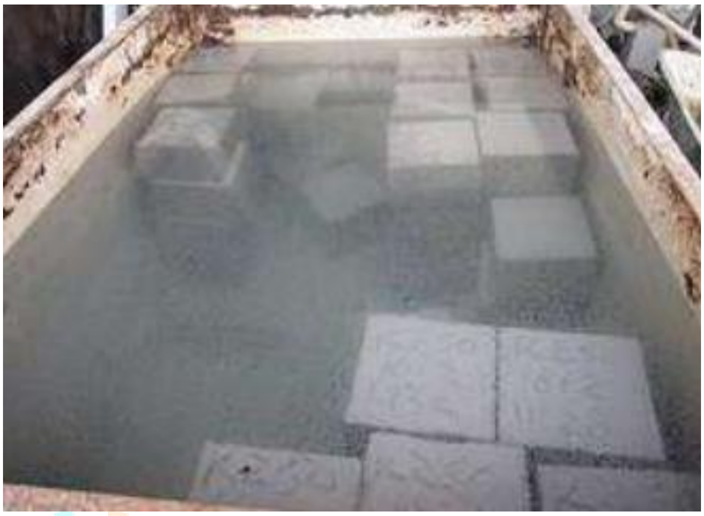
Cylindricalmould

5.9.4. Placing of mix in moulds

After mixing the proportions in the mixing machine, it is taken out into the bucket. The concrete is placed in to the moulds (cubes, beams & cylinders), which are already oiled simply by means of hands only without using any compacting devises.

5.9.5. Curing

After 24 hours the specimens were removed from the moulds and immediately submerged in clean fresh water and kept there until taken out just prior to testing.



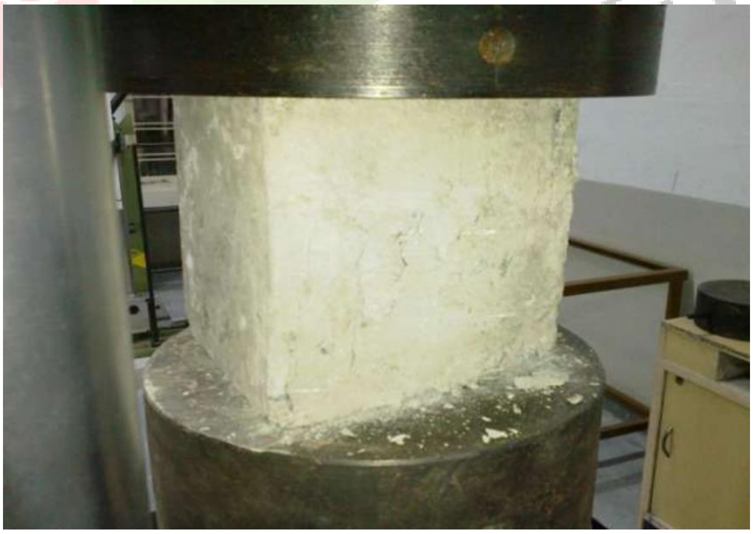
Curing of Concrete cubes

5.10. TESTS ON SCC SPECIMENS

5.10.1. Compressive strength of concrete

Compressive strength of concrete is defined as the load, which causes the failure of a standard specimen.(Ex 100 mm cube according to ISI)divided by the area of crossection in uniaxial compression under a given rate of loading. The test of compressive strength should be made on 150mm size cubes.

Place the cube in the compression-testing machine. The green button is pressed to start the electric motor. When the load is applied gradually, the piston is lifted up along with the lower plate and thus the specimen application of the load should be 300 KN per minute and can be controlled by load rate control knob. Ultimate load is noted for each specimen. The release valve is operated and the piston is allowed to go down. The values are tabulated and calculations are done



Testing of Compressive strength of concrete

5.10.2. Tensile strength of concrete.

5.10.2.1 Split tensile strength

A concrete cylinder of size 150mm dia×200mm height is subjected to the action of the compressive force along two opposite edges, by applying the force in this manner .The cylinder is subjected to compression near the loaded region and the length of the cylinder is subjected to uniform tensile stress.

Horizontal tensile stress = 2P/πDL

Where P = the compressive load on the cylinder.

L = length of the cylinder

D = dia of cylinder

5.10.2.2. Standard beam test

Standard beam test or modulus of rupture carried out on the beams of size (100mm×100mm×500mm), by considering the material to be homogeneous .The beam should be tested on a span of 400 mm for 100mm specimen by applying two equal loads placed at third points .To get these loads, a central point load is applied on a beam supported on steel rollers placed at third point. The rate of loading shall be 1.8 KN/minute for 100 mm specimens the load should be increased until the beam failed .Note the type of failure, appearance of fracture and fracture load.

Let, a be the distance between the line of fracture and the nearer support. Then for finding the modulus of rupture, these cases should be considered.

1. When a > 133mm for 100mm specimen

   Fcr = PL/bd^2
   Where P = total load applied on the beam.

2. When 10mm < a < 133mm Fcr = $3Pa/ bd^2$

3. when a < 110 mm

The result should be discarded

The estimation of tensile strength from compressive strength is flexural strength = fcr = 07 N/mm^2

Where fck = characteristic compressive strength of concrete.

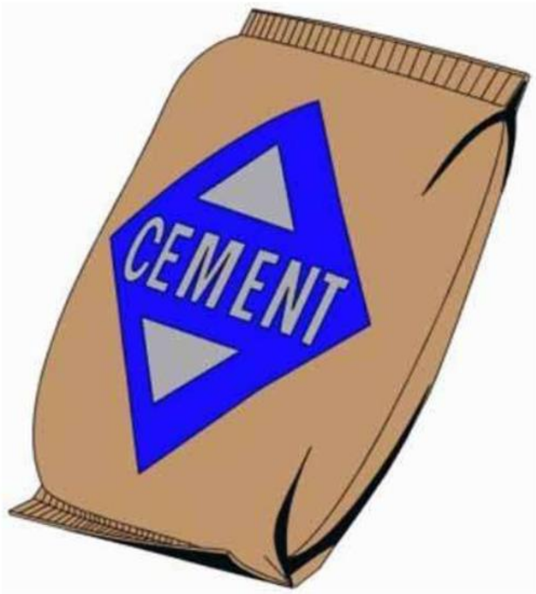
CHAPTER - 6
PROPERTIES OF MATERIALS

6.0 INTRODUCTION

In this chapter properties of materials used in SCC are furnished.

6.1. CEMENT

Ordinary Portland cement of 53 grade from the local market was used and tested for physical and chemical properties as per IS: 4031 – 1988and found to be conforming to various specifications as per IS: 12269-1987.



Tests on cement

1. Normal consistency : 30%
2. Initial setting time : 35 min
3. Compressive strength

7 days : 37 N/mm^2

14 days : 47 N/mm^2

28 days 53 N/mm^2

4. Specific gravity : 3.01

6.2. TESTS ON AGGREGATE

6.2.1. Fine aggregate

In the present investigation fine aggregate is natural sand from local market is used. The physical properties of fine aggregate like specific gravity, bulk density, gradation and fineness modulus are tested in accordance with IS :2386.

Fineness modulus of fine aggregate:

Weight of fine aggregate sample taken = 1000g.

Table 6.1 Fineness modulus of fine aggregate

I.S.Seive Size	Weight of aggregate retained in gms	Cumulative weight retained in gms	Cumulative % of weight retained	% of passing	Remarks
10 mm	0	0	0	100	
4.75 mm	0	0	0	100	
2.36 mm	0	10	1	99	Zone-II
1.18 mm	197.5	207.5	20.75	79.25	
600 µ	371.0	578.5	57.85	42.15	
300 µ	353.0	931.5	93.15	6.85	
150 µ	68.5	1000.0	100.0	0	

Fineness modulus of fine aggregate = 272.75/100 = 2.7275 = 2.72

Table 6.2 Physical properties of fine aggregate

Property	**Result**
Fineness modulus	2.72
Specific gravity	2.613
Bulk density (Kg/m3) Loose Compact	 1585 1690

6.2.2 Coarse aggregate

The crushed coarse aggregate of 12.5 mm maximum size rounded obtained from the local crushing plant, Robo silicon, keeseragutta; Hyderabad is used in the present study. The physical properties of coarse aggregate like specific gravity, bulk density, gradation and fineness modulus are tested in accordance with IS ; 2386.

Weight of coarse aggregate sample taken = 5000 g.

Table 6.3 Fineness modulus of fine aggregate

I.S.Seive Size	Weight of aggregate retained in gms	Cumulative weight retained in gms	Cumulative % of weight retained	% of passing
40mm	0	0	0	100
20mm	0	0	0	100
10mm	270	750	15	85
4.75mm	4250	5000	100	0
2.36mm	0	5000	100	0
1.18mm	0	5000	100	0
600 nu	0	5000	100.0	0
300 nu	0	5000	100	0
150 nu	0	5000	100	0

Fineness modulus of coarse aggregate = 615/100=6.15

Table 6.4 Physical properties of fine aggregate

Property	**Result**
Fineness modulus	6.15
Specific gravity	2.625
Bulk density (Kg/m3) Loose Compact	 1475 1690

6.3. FLY ASH

In the present investigation work, the fly ash used is obtained from Vijayawada thermal power station in Andhra Pradesh. The specific surface of fly ash is found to be 4250cm2/gm. by blaines permeability apparatus and its specific gravity is 2.3.

Table 6.5 Chemical composition of fly ash.

S.NO.	**Characteristic**	**Percentage**
1	Silica, SiO_2	49-67
2	Alumina	26-28
3	Iron oxide	4-10
4	Lime	0.7-3.6
5	Magnesia	0.3-2.6
6	Sulfur trioxide	0.1-2.6
7	Surface area m2/kg	230-600

6.4 GROUND GRANULATED BLAST FURNANCE SLAG

Ground Granulated Blast Furnace slag (GGBS) confirming to BS9966

Table 6.6 Physical properties of GGBS

S.NO.	Characteristic	Properties of slag used
1	Specific gravity	2.91
2	Fineness (Blaine‟ s) m2/kg	330
3	Glass content percent	93
4	Bulk density	1100
5	Color	Dull white

Table 6.7 CHEMICAL COMPOSITION OF GGBS

S.NO.	Characteristic	Requirements (BS:6699)	% Contents
1	SiO2	32-42	33.12
2	Al2O3	7.16	18.3
3	Cao	32-45	41.00
4	Fe203	0.1-1.5	1.3
5	Mgo	14 Max	11.6
6	So3	2.5 Max	1.0
7	Cao/SiO2	1.4 Max	1.23
8	Loss on ignition	3 Max	0.5

6.5 MICRO SILICA OR SILICA FUME

Micro silica is a highly efficient pozzolanic material and as considerable potential for use in concrete. Micro silica is obtained from elkemmetallurgy(p) ltd, 66/77 , mahavircentre , sector 17 , vashi , navi mumbai-400703 is used.

6.6 SUPERPLASTICIZER

The super plasticizer used in concrete mix makes it highly workable for more time with much lesser water quantity. It is observant that with the use of large quantities of finer material (fine aggregate + cement + fly ash) the concrete is much stiff and requires more water for required workability hence, in the present investigation SP430 is used as water reducing admixture.

6.7 DOSAGE

The optimum dosage is best determined by site trails with the concrete mix, which enables the effect of workability as a guide, the rate of addition is in the range of 2.5% of power value.

6.8 WATER

This is the least expensive but most important ingredient of concrete. The water, which is used for making concrete , should be clean and free from harmful impurities such as oil, alkali, acid, etc., in general, the water, which is fit for drinking should be used for making concrete.

6.9 STUDY OF FRESH CONCRETE

The experimental investigations made on self compact ability of concrete with fly ash, GGBS, micro silica as filler material can be characterized by the following properties.

- Filling ability
- Passing ability Segregation resistance
- A concrete mix can only be classified as self-compacting concrete if the requirements for all three characteristics are fulfilled.

6.10 MIX DESIGN AND TRAIL PROPORTIONS

The ingredients for self-compacting concrete are similar to conventional concrete. It consists of cement, coarse and fine aggregates, water, mineral and chemical admixtures. Similar to conventional concrete, SCC can also be affected by the physical characteristics of materials and mixture proportioning. A rational mix design method for self-compacting concrete using a variety of materials is necessary. The coarse and fine aggregate contents are fixed so that self- compact ability can be achieved easily by adjusting water-powder ratio, super plasticizer dosage. In the mix proportioning of conventional concrete, the water cement ratio is fixed at from the view point of obtaining the required strength. With self compacting concrete, however, the water powder ratio has to be decided by taking into account self compact ability because self compact ability is very sensitive to this ratio. In most case, the required strength does not govern the water cement ratio because the water powder ratio is small enough for obtaining the required strength of ordinary structures unless most of the powder materials in use not reactive.

The characteristics of the powder, super plasticizer and VMA largely affect the mortar property and so the proper water powder ratio and super plasticizer and VMA dosage cannot be fixed without trial mixing at this stage. Therefore, once the mix proportion is decided, self compact ability has to be tested by slump flow, l-box test and v-funnel test.

6.10.1 MIXING OF CONCRETE

In the process of mixing the materials are weighed with their proportions exactly and then the materials are stacked on a water tight platform. The materials are thoroughly mixed in their dry conditions before water is added. The prepared mix was immediately used for testing the workability of fresh mix.

6.10.2 CASTING OF TESTING OF SPECIMENS

After achieving self compact ability, with the same mix proportions cubes were casted .When tested for 3 days strength is achieved is good. Hence, the same proportions cubes, cylinders, beams of standard size were cast and cured for 28 days.

6.10.3 CURING OF TEST SPRCIMENS

After casting the moulded specimens are stored in laboratory at a room temperature for 24 hours. After this period the specimens are removed from the moulds and immediately submerged in clean, fresh water of curing water tank. The specimens are cured for 28 days in present investigation work.

6.10.4 STUDY OF HARDENED CONCRETE

The principles properties of concrete which are of practical importance are those concreting its strength, stress- strain characteristics, shrinkage and creep deformations, permeability and durability, of these the strength of the concrete assumes a greater significance because the strength is related to the structure of hardened cement paste and gives an over all picture of the quality of the concrete.

6.10.5 COMPRESSIVE STRENGTH

Determination of compressive strength has received a large amount of attention because the concrete is primarily meant to with stand the compressive stresses. Generally cubes are used to determine the compressive stresses. The cubes are usually of 100*100*100 or 150*150*150mm size. In the present investigation 100*100*100mm size cubes are used.

In the compressive test the cubes while cleaned to wipe of the surface water, is placed with the cast faces in contact with the planks of testing machine i.e. the position of the cube when tested is at right angles to that as cast. According to BIS 1881: PART 116:1983, the load on the cube should be applied at a constant rate of stress equal to 0.2 to 0.4 Mpa per second. Because of the non linearity of the stress-strain relation of concrete at high stress, the rate of strain must be increased progressively as failure is approached i.e. the speed of the movement of the head of the testing machine has to be increased. The compressive strength is reported to the nearest 0.5Mpa.

CHAPTER - 7
MIX DESIGN

7.0 INTRODUCTION

Mix design can be defined as the process of selecting suitable ingredients of concrete and determining with the object of producing concrete of certain minimum strength and durability as economically as possible.

Mix design forM30 grade concrete according to BIS method.

7.1. MIX DESIGN

7.1.1. Design stipulations

1. Characteristic compressive strength required in the field at 28-days : 30Mpa
2. Maximum size of aggregate : 12.5mm (rounded)
3. Degree of workability : 0.9(compaction factor)
4. Degree of quality control : Good
5. Type of exposure : Severe

7.1.2. Test data of materials

1. Specific gravity of cement : 3.01
2. Compressive strength of cement at 7-days : Satisfies the requirements of IS269-1989(37N/mm^2)
3. Specific gravities of

Coarse aggregate : 2.625

Fine aggregate : 2.613

4. Water absorption

Coarse aggregate : 0.5%

Fine aggregate : 1.0%

5. Free surface moisture

Coarse aggregate : NIL

Fine aggregate : 2.0%

6. Fineness modulus of

Coarse aggregate : 6.15

Fine aggregate : 2.72

7.1.3. Steps taken in the mix proportioning: Trail mix 1

1. Target mean strength for M30 grade concrete

$f_{ck*} = f_{ck} + Ks$

$f_{ck*} = 30 + 1.65 * 6.0 = 39.9N/mm^2$

Where,

K= probability factor for various tolerances (5%) = 1.65 from table 10.4

S = Standard deviation for different degrees of control (Good) =6.0 from table 10.6 2.

The water cement ratio required for the target mean strength of 39.9 Mpa is 0.38

3. Selection of water and sand content for 12.5mm maximum size aggregate and the sand confirming to ZONE -II.

For W/C-0.6, C.F-0.8, angular, sand confirming to ZONE-11.

(a). Water content per cubic meter of concrete = 208 l/m^3

(b). Sand content as percentage of total aggregate by absolute volume = 62%

(c). C.F. = 0.9

Corrections

Change in condition	Water	Sand
W/C(0.6-0.38 = 0.22)	0	-4.4%
C.F = 0.1	3%	0
Rounded	-15kg	-7%
Zone -2	0	0

The corrected water content per cubic meter of concrete

208 + ((3/100)*208) -15 = 199.24 l/m^3

The corrected sand content as percentage of total aggregate by absolute volume

62 % - 11.4% = 50.6%

4. Determination of cement content Water/cement = 0.38

Water = 199.24 l/m^3

The cement content = 199.24kg/m^3

5. Determination of coarse and fine aggregate contents for the specified maximum aggregate size of 12.5 mm, the amount of entrapped air in the wet concrete is 3%, taking this in to account and applying equations

V = [W/SW+C/SC+ fa/ (P*SFA)]*1/1000; V= [W/SW+C/SC+Ca/ ((1-p)*SCA)]*1/1000;

0.97 = [199.24+ (524.31/3.01) fa/ (0.506*2.613)]*1/1000.

Fa = 788.77kg/m^3

0.97 = [199.24+ (524.31/3.01) +Ca/ ((1-0.506)*2.625)]*1/1000.

Ca = 773.06kg/m^3.

The mix proportion then becomes

Cement	**Sand**	**Coarse aggregate**	**Water**
524.31kg	788.77kg	773.06kg	199.24
1	1.5	1.47	0.38

The obtained contents of cement, sand, aggregate and water per cubic meter of concrete are listed below.

Cement = 524.31kg

Sand = 788.77kg

Coarse aggregate = 773.06kg

Water = 199.24kg

Converting into SCC Proportions

The normal concrete mix proportions are modified as per EFNARC specifications and different trail mixes and caste. By considering the fresh properties and harden properties of the mixes we finally arrived at the SCC mixed proportions as

Cement = 524.31

Fine aggregate = 788.77

Coarse aggregate = 773.06

Total aggregate (T.A) = 788.77 + 773.06 = 1561.83

Taking 56% of T.A as F.A

F.A = 1561.830*0.56 = 874.62 Kg/m^3

C.A = 687.2kg/m^3

The modified proportion is

Cement	**Sand**	**Coarse aggregate**	**Water**
524.31kg	87462kg	687.2kg	199.24
1	1.67	1.31	0.38

Further in the trail mix-1 cementation material is taken as 270kg/ m^3 (55%) of fly ash,108kg/ m^3 (40%) of GGBS and 2.7kg/ m^3 (1% addition) of micro silica is used.

The water/cementations material is 0.38 The fine aggregate/total aggregate is 62%

The contents of cement, fly ash, GGBS, micro silica, fine aggregate, coarse aggregate, water, SP 430, VMA are listed below.

Cement = 270kg/ m^3

Fly ash = 148.5kg/ m^3

GGBS = 108kg/ m^3

Micro silica = 2.7kg/ m^3

Fine aggregate = 788.77kg/ m^3

Coarse aggregate = 773.06kg/ m^3

Water = 200.98 lit/ m^3

SP 430 = 13.23 lit/ m^3

VMA= 1.85lit/ m^3

SP430 dosage =2.5% of cementation materials

VMA = 0.35% of cementation materials

7.1.4. Steps taken in the mix proportioning: Trail mix 2

1. Target mean strength for M30 grade concrete fck* = f_{ck} +Ks

fck* =30 + 1.65*6.0 = 3909N/mm^2

Where,

K = probability factor for various tolerances (5%) = 1.65 from table 10.4

S= Standard deviation for different degrees of control (Good) =6.0 from table 10.6

2. The water cement ratio required for the target mean strength of 39.9Mpa is 0.38.

3. selection of water and sand content for 12.5mm maximum size aggregate and the sand confirming to ZONE-II.

For W/C-0.6,C.F-0.8,angular, sand confirming to ZONE-II.

(A).Water content per cubic meter of concrete = 207 l/ m^3

(B). sand content as percentage of total aggregate by absolute volume = 60%

(C).C.F. = 0.9 and take W/C = 0.4

Corrections

Change in condition	**Water**	**Sand**
W/C(0.6-0.40 = 0.2)	0	-4%
C.F +0.1	+3%	0
Rounded	-15kg	-7%
Zone -2	0	0

The corrected water content per cubic meter of concrete

207 + ((3/100)*207) – 15 = 198.21 l/m ^{3}

The corrected sand content as percentage of total aggregate by absolute volume

60% -11% = 49%

4. Determination of cement content

Water / cement = 0.40

Water = 198.21 l/ m ^{3}

The cement content = 198.21/0.40 =495.53 kg/ m ^{3}

5. Determination of coarse and fine aggregate contents for the specified maximum aggregate size of 12.5 mm, the amount of entrapped air in the wet concrete is 3%, taking this in to account and applying equations

V= [W/SW+C/SC+ fa/ (P*SFA)]*1/1000; V= [W/SW+C/SC+Ca/ ((1-p)*SCA)]*1/1000; 0.97= [198.21+ (495.53/3.01)+fa / (0.49*2.613)]*1/1000.

F.A =777.39kg/ m ^{3}

0.97= [198.21+ (495.53/3.01) +Ca/ (1-0.49*2.625)]*1/1000.

C.A =812.78kg/ m ^{3}.

The mix proportion then becomes

Cement	**Sand**	**Coarse aggregate**	**Water**
495.53kg	777.39KG	812.78KG	198.21
1	1.57	1.64	0.40

The obtained contents of cement, sand, aggregate and water per cubic meter of concrete are listed below.

Cement = 495.53kg

Sand = 777.39kg

Coarse aggregate = 812.78kg

Water = 198.21kg

Converting into SCC Proportions

The normal concrete mix proportions are modified as per EFNARC specifications and different trail mixes and caste. By considering the fresh properties and harden properties of the mixes we finally arrived at the SCC mixed proportions as

Cement = 495.53kg

Sand = 777.39KG

C. aggregate = 812.78KG

Total aggregate (T.A)= 777.39 + 812.78 =1590.17

Taking 55% of T.A as F.A

Fine aggregate =1590.17 * 0.55 = 874.59 kg/ m^3

Coarse aggregate = 715.58 kg/ m^3

The modified proportion is

Cement	**Sand**	**Coarse aggregate**	**Water**
495.53kg	874.59Kg	715.58Kg	198.21
1	1.76	1.44	0.40

Further in the trail mix-2 cementation material is taken as 255kg/ m^3 of cement,140.25kg/ m^3 (55%) of fly ash,102kg/ m^3 (40%) of GGBS and 2.55kg/ m^3 (1%) of micro silica is used.

The water/cementation material is 0.4

The fine aggregate/total aggregate is 60%

The contents of cement, fly ash, GGBS, micro silica, fine aggregate, coarse aggregate, waters 430 and VMA are listed below

Cement = 255Kg/ m^3

Fly ash = 140.25 Kg/ m^3

GGBS = 102 Kg/ m^3

Micro silica = 2.55 Kg/ m^3

Fine aggregate = 874.5 Kg/ m^3

Coarse aggregate = 715.58 Kg/ m^3

Water = 199.92 lit/ m^3

SP 430 = 12.5 lit/ m^3

VMA = 1.75 lit/ m^3

7.1.5. Steps taken in the mix proportioning: Trail mix 3

1. Target mean strength for M30 grade concrete : $f_{ck*} = f_{ck} + ks$

$f_{ck*} = 30 + 1.65*6.0 = 39.9 N/mm^2$

Where,

K = probability factor for various tolerances (5%) =1.65 from table 10.4

S = standard deviation for different degrees of control (good) =6.0 from table 10.6 2. The water cement ratio required for the target mean strength of 39.9Mpa is 0.38.

3. Selection of water and sand content for 12.5mm maximum size aggregate and the sand confirming to ZONE-II.

For W/C-0.6,C.F-0.8,angular,sand confirming to ZONE-II

(a) Water content for cubic meter of concrete 200 1/m3

(b) Sand content as percentage of total

Aggregate by absolute volume = 58%

(c) C.F=0.9 and take W/C=0.42

Corrections

Change in condition	**Water**	**Sand**
W/C(0.6-0.42 = 0.18)	0	-3.6%
C.F +0.1	+3%	0
Rounded	-15kg	-7%
Zone -2	0	0

The corrected water content per cubic meter of concrete

200 + ((3/100)*200) – 15 = 191.00 1/m3

The corrected sand content as percentage of total aggregate by absolute volume

58% - 10.6% = 47.4%

4. Determination of cement content Water/cement = 0.42

Water = 191.00 1/m3

The cement content =191.00/0.42=454.76 kg/m^3

5. Determination of coarse and fine aggregate contents for the specified maximum aggregate size of 12.5mm, the amount of entrapped air in the wet concrete is 3%, taking this into account and applying equations

V= [W/SW+C/SC+fa/ (p*SFA)]*1/1000; V= [W/SW+C/SC+Ca/ ((1- p)*SCA)]*1/1000; 0.97= [191.00+ (454.76/3.01) +fa/ (0.474*2.613)]*1/1000.

Fa=777.71Kg/m^3

0.97= [191.00+ (454.76/3.01) +ca/ ((1-0.474)*2.625)]*1/1000.

Ca=866.99 Kg/m^3.

The mix proportion then becomes

Cement	**Sand**	**Coarse aggregate**	**Water**
454.76Kg	777.71Kg	866.99Kg	191.00
1	1.71	1.90	0.42

The obtained contents of cement sand aggregate and water per cubic meter of concrete are listed below.

Cement = 454.76 Kg

Sand = 777.71 Kg

Coarse aggregate= 866.99Kg

Water191.00 Kg

Converting into SCC proportions

The normal concrete mix proportions are modified as per EFNARC specifications and different trail mixes and casted. By considering the fresh properties and harden properties of the mixes we finally arrived at the SCC mixed proportions as

Cement = 454.76 Kg

Sand = 777.71 Kg

Coarse aggregate = 866.99 Kg

Total aggregate (T.A) = 777.71 + 866.99 = 1644.70

Taking 54% of T.A as F.A

F.A = 1644.70 x 0.54 = 888.14 Kg/m^3

C.A = 756.57 Kg/m^3

The modified proportion is

Cement	**Sand**	**Coarse aggregate**	**Water**
454.76Kg	777.71Kg	866.99Kg	191.00
1	1.71	1.90	0.42

Further in the trail mix-3 cementation material is taken as 235kg/ m^3 of cement 129.25kg/ m^3 (55%) of fly ash, 94kg/ m^3 (40%) of GGBS and 2.35kg/ m^3 (1%) of micro silica is used

The water/cementation material is 0.42

The fine aggregate/total aggregate is 58%

The contents of cement, fly ash, GGBS, micro silica, fine aggregate, coarse aggregate, water, SP 430 and VMA are listed below

Cement = 235 Kg/ m^3

Fly ash = 129.25 Kg/ m^3

GGBS = 94 Kg/ m^3

Micro silica = 2.35 Kg/ m^3

Fine aggregate = 777.71 Kg/ m^3

Coarse aggregate = 866.99 Kg/ m^3

Water = 193.45 lit / m^3

SP430 = 11.5 lit/ m^3

VMA = 1.6 lit/m^3

SP 430 dosage = 2.5% of cementation materials

VMA = 0.35% of cementation materials.

7.1.6. Steps taken in the mix proportioning: Final mix

1. Target mean strength for M30 grade concrete : $fck^* = f_{ck} + Ks$

fck = 30+1.65*6.0 = 39.9 N/mm^2

Where,

K = probability factor for various tolerances (5%) =1.65 from table 10.4

S = standard deviation for different degrees of control (good)=6.0 from table 10.6

2. The water cement ratio required for the target mean strength of 39.9Mpa is 0.38

3. Selection of water and sand content for 12.5mm maximum size aggregate and the sand confirming to ZONE-II

For W/C-0.6,C.F-0.8,angular,sand confirming to ZONE-II

(a) Water content for cubic meter of concrete = 200 1/m^3

(b) Sand content as percentage of total

Aggregate by absolute volume = 58%

(c) C.F=0.9 and take W/C=0.42

Corrections

Change in condition	**Water**	**Sand**
W/C(0.6-0.41 = 0.19)	0	-3.8%
C.F +0.1	+3%	0
Rounded	-15kg	-7%
Zone -2	0	0

The corrected water content per cubic meter of concrete

200 + ((3/100)*200) – 15 =191.00 1/m^3

The corrected sand content as percentage of total aggregate by absolute volume

57 % - 10.8 % = 46.2 %

4. Determination of cement content

Water/cement = 0.41

Water = 191.00 1/m3

The cement content = 191.00/0.41 = 465.85 kg/ m^3

5. Determination of coarse and fine aggregate contents for the specified maximum aggregate size of 12.5mm, the amount of entrapped air in the wet concrete is 3%, taking this into account and applying equations

V= [W/SW+C/SC+fa/ (p*SFA)]*1/1000; V= [W/SW+C/SC+Ca/ ((1-p)*SCA)]*1/1000; 0.97= [191.00+ (465.85/3.01)+fa/(0.46*2.613)]*1/1000.

Fa=750.31Kg/m^3

0.97= [191.00+ (465.85/3.01)+ca/((1-0.46)*2.625)]*1/1000.

Ca=884.85 Kg/m^3

The mix proportion then becomes

Cement	Sand	Coarse aggregate	Water
465.85Kg	750.31Kg	884.85Kg	191.00
1	1.61	1.90	0.41

The obtained contents of cement sand aggregate and water per cubic meter of concrete are listed below

Cement = 465.85Kg

Sand = 750.31Kg

Coarse aggregate = 884.85Kg

Water = 191.00 Kg

Converting into SCC proportions

The normal concrete mix proportions are modified as per EFNARC specifications and different trail mixes and casted. By considering the fresh properties and harden properties of the mixes we finally arrived at the SCC mixed proportions as

Cement = 465.85Kg

Sand = 750.31Kg

Coarse aggregate= 884.85Kg

Total aggregate (T.A) = 750.31 + 884.85 = 1635.16

Taking 56% of T.A as F.A

F.A = 1635.16 x 0.56 = 915.69 Kg/m^3

C.A = 719.47 Kg/m^3

The modified proportion is

Cement	Sand	Coarse aggregate	Water
465.85Kg	915.69 Kg	719.47 Kg	191.00
1	1.96	1.54	0.41

Further in the trail mix-3 cementation material is taken as 240kg/ m^3 of cement 132 kg/ m^3 (55%) of fly ash, 96 kg/ m^3 (40%) of GGBS and 2.4 kg/ m^3 (1%) of micro silica is used

The water/cementation material is 0.41

The fine aggregate/total aggregate is 56%

The contents of cement, fly ash, GGBS, micro silica, fine aggregate, coarse aggregate, water SP 430 and VMA are listed below

Cement = 240 Kg/ m^3

Fly ash = 132 Kg/ m^3

GGBS = 96 Kg/ m^3

Micro silica = 2.4 Kg/ m^3

Fine aggregate = 915.69 Kg/ m^3

Coarse aggregate = 719.47 Kg/ m^3

Water = 191.88 lit / m^3

SP430 = 11.7 lit/ m^3

VMA = 1.6 lit/m^3

SP 430 dosage = 2.5% of cementation materials

VMA = 0.35% of cementation materials.

Ratios of mix proportions by weight:

Mix	**Grade of Cement**	**Cement**	**F.A**	**C.A**	**Fly ash**	**GGBS**	**Micro silica**	**Sp 430 dosage**	**VMA Dosage**
SCC	M30	1.0	3.81	3.0	0.55	0.4	0.01	0.050	0.007

7.2 FRESH CONCRETE PROPERTIES:

Table 7.1 Properties of Fresh concrete (SCC)

Trail mix	**Slump Flow**		**V-Funnel**		**L-Box**
	Mm	T_{50}(Sec	T_0(Sec)	T_5(Sec)	H2/H1
1	670	5.0	11	13	0.80

2	675 4.5	10 12	0.82
3	685 3.5	8 9	0.84
4	680 4.0	9 11	0.83

7.3 HARDENED CONCRETE PROPERTIES:

Table 7.2 Properties of Hardened concrete (SCC)

Trail mix		**Compressive**	**Strength**	**(N/mm)**		Tensile Strength (N/mm^2)
	1 day	3 days	7 days	28 days	7 days	28 days
1	18.5	22.0	30.5	42.0	2.542	3.108
2	18.0	22.0	30.0	41.0	2.386	3.264
3	16.0	20.5	28.5	39.0	2.392	2.929
Final Mix	17.0	20.0	26.5	40.0	2.312	3.607

PLATE 1 : SLUMP TEST

PLATE 2 : V – FUNNEL TEST

PLATE 3 : L – BOX TEST

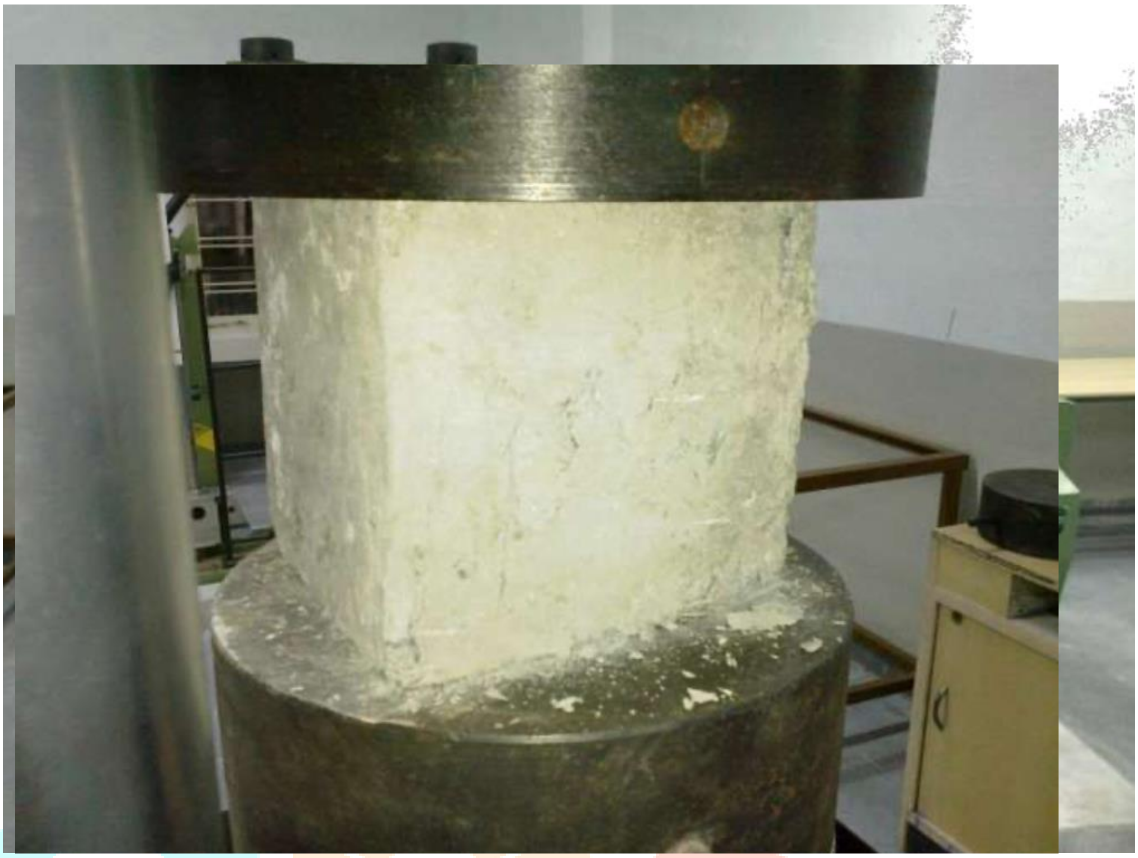


PLATE 4: CUBE UNDER COMPRESSIVE STRENGTH TESTING

PLATE 5: COMPRESSIVE STRENGTH TEST ON CUBES

CONCLUSION

Based on the investigation conducted for the study of behavior of self compacting concrete the following conclusions are arrived.

1. As no specific mix design procedures for SCC are available mix design can be done with conventional BIS method and suitable adjustments can be done as per the guidelines provided by different agencies.

2. Trail mixes have to be made for maintaining flow ability, self compatibility and obstruction clearance.

For Final Mix:

Compressive Strength of hardened concrete after 1 day = 17 N/mm^2

Compressive Strength of hardened concrete after 3 days = 20 N/mm^2

Compressive Strength of hardened concrete after 7 days = 26.5 N/mm^2

Compressive Strength of hardened concrete after 28 days = 40.0 N/mm^2

Tensile Strength of hardened concrete after 7 days = 2.312 N/mm^2

Tensile Strength of hardened concrete after 28 days = 3.607 N/mm^2

SCOPE FOR FURTHER WORK

Since a rational mix design method and an appropriate acceptance testing method at the job site have both largely been established for self compacting concrete, the main obstacles for the wide use of self compacting concrete can be considered to have been solved. The next task is to promote the rapid diffusion of the techniques for the production of self compacting concrete and its use in construction. Rational training and qualification systems for engineers should also be established. In addition, new structural design and construction systems making full use of the self compacting concrete should be introduced.

When self compacting concrete becomes so widely used that it is seen as the "Standard concrete" rather than a "Special concrete", we will have succeeded in creating durable and reliable concrete structures that require very little maintenance work.

REFERENCES

1. Bartos.P.J.M. " Measurement of Key properties of fresh self compacting concrete" , Proceeding of CENSTAR pnr Workshop on measurement, Testing and Standardization. Future needs in the field of construction materials, pairs, june 2000, university of Paisley, Paisley, Scotland,UK.

2. Bouzoubaa.N, and Lachmi.M, "Self-compacting concrete incorporating high volumes of class F fly ash, preliminary results" Cement and Concrete research, Vol.31, No.3,PP.413- 420, March 2001.

3. Brain poulson, EFNARC, Secretary general, "Specifications and guide lines for self compacting concrete", Feb 2002.

4. Campion.J.M. and JOST.P, "Self-compacting: Expanding the possibility of concrete design and placement". Concrete international, Vol 22, no4, PP, 31-34, April 2000.

5. Chaina, Ferraris: journal of research NISY Gaithersburg, Sep /Oct 1999. Measurement of the rheological properties of high performance concrete: state of the art report.

6. Emborg.M. , "Mixing and Transport", Final report of Task 8.1, Brite-Eu Ram Project no. Be 96-3801/Contract BRPR-CT 96-0366, Non-confidential information, 2000.

7. Frank Dehn, KlansHolschhemachen and Dirk weib-Self compacting concrete (SCC), time development of the material properties & the bond behavior.

8. Grauers. M . , „Mixing and Transport" , Final report of Task 8.1, Brite-Eu Ram Project no. Be96-3801/Contract BRPR-CT96-0366, Non-confidential information,1998.

9. Hajime Okamura and Masahiro Ochi "Self-Compacting Concrete" journal of advanced concrete technology Vol.1, No 1.5-15. April 2003.

10. Hashimoto. C., Maruyama.k. and Shimizu.k, „Study on visualization technique for blocking fresh concrete flowing in pipe" , Concrete library international, JSCE,No.12, pp.139-153,March 1989.

11. IS269-1958, Indian standard specification for ordinary, Rapid hardening and Low heat Portland cement, revised and reprinted, Aug 1965.

12. IS 269-1989, Indian standard specification for ordinary Portland cement, 33 grade, 4th revision, 1st reprint, June 1991, BIS 19901.

13. IS 383-1970, Specification for coarse and fine aggregate for natural sources for concrete, second revision, 9th reprint, 1993.

14. IS 456-2000, Indian standard plain and reinforced concrete-code of practice, 4th revision, 1st reprint Sep-2000.

15. IS 516-1959, Methods of test for strength of concrete, 16th reprint, Jan-1976.

16. IS 1489 (PART-I Fly ash based) 1991, specification for Portland-pozzolona cement, 3rd revision, BIS -1991.

17. IS 2386-1963 (All parts), Methods of tests for aggregate of concrete.

18. IS 3812-1981, Indian standard specification for fly ash for use as pozzolona and admixture, 1st revision, bureau of Indian standard, New Delhi, June 1981.

19. IS 10262-1982, Recommended guide lines for concrete mix design, 4th reprint, 1996.

20. IS 12269-1987(reaffirmed 1999), specification for 53 grade ordinary Portland cement, irst reprint Sep-1993.

21. Khayat. K.h, pautre.P and Tremblay.S, „Structural performance and in place properties of self compact concrete used for casting highly reinforced columns" , ACI materials journals, Vol.98,No.5,pp.371-378,Sep-Oct 2001.

22. Lars – GoranTviksta, task 8.4 quality control, guide lines, Brite-Eu Ram project No.Be96-3801/contract BRPR-CT96-0366, Non-confidential information,2000.

23. Mario collepadri, „a very close precursor of Self- Compacting concrete (SCC)" .