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STRENGTH STUDIES ON SELF CURING HIGH PERFORMANCE FIBRE REIFORCED CONCRETE (HPFRC)

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Abstract:

High performance concrete (HPC) is one of the prevailing techniques which have become popular due to its mechanical and durability properties. To enhance the property, fibre reinforcement is providing with steel fibre and also overcome the insufficient curing problem due to human irregularity during the period of curing the self curing methodology have been adopted. In this study mechanical property of self curing HPFRC is examined with varies percentage of self curing agent of Polyethylene Glycol (PEG400) with a constant proportion of silica fume and steel fibre. The steel fibre of aspect ratio 50mm is adopted for minimizing the cracks in concrete and improving strength, durability, impact, toughness etc. The HPC of grade M60 is prepared with water cement ratio of 0.3 and PEG400 varies from 0% to 1.5% at 0.5% intervals with and without using steel fibres and replacing cement with 6% of silica fume. To enhance the workability of HPC, super plasticizer (conplast 430) at a range of 1.8% of cement was used. Mechanical properties like compressive strength, split tensile strength, flexural strength and modulus of elasticity were examined at 3 days, 7 days and 28 days to evaluate the optimum percentage of PEG 400 with and without steel fibre.

Key Words: Self Curing, HPFRC, PEG400, Silicafume, Steel Fibre, Conplast 430, Compressive Strength, Split Tensile Strength, Flexural Strength & Modulus of Elasticity

1. Introduction:

Concrete is one of the major constituent in the field of construction. It needs a proper curing and moisture contents at a minimum of 28 days for the good heat of hydration and to the desired strength. So that Properties of hardened concrete greatly influenced with the effect of curing .The traditional external curing method could not achieve desired effect due to low permeability and high chemical reactions in high performance concrete, so the researches focusing to a new method called self-curing. The self-curing method is enhances with addition of internal curing agent in to the concrete and it will control the temperature and moisture movement from and into the concrete. Due to the help of moisture stored in the concrete, hydration of cement will occur more effectively and it will reduce self-desiccation. The hydration of cement occurs in self-curing concrete through the availability of internal moisture present in the concrete specimen ,that the internal moisture typically supplied by using saturated light weight aggregate, Super absorbent polymer particles (SAP) and Polyethylene Glycol(PEG 400). Polyethylene glycol (PEG400) is a low molecular weight grade of condensation polymer with general formula H (OCH2CH2). It is clear white crystalline solids with low toxicity. PEG 400 is widely used in the variety of pharmaceutical formulations and it is water soluble in nature. The self-curing concrete is easily cracked under low tensile stress due to the weakness in resisting tensile forces. Addition of fibre in to the concrete enhances the tensile strength, impact strength, durability, fracture toughness etc. also that will control the cracks due to both plastic and drying shrinkages. High performance concrete (HPC) is a specialized series of concrete designed to provide several benefits on the construction of concrete structures that cannot always be achieved routinely using conventional ingredients, normal mixing and curing practices. To produce high performance concrete it is generally essential to use chemical and mineral admixtures in addition to the same ingredients, which are generally used for normal concrete. Addition of silica fumes to be helps to improve strength and durability of concrete mix.

2. Experimental Investigation:

Materials Used:

Cement- 53 grade ordinary Portland cement with specific weight 3.15 g/cm^3

Fine aggregate- Clean and dry river sand available locally was used. Sand passing through IS 4.75 mm sieve was used for casting all the specimens. Fine aggregate used are confirming to IS 383-1970.

Coarse aggregate- Locally available crushed blue granite stones conforming to graded aggregate of nominal size 20 mm as per IS: 383 – 1970.

Super Plasticizer- A commercially available sulphonated Napthalene formaldehyde based super plasticizer (CONPLAST SP430) was used as chemical admixture to enhance the workability of the concrete. Obtained from Civil Doctor Chemical Company, Cross Cut Road, Coimbatore.

Polyethylene glycol- A polyethylene glycol (PEG 400**)** is used as the self curing agent. It is purchased from Mahindra Traders, no 52, char street, Bangalore.

Steel fibre- Steel fibres of aspect ratio 50 mm with specific gravity 7.48 g/cm^3 is obtained from Mahindra Traders, no 52, char street, Bangalore.

Water Castings of specimens were done with the potable water

Methodology: Materials required are procured as per the Codal provision and tested for physical properties of the materials. Mix proportioning is prepared for m60 grade concrete. The Cubes of 150x150x150 mm^3, Cylinders of 150m diameter x 300mm height and Prisms of 100x100x500 mm^3 are prepared and casted for the testing of specimens. As self curing agents are adapted at the range of 0%, 0.5%,1% and 1.5 %weight of cement .So that the water curing of specimens are neglected and the specimens are left in the ambient temperature for the periods of 3,7 and 28 days for which the required moisture for curing will be absorbed from the atmosphere. The specimens for Compressive strength, Split tensile strength and Flexural strength are tested. Modulus of elasticity evaluated for the cylinder specimens of 28 days alone.

Mix Proportion: The control mix was proportioned to obtain compressive strength of 60 MPa. The identification, mix proportion and quantity of material taken for one meter cube of self curing concrete mixes are given in Table 3.7.The mixes 1, 2, 3, 4, 5, 6, and7 were obtained by adding PEG 400 content 0%, 0.5%, 1%, and 1.5% of weight of cement with and without adding steel fibres at 3%. Super plasticizer CONPLAST SP430 is added 1.8% to the weight of binder and replacement of binder with 6% of silica fume.

Table 1: Mix Proportion per m^3

S.No	PEG400- % of Cement	Cement (kg)	PEG400 (kg)	Fibre (kg)	Silica fume (kg)	Fine aggregate (kg)	Coarse aggregate (kg)
1	0	540	0	0	35	739.47	1036.19
2	0.5	540	2.7	0	35	739.47	1036.19
3	0.5	540	2.7	16.2	35	739.47	1036.19
4	1	540	5.4	0	35	739.47	1036.19
5	1	540	5.4	16.2	35	739.47	1036.19
6	1.5	540	8.1	0	35	739.47	1036.19
7	1.5	540	8.1	16.2	35	739.47	1036.19

3. Results & Discussion:

The cube, cylinder and prism specimens were tested for compressive, split tensile strength, flexural strength and modulus of elasticity.

Compressive Strength:

Table 2: Compressive Strength result in MPa

	3 days Strength		7 days Strength		28 days Strength	
Control mix	**27.56**		**38.54**		**59.31**	
PEG400 in % of cement	**Without fibre**	**With fibre**	**Without fibre**	**With fibre**	**Without fibre**	**With fibre**
0.5	19.81	21.75	40.84	42.68	56.14	59.22
1	21.25	22.24	42.24	45.21	60.36	63.27
1.5	20.01	22.08	39.48	43.55	55.28	57.13

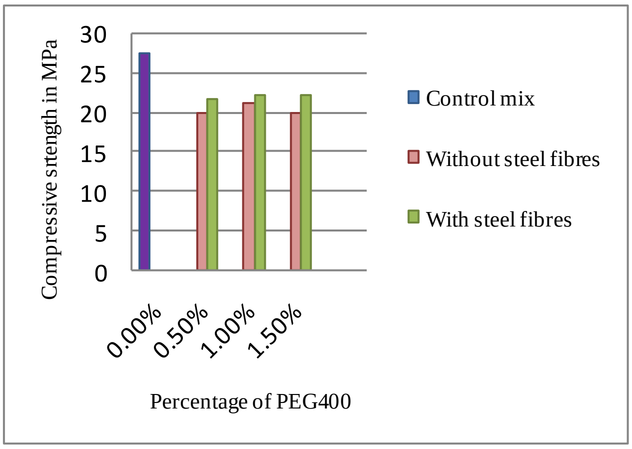

Figure 1: Compressive strength-3 days

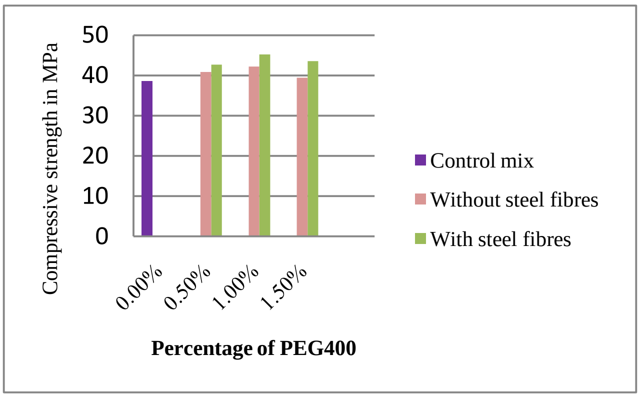

Figure 2: Compressive strength-7 days

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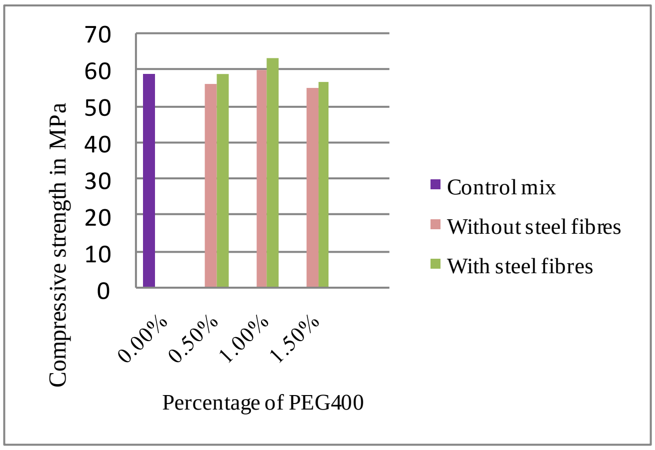

Figure 3: Compressive strength-28 days

Split Tensile Strength:

Table 3: Split Tensile Strength in MPa

	3 days Strength		7 days Strength		28 days Strength	
Control mix	**3.27**		**3.87**		**4.8**	
PEG 400 in % of cement	**Without fibre**	**With fibre**	**Without fibre**	**With fibre**	**Without fibre**	**With fibre**
0.5	2.74	3.01	3.98	4.21	4.67	4.75
1	2.82	3.08	4.14	4.33	4.83	4.95
1.5	2.79	2.97	3.38	4.11	4.63	4.71

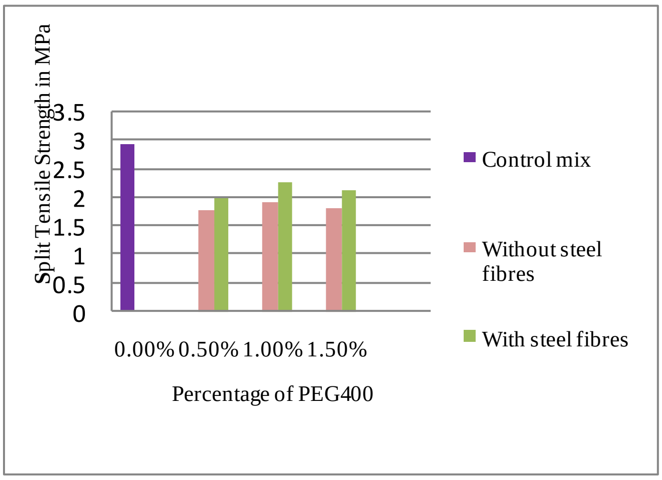

Figure 4: Split tensile strength-3 days

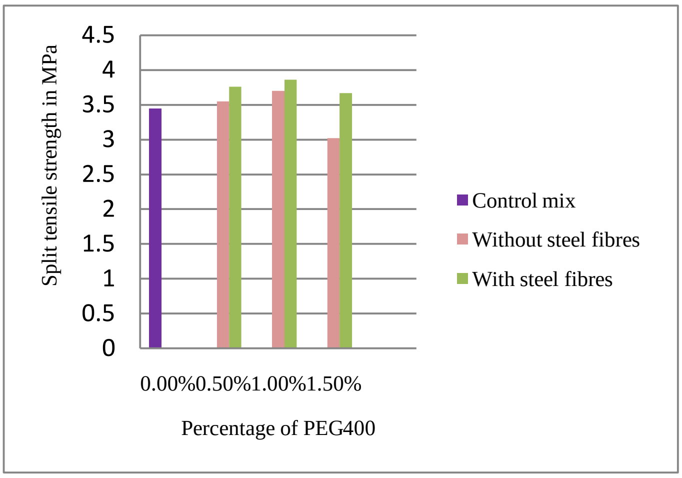

Figure 5: Split tensile strength-7 days

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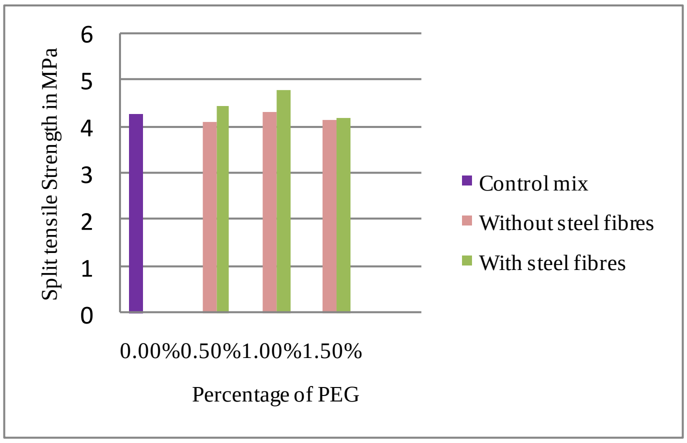

Figure 6: Split tensile strength-28 day

Flexural Strength:

Table 4: Flexural Strength in MPa

	3 days Strength		7 days Strength		28 days Strength	
Control mix	**3.27**		**3.87**		**4.8**	
PEG400 in % of cement	***Without fibre***	***With fibre***	***Without fibre***	***With fibre***	***Without fibre***	***With fibre***
0.5	2.74	3.01	3.98	4.21	4.67	4.75
1	2.82	3.08	4.14	4.33	4.83	4.95
1.5	2.79	2.97	3.38	4.11	4.63	4.71

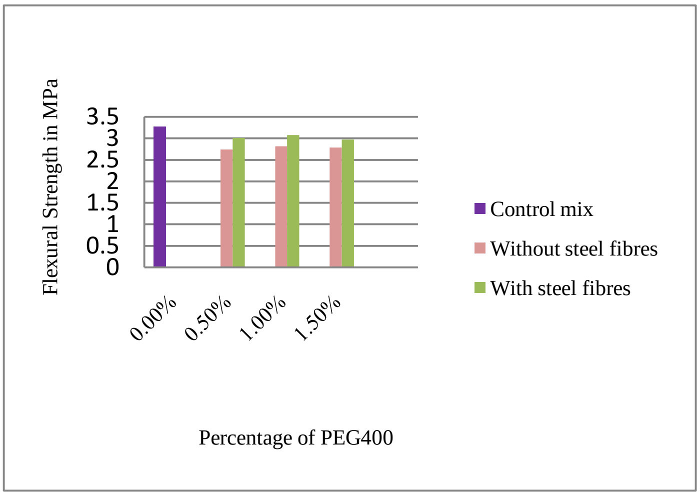

Figure 7: Flexural strength-3 days

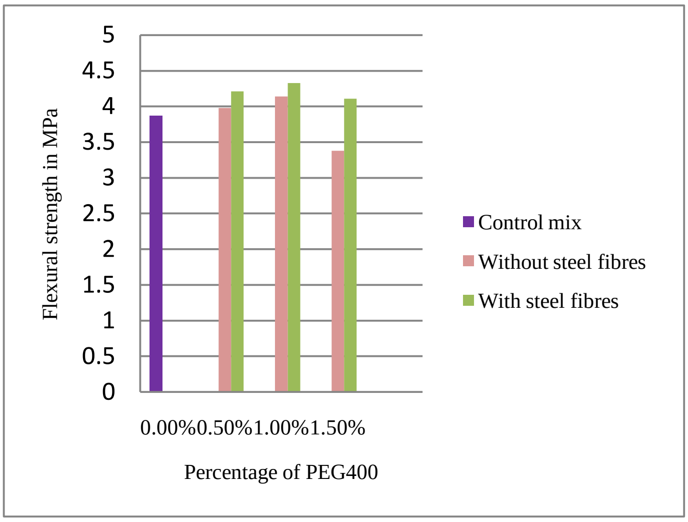

Figure 8: Flexural Strength-7 Days

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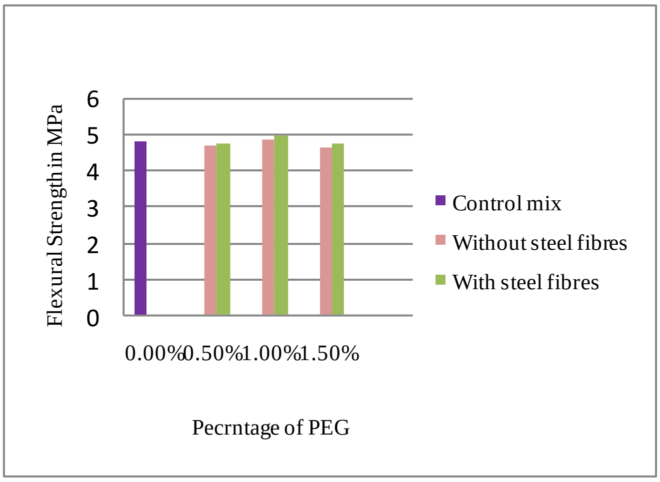

Figure 9: Flexural Strength-28 Days

Modulus of Elasticity:

Table 5: Modulus of Elasticity

	Modulus of elasticity- 28 days curing	
Control mix	**36427**	
PEG 400 in percentage of cement	**Without steel fibres**	**With steel fibres**
0.5%	35440	36091
1%	36681	37609
1.5%	35155	35748

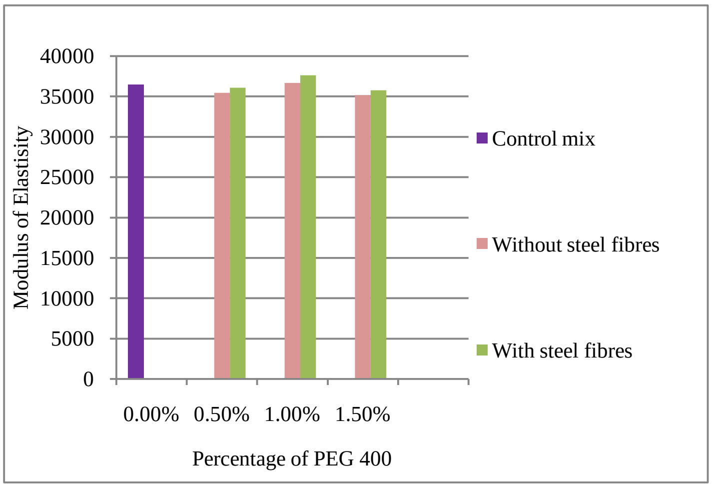

Figure 10: Modulus of Elasticity- 28 Days

4. Conclusion:

- ✓ The compressive strength has improved with addition of PEG400 at 1.0% of cement. The concrete specimen with 0.5% and 1.5% of PEG400 has lower in compressive strength than 1% of PEG400 and conventional concrete mix.
- ✓ Optimum value for split tensile strength is shown by 1% of PEG400 with the steel fibres. Also this result indicates that in1.5% of PEG400, the split tensile strength get decreases with conventional mix.
- ✓ Good flexural strength is obtained from the 1% of PEG400 mix with the steel fibres. The flexural strength of 1.5% PEG400 is 2% lower than conventional mix.
- ✓ Modulus of elasticity is maximum at 1% of PEG with 3% of steel fibres on cement and there is not much reduction in modulus values for other mixes.
- ✓ Maximum compressive stress, Split tensile, Flexural strength and modulus of elasticity develops in M-60 grade concrete at 3 days, 7 days and 28 days of self-curing is obtained by addition of 1.00% of PEG400 with 3% of steel fibres of cement.
- ✓ Addition of steel fibres improves the mechanical properties of concrete in the all mixes.
- ✓ Addition of self-curing agent (PEG400) does not make any marginal reduction in the Mechanical strength properties.
- ✓ PEG400 at 0.5% and 1.5% of cement gives up to 90% efficiency in the mechanical properties as compared with conventional concrete.

5. Scope of Future Work

- ✓ To determine the Performance of Durability Properties in high performance self-curing steel fibre reinforced concrete along with silica fume.
- ✓ High performance self-curing steel fibre reinforced concrete has been adopted to cast and test on shear behaviour of concrete columns.
- ✓ To study the load-deflection characteristics of high performance self-curing steel fibre reinforced concrete columns.
- ✓ To study the ductility performance of high performance self-curing steel fibre reinforced concrete columns.
- ✓ To determine the ultimate bearing capacity of high performance self-curing steel fibre reinforced concrete columns.

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