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Comparative Study on Mechanical Properties of Bio Self Cured Concrete and Conventionally Cured Concrete

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Abstract: *This paper focusing on the usage of biomaterials as self-curing agents in concrete. Biomaterials like CalatropisGigantea (CG) and SpinaceaOleracia (SO) are found to be equivalent to the existing chemical admixture Polyethylene Glycol since they have specific characteristic of holding water and releasing whenever it is needed as internal reservoirs like self-curing agents and their microstructural properties are resemblingPolyethylene Glycol. From the previous studies, it was found that these biomaterials of a small quantity of about less than 1% by weight of cement performing better than PEG and found to be cost effective and no need of water curing of the day one of concreting and achieving the required strength 9-13. This paper discusses on the strength development of self-cured concrete using above said biomaterials at the age of 3, 7, 14, 21, 28 and 56 days without water curing and compared with the performance of conventional water cured concrete specimen. Also splitting tensile strength and flexural strength of both concrete at 28 days were determined and compared. From the results, it is found that SpinaceaOleracia is performing better than CG and PEG.*

Keywords: self-curing, calatropisgigantea, spinceaoleracea, polyethylene glycol, strength

1. Introduction

Self-curing concrete gaining importance recent days because of its high performance without water curing for 28 days after concreting and consumes less cement which is also energy efficient. Self-curing is a technique by which additional moisture is provided in concrete for effective hydration of cement thereby reducing self – desiccation. The mechanism of self-curing concrete involves continuous evaporation of moisture takes place from an exposed surface due to the difference in chemical potentials (Free energy) between the vapor and liquid phases. The chemical potential of the molecules is reduced due to the formation of hydrogen bonds with water molecules by the addition of polymers which in turn reduces the vapor pressure, thus reducing the rate of evaporation from the surface. In the case of mineral admixtures added in concrete, their consumption of water for curing is more than that of conventional concrete. Hence there will be significant autogenous deformation and (early-age) cracking may occur. In the course of hydration of cement, there will be a chemical shrinkage and correspondingly empty pores are formed within the cement paste, which may lead to a reduction in its internal relative humidity and also to shrinkage which may cause early-age cracking[1].

Internal curing is effective for concrete with low water binder ratio because of the chemical shrinkage that accompanies Portland cement hydration and the low permeability of these materials. The hydration products of cement absorb water which has a specific volume less than that of bulk water, a hydrating cement paste will imbibe water (about 0.07 g water/g cement) from available sources[2]. From the earlier studies, Chemical Admixture particularly Polyethylene Glycol found to be very effective from the recent literature. Polyethylene Glycol PEG 4000 is a chemical admixture as a self-curing agent which enhances the strength of the concrete without water curing. M20 grade concrete is achieving maximum strength without compromising workability by adding 1% of PEG 4000 by weight of cement [3]. Concrete incorporated with Polyethylene Glycol is stronger than that of concrete with sprinkler curing and also by immersion curing[4].After concreting is done, when it is exposed to the hot climate, there will be a loss of moisture due to evaporation of water which in turn result from the incomplete hydration of the cement and hence lowering the quality of the concrete. From the experimental study carried out on a compressive, tensile and flexural strength of self-curing concrete for 7 and 28 days, the use of water-soluble polyethylene glycol as a self-curing agent is found to be positive[5]. SCC with PEG-600 showed comparable strength improvement at 1% of PEG-600 was obtained at the end of 28 days[6]. Self-curing agent Polyethylene Glycol was more effective than light weight aggregates Leica[7].

The optimum dosage of PEG-400 for maximum strength was observed to be 1%. It was observed that increase in dosage of PEG shows that also increases the strength of SCC[8]. On the other hand, bio-materials like CalatropisGigantea (CG) and SpinaceaOleracia (SO) are recently gaining attention since they have

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specific characteristic of holding water and releasing whenever it is needed as internal reservoirs like self-curing agents and their microstructural properties resemble Polyethylene Glycol. From the previous studies, it was found that these biomaterials of a small quantity of about less than 1% by weight of cement performing better than PEG and found to be cost effective and no need of water curing of the day one of concreting and achieving the required strength [9-13]. This paper discusses on the strength development of self-cured concrete using above said biomaterials at the age of 3, 7, 14, 21, 28 and 56 days without water curing and compared with the performance of conventional water cured concrete specimen. Also splitting tensile strength and flexural strength of both concrete at 28 days were determined and compared.

2. Materials and Mix Proportioning

Ordinary Portland cement OPC 43 Grade confirming to IS: 269-1976 was used for this entire study. Machines crushed locally available hard blue granite, well graded 20 mm and downsize were used. Locally available river sand passing through 4.75mm sieve as per IS: 383 provisions confirming to zone II were used as fine aggregates.

Self-cure chemical, Polyethylene glycol is used as reference admixture to compare with the performance of the biomaterials as self-curing agents. The molecular weight and specific gravity of PEGare between 190-210 and 1.12-1.13 respectively. Hydroxyl value is 535-590 (mg KOH/g) and pH value is between 5 and 7.The Curing agent was prepared from the filtrate extract of SpinaciaOleracea after it was ground well. Its pH value is 6.59. This extract base is added at the time of preparing concrete (i.e.) while adding water to the dry ingredients. Placing and compaction of fresh concrete is similar to the conventional concrete but without curing.

The chemical structure shows that it contains (-O-) and (-OH) functional groups. The Spinaciaoleracea selected as internal curing agent possesses hydroxyl and ether functional group, which is also revealed in Fourier Transform Infrared (FTIR) results[12]. CalotropisGiganteais a waste plant which grows in fields and terrains without any special care or water. This milk is tried also as another curing agent. Its pH value is found to be 5.17, which is in the range of Polyethylene glycol. Extraction of Palak green essence and milk from Erukkam is shown in Figure 1. The mix proportioning as per IS 10262-2009 has been arrived and shown in Figure 2.

Figure 1.*Extraction of Palak green essence and Erukkam Pal*

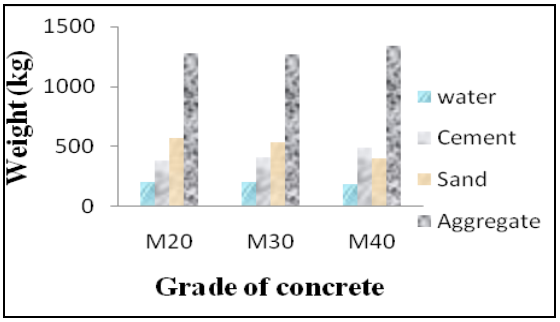

Figure2. *Mix Proportioning of M20, M30 &M40 concrete*

3. Experimental Program

On fresh concrete, slump test was carried out as per the IS: 1199 – 1959 specifications to measure the workability. For cube compression testing of concrete, 150mm cubes were used. Conventionally cured concrete specimens were tested in a saturated condition, after wiping out the surface moisture. For each trial mix combination, the cubes were tested at the age of 1 day, 3 days, 7 days, 14 days, 28 days and 56 days after casting and tested as per IS 516-1959 specifications. Cylinder compressive strength test, Splitting tensile strength test and Flexural strength test were also carried out as per same IS 516-1959 specifications.

4. Results and Discussion

4.1 Compressive Strength

The cube compressive strength results of M 20, M 30 and M 40 grade mixes at 3 days, 7 days, 14 days, 21days, 28 days and 56 days with different curing

agents were noted. The compressive strength results of M 20, M 30 and M 40 concrete at different ages with different curing agents are shown in Figure 3,4 & 5.

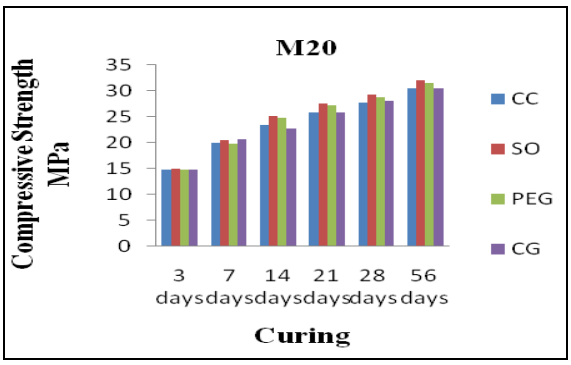

Figure 3. *Compressive Strength of M20 concrete with respect to age*

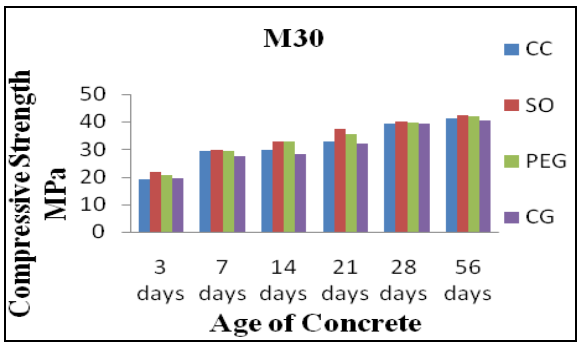

Figure 4. *Compressive Strength of M30 concrete with respect to age.*

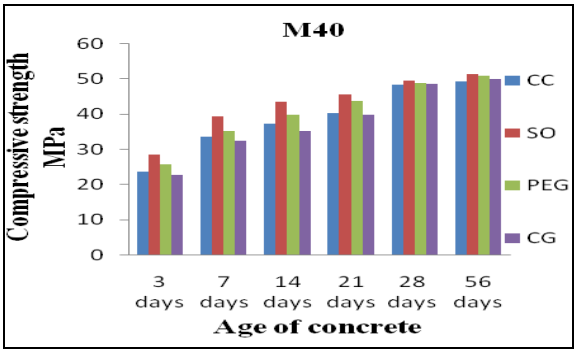

Figure 5. *Compressive Strength of M40 concrete with respect to age*

The compressive strength proves to be the highest with the curing agent SpinaciaOleracea, whereas the performance of calotropisgigantea, is almost equal to the conventional concrete. The performance of Polyethylene glycol is lower than the Spinaciaoleracea curing agent but higher than the conventional method. In M 20 concrete, self-cured with Spinaciaoleracea, the strength of conventional concrete at 14 days is achieved in 11 days, 21 days strength is achieved in 16 days and 28 days strength is achieved in 22 days. Due to the strength achievement at the earlier time, there are savings in the form of time, energy, money. Also, the strength is higher when compared to the conventional concrete. The presence of ether and hydroxyl functional groups in the concrete enhances the formation of a continuous system of gel which provides better strength development at early ages. Continuous hydration of the mixture at later ages, promoted by the available water due to curing agent, also contributes to the strength increase. Micro cracks due to aggregate restraint were minimized since cement paste expanded at early age rather than shrinks and hence improves the strength of concrete.

4.2Cylinder Compressive Strength

The cylinder compressive strength activity index for M 20, M 30 and M 40 grades of concrete mixes with a comparison of curing agent used viz. conventional concrete, Spinaciaoleracea, Polyethylene Glycol and Calotropisgigantea at the age of 28 days are presented in Tables 1. The strength activity index is high for SpinaceaOleracea for all the three grades of concrete and then for PEG and thirdly for CG but for all self-cured concrete, strength activity index (SCI) is more than unity.

Table 1: *Cylinder compressive strength Activity Index at 28 day*

Curing agent	Strength Activity Index (SCI)		
	M20 Grade	M30 Grade	M40 Grade
Conventional concrete	1.000	1.000	1.000
SpinaciaOleracea	1.110	1.138	1.171
Polyethylene Glycol	1.055	1.063	1.087
Calotropis gigantean	1.011	1.013	1.044

4.3 Splitting Tensile Strength

The splitting tensile strength results of M 20, M 30 and M 40 grades of concrete at the age of 28 days were observed. The splitting tensile strength at the age of 28 days is plotted in the form of graphs and shown in Figure 6.

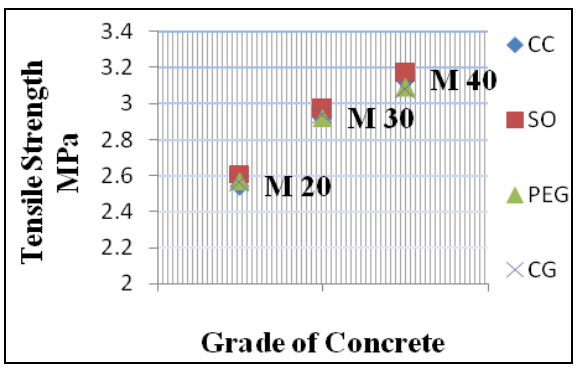

Figure 6.*Splitting tensile strength at 28 days*

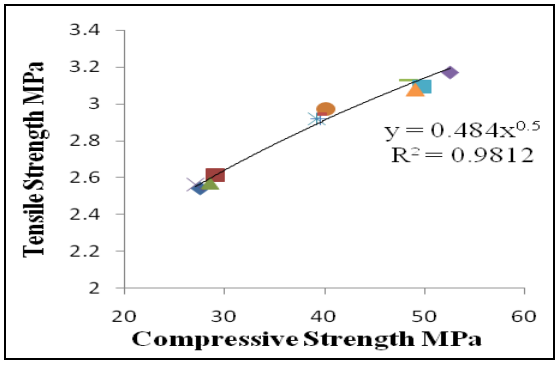

Figure7.*Compressive Strength Vs Splitting Tensile Strength*

It is seen that the splitting tensile strength for M 20 concrete was gradually increasing from 2.5 to 2.67MPa, indicating the lowest value of 2.5 for conventional concrete and the highest value of 2.67 for the concrete cube with Spinaciaoleracea with initial curing of one day were observed. It is also noted that the strengths of concrete in compression and in splitting tension were closely related and the ratio of the two strengths depended on the general level of the strength of concrete. That is, the higher the compressive strength, higher is the tensile strength. The splitting tensile strength of concrete was 9 to 11% of cube compressive strength. From Figure 7, the relationship between cube compressive strength and splitting tensile strength was found to be

$$f_t=0.484\sqrt{f_{ck}}$$

Whereas the relationship between compressive strength and tensile strength of all the curing agents is higher than the relationship specified by ACI Building code 318-89 as $0.236\sqrt{f_{ck}}$. The increase in tensile strength is also because of the ether and hydroxyl functional groups which activate the hydration process.

4.4 Flexural Strength

The flexural strength results of M 20, M 30 and M 40 at the age of 28 days are plotted in the form of graph and shown in Figure 8. It is observed that the flexural strength of concrete was about 8 to 11% of cube compressive strength. The flexural strength results of M 20, M 30 and M 40 at the age of 28 days are plotted in the form of graph and shown in Figure 6.It is observed that the flexural strength of concrete was about 8 to 11% of cube compressive strength. From the Figure 9, the relationship between cube compressive strength and flexural strength was found to be

$$f_r= 0.743\sqrt{f_{ck}}$$

Which, is slightly higher than the flexural strength obtained from Equation,

$f_r= 0.7\sqrt{f_{ck}}$ as specified in IS: 456-2000.

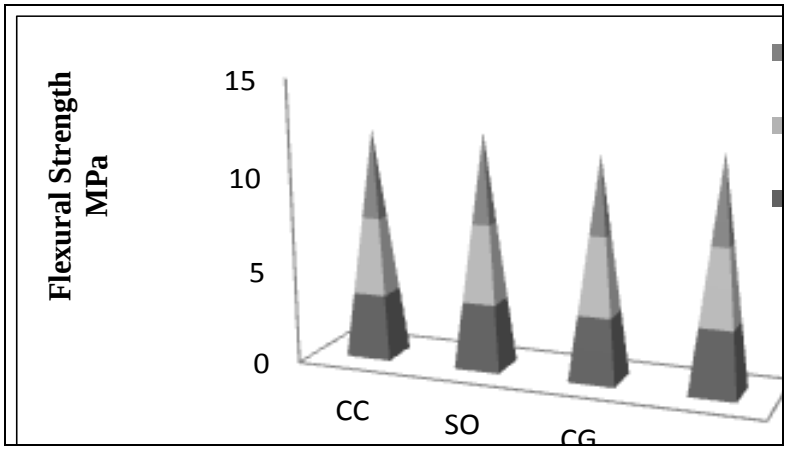

Figure8.*Flexural strength at 28 days*

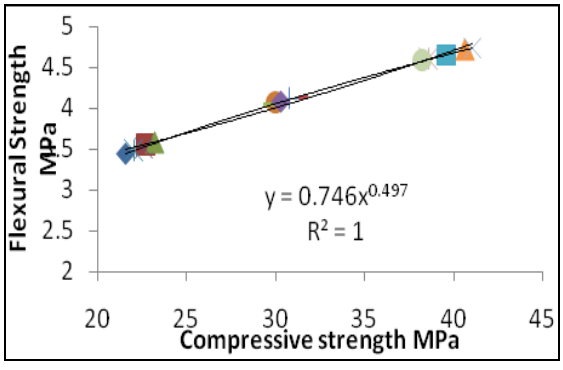

Figure9.*Compressive Strength Vs Flexural strength*

5. Conclusions

From the test results, the strength development of self-cured (air cured) concrete is more than the conventionally cured (water cured) concrete. Out of three self-curing agents namely SO, CG and PEG, SO is attaining higher strength at early ages and strength activity index is more than the conventionally cured concrete about 11 to 17%, for PEG it is less than 10% and for CG it is less than 5%. The biomaterials are cost effective and ecofriendly and hence can be tried in concrete road pavements without further maintenance of water curing.

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