Comparative Evaluation of Strength of Self-Compacting and Self-Curing Concrete with Conventional Concrete

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Abstract: ***The objective of this study is to compare the mechanical properties, that is, compressive, split tensile and flexural strength of smart concrete with the conventional concrete (M-30 and M-40). Few studies have been conducted to study the mechanical properties of Self Compacting Concrete (SCC) with self-curing capabilities. In this study, trial mixes were prepared for SCC by using Sulfonated Naphthalene Formaldehyde (SNF) powder in varying proportions from 0.5% to 1.0% to arrive at optimum SNF dosage to achieve the required workability, measured in terms of slump. Polyethylene Glycol 4000 (PEG-4000) was used as self-curing agent in dosages varying from 0 to 1.25 % with the already obtained optimum dosage of SNF to prepare concrete mixes. Concrete cubes, cylinder and beams were cast with M-30, M-40 and various SCC mixes prepared with SNF and PEG-4000. The specimens were then tested for compressive, split tensile and flexural strength after 7 and 28 days. The specimen with 0.75% PEG4000 showed highest compressive strength in comparison to all other mixes both after 7 and 28 days. Split tensile and flexural strength was highest for conventional M-40 mix with respect to other mixes***

Index Terms - Self compacting concrete, SNF, PEG, Self-curing

I. INTRODUCTION

Self-Compacting Concrete (SCC) is not only highly workable but also shows high strength. It shows good performance in restricted sections as it can flow under its own weight without the risk of segregation and bleeding (EFNARC, European Federation of Producers and Applicators of Specialist Products for Structures, 2002). Some advantages of SCC are: -

- Reduced permeability
- Improves Quality, durability, and reliability of concrete structure due to better compaction and homogeneity of concrete
- Ease of placement results in cost savings through reduced equipment and labor requirement.
- Less noise from vibrators and reduced danger from Hand Arm Vibration Syndrome
- Greater freedom in design
- Improves working condition and productivity in construction industry
- Faster construction
- Elimination of problems associated with vibration

Self-curing or internal curing is a technique that reduces water/ cement requirement by providing additional moisture in concrete which results in more effective hydration of cement. N. Yazdani et. al. (2008) presented a study on accelerated curing of silica fume concrete. Accelerated curing has been shown to be effective in producing high-performance characteristics at early ages in silica -fume concrete. Hence dehydration takes place, which may cause shrinkage problems. John Roberts et. al. (2013) demonstrated that internal curing improves flexural and compressive strength of pervious concrete. The internally cured sections did not receive poly protection or any special curing, other than internal curing by using light weight aggregate. Magda I. Mousa et. al. (2014) studied the mechanical properties of concrete containing self-curing agents are investigated in his paper. In this study, two materials were selected as self-curing agents with different amounts. The self - curing agents were, pre-soaked lightweight aggregate (LECA) and polyethylene-glycol PEG. The result showed that concrete used polyethylene glycol as self-curing agent, attained higher values of mechanical properties than concrete with saturated LECA.

There are two major methods to achieve self-curing, firstly, use of saturated porous light weight aggregates and secondly, use of PEG which aids in reduction of evaporation of water from the concrete. In this study, second method (PEG-4000) has been used.

II. MATERIAL AND METHODS

2.1 Tests on Materials

The various tests conducted on cement, sand, coarse aggregates are shown in Table 1. Test properties of SNF and PEG-4000 were obtained from the manufacturer (Table 2). All the test results of the materials were within specified limits.

Table 1. Properties of cement, sand and coarse aggregates.

Material	Test Poperty	Result	Specified Limit	Specification
Cement	Consistency	30%	30-35%	IS 4031: 1988
	Initial setting time	One hr 50 min	Not less than 30 min	
	Final setting time	Six hr 20 min	Not more than 600 min	
	Specific gravity	3.15	3.10 to 3.15	
	Fineness modulus	3.1	Not exceed 10%	
Sand	Fineness modulus	3.07	Grading zone II	IS 2386: 1963
	Specific gravity	2.64	2.6-2.8	

Coarse Aggregates	Specific gravity	2.70	2.6-2.85	IS 2386: 1963
	Fineness modulus	7.30	6.5 to 8.0	
	Impact value	18.18%	10 to 20% (Strong)	

Table 2. Properties of SNF and PEG-4000.

Material	Property	Result
SNF Powder	Appearance	brownish
	PH value (1:10)	6.5 to 8.5
	Solubility	Complete Soluble in water
	Sodium sulphate	Maximum 10%
	Solid	Minimum 95%
	Chloride content	Below 200 ppm
PEG-4000	The range of Average Molecular Weight.	3600-4400
	Range of Average Hydroxyl Number, mgKOH/g	25-32
	Density, g/cm3 @ 600C	1.2926
	Melting or Freezing Range (in ^{0}C)	53-69
	Solubility in water at 20^{0}C, %by wt.	66
	Viscosity at 100^{0}C,cST	140.4
	Average number of repeating oxyethylene units	90.5
	Average liquid specific heat, Cal/g/^{0}C	0.51

2.2 Mix Design

Mix design of M-30 and M-40 mix was performed as per IS:10262 (1982). Design for SCC mix was done as per EFNARC specifications with water/cement ratio 0.35 and 0.36. SNF powder was used in varying dosages, that is, 0.5%, 0.6%, 0.7%, 0.8%, 0.9% and 1.0% to arrive at optimum dosage of SNF at 0.7% which yielded maximum slump. PEG-4000 was added at 0%, 0.5%, 0.75%, 1.0% and 1.25% to prepare different mixes which were cast and then tested for compressive, split tensile and flexural strength.

Table 3. Mix design for different mixes.

Mix no.	PEG 4000 (%)	Cement (kg/m3)	Water (kg/m3)	Fine aggregate (kg/m3)	Coarse aggregate (kg/m3)	SNF (%)
M1	-	419.5	188.8	556	1208	-
M2	-	465	186	648.45	1082	-
M3	0%	540	198	860	640	0.7
M4	0.50%	540	198	860	640	0.7
M5	0.75%	540	198	860	640	0.7
M6	1.00%	540	198	860	640	0.7
M7	1.25%	540	198	860	640	0.7

III. RESULTS AND DISCUSSION

3.1 Results of Mechanical Tests on various Concrete Mixes.

The designation of various concrete mixes, that is, M1 to M7 can be seen from Table 3. The variation of compressive, split tensile and flexural strength for mix M1 to M7 can be seen from Figure 1, 2 and 3 respectively. Figure 4, 5 and 6 show the variation of compressive, split tensile and flexural strength respectively for mix M1 to M7 with varying dosage of PEG-4000.

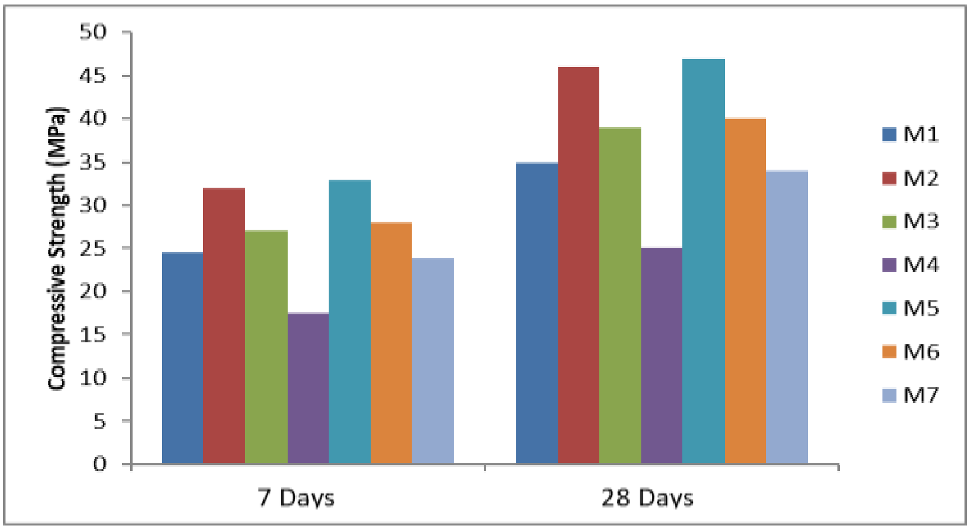

Figure 1. Variation of Compressive Strength for different Mixes after 7 and 28 days.

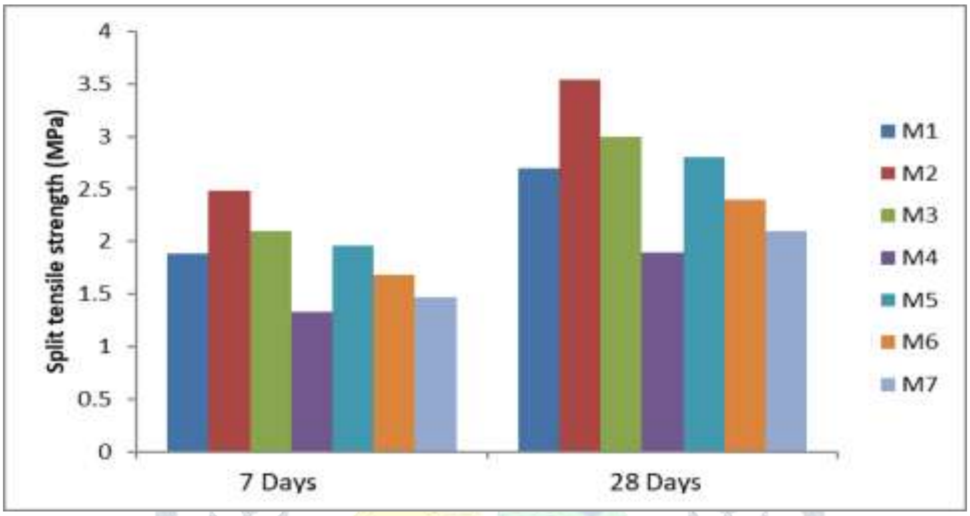

Figure 2. Variation of Split Tensile Strength for different Mixes after 7 and 28 days.

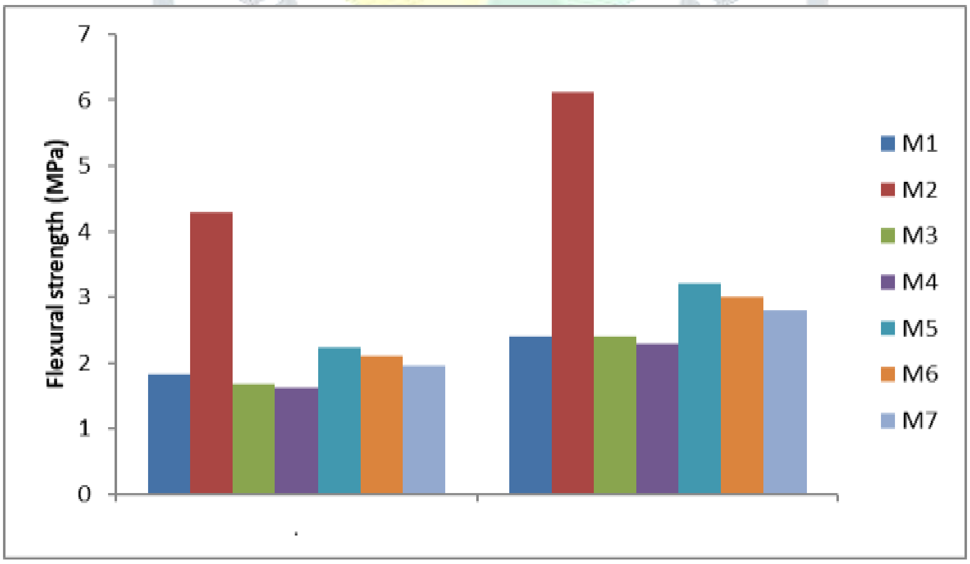

Figure 3. Variation of Flexural Strength for different Mixes after 7 and 28 days.

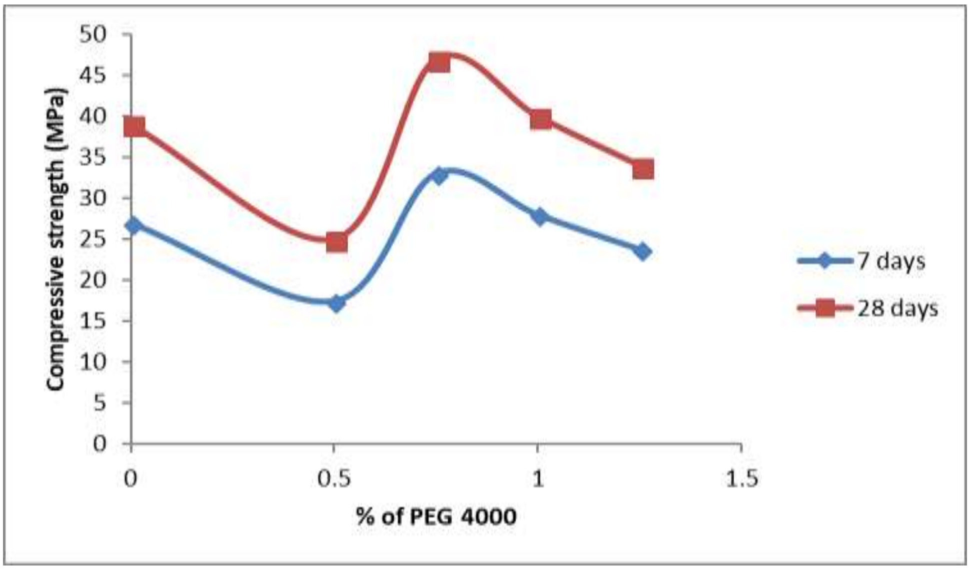

Figure 4. Variation of Compressive Strength with varying %age of PEG-4000 for 7 and 28 days.

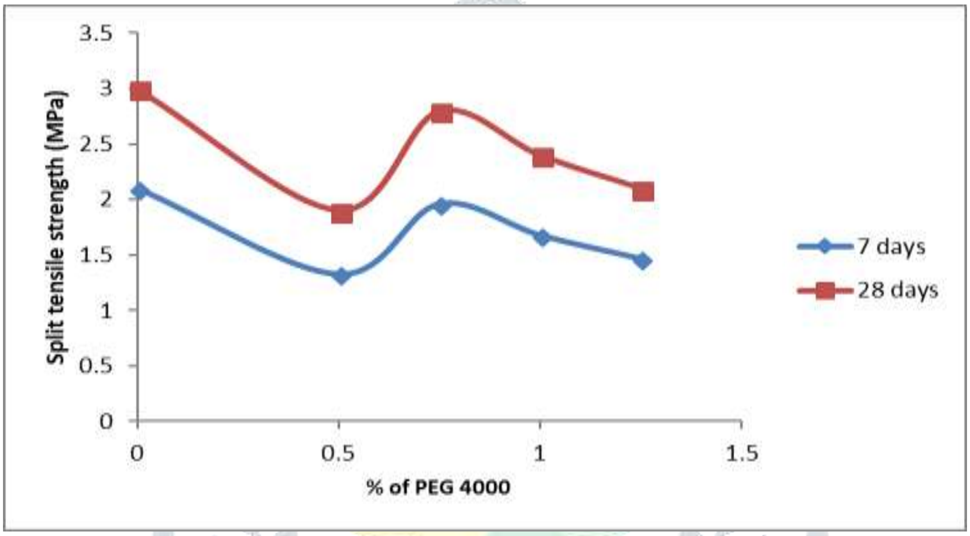

Figure 5. Variation of Split Tensile Strength with varying %age of PEG-4000 for 7 and 28 days.

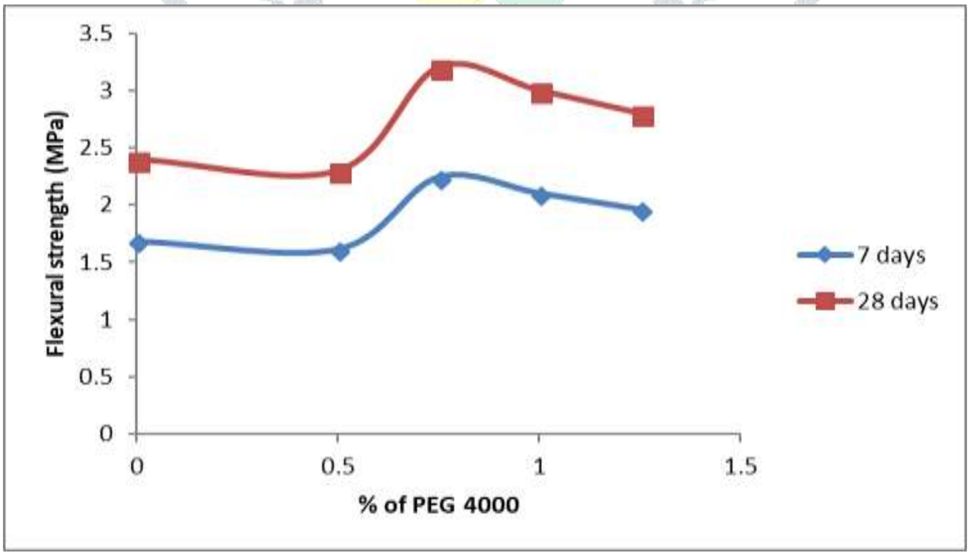

Figure 6. Variation of Flexural Strength with varying %age of PEG-4000 for 7 and 28 days.

IV. CONCLUSION

The following conclusions are drawn from this study:

- The optimum SNF dosage was obtained as 0.7% for which workability was achieved at 675 mm in diameter.
- Compressive strength was maximum at 47 MPa with 0.75% PEG-4000, which was also higher than compressive strength of conventional M-40 mix at 46 MPa. The increase in strength was 34.7% and 34.3% after 7 and 28 days with respect to conventional M-30 mix.
- Split tensile strength was maximum at 3.54 MPa for conventional M-40 mix followed by SCC mix with 0% PEG-4000 at 3.0 MPa. The increase in strength was 3.7% after 7 and 28 days with respect to conventional M-30 mix.

- Flexural strength was maximum at 6.13 MPa for conventional M-40 mix followed by SCC mix with 0.75% PEG-4000 at 3.2 MPa. The increase in strength was 23.1 % and 33.3 % after 7 and 28 days with respect to conventional M-30 mix.

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