AN EXPERIMENTAL STUDY ON SELF COMPACTING CONCRETE

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

Key Words: Self Compacting Concrete, Mix design, Mineral Admixtures, Fibers, Durability, Workability.

1.INTRODUCTION:

The introduction of the "modern" self-compacting concrete (SCC) is associated with the drive towards better quality of concrete pursued in Japan in late 1980's, where the lack of uniform and complete compactional been identified as the primary factor responsible for poor performance of concrete structures. There were and practical means by which full compaction of concrete of the need to compact, by vibration or any other means. on site was ever to be fully guaranteed, instead, the focus therefore turned onto the elimination. This led to the development of the first practicable SCC by researchers Okamura & Ouchi " at the University of Tokyo. The SCC, as the name suggests, does not require to be vibrated to achieve full compaction. These include an improved quality of concrete and reduction of on-site repairs, faster construction times, lower overall costs, facilitation of introduction of automation into concrete construction. The composition of SCC mixes includes substantial proportions of fine-grained inorganic materials; this offers possibilities for utilization of "dusts". Which are currently waste products demanding with no practical applications and which are costly to dispose of Current Indian scenario in construction shows increased construction of large and complex structures. which often leads to difficult concreting conditions. Vibrating concrete in congested locations may cause some risk to labour in addition to noise stress. There are always doubts about the strength and durability placed in such locations. So, it is worthwhile to eliminate vibration in practice, if possible. In countries like Japan, Sweden, Thailand, UK etc., the knowledge of SCC has moved from domain of research to application. But in India, this knowledge is to be widespread.

2 LITERATURE REVIEW:

Dr. Mrs. S.A. Bhalchandra et.al: Studied the performance of steel fiber reinforced self-compacting concrete as plain self-compacting concrete is studied in depth but the fiber reinforced self-compacting concrete is not studied to that extent.

Prof. Aijaz Ahmad Zende et.al: Studied on Self Compacting Concrete (SCC) and compares it with Normal Concrete (NC). The word " Special Concrete" refers to the concrete which meets the special performance and requirements which may not be possible by using conventional materials and normal methods of concreting. Self-Compacting Concrete of the type of a special concrete which flows and consolidates. One under its own weight thereby eliminates the problems of placing concrete in difficult conditions and also reduces the time in placing large section and at the same time giving high strength and better durability characteristics as compared to the Normal Concrete. This paper discusses the various aspects of SCC including the materials and mix design, different test methods such as slump flow test, compression test, flexural test and also its performance characteristics and properties in the fresh and hardened state.

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

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

Mounir m. Kamal et.al: Studied the optimum content of fibers (steel and polypropylene Fibers) used in SCC. The effect of different fibers on the fresh and hardened properties was studied. An experimental investigation on the mechanical properties, including compressive strength, flexural Strength and impact strength of fiber reinforced self-compacting concrete was performed. The results of the investigation showed that: the optimum dosage of steel and polypropylene fiber was 0.75% and 1.0% of the cement.

3. AIM AND OBJECTIVES FOR SCC:

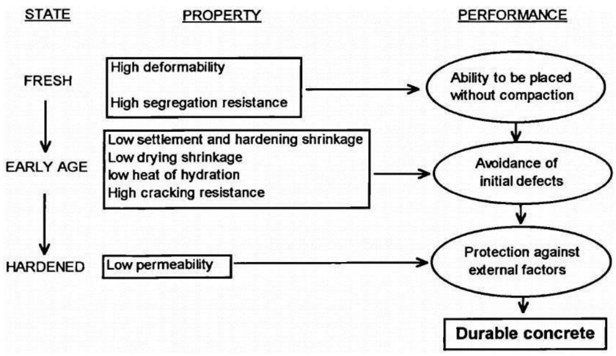
1. To identify the three key properties of SCC i.e., Filling, Ability, Passing ability and segregation resistance.
2. To determine the Workability of SCC using Slump Cone Test, U Tube Test, L- Box Test, Slump Flow Test, Compression Test, Flexural Test.
3. To study the Structural Strength of SCC while alkaline attacks on it.
4. To study the Strength and behavior of Ground Granulated Blast Furnace Slag (GGBFS) to the SCC.
5. Health and Safety benefits (as no vibration is required). Faster construction times. Increased workability and ease of flow around heavy reinforcement.

4. HISTORY OF SCC DEVELPOMENT:

Okamura was the first who proposed SCC in 1986. The first SCC mix was completed in 1988 at the University of Tokyo, using the same constituent materials as in NVC (Ouchi, 2001). The fundamental reasons behind the employment of SCC were to shorten construction time, to avoid vibrating confined zones, which are rather difficult to access, and to eliminate noise caused by vibration (Okamura and Ouchi, 2003). In the last two decades, SCC has been developed further by utilizing various new constituents such as pulverized fuel ash (PFA), condensed silica fume (CSF) and ground granulated blast-furnace slag (GGBS). What is more, the development of highly activewater-reducing admixtures (super-plasticizers) combined with high powder contents has been boosting the use of SCC much further. Consequently, SCC has gained a wide interest, especially for structures with complex shapes, complicated casting processes, and very congested reinforcements.

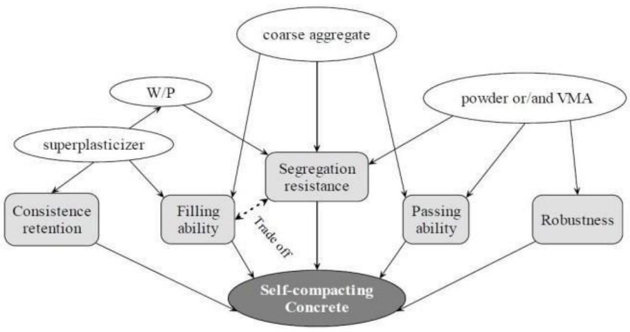
5.DEFINITION OF SCC:

There are various definitions of SCC in the literature. SCC can be defined, to a great extent, by its workability. It is an advanced type of concrete (also known as a super workable concrete) that sees the addition of super-plasticizer and a stabilizer significantly increase the ease and rate of flow and pass through complex geometrical configurations under its own weight without vibration maintaining homogeneity. The BS EN 206-9 (2010) defines SCC as "concrete that is able to flow and compact under its own weight, fill the formwork with its reinforcement, ducts, boxouts, etc., whilst maintaining homogeneity". The American Concrete Institute (ACI) (2007) defines SCC as "a highly flowable, non-segregating concrete that can spread into place, fill the formwork, and encapsulate the reinforcement without any mechanical consolidation".



6. PROPERTIES OF FRESH SCC

The properties of significance for any discussion of fresh SCC are those that affect its placement and compaction. It is in these properties that SCC shines and differentiates itself from other concrete types. Characteristics of SCC are literally linked to its fresh properties. SCC has three key fresh properties: filling ability, passing ability and segregation resistance and they should be secured during transporting and after placing (The Concrete Society (BRE), 2005; Pade, 2005; Anon, 2005). These properties are interdependent and related to each other. Any change in one property will normally result in a change in the others. In other words, poor filling ability and/or high segregation resistance can cause insufficient passing ability, i.e., blocking. Hence, SCC can be basically considered as a trade-off between filling ability and segregation resistance as illustrated in Figure.



1. Filling ability:

Filling ability is the ability of fresh SCC to flow into and fill formwork under the action of gravity. It reflects the changes in SCC's deformability, i.e., the ability of fresh SCC to change its shape driven by its own weight and casting energy (Khayat, 1999). The deformability consists of two primary aspects: the deformation capacity, which is the maximum ability to deform i.e., how far concrete can flow; and the deformation velocity, which refers to the time needed by concrete to stop flowing, i.e., how fast concrete can flow. Filling ability is a harmony between capacity and velocity of deformation. For example, an SCC of high deformation capacity and low deformation velocity tends to be very viscous and would take a long time to fill the formwork. The inter-particle friction between solid particles (powder, fine aggregate, and coarse aggregate) should be reduced to attain SCC with high filling ability. This can be achieved by utilizing additional water, which is not the optimal option as it can cause segregation due to its adverse effect on viscosity and yield stress. Too much water also has undesirable consequences for strength and durability. Unlike wateraddition, the incorporation of high range water reducing admixtures (super-plasticizers) can not only reduce the inter- particle friction by dispersing cement particles but also maintain the filling ability (Figure 2.2) (Khayat, 1999a; Sonebiand Bartos, 2002.

2. Passing Ability:

Passing ability, which is a property unique to SCC determines and guarantees how well an SCC mix will flow through restricted spaces and tight openings without blocking, which consequently secures its specific applications in densely reinforced structures, such as bridge decks, tunnel linings or tubing segments. Passing ability relates to the risk of blocking, which results from the interaction between aggregate particles and also between aggregate particles and the restricted space. When SCC approaches a tight space, the different flowing velocities of the aggregate and mortar cause a local increase in the content of coarse aggregate. Thus, some aggregates may bridge or arch at the narrow openings preventing the rest of concrete from passing, as shown in Figure 2.3 (Noguchi et al., 1999; Okamura and Ouchi, 2003) a goal. Okamura and Ouchi (2003) have proposed the following three main rules in Figure

3. Self-compact Ability Criteria:

To secure self-compactability, it is necessary to maintain superior filling ability, real obstacle passing ability, and sufficient segregation resistance. In other words, SCC must be as fluid as possible in its fresh state to fill, under its own weight, all the far- reaching corners of the formwork and pass smoothly through heavy reinforcement without blocking or segregation. The methodology of selecting the right amount of materials and admixtures is essential in achieving the self-compactability goal. Okamura and Ouchi (2003) have proposed the following three main rules.

Figure. The core rules for obtaining self-compacting concrete

4. Limited Aggregate Content:

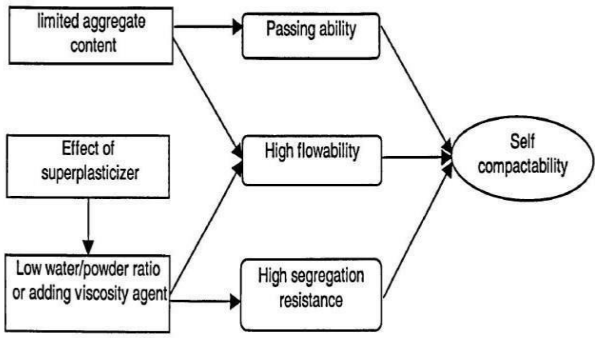
The properties of SCC, especially the passing ability, are highly affected by the friction between the aggregate's particles. In densely reinforced areas, the passing ability can be enhanced by reducing the volume and the maximum size of coarse aggregate and/or using round aggregate instead of crushed one. In other words, when the relative distance between aggregate particles reduces, the frequency of collision as well as the contact between them will increase (Okamura and Ouchi, 1999), causing high internal stress, particularly when concrete gets deformed near obstacles resulting in blocking of aggregate particles. Thus, limiting the coarse aggregate content, whose energy consumption is particularly intense to a level lower than normal proportions is very effective in avoiding any blocking.

5. Low water to powder ratio

Highly viscous SCC is often required to be able to carry coarse aggregate particles and prevent segregation. Such a goal can be secured by the incorporation of high amounts of powder materials, which also have a positive influence on filling ability (Khayat, 2000). Using additions such as GGBS, silica fume, fly ash and limestone filler are the best solution to be included within the significant amount of the powder materials to avoid the subsequent adverse effect of using only Portland cement. Another effective alternative for increasing the paste volume is by using viscosity modifying agents (VMAs), which give the same effect in minimizing the tendency of coarse aggregate to segregation by thickening the paste and keeping the water in the skeleton. VMAs are assumed to make SCC less sensitive to water variations. However, the small quantities of VMAs used cause difficulties in achieving an accurate dosage.

6. Effect of super-plasticizer

High deformability (i.e., filling ability) can be effectively attained by the use of a super-plasticizer, which disperses flocculated cement particles, reducing the attractive forces among them and keeping the water to powder ratio at very low value. However, it has been stated that a highly fluid SCC, which results from low viscous SCC due to the use of high super-plasticizer dosage could be more prone to have its coarsest particles segregated (Roussel et al., 2009; Desnerck et al., 2011). Low viscous SCC can cause an increase in the coarse aggregate local volume fraction near obstacles and nonhomogeneous concrete (Figure 2.7). Therefore, it is necessary to employ an optimum dosage of super-plasticizer as low resistance to segregation might result when higher dosage is used.



7. MATERIALS REQUIRED FOR SCC

7.1 General

Mix proportions for SCC differ from those of ordinary concrete, in that the former has more powder content and less coarse aggregate. Moreover, SCC incorporates high range water reducers (HRWRA, superplasticizers) in larger amounts and frequently a viscosity modifying agent (VMA) in small doses. However, the constituent materials for SCC are the same those used in traditional vibrated concrete conforming to IS 456:2000. In most cases the requirements for constituents are individually covered by relevant Indian standards. However, in order to be sure of uniform and consistent performance for SCC, additional care is needed in initial selection and also in the continual monitoring for uniformity of incoming batches. The questions that dominate the selection of materials for SCC are: (i) limits on the amount of marginally unsuitable aggregates that is, those deviating from ideal shapes and sizes, (i) choice of HRWRA, (ii) choice of VMA, and (iv) interaction and compataibility between cement, HRWRA and VMA. These are discussed below. To achieve these requirements the control of the constituent materials needs to be increased and the tolerable variations restricted, so that daily production of SCC is within the conformity criteria without the need to test and/or adjust every batch.

7.2 Cement

Cements conforming to the concerned Indian Standard can be used for the production of SCC. The correct choice of cement type is normally dictated by the specific requirements of each application or what is currently being used by the producer rather than the specific requirements of SCC. However, there exists the problem of incompatibility between cement and HRWRA (high range water reducing admixture) particularly at low water contents. In concretes having low water content and high super plasticizer dosage (SNF based), gypsum (present in cement) may precipitate out causing premature stiffening of the paste and consequent loss of slump. As it is difficult for the field engineer to either verify the compatibility himself or get it tested every time. It is better to get a certificate / confirmation from admixture supplier about this aspect, as supplier would have done detailed compatibility study on each brand grade of cement in the market. This certificate will also be useful for getting an estimate of optimum dosage.

7.3 Additions (Additives / Mineral admixtures)

Due to the fresh property requirements of SCC and higher powdery content, inert and pozzolanic/hydraulic additions are commonly used to improve and maintain the cohesionand segregation resistance. The addition will also regulate the cement content in order to reduce the heat of hydration and thermal shrinkage. These are also called as mineral admixtures.

7.4 Fly ash

Fly ash has been shown to be an effective addition for SCC providing increased cohesion and reduced sensitivity to changes in water content. In India, in particular fly-ash. However, high levels of fly ash may produce a paste fraction which is so cohesive that it can be resistant to flow. Fraction of fly ash below 45 mm are useful as pozzolanic, however, particles finer than 5 mm are highly useful. Fly ash must confirm to the relevant IS Standards (IS: 3812-2007).

7.5 Micro silica /Silica fume

The high level of fineness and practically spherical shape of silica fume results in good cohesion and improved resistance to segregation. However, silica fume is also very effective in reducing or eliminating bleed and this can give rise to problems of rapid surface crusting. This can result in cold joints or surface defects if there are any breaks in concrete delivery and also to difficulty in finishing the top surface. Also, since silica fume has to be imported it is a costly alternative. The silica fume shall confirm to /$75388. Typically, substantial part of micro silica should be below Lum size, and silica fume should have particles below 0.1 um.

7.6 Ground Granulated Blast Furnace Slag

Ground granulated blast furnace slag (GGBS) provides reactive fines with a low heat of hydration. GGBS is already present in some cement but is also available as an addition and may be added at the mixer. A high proportion of GGBS may affect stability of SCC resulting in reduced robustness with problems of consistence control while slower setting can also increase the risk of segregation. The GGBS shall confirm to IS72089. Typically, active hydraulic slag has particle size smaller than cement.

3.7 Aggregates

Aggregates constitute the bulk of a concrete mixture, and give dimensional stability to concrete. Among the various properties of aggregate, the important ones for SCC are the shape and gradation. Many researchers have been able to produce self-compacting concrete with locally available aggregate. It is observed from these studies that self-compactability is achievable at lower cement (or fines) content when rounded aggregates are used, as compared to angular aggregates. Although there have been several studies on the effect of coarse aggregate content on the flow behavior of SCC, enough attention has not been paid to quantify the effect of the shape of the aggregate. The reinforcement spacing is the main factor in determining the maximum aggregate size. Aggregate blocking must be avoided as SCC flows through the reinforcement and the L-box should test generally is be indicative limited of the to 12- passing 20 mm, ability of although an SCC larger mix sizes they are being maximum used. The particle size distribution and the shape of coarse aggregate directly influence the flow and passing ability of SCC and its paste demand. As already indicated the more spherical the aggregate particles the less they are likely to cause blocking and the greater the flow because of reduced internal friction.

3.8 Fine Aggregate/ Sand

The influence of Fine aggregates on the fresh properties of the SCC 0.075 is significantly greater than of coarse aggregate. Particle size fractions of less than 0.075 mm should be included in the fines content of the paste and should also be taken into amount in calculating the water ratio. Option of using Crushed Stone Sand or Manufactured sand (M-sand) can be considered. In fact, research studies have concluded that M-sand is more suited to SCC as it contains higher percentage of micro fines passing through 150 micron and 75 microns in comparison to natural river sand. Use of M-sand demands slightly more water and higher dosage of admixture. This can be established through laboratory trials.

3.8 Admixtures

SCC invariably incorporates chemical admixtures - in particular, a high range water reducing admixture (HRWRA) and sometimes, viscosity-modifying agent (VMA). The HRWRA helps in achieving excellent flow at low water contents and VMA reduces bleeding and improves the stability of the concrete mixture. An effective VMA can also bring down the powder requirement and still give the required stability. Moreover, SCC almost always includes a mineral admixture, to enhance the deformability and stability of concrete. Superplasticizers or high range water reducing admixtures (HRWRA) conforming to 1S9103.Viscosity modifying admixtures (VMA) may also be used to help reduce segregation and the sensitivity of the mix due to variations in other constituents, especially to moisture content. Other admixture including air entraining, accelerating and retarding may be used in the same way as in traditional vibrated concrete but advice should be sought from the admixture manufacturer on use and the optimum time for addition and they should confirm to IS9103.

8. METHODOLOGY

1.Test methods

A wide range of test methods have been developed to measure and assess the fresh properties of SCC. Table lists the most common tests grouped according to the property assessed. The various equipment for testing is as shown below (Photograph) No single test is capable of assessing all of the key parameters, and a combination of tests is required to fully characterize an SCC mix. However, one of the well- known methods Indian methods of mix proportioning is published in the ICJ (Indian Concrete Journal) in 2004. It is titled "Mixture proportioning procedures for Self-Compacting Concrete" by Jagadish Vengala & RV Ranganath. The Indian Concrete Journal, 78**.**

2 Introduction

It is important to appreciate that none of the test methods for SCC has yet been standardized, and the tests described are not yet perfected or definitive. So far, no single test has achieved universal approval and most of them have their limitations. Similarly, no single method of test has been found which characterizes all the relevant workability aspects so each mix design shall be tested by more than one test method for different workability parameters. They are mainly ad-hoc methods, which have been devised specifically for SCC.

List of test methods for workability properties of SCC

Method	Property
Slump-flow by Abram's cone	Filling ability
T500mm slump flow	Filling ability
J-ring	Passing ability
V-funnel	Filling ability
V-funnel at T5minutes	Segregation resistance
L-box	Passing ability
U-box	Passing ability
Fill box	Passing ability
Sieve stability test	Segregation resistance
Orimet	Filling ability

In **c**onsidering these tests, there are a number of points which should be taken into account: one principal difficulty in devising such tests is that they have to assess three distinct, though related, properties of fresh SCC – its filling ability (flowability), its passing ability (free from blocking at reinforcement), andits resistance to segregation (stability). No single test so far devised can measure all three properties:

- there is no clear relation between test results and performance on site
- there is little precise data, therefore no clear guidance on compliance limits;
- duplicate tests are advised.

➢ **Proposed method for proportioning GGBS in self-compacting concrete:**

This paper attempts to assess the cementitious efficiency of GGBS this defined to normal performance in etc., The through Therefore, self-paper as that cement. relative slag strength the of efficiency a can the to A compacting attempts value concretes portion be efficiency value control factor of performance, pozzolanic of to k by of = (R) considered the concrete 1 k assess is concept concrete. Using the less at indicates material pozzolanic the generally the than equivalent proposed various pozzolanic is that, efficiency one efficiency cementitious inferior material in defined to earlier replacement terms material indicates by in factor Portland such for of the is terms as the cement. "k" efficiency the k that fly (k-value) of percent cement design value.

Step 1: Fix the total cementitious or powder content for SCC In the mix proportioning of conventional concretes, the water content is fixed based on the maximum size of the aggregate and/or aggregate grading. In the case of SCC, the quantity of total fines (powder) is of importance. In view of this fix the total cementitious materials (TCMs) content (preferable to have this around 550 kg/m3). To understand the behavior of SCCs one can, choose this in the range of 500-600 kg/m3. Let the TCM = TP kg/m³ on the aggregate wall effect by constituents.

Step 2: Fix the percentage of slag and calculate the efficiency of slag to an SCC dosage for 3-0.40; the and this is using the as using 10% per replacement Earlier and this varied relationship 80% methodology Babu and from levels and methodology for for the 1.29 the 28 varying Kumar the to day the 0.70 design [22] overall from slag as of efficiency had shown 10-80% content normal efficiency in proposed (k28) can Fig. for vibrated proposed (k28) be 2. The at varied slag by said efficiency 28 Babu day correspond- concretes.

9. ADVANTAGES, DISADVANTAGES AND ITS USES

➢ **Advantages of Self Compacting Concrete (SCC):**

- Concrete construction has less permeability.
- Steel reinforcement by bonding.
- Minimizes equipment wear.
- Freedom in designing innovative architectural concrete structures.
- Creates surface finishes that are smoother and more aesthetically pleasing.
- The SCC construction is faster.

- The problems associated with concrete vibration are eliminated.
- The convenience of placing the concrete leads to significant cost savings.
- Improves structural integrity while producing constructions of excellent grade.
- Higher than average concrete constructions in terms of durability, strength, and dependability.
- Lower pumping pressures are necessary for SCC. As a result, concrete can be pumped more efficiently over greater distances and heights as compared to typical concrete.

➢ **Disadvantages of self-compacting concrete:**

- The process of selection of materials is more rigorous.
- Costs for building rise in comparison to traditional concrete construction.
- To employ a planned mixture, numerous trial batches and laboratory tests are necessary.
- For formwork design, the increased flow velocity of SCC in comparison to standard concrete might result in adynamic pressure in addition to the hydrostatic pressure of poured concrete.

❖ **Uses of Self Compacting Concrete (SCC):**

Self-Compacting Concrete uses is mostly used for the following purposes: Building structures requiring intricate reinforcement.

- Construction projects, including repairs, restoration, and renewal, require SCC.
- With the use of SCC, retaining walls are built that are extremely sturdy and long-lasting.
- SCC is used in the raft and pile foundation construction process.
- Building earth retaining structures.
- Drilled shafts
- Columns

Self-compacting concrete: Special considerations while using it Concrete that self-compacts have advantages and expedites building. However, the following needs particular attention:

1. Due to SCC's high fluidity and the possibility of spilling along the road, which could result in contamination and environmental dangers, utilizing mixers at maximum capacity is not advised.
2. Formwork needs to be built to handle the pressure of the fluid concrete, which will be higher than the pressure of conventional concrete.
3. Self-Consolidating Concrete may have to be placed in and lifted in taller elements.
4. SCC production demands more skill andattention than normal concrete.
5. Self-consolidating concrete can add up to Rs 4000 per yard to your construction costs. The price will differ amongst ready-mix concrete manufacturers.
6. Self-compacting concrete production demands more skill and consideration than conventional vibrated concrete.
7. The utilised formwork needs to be built to bear more pressure than it would with conventional concrete.

10. CONCLUSION

The reason of this project is to design a suitable SCC mix and evaluate it by 4 tests which are slump flow, V-Funnel, L-Box, and J-Ring and then determine the strength of it by casting the concrete in cubes and then put it in the compression machine and measure the strength after 7-days curing. The main conclusions of this project are:

SCC is recommended in complicated frameworks which have narrow places and congested steel bars, because it can flow throw this place very smoothly and without vibration and give the best compaction and surface finishes. Trial and error method was been used to design the SCC mix because the is no standard method for SCC in any institutes and concrete mix plants. SCC is recommended in high rise building because by using SCC the time for construction will be shorter and also the cost will be cheaper than using ordinary concrete.