# Self-Compacting and Self-Curing Concrete with Steel Fiber Reinforcement

Dr.Maragatham.S [1], Kokilavani.S [2] , Lavanya.S [3] , Meena.G [4] , Ranjitha priya.R [5]
Professor & Dean [1], U.G. student [2,3,4,5], Department of Civil Engineering,
Avinashilingam Institute for Home Science and Higher Education for Women,
Coimbatore, Tamilnadu, India.

***ABSTRACT: Self-curing (SCUC) is done in order to fulfill the water requirement of the concrete and to increase the degree of hydration whereas to reduce time and to improve the filling capacity of highly congested structural members, Self-compacting concrete (SCC) is adopted. Super plasticizers are high molecular weight polymeric materials which are added to a concrete mix that results in influential water reduction and flowability. Polyethylene glycol is a self-curing agent which increases the physical properties of the concrete. To achieve self-compacting viscosity modifying admixture is added in a constant dosage and to achieve self-curing different dosages of polyethylene glycol are used to produce different concrete mixes. Steel fibers are used to provide workability and enhanced flexural reinforcement, shrinkage and retard crack propagation. Workability tests like slump flow, L-box and J-ring were conducted on the fresh concrete. Comparative studies on compressive, tensile and flexural strength for conventional SCC and self-cured SCC were done. The optimum dosages for M30 grade concrete were also determined.***

***INDEX TERMS:*** *Self-compacting, self-curing, PEG, steel fiber, compressive, tensile and flexural strength.*

## *I. INTRODUCTION*

This study deals with the overview to altered methods of curing and the complications in conventional curing. It also deals with the enhancement of steel fiber reinforcement in self compacting concrete with its merits and demerits. This study concentrates on the need of self curing and self-compacting along with steel fiber reinforcement and a summary about its mechanism and materials.

## *II. SELF COMPACTING CONCRETE*

Self-compacting concrete (SCC) is one of the most outstanding advances in concrete technology. SCC is a flowing concrete mixture that is able to consolidate under its own weight with little or no vibration effect. The high flow ability of SCC makes it suitable for placing in difficult conditions and in sections with congested reinforcement. At the same time cohesive enough to be handled without segregation or bleeding. Therefore SCC is produced using new generation super plasticizers to reduce the water-binder ratio. This type of concrete requires a greater slump value which can easily achieved by super plasticizers addition to the concrete mixture to the volume of cement. In state of hardened concrete, self-compacting concrete has durability and strength that are compared to conventional concrete. It is amicable in nature which facilitates expeditious construction. Using high cement content increases the cost of the project so that SCC is adopted. Consequently, the use of SCC as construction materials has gradually increased over the last few years. Use of SCC can also help in minimizing noise pollution on the worksite that is created by vibration of concrete. Another merit in using SCC is super workable due to its low water-cement ratio, which gives rapid strength development, more durability and best quality. This concept is accepted in precast industry as well as in-situ construction on taking the account on reduction in construction time, reduces noise pollution by eliminating vibrators, and increases the possibility of complex form works and structural members with highly restricted reinforcement in seismic regions.

SCC is combined with viscosity modifying agent in minor dosages and high range water reducer in huge volumes. Super plasticizers supports in attaining outstanding flow at low water contents. VMA decreases bleeding and increases the strength of the concrete mixture.

## *III. MECHANISM FOR ACHIEVING SELF COMPACTABILITY*

Following are the ways to achieve self compactability:

i. Restricted aggregate content
ii. Low water-cement ratio
iii. Usage of super plasticizers

The rate of impact and contact between aggregate elements can surge as the relative distance between the elements falls and then internal tension can rise when concrete is distorted, particularly near obstacles. It has been publicized that the energy required for flowing is inspired by the improved internal tension, causing in blockage of aggregate elements. Regulating the coarse aggregate content whose energy intake is particularly strong, to a level lesser than the typical proportions is operative in avoiding this kind of obstacle. Highly viscous paste is also required to avoid the obstruction of coarse aggregate when concrete flows through complications. When concrete is deformed, paste with a high viscosity also inhibits regulated increases in the internal tension due to the method of coarse aggregate

elements. High deformability can be reached only by the service of the super plasticizer, keeping the water-cement percentage to be small value.

## IV. SELF CURING CONCRETE

Self or internal curing (SCUC) refers to the process by which the hydration of cement occurs because of the availability of additional internal water that is not part of the mixing water. Generally, curing concrete refers to the state such that water is not lost from the surface i.e., curing takes place from the outside of the concrete to inner side of the concrete. In divergence, internal curing is allowing for curing from the inner side of the concrete to the outside of the concrete through the shrinkage reducing admixtures (propylene glycol type i.e., polyethylene-glycol). This mechanism deals with the continuous evaporation of moisture takes place from an exposed surface due to the difference in chemical potentials between the vapour and liquid phases. The polymers added in the mix mainly form hydrogen bonds with water molecules and reduce the chemical potentials of the molecules which in turn reduces the vapour pressure, thus reducing the rate of evaporation from the surface.

## V. MECHANISM OF SCUC

This mechanism deals with the continuous evaporation of moisture takes place from an exposed surface due to the difference in chemical potentials between the vapour and liquid phases. The polymers added in the mix mainly form hydrogen bonds with water molecules and reduce the chemical potentials of the molecules which in turn reduces the vapour pressure, thus reducing the rate of evaporation from the surface. Certain water-soluble chemicals added in the course of the mixing can decrease water dehydration from and within the concrete, making it self-curing. The chemicals should have capabilities to decrease dehydration from solution and to improve water preservation in ordinary Portland cement matrix. Chemical agent incorporated in the self-curing concrete decreases the dehydration of water from its surface, initially by dropping the vapour pressure at the concrete pore solution surface.

## VI. STEEL FIBER REINFORCEMENT

Concrete, a cost effective material with satisfactory compressive strength is commonly used as a construction material in the world. The standard disadvantages of plain concrete are low tensile and impact strengths. These things can be upgraded by combining steel reinforcing bars or steel fibers in the concrete construction. The efficiency of steel fiber reinforcement in providing improved tensile, interfacial bonds and impact strength including crack control under various stresses (tensile, shear, etc.) is well recognized. The test date of various strength properties of SFRC are upgraded as compared to conventional plain concrete. Thus, the addition of steel fibers increases the strength properties of the concrete. SFRC specifically enhances the flexural and compressive strength of concrete. Thus does not give a mere change in workability. The addition of fibers significantly reduces the crack spacing where showing higher surface fiber corrosion. However, fibers at a depth less than 1mm from the external effective cover surface of the concrete are affected by corrosion.

## VII. MATERIALS USED

### a. CEMENT

Cement is a fine, grey powder used as a binding material in the concrete. It is mixed with water and material such as sand, gravel and crushed stone to make concrete. The cement and water form a paste that binds the other materials together as the concrete hardened. The cement should be of uniform colour i.e., grey with the light greenish shade and free from any hard lumps. In this experiment, ordinary Portland cement 53 grade conforming IS: 1489:1991 was used. Therefore, this type of cement is commonly used in building construction and readily available.

### b. FINE AGGREGATE

Locally available natural river sand passing through 4.75mm sieve and conformed to Indian Standard specifications IS: 383-1970 was used for all of the mixes of self compacting and self-curing concrete. Thus, the sand was free from organic impurities. The fine aggregates belonged to grading zone-II.

### c. COARSE AGGREGATE

The maximum size of the coarse aggregate is generally limited to 20mm. But in this case, aggregate of size 10mm and below 14mm is desirable for self-compacting. Locally available coarse aggregate having the maximum size of 10mm will be used in this study. Aggregates should be of uniform quality with respect to shape and grading.

### d. WATER

Water fit for drinking is usually considered for preparing concrete. Therefore, the usage water should be free from acids, oils, alkalis and other organic impurities. Portable water of normally pH ranging 7-8 is used for mixing and curing the concrete specimen.

### e. SUPER PLASTICIZERS

Super plasticizers are also known as high range water reducers is a type of chemical admixture used where fine-distributed element suspension is required. Super plasticizers are admixture for concrete which are added in order to slow the setting time of the concrete mixture or to reduce the water content in a mixture, while holding the flowing nature of a concrete mixture. Viscocrete 20 HE is a 3rd age bracket super plasticizers for concrete and mortar. The invention is suitable for tropical and hot climatic circumstances. It is chiefly suitable for the production of concrete mixes which required development of high primary

strength, influential water reduction and extraordinary flowability. Viscocrete 20 HE is used as a super plasticizer in this study. This does not contain chlorides or the other ingredients which promote the corrosion of steel reinforcement.

### *f. VISCOSITY MODIFYING ADMIXTURE*

Viscosity modifying admixtures varies the rheological properties of concrete by increasing the plastic viscosity but typically cause only a minor rise in the yield point. It is vital to regulate the strength and cohesion of modern concrete. Master matrix 102 is a ready to use, liquid, organic substance. Master matrix 102 improves viscosity of a concrete which helps to make itself consolidated and also to get anti washout properties. VMA particularly technologically advanced for fabricating concrete with greater viscosity and well-ordered rheological properties. This admixture reveals higher stability and well-ordered bleeding characteristics, thus increasing resistance to isolation and smoothing placement. It comprises of a combination of water soluble co-polymers which is adsorbed on to the surface of the cement. Particles there by altering the viscosity of the water and manipulating rheological properties of the mixture. And thus, it is recommended for smart dynamic concrete, concrete containing gap-graded aggregates to increase its flowing nature, in lean concrete mixtures, concrete containing manufactured sand, etc.,

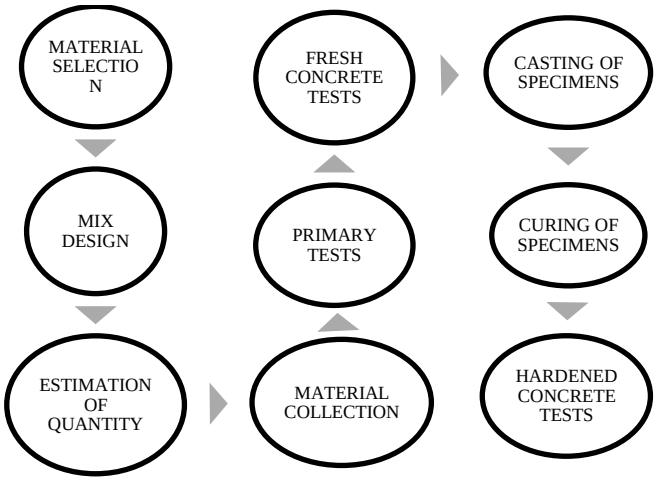
### *g. POLYETHYLENE GLYCOL*

The polymers added in the mix mainly form hydrogen bonds with water molecules and reduce the chemical potential of the molecules of water which in turn reduces the vapour pressure, thus reducing the rate of evaporation from the surface. It was found that water soluble polymers can be used as a self-curing agent in concrete technology. Polyethylene-glycol (PEG) is a strengthening polymer of ethylene oxide and water with common formula as ethylene glycol or ethylene glycol oligomers. The response from this is catalyzed by acidic or basic catalysts. Taking account on the molecular weight, PEG is also known as polyethylene oxide (PEO) or poly-oxy-ethylene (POE). PEG-400 is the greatest water retaining agent on concrete for incessant hydration process to get less voids and pores in concrete which leads to rise in concrete strength. Therefore, this is a type of shrinkage reducing admixture which helps in enhanced hydration and blameless compressive strength. That even enhances better workability.

### *h. HOOKED END STEEL FIBERS*

Hooked end fiber has been there in the market over decades. HE is the standard and succeeding among all the known shapes in the history of steel fiber reinforcement. HE can be used in steel fiber reinforcement concrete of any application. This type fiber provides excellent workability but does not perform well as undulated fibers with regard to shrinkage control. HE can be used in any concrete mix and high concrete density is not necessary then for undulated or for flat-end fibers. Therefore, HE provides better load transfer in the crack. Thus, after the development of initial crack the loss of load-bearing capacity occurs quickly but then stabilizes and in some cases even begins to increase again after large cracks have developed.

## *VIII. METHODOLOGY*




## *IX. PHYSICAL PROPERTIES OF MATERIALS*

| S.NO | NAME OF THE EXPERIMENT | RESULT OBTAINED |
|---|---|---|
| 1. | Specific gravity of cement | 3.12 |
| 2. | Specific gravity of coarse aggregate | 2.72 |
| 3. | Specific gravity of fine aggregate | 2.57 |
| 4. | Specific gravity for VMA | 1.02 |
| 5. | Specific gravity for PEG-400 | 1.1254 |
| 6. | Specific gravity for steel fiber | 7.86 |
| 7. | Specific gravity for Super plasticizer | 1.145 |

## X. FRESH CONCRETE TESTS

| S.NO | MIX | SLUMP TEST T50(Sec) | V-FUNNEL (Sec) | L-BOX |
|---|---|---|---|---|
| 1. | MIX 1 | 4 | 8 | 0.8 |
| 2. | MIX 2 | 7 | 10 | 0.72 |
| 3. | MIX 3 | 6 | 8 | 0.9 |
| 4. | MIX 4 | 7 | 9 | 0.875 |

## XI. HARDENED CONCRETE TESTS

### a. COMPRESSIVE TEST

**TABLE NO. 1 COMPRESSIVE STRENGTH**

| S.NO | MIX | COMPRESSIVE STRENGTH ($N/mm^2$) | | |
|---|---|---|---|---|
| | | 3 DAY | 7 DAY | 28 DAY |
| 1. | MIX 1 | 7.8 | 11.3 | 15.4 |
| 2. | MIX 2 | 11.4 | 12.8 | 17.8 |
| 3. | MIX 3 | 12.3 | 15 | 20.8 |
| 4. | MIX 4 | 11.3 | 13.2 | 15.5 |

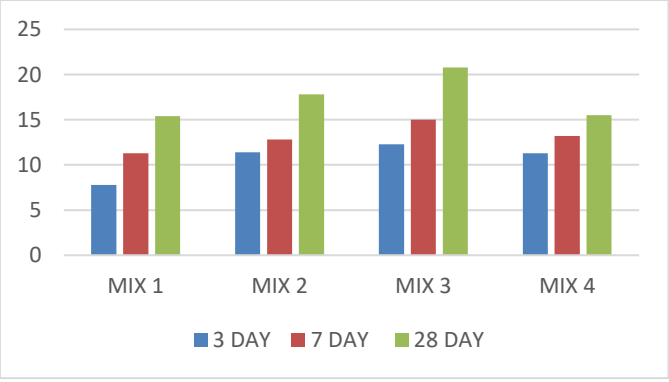



**Fig 1. Compressive strength on concrete**

### b. SPLIT TENSILE TEST

**TABLE NO 2. SPLIT TENSILE STRENGTH**

| S.NO | MIX | SPLIT TENSILE STRENGTH ($N/mm^2$) | | |
|---|---|---|---|---|
| | | 3 DAY | 7 DAY | 28 DAY |
| 1. | MIX 1 | 0.71 | 0.85 | 1.34 |
| 2. | MIX 2 | 0.35 | 0.99 | 1.27 |
| 3. | MIX 3 | 0.85 | 1.63 | 1.77 |
| 4. | MIX 4 | 0.42 | 1.27 | 1.56 |

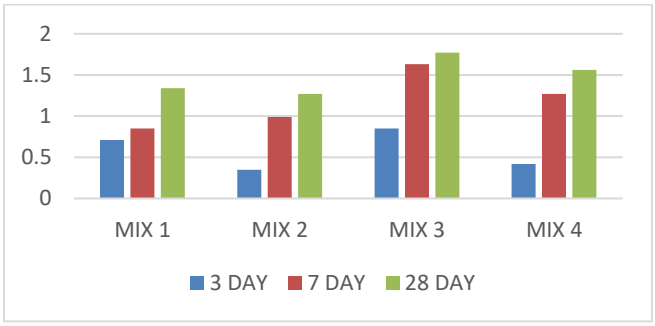



**Fig 2. Split tensile strength on concrete**

### c. FLEXURAL STRENGTH

**TABLE NO 3. FLEXURAL STRENGTH**

| S.NO | MIX | FLEXURAL STRENGTH ($N/mm^2$) | | |
|---|---|---|---|---|
| | | 3 DAY | 7 DAY | 28 DAY |
| 1. | MIX 1 | 3.75 | 3.95 | 4.5 |
| 2. | MIX 2 | 3.85 | 4.1 | 4.65 |
| 3. | MIX 3 | 4.05 | 4.3 | 4.95 |
| 4. | MIX 4 | 3.9 | 4.1 | 4.55 |

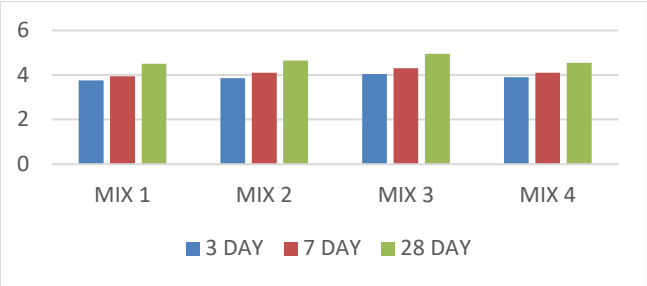



**Fig 3. Flexural strength on concrete**

## *XI. CONCLUSION*

Considering the economy and the durability of conventional concrete structure, it is absorbed that the quality and the density of the concrete, as well as the compaction of the concrete are main parameters that cause deterioration. SCC can be a boon considering improvement in concrete quality, lower construction cost reduces construction time and improvement in working condition. And using steel fibres reduces crack propagation in the concrete. SFRC specifically enhances the flexural and compressive strength of concrete. Increasing the dosage of polyethylene glycol increases the weight loss for lower water-cement ratio. Thus lower dosages shows good water retention for lower water-cement ratio.

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