CHAPTER – II
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2.0 REVIEW OF LITERATURE


Self compacting concrete (SCC) is ideally suited for the concreting of structures which have heavily congested reinforcement or wherein the access for concreting is difficult. The authors on the topic "Use of SCC in a pump house at TAPP 3 & 4, Tarapur" described in brief the methodology adopted for the design of SCC mix, test methods to qualify SCC, and method adopted for concreting of walls and other structures of a condenser cooling water pump house at Tarapur Atomic Power Project 3 and 4 (TAPP 3 & 4).

Based on the experimental investigation, they concluded that

- SCC was used for concreting these walls and a few appurtenant structure of a pump house in Tarapur Atomic Power Project. The placing conditions were difficult and reinforcement was congested. These structures could be concreted without vibration and the results were excellent.

- The usual limits of proportions had to be exceeded in respect of some parameters. The maximum size of coarse aggregate was 20 mm and the sand was coarse. Therefore the coarse aggregate content was limited to 23 percent (on solid volume basis) instead of the recommended 28 percent of total concrete volume.

Other notable features were the water content of 175 l/m³, and a low powder content of 500 kg/m³. The SCC produced with the properties given in the text, was suitable for placing in difficult conditions without using external vibration.
2.0.2 AMIT MITTAL, KAISARE. M. B AND SHETTI. R.G (2008) [3]

Self compacting concrete (SCC) is defined as “concrete that does not need compaction”. It means SCC gets compacted without external efforts like vibration, floating, poking etc. The mix therefore is required to have the ability of passing, filling voids and being stable. Due to these characteristics, SCC is ideally suited for concreting structures, which have heavily congested reinforcement or difficult access conditions. Some of the wall of a pump house of Tarapur Atomic Power Project 3&4 (TAPP 3&4) were 14.4 m high and all the other structures around these walls were completed and it was very difficult to place conventional concrete and achieve good compaction. The use of SCC in this structure provided an excellent example of how innovative concrete technology can be used to solve practical problems and improve the efficiency of concreting operation. The authors on the topic “Self Compacting Concrete – An Innovative Solution for Construction” described in brief SCC, its design methodology adopted, test methods to qualify SCC, and methodology adopted concreting of W7 walls other structures of a pump house of Tarapur Atomic Power Project 3 & 4 (TAPP 3 & 4).

Based on the investigations they observed that the use of SCC in pump house provided an excellent example of how innovative concrete technology can be used to solve practical problems and improve the efficiency of concreting operation.

2.0.3 ANNE-MIEKE and GREET DE SCHUTTER (2005) [3]

Due to its advantages during pacing, self compacting concrete (SCC) seems to be a very promising material for concrete construction. At this moment however, not much information is available concerning the fundamental background of the properties of the SCC. At the Magnel Laboratory for Concrete Research, an extended research programme is going on in order to more fundamentally understand the behaviour of this material.
This research project includes the study of the fresh, hardening and hardened SCC, with due attention given to the time dependent mechanical behaviour.

In this contribution, results are reported concerning the creep and shrinkage of SCC. The measurements are carried out on sealed and unsealed specimens in order to be able to extract basic and drying creep and shrinkage. Different mix proportions are considered, studying different parameters, like cement type, filler type, c/p (cement to powder ratio).

The authors on the topic "Creep and Shrinkage of Self Compacting Concrete" made an attempt to study the deformations in more detail, the applicability of traditional creep and shrinkage models. Well known models like CEB-FIP Model Code 1990, the ACI-model and the model of de Larrard are evaluated. Some suggestions are made to include the influence of the addition of the fillers in the model of the model code.

After evaluation of the findings of the test series as described, the following conclusions can be formulated:

- With increasing c/p ratio, and consequently increasing cement content and decreasing w/c ratio, a decrease of the creep deformations is found.
- The fineness of the tested fillers has almost no influence on the deformations.
- Comparison of the experimental results with some traditional models shows that the ACI-model results into a accurate prediction while the models suggested by de Larrard and Model Code result into an underestimation of deformations.
- Based on the available experimental results it can be stated that the magnitude of the deformations of the self compacting concrete is comparable with the magnitude of the deformations of the traditional concrete. The use of self compacting concrete will probably not lead to a necessity to take extra preventions considering shrinkage and creep behaviour of the structure.
The influence of the different components and the mix compositions of the self compacting concrete have to be studied closely, for which a broader series of mixes has to be tested.

2.0.4 ANIRWAN SENGUPTHA and MANU SANTHANAM (2006) (4)

EFNARC-2002 was the first internationally recognized set of guidelines and specifications for self compacting concrete. However, it proposed a single range of workability for all applications. Subsequent studies from Europe indicated that different applications require the self compacting concrete to have different ranges of flowability and segregation resistance. This aspect has been incorporated in EFNARC_2005. SCC is now classified into different consistency classes based on its slump flow and floe time through V Funnel. The authors on the topic “Application based mix proportioning for self compacted concrete” in their investigation attempted to arrive at optimum mix proportions for various consistency classes of SCC with locally available materials. Adequate passing ability for all mixes was ensured by keeping the proportion of coarse aggregates low as the aggregates had high degree of flakiness and elongation.

Based on the experimental investigation they concluded that,

- Six different consistency classes of SCC as per EFNARC-2005 were produced in the laboratory using locally available materials. ALL mixes satisfied the criteria set forth by EFNARC, and showed good passing ability and segregation resistance.
- Higher powder contents were needed to design SCC high flow combined with stability. The higher powder content mixtures also resulted in the highest compressive strengths.
- A good correlation was found between the initial V-funnel flow time and the T-50 from slump flow test.
The use of Self Compacting Concrete (SCC) in actual construction is still in its infancy in India. Lack of awareness, technology know-how, technical data and experience could be cited as the main reasons. For adoption of any new material or technology, it generally needs to have a considerable proven performance record over traditional existing materials. Considerable research has been carried out at Structural Engineering Research Centre (SERC), Chennai, India, towards the technology development so that SCC would soon find a place in the Indian Construction Industry once its added value in terms of performance and cost are established.

The authors on the topic "Evaluation of Technical Feasibility of Self compacting concretes in the Construction of Horisontal and Vertical Structural members" Expressed the reports on the findings of two demonstration projects, where the flow characteristics and self compatibility of SCC mixtures were studied on both the horizontal and vertical structural members. The mix proportioning method, production and construction technology, mechanical and durability properties of the SCC mixtures achieved in the two projects are also presented. The results of this investigation show that SCC would soon emerge as the best choice for the construction of special as well as ordinary structures leading to highly durable concrete structures.

Based on the comprehensive research and development programme conducted on the self-compacting concrete including full-scale field trials on SCC piles, the following conclusions can be drawn:

- With existing knowledge of concrete technology self-compacting concrete mixtures can be designed. Carboxylic ether based super plasticiser is useful to achieve higher flowability of SCC mixes. Viscosity Modifying Agents (VMA) are useful to impart cohesively and stability to the SCC mix. Though SCC and CVCC
(Conventionally Vibrated Cement Concrete) have different modes of compaction, both mixes led to similar strength levels at ages of 1, 3, 7 and 28 days. Besides compressive strength, split tensile, flexural and bond strength of both the SCC and CVCC mixes were similar.

- Even though SCC has lower coarse aggregate content, its modulus of elasticity is almost similar to that of CVCC. The possible adverse effect of lower content of coarse aggregate on modulus of elasticity of concrete is offset in SCC by the improved denseness of matrix and strengthened transition Zone due to the presence of large content of pozzolanic admixtures in SCC.

- As the strength of the mixes increases with age, the stress-strain relationship becomes linear almost up to failure load and the deformation beyond the ultimate load is found to be negligible.

- The durability properties of SCC were superior to that of CVCC of similar strength as seen from the results of permeability, rapid chloride permeability and carbonation tests.

- The ductile detailing provisions envisage increased lap length, anchorage length, increased number of lateral ties at various locations, and specialized detailing at corners. All these would lead to increased congestion of reinforcement and hence SCC would be a preferred option for structural elements.

- Under-reamed piles are good examples where SCC can be used with confidence. Visual inspection on the exhumed piles showed that the SCC pile shaft and bulbs were well formed indicating that the mix had flown easily into the borehole. The surface finish of SCC piles was excellent without any signs of segregation, presence of honey combs or voids. The ultrasonic pulse velocity measurements were greater than 4.4 km/sec indicating the excellent integrity and quality of concrete.
Due to several advantages offered by SCC over conventional concrete including easy placement and self-compaction, it can be used with confidence in structures and foundations, as all the tests conducted have shown equal or better properties for SCC as compared to CVCC.


Self compacting concrete is made from almost the same ingredients as that of conventionally vibrated concrete (CVC) expect that relative proportions of these ingredients are to be carefully selected to impart self leveling and self compacting property to fresh concrete without a need for any external compacting and vibrating equipment. SCCs have generally higher content of fines (cement, fine aggregate) and chemical admixtures so that enhanced cohesiveness with no tendency for segregation is achieved. Thus, CVCs and SCCs are designed to have different characteristics when the concrete is fresh. In order to understand the structural behaviour of these two concretes in hardened stage, reinforced concrete (RC) beams of size 150 mm x 400mm x 3000 mm with similar concrete strength and identical reinforcement. The authors on the topic “Flexural behaviour of RC beams using self-compacting concrete” compared the structural behaviour such as load-deflection characteristics, crack-widths, spacing of cracks, number of cracks, crack pattern, ultimate load-carrying capacity, moments-curvature relationship, longitudinal strain in both concrete and steel for SCC and CVC.

Based on the investigations the following observations are made:

- Through SCC and CVC have different modes of compaction, both mixes yielded to similar strength levels at ages of 1,3,7, and 28 day. Besides compressive strength, split tensile, flexural and bond strength of both the mixes were similar. The mixes were designed to have a 28-day mean compressive strength of 70 Mpa.
• The UPV readings taken on SCC were similar to those of CVC showing that SCC had flowed through the reinforcement and felled the beam completely without voids, honey combs etc.

• The load-deformation behaviour of both SCC and CVC beams were similar up to the peak load stage. Beyond the peak load stage, CVC beams showed no drop in load with increased deformation while SCC beams showed drop in load with increased deformation. While the peak and failure loads were nearly the same for CVC beams, the failure load was nearly 25 percent lower compared to the peak load in SCC beams.

• Crack widths were within the limits specified by IS 456 at all load stages. The average crack widths of both the types of beams were comparable.

• The crack spacing of both CVC and SCC were almost the same.

2.0.7 AUDENAERT , K , BOEL, V. and DE SCHUTTER, G (2005) (7)

Durability and more specifically chloride penetration, is of major importance for reinforced concrete structures. As the conception of self compacting concrete (SCC) is totally different from traditional (TC), some changes in durability behaviour might occur. In order to locate and prevent possible problems, the chloride penetration in SCC has to be investigated.

The authors on the topic “Chloride penetration in Self Compacting Concrete by Cyclic Immersion” made an extended experimental programme. The chloride penetration of 16 self compacting concrete mixtures and 4 traditional concrete mixtures was determined. The test is performed on cylindrical specimens with a diameter of 230 mm and a height of 70 mm. These specimens are alternately immersed in a solution containing chlorides and exposed to air. One cycle takes approximately 1 hour. After
6, 12, 18, 24, 30 and 36 weeks the specimens are broken and penetration depth is measured.

For the self compacting concrete, four types of cement and three types of filler (fly ash and two types of limestone filler with a different grading curve) are used and the influence of the amount of the powder, water, the water/cement ratio and the cement/powder ratio is studied.

Based on these tests, the conclusion is that the penetration depth in real conditions is strongly influenced by water/cement and water/(cement + filler) ratios. Decreasing one of these ratios or both is leading to a decreasing penetration depth. Another important conclusion is that the chloride penetration depth in SCC by cyclic immersion is lower than the penetration depth in TC.

2.0.8 AZAMARD.H AND BEHESHTI ZADEH (2005) (B)

Concrete is a most widely used in construction material in the world. As the use of concrete becomes widespread the specifications of concrete like durability, quality, compactness and optimization of concrete becomes more important. Self compacting concrete (SCC) is a very fluid concrete and a homogeneous mixture that solves most of the problems related to ordinary concrete. Besides, SCC gets compacted under its own weight and there is no need for an internal vibrator for the body of the mould. This specification helps the execution of construction components under high compression of reinforcement. The authors on the topic “A Criticism of Self Compacting Concrete” made an investigation on the durability and strength of the concrete and studies the role of all important factors in durability of SCC by doing some examinations. Another part of the paper studies the obstacles in improvement in SCC. The last of the paper introduces some important projects executed with SCC in U.S.A, France and Japan and gives a brief
information about these projects and will provide the readers with reasons that why SCC is used in these projects.

Based on their investigation they concluded that if we obtain a reasonable mix design and suitable methods of acceptability test in workshops and overcome the economic problems considering the accessible resources of each country, the main obstacles mentioned for widespread use of S.C.C will be removed.

2.0.9 BINDIGANAVALIE.V and BANTHIA.N (2002) (9)

The authors on the topic "Some Studies on the Impact Response of Fiber Reinforced Concrete" made an attempt to examine two major issues related to impact loading on plain and fiber reinforced concrete. Firstly, within the context of drop weight impact tests, a number of machine parameters were examined including capacity size (150J - 15,000J) and drop heights (1.2m - 2.5m). It was found that the machine parameters strongly influence the observed material response to impact. Secondly, a comprehensive test program launched where steel and polymer fibers with widely different constitutive properties were compared as reinforcement in concrete under impact loading.

Based on the experimental investigation they observed that

- For cement-based materials, the measured impact response is highly dependent on the characteristics of the drop-weight impact machine used for testing. The pulse duration was found to depend upon the drop-height, with greater drop-height leading to shorter pulses. Results appear to be far less sensitive to the mass of the hammer than to the drop-height. This observation forms a useful basis for standardizing impact testing of plain and fiber reinforced concrete. Results from two different machines with varying hammer masses can be compared if the drop-height were identical.
Crimped polypropylene fiber is less effective than steel fiber at quasi-static rates of loading. However, a higher stress rates, in performed better than the steel fiber. This 'switch' in the behaviour of FRC is attributed to the greater strain rate sensitivity of polypropylene vis a vis steel.


Nuclear Power Corporation of India Ltd. (NPCL) intends to adopt the technology of self compacting concrete (SCC) for various structures in nuclear power plants (NPPs), especially for those having congested reinforcement. The authors on the Topic "Using SCC in nuclear power plants-laboratory and mock-up trails at kaiga" described the efforts in developing SCC mixtures on congested reinforcement. The authors discussed that an economical SCC mixture can be developed incorporating low powder and water contents and also says that with SCC it was possible to achieve faster progress, enhanced quality of construction, enhanced durability, better surface finish, better mould ability and reduction in noise level at construction sites and recommended a high volume of paste is essential to keep the concrete cohesive.

Based on the experimental investigation they observed that

- After de-shuttering which was done 13 hours after concreting it was observed that concrete flowed and occupied the form completely. Surface finish, both for the column and wall was good. Uniform distribution of aggregate was observed.

- The mix was designed for M30 grade, 56-day strength achieved was 50 MPA.

- It was possible to produce SCC with a low water content of 165 Kg/m³ and a powder content of 450 Kg/ m³.

- Cement content could be as low as 225 Kg/ m³.
Manufactured Sand (crushed Sand) percentage could be as high as 70% of the total fine aggregate content.

The finished product obtained was more durable, had better quality, with reduced peak heat of hydration. It was eco-friendly too.


The experimental work done by authors on “Effect of thermal cycles on compressive strength, modulus of rupture and dynamic modulus of concrete” is significant step towards determination of variation in strength of concrete exposed to thermal cycles. The investigation was planned to be carried out through an experimental program on concrete specimens for which M20 grade concrete mix was designed as per the guidelines laid down by IS 10262 – 1982. Ordinary Portland cement confirming to IS269- 1967 was used. Locally available coarse and fine aggregates were used to prepare the mix. The maximum size of the coarse aggregate used was 20-mm. Aggregate cement ratio of 6.0 and water cement ratio of 0.53 was used in the test program. The specimen used was plain concrete beams of the size 100 x 100 x 500 mm. In their study two cases of thermal cycles were chosen. In one case concrete was heated to a maximum temperature of 60° C and in another it was heated to a maximum temperature of 90° C. The specimens were heated in an oven from room temperature in about two hours, maintaining the maximum temperature for about 6 hours and then letting it cool down to room temperature in another 16 hours, all these constitute the completion of one thermal cycle. The specimen were subjected to 0, 30, 60,120,240,365 thermal cycles.

After subjecting to the requisite number of thermal cycles the specimens were treated for dynamic modulus of elasticity as measured by the resonant frequency method. To find the dynamic modulus of elasticity the beam was first held as a cantilever beam, with one
end fixed (held under a screw jack) and other end free. Miniature piezo electric transducer was fixed at the free end of the specimen. An impact was applied using an impact hammer. The beam vibrated under this impact load. The vibrations were picked using the miniature piezo electric transducer. The signal obtained from the transducer was amplified using amplifiers and then the signals were analyzed using a FFT (Fast Fourier Transform) analyzer to obtain the natural frequency of vibration of the specimen. This value of natural frequency was further utilized to determine the dynamic modulus of elasticity. After completion of the dynamic modulus of elasticity test, the specimens were tested to determine the modulus of rupture using the two point loading as per I.S. 516-1959. The compressive strength was measured from tests carried out on broken pieces of the beam obtained after the flexural test. Each value of the compressive strength, flexural strength and dynamic modulus of elasticity was taken as an average of three values obtained from three identical specimens.

From the experimental investigation carried out the following conclusions were given by them.

- The dynamic modulus of elasticity decreased with increased in the number of thermal cycles. At both 60°C and 90°C thermal cycles, the rate of reduction is found to be maximum after 30 thermal cycles and it is reduced with increase in the number of thermal cycles. At 60°C the rate of reduction is found to be 17.1% for thermal cycles and 26% for 365 thermal cycles. In case of concrete subjected to 90°C the rate of reduction after 30 thermal cycles is 27% and 41% for 365 thermal cycles. The maximum reduction occurred after 365 thermal cycles for both 60°C and 90°C. However the rate of reduction is higher for specimens subject to 90°C thermal cycles, as compared to that of specimens heated at 60°C thermal cycles.
- Similarly, thermal cycles have an adverse effect on the compressive strength as well. Once again the rate of reaction is found to be maximum after 30 thermal cycles for specimens subjected to both 60°C and 90°C, which is 16% and 21% respectively, and there after decreased gradually with increase in the number of thermal cycles. However the maximum reduction in compressive strength occurred after 365 thermal cycles for specimens subjected to thermal cycles at 60°C and 90°C which is 26% and 35% respectively, showing that the specimens heated at 90°C are more adversely affected when compared to those heated at 60°C.

- Thermal cycles affect the flexural strength as well. For flexural strength also the rate of reduction in strength is highest at 30 thermal cycles and it decreases gradually with further increase in thermal cycles. The percentage reduction is 3.9% for 60°C and 17% for 90°C. The rate of reduction once again being higher for specimens subjected to 90°C.

The adverse effect of thermal cycles on the studied properties of concrete is probably due to thermal incompatibility of concrete constituents. Investigations have shown that micro cracks exist at the interface between coarse aggregate and cement paste even prior to the application of load on concrete. In the case of concrete subjected to thermal cycles, the micro cracks further increase probably due to the different coefficient of thermal expansion of cement matrix and aggregates. Internal stresses created due to unequal expansion or contraction of the concrete constituents might lead to an increase in the micro cracks.
2.0.12 CHAO-LUNG HWANG and CHICH -TA-TSAI (2005) (13)

The authors on Topic “The Effect of Aggregate packing types on engineering properties of self consolidating concrete” made an attempt to share the experience of SCC (self consolidating concrete) that has been done in Taiwan. The main theme is to study the effects of aggregate packing types on the engineering properties of SCC.

Three types of aggregate packing (primitive, dense and gap gradation) and five paste contents (1.2, 1.4, 1.6, 1.8, and 2.0 of void within aggregate) are major parameters for evaluating the properties of SCC.

The test results indicates the denser the aggregate packing the better the workability and engineering properties under sufficient paste content. The application of the densified mixture design algorithm (DMDA) to design SCC for every aggregate package type can obtain high flowability and suitable strength growth. The strength efficiency of SCC designed by DMDA is much higher than that by traditional one. The significant contribution of the aggregate packing to the performance of hardened SCC is obvious.

2.0.13 CHAKRABARTI S.C., SHARMA K.N. and ABHA MITTAL (1994) (14)

The authors on the topic “Residual Strength in concrete after exposure to elevated temperature” reveal that the loss of concrete strength when exposed to higher temperatures and the recovery of lost strength due to rehydration of concrete with time was a support of evidence for the earlier experimental works done on the effect of high temperatures on compressive strength of concrete.

Based on the Experimental investigations they concluded:

- An increase in compressive strength for exposure to lower temperature below 100’ C this may be partly attributed to accelerated hydration of unhydrated cement. The compressive strength is drastically affected in higher ranges of temperature and the time of exposure.
With time, there is a recovery of compressive strength due to rehydration of concrete. The recovery may be about 80 percent of the initial strength. This was also been observed by other research workers, that concrete which has been heated at temperature below 500°C rehydrates while cooling down and gradually regains most of its lost strength.


The authors in their experimental work on the topic “Effect of maximum size and volume of coarse aggregate on the properties of SCC” described how to develop SCC and to study the effect of maximum size and volume of coarse aggregate on the properties of SCC. Twelve mixtures were investigated. The water-powder ratio was kept fixed throughout the programme. The superplasticiser dosage was determined from mortal trails and was kept constant. To achieve self-compacting properties, successive replacement of coarse aggregate by fine aggregate was adopted. Self-compacting concrete without using any viscosity modifying agent was developed. Slump flow test, V-funnel test, U-box test and GTM screen stability test on fresh concrete were carried out as per EFNARC guidelines. The compressive strength of the concrete after 7 and 28-day curing were also investigated.

Based on the experimental investigation, they concluded that to achieve the self-compacting properties the mix should contain a lower volume of coarse aggregate. It is difficult to develop self-compacting concretes with a coarse aggregate content higher than 45 percent or lower than 15 percent of the total aggregate.

(i) Self-compacting properties can be achieved even for a very high percentage of sand content (that is up to 85 percent).

(ii) Self-compacting concrete can be developed without using any viscosity modifying agent. However, in actual practice, the use of VMA is found useful to cater to variation in moisture content and gradation of aggregates.
As the maximum size of the coarse aggregate increases, the tendency of the mix to segregate increases.

In this investigation the best-compacting properties were obtained for a sand content of 70 percent and a coarse aggregate content of 30 percent of the total aggregate using a 43 grade cement. The volume of paste was 41.5 percent and the water-powder ratio was 0.32.

2.0.15 FRANK DEHN, KLAUS HOLSCHEMACHER AND DIRK WEIBE

The authors on the topic Self-Compacting Concrete (SCC) Time Development of the Material Properties and the Bond Behaviour reported on the time development of the material properties and the bond behaviour between the reinforcing bars and the self-compacting concrete as basis for the description of the load bearing capacity of reinforced concrete structures.

Based on the Experimental investigations they concluded that

- In this investigation, the time development, of the bond behaviour between the reinforcing bars and the self-compacting concrete (Powder-type) was tested under monotonic loading. Depending on the mix design and the modified test specimens it was found out, that the bond behaviour in SCC is better than the correlated bond stresses according to the bond law of Konig/Tue[3].

In the next step, tests under cyclic loading are prepared. Therefore, different ranges of steel stresses and loading shall be provided in order to obtain creep displacement factors for self-compacting concrete. To compare the results found for the dynamic loading, tests with normally vibrated concrete, with vibrated concrete which has a large amount of sand, as well as with SCC are planned.

The authors in their experimental work on the topic "Durability aspects of steel fibre – reinforced SCC" studied the effect of steel fibres on the durability parameters of self-compacting concrete (SCC) such as permeability, water absorption, abrasion resistance, resistance to marine as well as sulphate attack. The variables considered were aspect ratio, (0, 15, 25 and 35) and volume fraction (0, 0.25, 0.5 and 0.75 percent) of steel fibres. The water-cement ratio of 0.36 by weight and a trinary blend of cement, fly ash and silica fume were used. A total of 244 specimens were cast and tested for this study. It was observed that the coefficient of permeability and wear of SFRSCC were lower than the corresponding moderate strength concrete. Under the marine and sulphate attack, the losses in mass of concrete and compressive strength of cubes were found to be negligible. It was observed that SFRSCC resists these attacks within tolerable limits and the optimum dosage of fibres for better performance was found to be 0.5 percent.

Based on the experimental investigation, they concluded that addition of steel fibres improved the durability aspects of self compacting concrete. The loss in mass and compressive strength of cubes was found to be negligible under marine and sulphate attacks. It was observed that SFRSCC resists all these attacks within tolerable limits and the optimum dosage of fibres for better performance was found to be 0.5 percent.


The authors on the topic "State of the Art Report on self compacting concrete" made an attempt to review available literature on studies of self-compacting concrete (SCC). SCC is a recently developed concept in which the ingredients of the concrete mix are proportioned so that the concrete compacts by its own weight without external or internal vibrators. Due to its free flow nature, it has been found to be extremely useful in the case of column beam junctions and other parts of structure where congestion of
reinforcement causes serous problems. The first application of SCC was carried out in Japan in 1980's. Since then several attempts have been made by researches on strength and characteristics of SCC in various parts of the world. They reviewed these attempts in detail in the subsequent sections. This state-of-the-art report covers more than 35 publications in the field of SCC.

From the review, it may be noted that self compacting concrete appears to be a very useful composite due to its high performance, applicability in the congested zones and durability. While several attempts have been made in the recent years on studies on strength and behaviour SCC, only a few attempts have been come across on the strength and behaviour of structural elements made of SCC. Hence, it is felt that more number of studies have to be carried out to understand short term and long term behavior of structural elements such as beams, beam-column joints can using SCC.

2.0.18 GANESHAN N, INDIRA P.V AND SANTHOSH KUMAR P.T (2005) [18]

The authors on the topic “Strength and Behaviour of Steel Fibre Reinforced Self Compacting Concrete in Flexure” made an attempt to study the effect of steel fibres on the strength and behaviour of fibre reinforced SCC structural elements subjected to flexure. Twenty beams were cast for this study, out of which two were plain SCC beams without fibres. The variables in this study were aspect ratio (15.25 and 35) and percentage of volume fraction (0, 0.25, 0.5 and 0.75) of fibres. Based on the Experimental investigation they observed that the first crack load and the post cracking behaviour were found to have improved due to the addition of fibres. A marginal improvement in the ultimate strength was observed. The addition of fibres had enhanced the ductility significantly. The optimum volume fraction of fibres was found to be 0.5 percent.

The authors on the topic “Ultimate strength of steel fibre reinforced self compacting concrete flexural elements” made an attempt has been made to study the effect of steel fibres on the strength and behaviour of Self Compacting Concrete (SCC) flexural elements. Twenty beams were cast for this study out of which two were plain SCC beams without fibres. The variables in this study were aspect ratio (0, 15, 25 and 35) and percentage of volume fraction of fibres (0, 0.25, 0.5 and 0.75). First crack load and the post cracking behaviour were found to have improved significantly due to the addition of fibres. A marginal improvement in the ultimate strength was observed. The addition of fibres enhanced the ductility significantly. The optimum volume fraction of fibres for better performance in terms of strength and ductility was found to be 0.5 percent. Experimental values of the ultimate moment were compared with various analytical models. The comparison indicate that Swami and Taan model compares better with the test results than that of the other models.

2.0.20 GIRISH S., PUTTE GOWDA B.S., JAGADISH VENGALA AND RANGANATH R.V. (2005)

The authors on the topic “Influence of different Super plasticizers on the Properties of Self-compacting concrete” presented the detailed study carried out to develop SCC in the laboratory using a sequential procedure. Development of SCC included the use of fly ash from Raichur Thermal Power Plant and three different super plasticizers. The study included the evaluation of key SCC properties with respect to time by using testing methods such as slump flow, V-funnel, L-Box, and U-box. The results show that SCC can be obtained by using the sequential procedure. The measurable values of SCC properties using Slump flow, V-funnel, L-Box and U-Box fall below the acceptable values beyond 30-45 min. from the time of mixing for all the mixes studied.
using different super plasticizers. However, re-dosage with super plasticizer and/or retarder would help significantly to regain the required SCC properties.

Durability is considered to be one of the important aspects of any concrete structure, which is directly related to the degree and quality of consolidation efforts. There are no practical means by which compaction of concrete on a site ever be fully guaranteed. The lack of uniform and complete compaction had been identified as the primary factor responsible for poor performance of concrete structure.

Based on the experimental investigation, it was observed that self compacting concrete can be achieved using the sequential procedure with different super plasticizers for the given mix proportions with minor adjustment of super plasticizer dosages. Among the super plasticizers, used in the present study, performance of polycarboxylic either based super plasticizer was found to be superior with respect to time retention. The flow retention of the SCC mix can be achieved by repeated dosage of super plasticizers at regular time intervals or by using small dosages of compatible retarder. For measuring SCC properties the slump flow test and U-Box test, gives a good combination.

2.0.21 HEGGER J. and NIEWELS J. (2005) (21)

The authors on the topic “Textile Carbon Reinforcement for Base Slabs of Self-Consolidating Concrete” presented a new concept for base slabs made of textile reinforced self-consolidating concrete (SCC) in order to rationalize the fabrication of large slabs. Large base slabs in the industry are exposed to different types of loading in many cases, the restraint to imposed deformations due to temperature and shrinkage is decisive for the design. The advantages of textile reinforcement compared to ordinary steel reinforcement are pointed out. The main objective is limit the crack width and to avoid expansion joints. Therefore, numerous tensile tests with differently prepared carbon roving have been performed in order to analyze and advance the bond behaviour
of carbon reinforcement in SCC. These roving serve as the basis for a technical textile as reinforcement for large base slabs.

Based on the experimental investigation, the following conclusions are drawn. A total of 34 tensile tests of carbon reinforced concrete specimens were performed to investigate the influence of the resin, the profile of the roving, the carbon material and the concrete on the bond performance. According to the complex interaction there is still need for research to optimize the bond performance. The aim for using carbon as reinforcement for large base slabs is to have a very good bond generating a fine crack pattern with low splitting tendencies at costs. It could be a good approach to have aramid or a less expensive material wrapped around the rovings combined with a very stiff resin of high strength forming steep rib in order to reduce the tendencies. The tests show that carbon rovings STS 5631 by Tenax wrapped with aramid and laminated with epoxy resin EP 285 are a suitable basis for technical textiles as reinforcement for base slabs. Since the longitudinal cracks occurred in the layer of the rovings it is still possible to reduce the concrete cover as long as there are no longitudinal cracks vertical to the layer of the rovings. Furthermore, the small mesh configuration of the textile with interbreeding rovings could help to advance the anchorage within the concrete.

For the design of large slabs reinforced with a carbon textile the focus has to be on the serviceability limit state as the tensile strength of the carbon is more than sufficient and there are no problems to be expected concerning the ultimate limit state. Similar to steel reinforcement the acceptable stress of the carbon has to be confined in order to limit the crack width. For this reason the bond performance is of great importance.
The authors in their experimental work on topic "Preliminary Examinations for the Production of Self-Compacting Concrete Using Lignite Fly Ash" gave the results obtained show a possible application of lignite fly ash for the production of Self-Compacting Concrete (SCC). The use of lignite fly ash as building material represents an interesting possibility for the use of secondary raw materials in the construction industry. The lignite fly ash has not only some characteristics of potential hydraulic materials, it can also clearly improve the rheological properties of the fresh concrete because of its fineness, which is a primary advantage for SCC. Self-compacting concrete with lignite fly ash shows a good flowing ability and high self-compactability.

The existing investigations show the possible application of lignite fly ash both as binder and filler in the cement. The use of secondary raw materials in the building material industry will gain in importance with increasing energy cost. By the use of LFA as fine aggregate, the energy consumption in the cement production could clearly be reduced, without losses in the compressive strength development.

This contribution shows also that the use of LFA in SCC is sensibly and feasible, according to the promising future of SCC. The use of LFA as binder should absolutely be followed up. How much shrinkage can be compensated by swelling should be determined in further investigations. Because of the large differences of LFA further investigation on chemical and physical characteristics are required, in order to use LFA in the building material industry. Each fly ash must be examined in particular case, so that its suitability for concrete production can be confirmed. In order to guarantee the high quality of concrete, systems for quality control of ashes must be developed.
2.0.23 JAGADISH VENGALA AND RANGANATH R.V. (2003). (23)

The authors on the topic "Effect of Fly Ash on Long term Strength in High Strength Self Compacting Concrete" made investigation and discussed the results of an experimental study of the fresh concrete properties and the development of strength of high performance self-compacting concrete at ages of 180 and 270 days. Based on fresh and hardened properties of SCC mixes they concluded that inclusion of fly ash as part replacement of coarse aggregate, as done in this study, has increased the paste content and hence enhances the self-compacting properties. In fact a high powder content has been advocated by development of SCC, which is the case here. It contributes to its long-term strength and durability as it imparts a continuous hydrating system to the concrete. It appears that in case of normally vibrates concretes having the fly ash greater than 140 kg per cum of concrete, an increase of the order of 35% occurs at later ages whereas similar increases in SCC mixes of High volumes of fly ash likely to be of the order of 35-60%.

2.0.24 KLAUS HOLSCHEMACHER AND YVETTE KLUG (24)

Self compacting concrete consists basically of the same components as normal vibrated concrete, however, there exist clear differences regarding the concrete composition. In this context it is to verify, whether the properties of hardened self compacting concrete and normal vibrated concrete differ significantly from each other. For the clarification of this question the authors on topic "A Database for the Evaluation of Hardened Properties of SCC" created a data base with own and internationally published test results to clarify whether the properties of hardened self-compacting concrete and normal vibrated concrete differ significantly from each other. They evaluated regarding the relations between compressive strength, tensile strength,
modulus of elasticity and bond properties. Furthermore creep and shrinkage deformation of SCC and vibrated concrete were compared.

The results of the interpretation of the database can be summarized as follows:

- The concrete strength of SCC and normal concrete are similar under comparable conditions, this statements includes also the time development of concrete strength.
- Tensile splitting strength, modulus of elasticity and shrinkage of SCC and normal concrete differ, but the differences vary within the usual scatter width, known for normal concrete.
- No final tendency can be given for creep of SCC.

Based on these facts it can be concluded, that extra design rules for SCC are not necessary. Further research projects are required to influence on the hardened properties of SCC more precise. Therefore further investigations have to follow, to got knowledge about the influence of any parameter, as for example the current type, the type of filler and its portion, the water - binder ratio and so on.

To use the advantages of SCC efficiently, all parameters affecting the properties of concrete in respect of the production and the durability of concrete structures should exactly be known. In this way SCC can be designed optimally only, without causing later damages by the usage of a new and modern building material.

The use of self-compacting concrete is recommended for all applications, where the mentioned advantages are necessary to assure a good concrete quality. Especially in highly reinforced concrete members like bridge decks or abutments, tunnel linings or tubing segments, where it is difficult to vibrate the concrete, or even for normal engineering structures, SCC is favourably suitable.

Mechanical properties of high strength concrete exposed to elevated temperatures were measured by heating 100x200 mm cylinders at 5°C/min to temperature up to 600°C. Heating was carried out with and without a sustained stress, and properties were measured at elevated temperatures as well as after cooling to room temperature. Four mixtures with water-cementitious materials ratios (w/cm) ranging from 51 to 98 MPa were used. Two of the mixtures contained silica fume. Measured compressive strengths and elastic modulii were normalized with respect to room temperature values, and analysis of variance was used to determine whether the test condition, the values of w/cm, or the presence of silica fume affected the results. The influence of these variables on the tendency for explosive spalling was also examined by the authors on the topic “Effects of Test Conditions and Mixture Proportions on Behavior of High-Strength Concrete Exposed to High Temperatures”. Results indicate that losses in relative strength due to high temperature exposure were affected by the test condition and w/cm, but there were significant interactions among the main factors that resulted in complex behaviours. The presence of silica fume does not appear to have a significant effect. Measurements of temperature histories in the cylinders revealed complex behaviours that are believed to be linked to heat-induced transformations and transport of free and chemically combined water.


Self compacting concrete (SCC) is a new kind of high performance concrete (HPC) with excellent deformability and segregation resistance. The major steps in the production of SCC are, designing an appropriate mix proportion and evaluating the properties of the concrete obtained. In practice, SCC in its fresh state shows high fluidity, self compacting ability and segregation resistance. All these properties contribute to reduce the risk of
honeycombing of concrete. Hence, 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 production has taken into consideration the requirements in the structural design.

The authors in their experimental work on the topic “Development of Mix Design Chart for various Grades of Self Compacting Concrete” studied the flow properties and strength properties of the design mixes of SCC for different grades varying from M20 to M60. The flow properties such as passing ability, filling ability, viscosity and segregation resistance and compaction factor are checked by conducting various tests. The compressive strength of concrete are checked after 7 and 28 days curing and also the split tensile strength was obtained after 28 days curing. The charts have been developed for obtaining quantity of cement, fly ash and coarse aggregate required for different grades of SCC.

Based on the Experimental investigations they concluded

- The flow properties of developed SCC for various grades are satisfying the recommended values.
- The segregation resistance of all SCC grades is also good.
- The water cement ratio of SCC may be slightly higher for SCC but water binder ratio is very less, it varies from 0.3 to 0.4.
- For the developed mix design, all grades of SCC attained the target mean strength at 28 days.
- The difference between the tensile strength of normal concrete and SCC is very negligible.
- The relationship between compressive and split tensile strength designed SCC mixes is obeying Power law similar to normal concrete.
2.0.27 MAHESH Y.V.S.S.U AND MANU SANTHANAM (2004)

Self compacting concrete (SCC) requires a mixture with high fluidity while avoiding segregation. In order to characterize the rheological properties of SCC, many test methods have been developed, such as slump flow test, U-box test, L-box test, V-funnel test, fill box test, etc. Measurements of rheological parameters are also sometimes performed using sophisticated and expensive rheometers. The authors on the topic “Simple test methods to characterize the rheology of self-compacting concrete” made an attempt to correlate multiple field test methods for flow behaviour of SCC, so that these can used interchangeably.

Based on the laboratory work, they concluded that

- The slump flow value and the U-box test can be used to qualitatively characterize the SCC mixture as acceptable or unacceptable.
- Viscosity of the SCC mixture decreases with an increase in the water-to-powder-ratio. The decrease in viscosity is indicated by the drop in T50 and V-funnel flow time.
- Data suggests a linear relationship between the V-funnel flow time and the T50 slump flow. Thus, these two tests can be used interchangeable in the field.
- It is crucial to complete testing of the fresh properties within a short time period after mixing, in order to get a true measure of the performance in various tests. The L-box is particularly sensitive to delays.
- Further work is necessary to correlate the field test values with a rheometer based study of the rheological parameters for SCC.
Over the last ten years, significant amount of work has been carried out on self-compacting concrete (SCC) all over the world. The potential for the use of SCC in construction projects has been effectively demonstrated in some countries. However, a number of issues need to be addressed further to make this a widely acceptable technology. The authors on the topic "Current developments in self-compacting concrete" discussed the existing research about various aspects of self-compacting concrete, including materials and mixture design, test methods, construction-related issues, and properties.

They summarized that Self-Compacting Concrete is a recent development that shows potential for future applications. It meets the demands placed by requirements of speed and quality in construction.

Based on the existing research and available knowledge, the following trends are emerging:

- Use of viscosity modifying agents (of the pseudoplastic variety) compiled with high-range water reducing agent for dynamic control of flow and segregation is increasing.

- A better understanding of the rheological parameter yield stress and plastic viscosity—has made it easy to describe the role of superplasticiser, particle packing (increased fines content etc.) and pseudo plastic VMA in SCC. It has also given the user a tool to prescribe variants of SCC based on the type of application and placing conditions.
2.0.29 MOHAMMED BHAI G.T.G (1983)\textsuperscript{[30]}

The experimental work done by Prof.G.T.G.MOHAMMED BHAI, describes tests carried out to determine the effect of high temperatures on the residual compressive strength of concrete used in Mauritius. The rock formation in Mauritius, an island of the volcanic origin is mostly basaltic. The course aggregate used for making concrete in Mauritius is invariably crushed basalt. The fine aggregate can be either coral sand or crushed basalt. The effect of method of cooling and that of age after heating were included in the investigation. In order to determine whether any physical or chemical changes take place in the coral sand and basalt on heating-ray diffraction tests were carried out on powdered samples of the two aggregates. For each aggregate four test were carried out, one on un heated sample and other three on samples which has been heated for two hours to 200° C, 500° C and 800°C respectively and then cooled down to room temperature.

The following conclusions were drawn by the author:

1. When subjected to high temperatures the residual strength of concrete made with coral sand is significantly less than that of concrete made with basalt sand. This appears to be due to some chemical/physical changes, which occur, in coral sand when heated beyond 300° C.

2. The method of cooling has no significance influence on the residual strength of concrete heated up to 400° C, but for higher temperatures air cooled specimens have a lower residual strength than water cools ones.

3. Air-cooled specimens show a further loss in strength from one day to seven days after heating. Water cooled specimens, however exhibited a recovery in strength over the same period.
2.0.30 MICHAEL STEGMAIER AND HANS-WOLF REINHARDT (2004) (31)

The authors on the topic "Fire Behaviour of Plain Self-Compacting Concrete" in their research work self compacting concretes are designed as powder type, viscosity-agent type and combination type with respect to their behaviour at fire conditions. The concretes showed a relatively high residual compressive strength which depended also on the (w/c)\textsubscript{eq}-ratio and the cement-powder ratio (c/p) of the mix.

2.0.31 NAVEEN KUMAR C. KIRAN V. JOHN, JAGADISH VENGALA AND RANGANATH R.V. (2006) (32)

The successful use of fillers other than fly ash in self compacting concrete (SCC) have been reviewed with reference to some published literature to bring out the advantages of such fillers when used in SCC. The promise of metakaolin, an extremely fine powder is highlighted. The authors on the topic "Self-compacting concrete with fly ash and metakaolin" presented the results of experimental studies where in fly ash, metakaolin and their blends were used as fillers in SCC. The results showed that SCC can be produced with cement content, as low as 200 Kg/m$^3$ of concrete together with rest of the powder coming from fly ash. High strength SCC can be obtained through incorporation of metakaolin.

Based on the Experimental investigations they concluded

- The brief literature review of SCC mixes made with non-fly ash fillers showed that such fillers can also be used in SCC whenever economic, environmental and easy availability considerations predominate without much apprehension.

- Mixes with different fillers like silica fume and metakaolin help in attaining a high early strength of around 50-70 MPa which is very useful in pre-cast applications. They also can provide high durability when used along with fly ash.
SCC can be obtained for widely differing fly ash contents or cement contents as long as the paste volume constituted by the powder and water is kept unaltered.

The experimental study reported in this paper showed that fly ash can be used in large quantities in SCC and cement content can be reduced to as low as 200 Kg.

2.0.32 OKAMURA HAJIME AND MASAHIRO OUCHI (2003) [24]

Self compacting concrete was first developed in 1988 to achieve durable concrete structures. Since then, various investigations have been carried out and this type of concrete has been used in practical structures in Japan, mainly by largely construction companies. The authors carried work on topic “Self-Compacting Concrete” made investigation for establishing a rational mix-design method and self-compactability testing methods have been carried out from the viewpoint of making self-compacting concrete a standard concrete.

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 its use in constriction. Rational training and qualification systems for engineers should also be established. In addition, new structural design and constriction systems making full use of 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.
2.0.33 Paratibha Aggarwal, Yogesh Aggarwal, Gupta S.M. and Siddique R. (2005) 

Self compacting concrete can be defined as the concrete which requires no vibrations and can flow around obstructions, encloses the reinforcement and fills up the formwork completely under its self weight. Over the last ten years, significant amount of work has been carried out on self compacting concrete all over the world. In countries like Japan, Sweden, Thailand, UK etc., the knowledge of SCC has moved from domain of research to application.

The authors in their research work on the topic "Properties of Self-Compacting Concrete - An Overview" discussed the existing level of research various aspects of self-compacting concrete, including materials and mixture design, test methods such as V-funnel test, L-Box test, J-ring etc., construction-related issues like Tribological behavior of SCC, performance of SCC for under water applications, in basement walls, columns, beams, etc. and properties including fresh concrete properties like slump flow, segregation resistance, compressive strength, permeability and diffusivity. Durability properties like sulfate resistance, internal frost resistance, resistance to freezing and thawing, deicing salt surface scaling resistance. It also provides insight into the research being carried out to predict the performance of SCC mixtures using modeling techniques like factorial design method and artificial neural network. The models developed can be used as economical tools for optimized design of SCC mixtures thereby reducing number of mix trails and can be used to generate future results using other materials.

Based on the literature and findings they observed that:

- Workability parameters for initial mix design of SCC which need to be assessed can be summarized as filling ability, passing ability, and segregation resistance.
- It is evident that the properties of SCC in hardened state are similar to those of conventional concrete.
Different studies show that high strengths and adequate durability can be obtained using SCC better internal frost resistance was exhibited by SCC as compared to normal concrete.

Permeation properties like water sorptivity and oxygen permeability was lower for SCC. Also SCC had higher resistance against chloride penetration, frost thaw and scaling due to the increased dispersion to cement and filler, and a denser ITZ compared to conventional concrete.

Different design methodologies like ANN, factorial design method etc., for SCC have been suggested to develop models that can be used as economical tools for optimized design of SCC mixtures with desired properties.

2.0.34 PAI B.V. B. (2004) (144)

The authors on the topic "How economic is self compacting concrete?" developed as an answer to the problem of consolidating concrete in heavily reinforced structures by using Self Compacting Concrete (SCC). There is a feeling amongst certain engineers that SCC cost is much more than that of the corresponding normal strength or high-strength concrete (NSC/HSC). Is it really so? The cost of the ingredients of NSC/HSC and SCC differ marginally –SCC materials cost just about 10-15 percent higher. If an in-depth analysis of the other components of costs like the cost of consolidation, finishing, etc is carried out, then one would realize that SCC is certainly not a costly concrete.

Based on the laboratory work, they concluded that

- SSC is comparable in fact, superior to conventional concrete in respect of all properties.
- It should be the preferred choice when concreting conditions are difficult.
- Cost of only materials of SSC may appear to be slightly more, say about 15 percent or so.
• However, on a more rational basis of the total costs, including the labor charge
for formwork and making good finished surfaces, SSC will be more advantageous.
• From holistic considerations, SSC will be more cost-effective.

2.0.35 PRAVEEN KUMAR AND KAUSHIK S.K. (2005) [87]

Crushed stone aggregate are widely used in concrete. In the process of producing of
20 mm and 10 mm nominal size aggregates significant amount of crusher dust and stone
chips in the size of 2-6 mm are also obtained. Usually, most of these are not used in
concrete. However, economical and environmental considerations warrant investigations
on their possible use in concrete. The authors in their experimental work on the topic
"SCC with crusher dust, fly ash and micro-silica" presented the test results on use
age of crusher dust, stone chips, and fly ash in self-compacting concrete (SCC). Test
results indicate that SCC with satisfactory strength can be produced with such marginal
materials when used together with fly ash and micro-silica.

Based on the experimental investigation, they concluded that

• Crusher dust may be used as fine aggregate in conjunction with low-calcium fly
ash to produce SCC mixes.

• Sufficiently low water-to-powder ratio can be attained even with the use of
crusher dust, leading to high compressive strengths.

• Employment of a low coarse aggregate content with high fly ash content can lead
to similar strength at later ages, when compared with mixes containing relatively
higher coarse aggregate content and lower fly ash content.

Self compacting concrete generally possesses a high powder content which keeps the concrete cohesive with high flowability. For achieving economy, a substantial part of this powder could contain fly ash. In such cases, early age strength development may prove to be a decisive parameter, particularly when the formwork has to be reused. The authors on the topic “Early age strength of SCC with large volumes of fly ash” presented the test results of an experimental work, which involved fly ash contents of more than 50 percent of the total powder material. Compressive strength and split tensile strength test results are reported at the ages of 3, 7, 28 and 56 days.

Based on the experimental investigation, they concluded that

- It is possible to produce SCC with low powder contents (water volume / powder volume = 0.66) in comparison with the usual range of 0.9 to 1.25 mentioned in the literature.

- It has been possible to obtain self-compacting concrete with a low water content of 160 to 180 l/m³, as against to 190 to 220 l/m³ mentioned in the literature. For this a polycarboxylic either-based superplasticiser and a high content of fly ash have been employed.

- The mixture of SCC contained 52-56 percent fly ash in the total powder content. All the three mixes showed adequate strength development at 28 days, mix 1 with a cement content of 250 kg/m³, developed 32.6 MPa at 28 days.

For strength development at early ages similar to normal concrete, a minimum cement content of about 300 kg/m³ is required 7-day strength of the order of 30MPa is obtained in such SCC mixes.
The microstructure of the interfacial transition zone (ITZ) in the concrete governs its mechanical properties and durability. The two basic differences in self-compacting concrete (SCC) and the conventional concrete are the relatively high water content in SCC (for similar compressive strength of conventional concrete at 28 days) and the presence of extra powdery material like fly ash and micro silica in some cases in the former. The authors on the topic "Transition Zone in Self Compacting Concrete" presented the investigation of interfacial transition zone (ITZ) in SCC and conventional concretes with similar compressive strengths at 28 days. A new model for ITZ in SCC is proposed.

Based on the experimental investigation the following concluding remarks are observed.

- Observations using scanning electron microscopy on the transition zone in samples of self-compacting concrete reveal a microstructure distinctly different from that observed in normal concrete.
- The transition zone in self-compacting concrete was free of micro-cracks, in contrast to the normal concrete.
- The presence of micro silica and fly ash particles in the transition zone densifies and reduces the porosity of this zone.
- These distinctive features of the transition zone in self-compacting concrete lead to the expectation that the durability of self-compacting concrete, incorporating fly ash and micro silica, will be better than normal concrete, not withstanding the higher water content in self-compacting concrete.
2.0.38 PRAVEEN KUMAR, AND KAUSHIK S.K (2005)

The peak rise in temperature due to hydration reactions in mix proportioning of high strength self compacting concretes need to be limited through proper selection of the powder composition. In the Indian context, an economical solution is to employ a ternary mix of OPC-low calcium fly ash and silica fume. The authors on the topic “High Strength Self Compacting Concrete”, discussed about the optimum mix proportions employed and the effect of \(V_w/V_p\) on the compressive strength. Test results from experimental investigations are reported. Compressive strengths in the range 60-75 MPa could be attained at the age of 28 days with low water-cementitious ratio and cement content below 400 kg/m\(^3\).


Self compacting /consolidating concrete (SCC) was first developed at Tokyo University in Japan. SCC can be defined as a cement based, self consolidating concrete in which no additional internal or external vibration is necessary for compaction. SCC is highly flowable and can spread easily through restricted sections under its own weight without segregation and blockage. SCC consists of almost same ingredients of conventionally vibrated concrete (CVC) viz., cement, aggregates, water, additives and admixtures. However, SCC has higher amount of superplasticiser and finer particles, and also often Viscosity Enhancing Admixtures (VEAs). The authors on the topic “A Technical Review on properties of self-compacting concretes” made investigation on the properties of SCC and reviewed the properties of SCC in hardened stage.

Based on the experimental investigation, they concluded that
Self-compacting / consolidating concrete (SCC) has considerable advantages for large construction projects complicated and heavily reinforced structural elements.

- Can produce considerable saving in labour, turn around time of formwork and production time besides being more eco-friendly in terms of noise reduction.
- Utilizes many mineral and chemical admixtures.
- Has to be proportioned, at present, using experimental trails, considering the guidelines evolved by the various researches.
- The structural behaviour of SCC is similar to conventionally vibrated concrete and any strength level of SCC can be achieved by proper combination of powdery materials and water-binder ratio.

2.0.40 RAKESH KUMAR AND RAM KUMAR (2005)

The authors on the topic "Manufacturing Cost of Self-Compacting Concrete, Conventional Concrete, and Pumpable Concrete of the Similar Compressive Strength" made an attempt for the manufacturing of economical self-compacting concrete incorporating ASTM class F fly ash. The cost of this SCC mix based on the cost of materials viz. cement, aggregates, chemical admixtures, was estimated and compared with respect to a conventional plasticized concrete and a pumpable concrete of similar compressive strength, that is, about 40 MPa at 28 days.

Based on a comparative study of the manufacturing cost at laboratory for these concrete mixes they concluded that SCC is approximately 16% costlier than the conventional plasticized structural grade concrete and 5% cheaper than a pumpable concrete of similar compressive strength. Further, in-terms of strength developed per unit i.e. MPa, SCC and conventional plasticized concrete are equally costly.
2.0.41 RAVINDRA GETTU, HANNAH COLLIE, CAMILO BERNAD, TOMAS GAREIA AND CLOTILDE ROBIN (2003) \(^{(43)}\)

Self compacting concrete is a relatively new construction material with a promising future in the prefabrication industry. The authors on the topic "Use of High-Strength Self-Compacting Concrete in Prefabricated Architectural Elements" made investigation on a previously proposed experimental mix optimization methodology is applied to develop a suitable concrete for manufacturing a street/park bench with a complex shape. Good results have been obtained in terms self-compatibility and strength (40 Mpa at the age of 24 hours) with a concrete containing a high volume of fly ash, an appropriate superplastisizer and adequate paste content.

The main Conclusion of this study is that Self Compacting Concrete (SCC) has a promising future in prefabrication. The benefits of using it include the complete elimination of vibration needed to compaction. In addition to reducing costs, this leads to the improvement of the factory environment and worker health, extension of the life of the moulds and good surface finishes that reduce / eliminate the need for manual finishing. A prototype of a street/park bench has been cast with success demonstration the early advantages of using SCC.

2.0.42 RUDOLF HELA (2005) \(^{(44)}\)

The research of SCC especially under the effect of cyclic freeze and thaw process and in combination of freezing with chemical defrosting substances is not too much described in professional publications. The authors in the paper titled "Durability of Self compacting Concrete" are concerned with the manufacturing problem of self compacting concrete, containing special aerating additives to achieve values usual with normal aerated concrete. The test methods for determining the rheology of fresh SCC are described including the determination of aeration measure. Further the results received
in tests with hardened concrete are published-compression strength, E-moduli. Mainly
the durability was checked by frost resistance measuring methods and under the effect of
chemical defrosting salts. In the way the possibility of utilization of SCC even in
climatically demanding conditions was proved.

2.0.43 SAEED AHMED, IMRAN A. BUKARI , AYUB ELahi AND SAJJAD AFZAL
( 2006 )

Self Compacting Concrete (SCC) ia an innovative building material, which offers
various advantages in construction process due to its outstanding characteristics. Both,
the quality and productivity of the concrete members can be improved by using SCC.SCC
essentially represents a technological shift in the production of concrete. There are
obvious benefits in the use of SCC, including the reduction in noise and pollution,
manual labour, energy consumption, increased speed and ease of placement. Filling
ability, passing ability, and resistance to segregation are the key properties of SCC. The
authors on the topic "Production and Effects of Self-Compacting Concrete on
Various Properties of Concrete" made an attempt to get more knowledge about the
properties of fresh and hardened SCC. Eight reinforced concrete beams with web
reinforcement were cast. Test variables was shear span to effective depth ratio (a/d). Two
sets of four beams were made for normal concrete and SCC separately. The cross
sectional dimensions were kept constant for all the beams i.e 6" x 12" . However, length
of the beams varied from 5 feet to 11 feet. The control specimens were cast for each
beam and tested at age of 7 and 28 days. For the development of self compacting
concrete, Gelinium-110 with dose of 0.8% was used.

Mix and w/c ratios were kept constant in both the cases. Mix was of 1:2:4 ratio and
w/c was 0.5. No significant change in compressing strength was noted. Slump in case of
normal concrete was achieved from 38 mm to 24 mm, but for same w/c ratio, Slump of
SCC collapsed totally. To achieve the same workability of normal concrete as that of SCC, w/c ratio has to be increased up to 0.9 i.e 80% higher, which ultimately reduces the compressive strength of concrete.

Based on their experimental investigation they concluded the following

Conclusions

- At a fixed W/C ratio of 0.5 slump in case of Normal concrete was achieved from 38 mm to 42 mm, but for SCC having 0.8% Gelinium 110 mm total collapse of slump was observed.
- To achieve the same workability of NC, as in the case of SCC, w/c ratio has to be increased up to 0.9 (80%) which ultimately reduces the compressive strength of concrete.
- The concrete strength of SCC and Normal concrete are almost similar under comparable conditions. This statement also includes the time development of concrete strength.
- SCC requires greater mixing time as compared to NC.
- Under similar conditions, Normal concrete beams showed greater deflection as compared to the SCC beams however this difference was more at higher shear span to depth ratios.
- For normal concrete beams, gradual increase in relative flexural strength of the beams was observed with increase in shear span to depth ratio equal to 4, where as for higher values of a/d relative flexural strength increased at a higher rate.
- For SCC beams, gradual increase in relative flexural strength of the beams was observed with increase in shear span to depth ratio equal to 4, and afterwards decrease was noted.
- At a constant w/c ratio, no considerable difference compressive strength of NC and SCC was observed.
Silica fume is known to possess superior pozzolanic properties in making concrete. Use of silica fume is advantageous particularly in the production of high strength concrete and ultra high strength concrete. In addition to the highly pozzolanic nature silica fume also helps in refinement of the pore structure of the concrete. This leads to better performance of concrete. Water demand of silica fume concrete is high compared to the concrete of same strength without silica fume. This is attributed to the higher fineness of silica fume. Thus net water-cementitious materials ratio in turn affects its relation with the compressive strength of concrete. This demands a retrospection of the well known Abram's water-cement ratio relation. With this view, as part of an on going research programme, the authors on the topic "Relationship of Water-Cementitious Materials Ratio and Compressive Strength of Silica Fume Concrete" made an attempt to study the relationship between water-cementitious materials ratio and compressive strength of silica fume concrete.

Based on their experimental investigation the following conclusions are drawn:

- The silica fume used in this investigation exhibits good pozzolanic properties and can be used in the production of high strength concrete.

- The relation between compressive strength (MPa) and water-cementitious materials ratio of silica fume concrete with nine percent replacement of by silica fume can be expressed as:

$$f_c (\text{MPa}) = 179.51 / [14.8^w/(c.m)]$$

- Alternately, the water-cementitious material ratio can be expressed in terms of compressive strength (MPa) for silica fume concrete as

$$w/(c.m) = 12.19 / [f_c^{0.83}]$$
Self compacting concrete is the new category of high performance concrete characterized by its ability to spread and self consolidate in the form work without exhibiting any significant separation of constituents. Understanding of this concrete flow property is of interest to many researchers. Series of experiments were designed to correlate the rheological properties with the empirical test methods. The authors on the topic "Rheological Measurements and Empirical Test Methods of SCC" presented the rheological measurement correlations to the L-Box, V-funnel and slump spread developed from the experimental programme.

Based on the experimental investigation, it was observed that the ideal range of slump-spread values 500-600mm has been related to all the empirical test procedures, shear stress and viscosity values. These tests also explain the influence of various types of cements, aggregates, mineral and chemical admixtures used throughout the country. These results are inline with the other researchers and recommended values in the draft codes specifications. Such similar test procedures can be followed throughout the country to have a unified approach for making the guidelines in codes of practice for SCC. SCC also satisfies all the requirements of hardened concrete, except modulus of elasticity. In the recent past IS: 456-2000 also has suggested lower modulus of elasticity values for conventional concrete ranging between M20 to M40 as compared to earlier suggested values for design purposes. The SCC beam tests at SERC show post-softening behavior (Lakshmanan, 2004) in the case of SCC M60 grade. Further tests are to be continued to have common value of modulus of elasticity for design purposes particularly for high paste fly ash based concrete mixes.

The elimination of vibration for the compaction of concrete during placing through the use of self compacting concrete leads to substantial advantages related to better homogeneity, enhancement of the working environment and improvement in the productivity by increasing the speed of construction. This could become even more important. The authors on the topic "Development and Characterization of Steel Fibre Reinforced Self-Compacting Concrete" presented the development and characterization of steel fiber reinforced self-compacting concrete.

Based on the experimental investigation they observed that SFR-SCC can be achieved by using an appropriate mix design methodology. A concrete that satisfies the recommendations of flowability, passing ability and stability can be obtained for fibers contents up to 40 kg/m³. The obtained SFR-SCC succeeded in homogeneously filling a highly demanding application-specific element designed to simulate the placing process during the repair or strengthening of a box girder. The mechanical properties of the SRPC-SCC are in accordance with the expected trends of conventional SFRC.


Concrete structures are exposed to temperature variations mainly due to solar radiation. As reported in literature, concrete containing 100 percent ordinary portland cement (OPC) exhibited a steady decline in residual compressive concrete strength when subjected to thermal cycles. The authors on the topic "Effect of thermal cycles on the strength properties of OPC and fly ash concretes" made investigation on M20 and M30 grades of concrete containing OPC and fly ash by exposing them for various thermal cycles at different temperatures. Different properties of concrete, that is compressive strength, split tensile strength, dynamic modulus of elasticity were evaluated and
compared. The results revealed that concrete containing fly ash was more effective in resisting the effect of thermal cycles than concrete containing OPC.

Based on the Experimental investigations they concluded

- The thermal cycles have adverse effect on the compressive strength of ordinary concrete.

- The compressive strength of ordinary concrete for M20 and M30 decreased by about 13 percent at 50°C after 28 thermal cycles. However for fly ash concrete the compressive strength was found to increase by 11 percent, after 28 thermal cycles at 50°C.

- The compressive strength of ordinary concrete for M20 and M30 decreased by about 25 percent at 100°C after 28 thermal cycles. However for fly ash concrete the compressive strength was found to increase by 11 percent, after 28 thermal cycles at 100°C.

- The split tensile strength of ordinary concrete for M20 decreased by about 14 percent and for M30 decreased by 11 percent at 50°C after 28 thermal cycles. However for fly ash concrete the split tensile strength was found to increase by 12 percent and 7 percent for M20 to M30 after 28 thermal cycles at 50°C respectively.


The extensive use of concrete as a structural material for the high rise buildings, storage tanks, nuclear reactors, and pressure vessels increase the risk of concrete being exposed to high temperatures. This has led to a demand to improve the understanding of the effect of the temperature on concrete. The behaviour of concrete exposed to high temperatures is a result of many factors including the exposed environments and constituent materials. High strength concrete (HSC) is characterized by the use of
extremely low w/b ratio and a highly compact mix using suitable methodologies. The authors on the topic "Effect of age of HSC on Residual compressive strength under Elevated Temperatures" in their experimental investigation on the effect of temperature and to evaluate the structural safety an attempt was made to study the residual strength of high strength concrete exposed to high temperatures at different ages. From this study it was found that older concrete suffered less loss than younger concrete within the temperatures range of 100°C to 250°C.

In older concrete of 28 and 56 days of age the behavior is similar. This may be due to completion of hydration of cement and micro cracking around hydroxide crystals.

Based on the Experimental investigations they concluded:

- Rapid decrease in strength was observed at 50°C for all exposure durations of 1, 2 and 3 hrs at 7 days age of concrete. This may be due to incomplete hydration of cement.

- An increase in strength was observed in the temperature range of 50°C to 100°C for all exposure durations of 1, 2 and 3 hrs at 7 days age of concrete. This may be attributed to the accelerated hydration of cement.

- A gradual reduction in strength was found with increase in temperature from 100°C to 250°C for all exposure durations of 1, 2 and 3 hrs at 7 days age of concrete.

- Behavior of 28 and 56 days concrete was similar showing reduction in strength with increase in temperature for all exposure durations.

- Older concrete exhibited less loss of strength compared to younger concrete at all temperatures.
2.0.49 Srinavasa Rao, K., Potha Raju, M. and Raju, P. S. N. (2006) [82]

High strength (HSC) is being used in high rise buildings and a variety of industrial structures which may be subjected to elevated temperatures during operation or in case of an accidental fire. Bed ford reported that staggering loss of £ 850 million per annum occurs on account of fire damage to buildings. This necessitates proper understanding of the effects of elevated temperatures on the properties of HSC. The authors on the topic “Effect of elevated temperature on compressive strength of HSC made with OPC and PPC” made an attempt to study the effects of elevated temperatures ranging from 50°C and 250°C on the compressive strength of HSC made with both ordinary portland cement (OPC) and portland pozzolana cement (PPC). The residual compressive strengths were evaluated at different ages. The results showed that at later ages HSC made with Portland pozzolana cement performed better by retaining more residual compressive strength compared to concrete made with ordinary Portland cement.

Based on the experimental investigation they concluded:

- Both OPC and PPC concrete gained compressive strength on heating till a temperature of 150°C at early ages of 1 and 3 days. This could be due to acceleration in hydration process on heating. The increase in percentage residual compressive strength in the range of 10 to 30 percent for OPC and PPC concretes when exposed to elevated temperatures for 3 hours. Both concretes experienced reduction in residual compressive strength at the age of 1 and 3 days beyond 150°C temperature.

- The residual compressive strength of OPC and PPC concretes at the age of 7, 28, 56 and 91 days decreased steadily with increase in temperature.

- OPC concrete retained more percentage of residual compressive strength compared to PPC concrete at early ages up to 7 days. However, PPC concrete
performed better by retaining more residual compressive strength compared to OPC concrete at later ages.

- PPC concrete appeared to have lower decrease in percentage residual compressive strength than OPC concrete for similar conditions. OPC concrete exhibited maximum decrease of 40 percent residual compressive strength at 250°C whereas, PPC concrete exhibited maximum decrease of 18 percent in residual compressive strength.

2.0.50 SP SWEDISH NATIONAL TESTING AND RESEARCH INSTITUTE

The experimental work of SP SWEDISH NATIONAL TESTING AND RESEARCH INSTITUTE showed that the Examined self compacting concrete got Explosive spalling if no precaution such as polypropylene fibres in the admixture, the amount of spalling could be reduced and the same level of spalling as that for normal concrete was achieved. A difference between conventional vibrated concrete and self compacting concrete is the use of fine filler. Filler could be glass or limestone powder, by adding filler the concrete will be much denser and thus permeability will be lower.

The Study includes preparation of methodology for determination of spalling of concrete as there is no standard measurement of the amount of spalling in European or any other international standard. Guidance for production of self compacting concrete including polypropylene.

The Authors In their experimental programme divided into 5 work packages. First work package is for the determination of risk for spalling exposed to fire. Second work package focused on manufacturing of Self Compacting Concrete and documentation on production of Self-compacting concrete with polypropylene fibres. Third work package contains the main fire test program. Fourth work package deals with the durability of concrete containing fibres of polypropylene. Fifth work package include the analysis and
modeling of the data collected and development of a guideline for self compacting concrete with good fire spalling properties. Sixth work package include dissemination of results.

Based on the Experimental investigations they concluded:

- Studies showed that spalling occurred to a considerably higher degree than conventional concrete.
- Comparison of results from different laboratories is contradictory as some resulted in extensive spalling while other almost no spalling at all.
- Geometry of the test specimen and the load level and configuration have a great effect on spalling.
- Due to lot of variations in results only observations were made.

2.0.51 SUBRAMANIAN. S AND CHATTOPADHYAY D. (2002) (85)

Self compacting concrete is a fluid mixture, which is suitable for placing in difficult conditions and in structures with congested reinforcement without vibration. It is characterized by a high powder content. The resulting concrete has an excellent surface finish. The authors on the topic “Experiments for mix proportioning of self-compacting concrete” discussed the development of the mix proportions for self-compacting concrete and also the procedure used for selecting the combination of viscosity modifying agent, superplasticizer and ultra fine powders. The results of the preliminary trails with the mixture so developed are described.

Based on the Experimental investigations they concluded

- The trail proportions suggested by Okamura and Ozawa appear to be suitable for rounded gravel aggregate. When using crushed angular aggregate, the proportions are to be adjusted, incorporating more fines.
• This sensitivity to changes in mixture proportions requires that a viscosity modifying agent (VMA) be used. Out of the four VMAs tried, welan gum was found to give superior performance because of its rheological characteristic.

• The optimum dosage of welan gum should be arrived at considering the bleeding tendency, setting time and compatibility with the superplasticiser used.

• Micro silica at an appropriate dosage may be beneficial in reducing the dosage may be beneficial in reducing the dosage of welan gum. This may reduce the final setting time and increase the compressive strength.

• Suitability of self-compacting concrete mixture proportion was verified through placement trails in a complicated mould and in a field trail. The results are encouraging.

2.0.52 TIMO WIJSTHOOLZ (2003) [56]

The authors on the topic "Fresh properties of Self Compacting Concrete (SCC)" presented a simple method – based on the so-called J-Ring test which allows the quantification of the part of the blocked concrete volume. Furthermore some empirical relationships between different test results are presented which were found for the tested SCC mixtures.

Based on their work it could be shown that the blocked concrete volume is proportional to the step of blocking which adjusts itself directly in front and behind the steel rods of J-Ring. This method was compared with the conventional method which evaluates the blocking behaviour of SCC by the difference of spread between the slump flow test and the J-Ring test. It could be derived that the conventional method is not suitable to quantify the blocking behaviour. Also some empirical relationships between different test results were presented which had been found for the tested SCC mixtures.
2.0.53 USMAN GHANI, FAISAL SHABBIR AND KAMRAN MUZAFFAR KHAN (2008) 

The authors on the topic “Effect of the Temperature on Different Properties of Concrete” in their research work, they investigated the effect of low and high temperature on various properties of concrete like modulus of rupture of concrete beams, compressive strength and tensile strength of concrete.

Based on their experimental investigation they concluded that the temperature variation results in both positive and negative impacts on different properties of concrete. It also yields good results but keeping in view the demand of concrete's strength the temperature of the environment under which it is mixed, cast, cured and finally tested must be controlled. Increase in temperature increases initial strength while at the same time it reduces the long term strength.

2.0.54 VENKATESH BABU D.L.(2003) 

The authors on the topic “Study on properties of self compacting high performance concrete” presented an experimental investigation on the properties like workability and compressive strength of self-compacting concrete. They conducted several tests involving various binder combinations, water-binder ratio and high range water reducing admixtures and set retarding admixtures to optimize the mix proportions for flowable Self Compacting Concrete. Test methods used to study the characteristics of fresh concrete includes slump test, U-tube, V-funnel and L-Box. The properties like compressive, tensile and flexural strength of SCC were also investigated. Test results show that the workability characteristics of SCC are within limiting constrains of SCC. The highest compressive strength of SCC mix at 28 days of age of curing is 71.33 MPa.

Based on the experimental investigation, they concluded that

- The test results of fresh concrete are within the limits of Self Compacting Concrete i.e. flowability, passing ability and resistance against segregation.
The self-compacting high performance concrete for 7 days compressive strength is 52.5 MPa and 28 days strength of 71.33 MPa has been obtained with a water-cement ratio of 0.45 and Fly ash / cement ratio is 0.45.

2.0.55 Wenzhong Zhu and Peter JM Bartos (2005) [89]
The interfacial transition Zone (ITZ) between cement paste and aggregates or reinforcement is an area of particular interest, its association with and significant influence on engineering properties and durability of concrete or cementitious composites being widely recognized. The formation of ITZ in concrete is due, to a large extent, to a wall effect that prevents effective filling of the space adjacent to the aggregate / reinforcement by cement or other particles, as well as to internal bleeding or settlement in the fresh mix. Considering the different characteristics in particle packing (due to the increase of fines) and the highly flowable and vibration – free pacing nature of SCC, there are general concerns that the ITZs around steel bars and coarse aggregate in structural SCC could be radically different from those in conventional concrete.

The authors in this paper titled “Microstructure and properties of interfacial transition zone in SCC”, the microstructure and properties of the ITZ around coarse aggregate in both SCC and conventional concretes is assessed. Results of micro-mechanical properties of the ITZ obtained by a death – sensing nanoindentation method appeared to indicated that the ITZ was denser and significantly more uniform in SCC than in conventional vibrated concrete.
A compilation of fire test data has shown distinct behavioural differences between high performance concrete and traditional concrete at elevated temperature. The differences in fire behaviour are largely depending on the micro structural properties, especially on the porosity, pore size distribution and the connectivity of pores. Self compacting concrete, as a new smart building material with varies advanced properties, has been used for a wide range of structures and infrastructures. However the microstructure changes of self compacting concrete at elevated temperature are not investigated.

In this contribution, the authors on the topic "Microstructure aspects of self compacting concrete at elevated temperature" examined the microstructure changes of self compacting concrete at elevated temperature by mercury intrusion porosimetry and scanning electron microscopy. The chemical decomposition of self compacting concrete at different temperatures is determined by thermogravimetric concrete analysis. The experimental results of self compacting concrete are compared with high performance concrete and traditional concrete.

The major results obtained in this study are as follows:

- The total porosity and the critical pore diameter increase with the position closer to the heating face. The total porosity increases by a factor of 2 and the critical pore diameter increases by a factor of 10 at 10 mm depth for SCC mixtures.
- SCC could show larger damage than HPC under fire.
- Presence of PPF can dramatically reduce the dame of microstructure when concrete is exposed to fire. 1 kg/m³ of PPF in the SCC reduces the change of the total porosity in all depths with a factor of 3.
- TGA/DTA experiments indicate that samples made with SCC shows a better stability below 700°C. However, when the temperature is higher than 700°C, a
dramatic loss of mass was observed in the SCC samples. This also confirms that SCC will probably show larger damage once exposed to fire.


The authors on the topic "Implementation of Self-Consolidating Concrete for Prestressed Concrete Girders" described the first experience of using self-consolidating concrete for prestressed concrete bridge girders in North Carolina. Under construction in eastern North Carolina, is a multi-span bridge which will use one hundred thirty AASHTO Type III girders, each 54.8 ft (16.7m) long. To demonstrate the full-scale field production of self-consolidating concrete, and for comparative purposes, three girders from one production line of girders were selected for the experimentation. Two of the girders were cast with self-consolidating concrete and one with normal concrete as control.

The plastic and hardened properties of both the self-consolidating concrete and the normal concrete were monitored and measured. The plastic properties of self-consolidating concrete included unit weight, air content, slump flow, visual stability index (VSI) and passing ability measured by J-ring and L-box. Hardened properties of the two concretes included temperature development during curing, compressive strength, elastic modulus, and flexural tensile strength. The prestressing force was monitored by load cells. The transfer lengths of the prestressing strands were determined by embedded strain gauges and form the measured strand end-slips. Finally, the three girders were tested in flexure up to the design service load to determine and compare their load-deformation characteristics.

Based on the experimental investigation, they concluded that

- The two slightly different concrete placement procedures for casting the two SCC girders were equally successful and the final product was of good quality.
• The SCC mixture proportion should be improved. Its flowability and passability were less than desirable. To increase the fine particles in the mixtures, fly ash and inert powder should be used rather than increasing the amount of cement.

• The SCC and the normal concrete were quite similar in their performance in many respects such as the concrete temperature development during curing, the development of compressive strength, modulus of elasticity, flexural modulus, and the bond characteristics with prestressing strand, both in terms of strand transfer length and strand end-slip. The bond behaviour for the top strand was similar to that for the bottom strand.

• The modulus of elasticity and the flexural modulus of both the SCC and the normal concrete were less than what would be expected, based on the compressive strength achieved. This deficiency is attributed to the lack of moist curing and the use of manufactured marine marl limestone as fine aggregate, which is more porous and less stiff.

• For all three test girders, the prestress transfer length was 40% more than recommended by AASHTO.

• The three test girders behaved elastically and exhibited virtually identical load-deflection relationship up to the design service load, with no cracks observed. Upon unloading, the girders exhibited full recovery of their deformations. The performance of the three girders was excellent and practically identical.

• The stiffness of all three test girders was the same under short-time static loading. However, under sustained loading, the stiffness of the SCC girders appeared to decrease more than the stiffness of the normal concrete girder.