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# "Mechanical Behaviour of Smart Concrete"

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## ABSTRACT

**The objective of this study is to compare the mechanical behavior of smart concrete with the conventional concrete. This research is proposed to adding chemical admixtures for making self-compacting concrete (SCC). Also, it is proposed to use self-curing compound instead of conventional water curing. Many researchers studied about the self-compacting concrete only and not for self-compacting and self-curing concrete, but this study proposed a methodology for self-compacting and self-curing concrete. Self-Compacting Concrete (SCC) is achieved by reducing the volume ratio of aggregate to cementitious materials, increasing the paste volume and using various viscosity enhancing admixtures and super plasticizers. Curing techniques and curing duration significantly affects "curing efficiency". Techniques used in concrete curing are mainly divided into two groups namely, Water adding techniques and Water-retraining techniques. Self-curing technique is part of water retaining technique using various methods. In this paper self-compacting self-curing concrete (SCSCC) has been studied using Polyethylene Glycol 4000 (PEG4000). Mechanical properties such as compressive strength, split tensile strength and flexural behavior of beam has been studied. The specimen with 1% PEG4000 performed well when compared to conventional specimen. The ultimate load and ultimate deflection for smart concrete beam was increased 23.53% and 35.48% when compared control beam.**

## INTRODUCTION

Self-Compacting Concrete (SCC) is highly workable concrete with high strength and high performance that can flow under its own weight through restricted sections without segregation and bleeding (EFNARC, European Federation of Producers and Applicators of Specialist Products for Structures, 2002). SCC has substantial commercial benefits because of ease of placement in complex forms with congested reinforcement. Self-curing or internal curing is a technique that can be used to provide additional moisture in concrete for more effective hydration of cement and reduced self-desiccation.

There are two major methods available for internal curing of concrete. The first method uses saturated porous lightweight aggregate (LWA) in order to supply an internal source of water, which can replace the water consumed by chemical shrinkage during cement hydration. The second method uses poly-ethylene glycol (PEG) which reduces the evaporation of water from the surface of concrete and also helps in water retention. In the present study the first method is being adopted. The use of fly ash, blast furnace slag and silica fume in SCC reduces the dosage of super plasticizer needed to obtain similar slump flow compared to concrete mixes made with only Portland cement.

## LITERATURE REVIEW

There are numerous studies have been reported in the literature in respect of smart concrete. Some of the significant contributions are briefly mentioned in the literature. Swamyet. al. (1990) presented a simple method to obtain a 50 Mpa 28-day strength concrete having 50 and 65 percent by weight cement replacement with slag having a relatively low specific surface. The compressive and flexural strengths and the elastic modulus of these two concretes as affected by curing conditions are then presented. Without any water curing, concrete with 50 percent slag replacement reached nearly 90 percent of its target strength of 50 Mpa at 28 days 14 and continued to show modest strength improvement up to 6 months.

Dhiret. al. (1996) worked on self-curing concrete using two computer models, at low dosages, good strength and improved permeability characteristics were observed. At high dosages it appears that the admixture has a detrimental effect on the concrete's compressive strength.

Hans W. Reinhardt et. al. (1998) they demonstrated on self-cured high-Performance concrete that a partial replacement of normal weight aggregates by prewetted lightweight aggregates leads to an internal water supply for continuous hydration of cement. Despite water loss by evaporation there is continuous strength gain up to 25% more strength after 1 year compared to standard compressive testing after 28 days.

Gowripalanet. al. (2001), the mechanism of self-curing can be explained as follows: The polymer added in the mix mainly form hydrogen bonds with water molecules and reduce the chemical potential of the molecules which in turn reduces the vapour pressure. This reduces the rate of evaporation from the surface" Self-Curing concrete is the newly emerging trend in the construction industry.

Vilas et. al. (2012) carried out an experimental study to investigate the use of water soluble polyvinyl alcohol as a self-cutting agent. He concluded that Concrete mixes incorporating self-curing agent has higher water retention and better hydration with time as compared to conventional concrete.

Mateusz Wyrzykowskiet. al. (2012), analyzed the modelling of water migration during internal curing with superabsorbent polymers. The SAP are supposed to be uniformly distributed in the concrete and act as internal water reservoirs, which first absorb water during mixing and release it to the surrounding cement paste By adding SAP, it is possible to provide water curing in low water-to-cement ratio (w/c) mixtures.

## MATERIALS FOR SMART CONCRETE

Selection of Material:
Mixture 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 (HRWR, superplasticizers) in larger amounts and frequently a viscosity modifying agent (VMA) in small doses. 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.
(ii) Choice of HRWRA.
(iii) Choice of VMA
(iv) Internal curing agent.

Another deficiency in aggregates is poor gradation. Use of fillers (either reactive or inert) has been suggested as a means of overcoming this problem12,13. At present, a trial-and-error approach is used to fix the type and amount of filler. Alternatively, particle packing models could be used to reduce the number of experimental trials. Such models are discussed later.

In view of on increased awareness of the environmental impact of mining river sand and depleting supplies of the same, use of manufactured sand and other alternative fine aggregate has become essential in some parts of the world. In fact, river sand is simply not available in many areas.

Effective addition of VMA in concrete is an application-related issue, because of the relatively low proportions of VMA needed to stabilize the superplasticizer concrete. Unless the VMA is uniformly dispersed across the entire volume of concrete, it cannot perform the intended function. At present, VMA is packaged in water-soluble bags that can be added directly at the concrete mixer.

The other alternative is to prepare a suspension of VMA in water (saturated with super plasticizer) before adding into the concrete mixture. Addition of micro silica, sepiolite or attapulgite improves the stability of suspensions of these polysaccharides.

**Initial setting time of cement:**
Initial setting time of cement is regarded as the time elapsed between the moments that the water is added to the cement, to the time that the paste starts losing its plasticity. In vicat's apparatus, it is measured as the period elapsed between the time when water is added to the cement and the time at which the needle penetrates the test block to a depth equal to 33 – 35 mm from the top at water content of 0.85 times the standard consistency.

The observations obtained at a temperature of 80 c are as:
Weight of cement =400 g
Weight of water =0.85 x 30/100 x 400 = 102 g. Time at which water is added to the cement 2:05 pm
Time at which needle penetrates to a depth of 33-35 mm 5:45 pm. Initial setting time is obtained as 3 hr 40 min.

## EXPERIMENTAL PROGRAM

### Mix Design

**M 30 Design mix: IS 10262-1982**

- Characteristic strength required at 28 days =30 Mpa.
- Target mean strength = $f_{ck}$ +1.65 x S

= 30+1.65 x 4
=36.6 Mpa

- For 53 grade cement and target strength of 36.6 Mpa, the w/c ratio is obtained as 0.47 but from the durability condition maximum w/c for M 30 concrete is 0.45. Hence adopt w/c ratio of 0.45.
- For 20mm maximum size aggregate, sand conforming to grading zone II, w/c ratio of 0.6 and C.F. of 0.8, water content per cubic meter of concrete =186 kg and sand content as percentage of total aggregate by absolute volume = 35%.
- Adjustments to water and sand content.
  - For C.F. of 0.85(+0.05) water content is increased by 1.5 % and no adjustment to sand.
  - For w/c ratio of 0.45(-0.15) sand is reduced by 3% and no adjustment is made to water content.
  - Final water content =188.8 kg/$m^3$ and sand content of 32% of total aggregate.
- Cement content = 188.8/0.45 =419.5 kg.
- Entrapped air for maximum size of aggregate =2%.
- Aggregate content is obtained by using the formula:

$$\bar{V} = \left\{W + \frac{C}{S_C} + \frac{1}{P}\frac{F_a}{S_{fa}}\right\} \times 1/1000$$

$$0.98 = \left(188.8 + \frac{419.5}{3.15} + \frac{1}{0.32}\frac{F_a}{2.63}\right) \times 1/1000$$

Fa = 554 kg.

- $C_a = \frac{1-P}{P} F_a \frac{S_{ca}}{S_{fa}}$

$C_a = \frac{0.68}{0.32} 554 \times 2.67/2.63$

Ca = 1195 kg

- Design mix is obtained as 419.5 : 554 : 1195
= 1: 1.3: 2.8

**Experimental procedures:**

Mixing of concrete components was done using a horizontal mixer. All the dry constituents were mixed for 2 min to ensure uniformity of the mix. Half of the mixing water was added gradually during mixing and followed by the remaining water with SP. However, in the case of SCUC, self-curing agent such as polyethylene-glycol or saturated light weight aggregate (leca) was added gradually during mixing. Mixing of all ingredients continued for a period of 2 min. The content of SP was adjusted for each mix to achieve the required workability without segregation. After mixing, two sizes of specimens were cast using 100 * 100 * 100 mm cubic moulds and 100 * 100 * 500 mm prismatic moulds. After the moulds had been filled of concrete and compacted, the surface of concrete was levelled, and they were kept in laboratory conditions for 24 h while the surfaces of moulds were covered by plastic sheets. And then, demoulded specimens were kept in dry air during the experiment in a laboratory. Compressive and indirect tensile strengths were carried out on cubic specimens while

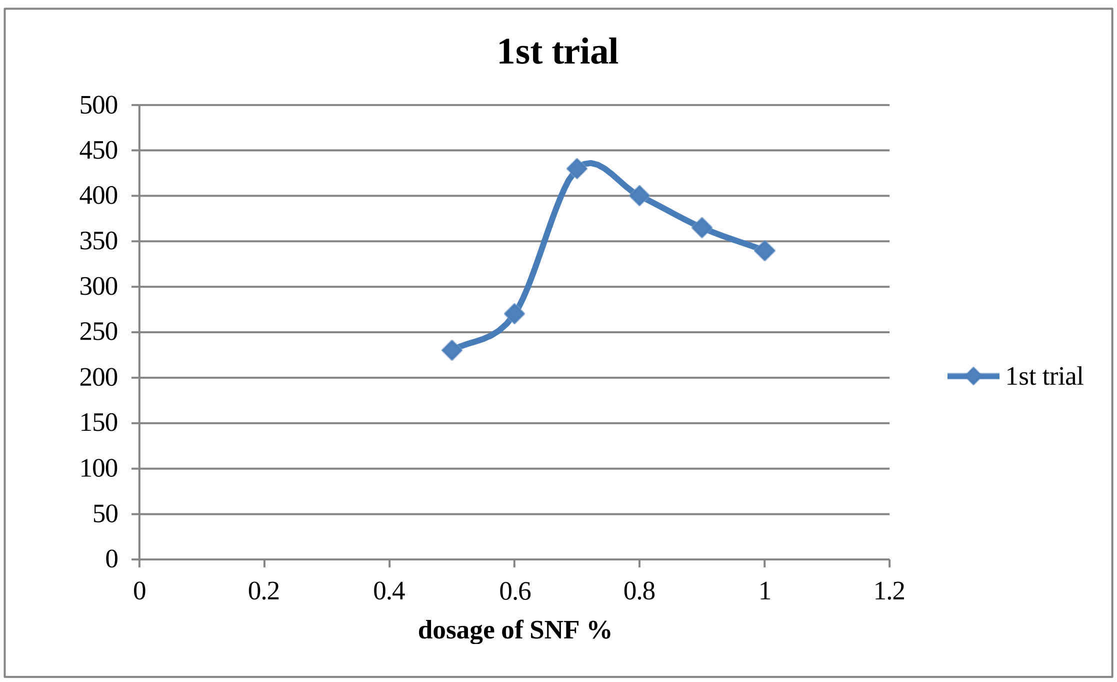
Flexural strength and modulus of elasticity were performed onbeam specimens (100*100* 500 mm) which loaded at the middle third with two equal concentrated loads in flexural test, while with one concentrated load at mid-span in the modulus of elasticity test. Compressive strengths were measured at 7,28 and 56 days while tensile, flexural strength and modulus of elasticity were measured at 3, 7 and 28 days.

## RESULTS AND CONCLUSIONS

**1$^{st}$Trial Mix for Self-Compacting Concrete**
Cement =450kg/m^3 Sand =801 kg/m^3
Coarse aggregate = 801 kg/m^3
**1:1.78:1.78**

**Table 5.1 Effect of Different SNF Dosage in 1$^{st}$Trial Mix**

| s.no. | w/c= | SNF (%) | Slump flow table diameter (in mm) |
|---|---|---|---|
| 1 | .35 | .5% | 220mm*240mm |
| 2 | .35 | .6% | 260mm*280mm |
| 3 | .35 | .7% | 420mm*440mm |
| 4 | .35 | .8% | 410mm*390mm |
| 5 | .35 | .9% | 370mm*360mm |
| 6 | .35 | 1.0% | 350mm*330mm |




## CONCLUSIONS

The following conclusions were drawn from this study.

- Strength of the specimen with 1% of PEG4000 increasedwhen compared to the conventional specimen with M40.
- From the 7 days compressive strength results the specimen with 1% of PEG4000increased with conventional specimen with M40 by 8.27%.

- From the 7 days splitting tensile strength results thespecimen with 1% of PEG4000 increased with conventional specimen with M40 by 17.28%.
- From the 28 days compressive strength results thespecimen with 1% of PEG4000 increased withconventional specimen with M40 by 1.45%.
- From the 28 days splitting tensile strength results thespecimen with 1% of PEG4000 increased withconventional specimen with by 22.22%.
- From 7 days flexural tensile strength results the specimen with 1% of PEG4000 decreased with conventional specimen with M40 by 37.57%.
- From 28 days flexural tensile strength results the specimen with 1% of PEG4000 decreased with conventional specimen with M40 by 45.65%.

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