ACHIEVING THE MECHANICAL PROPERTIES IN CONVENTIONAL CONCRETE BY USING SUPER PLASTICIZER AND POLYPROPYLENE GLYCOL 4000

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Abstract - The objective of this study is to compare the mechanical behavior of self-compacting and self curing concrete with the conventional concrete. This research is proposed to adding chemical admixtures and pozzolanic material for making self-compacting concrete (SCC). Also, it is proposed to use self-curing compound instead of conventional or ambient 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 by using fly ash and super plasticizer (SNF). Curing techniques and curing duration significantly affect "curing efficiency." Techniques used. 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 the beam for the age of curing 7days, 14days & 28 days has been studied. The specimen with 1% PEG4000 performed well when compared to the conventional specimen.

***Key Words*:** Self compacting concrete, self-curing concrete, super plasticizer.

1. 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 bleed (EFNARC, European Federation of Producers and Applicators of Specialist Products for Structures, 2002). . In this study compressive strength and spilt tensile strength self curing concrete with varying percentages (0.5%, 1%, 1.5%, 2%, 2.5%, 3%) for 7, 14, 28 days are analyzed. SCC has substantial commercial benefits because SCC is defined as concrete that can flow and consolidate under its own weight. SCC is considering to be one of the most successful innovations in the industry of construction Self-compacting concrete (SCC) is a highly flow able concrete which does not segregate and can spread into place; fill the formwork with heavily congested reinforcement without any mechanical vibration. In SCC, the aggregates contribute 60–70% of the total volume Aggregate characteristics such as shape, texture and grading influence workability, finish ability, bleeding, pumping ability, segregation of fresh concrete and strength, stiffness, shrinkage, creep, density, permeability, and durability of hardened concrete.

2. OBJECTIVE OF STUDY

The main objective of this investigation is to determine the suitable percentage of sand, coarse aggregate, cement and influence of different proportioning of super plasticizers in SC that gives the highest value of concrete compressive strength. Inter curing agent provide internal water reservoir, increase relative humidity by making a thin film with the water that reduces the self desiccation at strength.

Concrete is a very strong and versatile construction material. It consists of cement, sand and aggregate (e.g., gravel or crushed rock) mixed with water. Since the time that concrete has been acknowledged as an asset for development of building, researchers have been attempting to help its strength and enhance its performance. One such thought has prompted the change of Self Compacting Self Curing Concrete (SCCSC). It is reflected as "the most innovative development in concrete construction".

3. SELF COMPACTING CONCRETE

Self-compacting concrete (SCC) represents one of the most outstanding advancement in concrete technology during the last decade. SCC is another sort of concrete with huge deformability and segregation resistance. SCC was first developed in 1988 by professor Okamura intended to improve the durability properties of concrete structures. SCC is a flowing concrete mixture which is able to consolidate under its own weight. The method for achieving self-compatibility involves not only high deformability of paste or mortar, but also resistance to segregation between coarse aggregate and mortar when the concrete flows through the confined zone of reinforcing bars. Okamura and Ozawa have employed the methods to achieve self-compatibility such as limited aggregate content, low water-powder ratio and use of super plasticizer.

4. Mechanism of Self Curing

It is important to know the mechanism behind the process of internal curing. In normal concrete what usually happens is the continuous evaporation of moisture from an exposed surface due to the difference in chemical potentials (free energy) between the vapour and liquid phases. glycol (PEG) is a condensation polymer of ethylene oxide and water with the general formula H-(OCH2CH2)n-OH, where n is the average number of repeating oxy-ethylene groups typically from 4 to about 180. Polyethylene glycol is nontoxic, odorless, neutral, lubricating, non-volatile and nonirritating and it is used in a variety of pharmaceuticals [5]. The importance of incorporating self curing technique in concrete includes the following:

- Eliminates autogenously shrinkage,
- Reduces permeability
- Protects reinforcing steel
- Increases mortar strength
- Provides greater durability
- Greater utilization of cement
- Lower maintenance
- Higher modulus of elasticity
- Reduces the effect of insufficient external curing

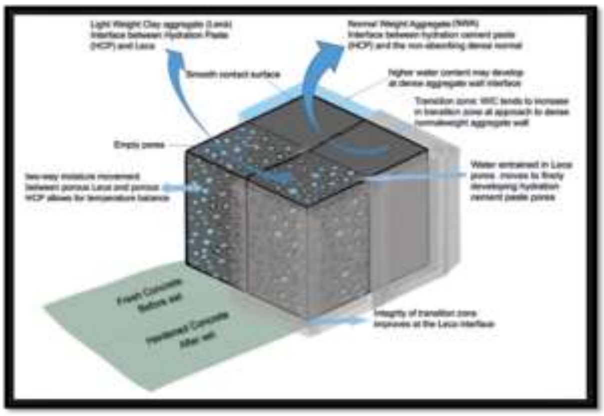


Fig: 1 Self curing of SCC

5. Ingredients of SCC

5.1. Cement: Ordinary Portland Cement (53 grade) Dalmia cement conforming to IS 8112 was used. The different laboratory tests were conducted on cement to determine standard consistency, initial and final setting time, and compressive strength as per IS 4031 and IS 269-1967. The results are tabulated in Table-1.

SL. No	Tests Conducted	Results
1	Standard Consistency	32%
2	Initial Setting Time	150min
3	Final Setting Time	330min
4	7 days compressive strength	27.67 N/mm2
5	28 days compressive strength	54.60 N/mm^2

Table 1: Results of Cement

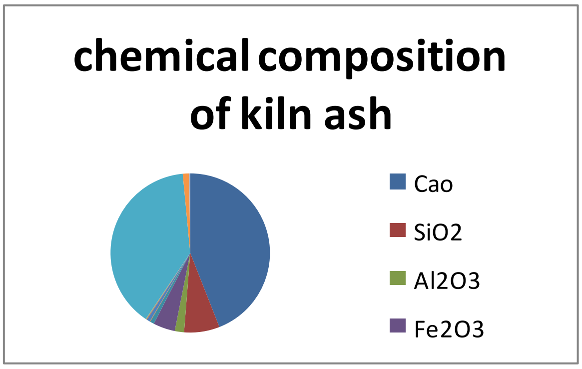
5.2.Fine aggregates: Fine aggregates used were obtained from a nearby source. The fine aggregate confirming to zone 3 was used. Natural sands, crushed and rounded sands, and manufactured sands are suitable for SCC. River sand of specific gravity 2.58 and conforming to zone II of IS 363 was used for the present study. The particle size distribution is given in Table-2.

5.3. Chemical admixtures:

Super plasticizers or high range water reducing admixtures are an essential component of SCC. Conplast SP 430 was used as super plasticizer and Structure 485 was used as viscosity modifying agent and Concur was used as self curing admixtures.

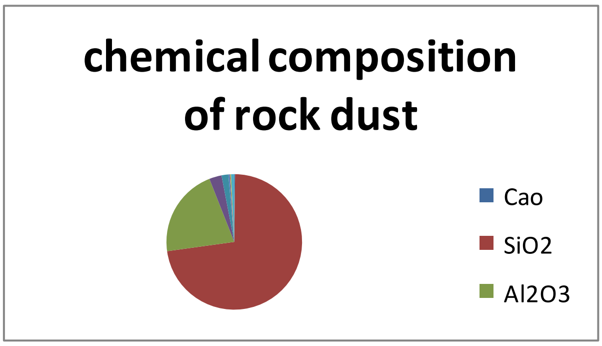
5.4. Kiln Ash:

A high quality kiln ash generally permits a reduction in water content of a concrete mixture, without loss of workability. Kiln ash obtained from Dr Narla Tata Rao Thermal Power Plant, Vijayawada was used for the study. The chemical composition of kiln ash is given in below



Graph 1:Chemical Composition of Kiln Ash

5.5. Rock dust: The granite fines obtained as by-product in the production of concrete aggregates are referred as quarry or rock dust. Rock dust of specific gravity 2.37 passing through 150-micrometer sieve was used in this study. The chemical composition of rock dust is given in below



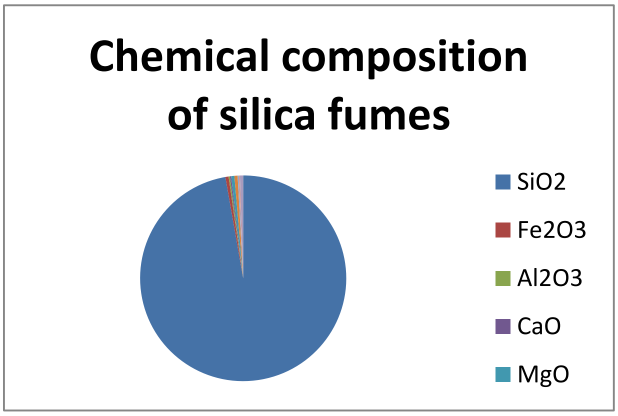
Graph 2: Chemical Composition of Rock Dust

5.6. Silica fumes:

Silica fume imparts very good improvement to rheological, mechanical and chemical properties. It improves the durability of the concrete by reinforcing the microstructure through filler effect and thus reduces segregation and bleeding. It also shows KAs in achieving high early strength. Silica fume of specific gravity 2.34 was used in this study. The chemical composition of Silica fumes.

SL.NO	CONSTITUENTS	QUANTITY %
1	SiO_2	97
2	**Fe_2O_3**	**0.5**
3	**Al_2O_3**	**1.2**
4	**CaO**	**0.2**
5	**MgO**	**0.5**
6	**K_2O**	**0.5**
7	**N_2O**	**0.2**
8	**SO_3**	**0.15**
9	**C_1**	**0.12**
10	**H_2O**	**0.5**

Table 2: Chemical Composition Of Silica Fume



Graph 3: **Composition of Silica Fume**

6. Experimental investigation:

Tests on fresh concrete were performed to study the workability of SCC with various proportions of rock dust and silica fume. The tests conducted are listed below:
Slump flow test
V- Funnel flow test
Orimet test
U-tube test
J- Ring test
L-box test

7. Mix proportion of SCC

There is no standard method for SCC mix design and many academic institutions, admixture, ready-mixed, pre cast and contracting companies have developed their own mix proportioning After several trials, SCC mix satisfying the test criteria was obtained. The details of the design mix
Coarse aggregate
Water
Polyethylene glycol
Super plasticizer

8. STUDY OF MATERIALS

The materials that used in the study are
Cement
Fine aggregates
Course aggregates
Sodium Naphthalene Formaldehyde (SNF) powder
Polyethylene glycol 4000 (PEG 4000)
Fly ash
Water

8.1. CEMENT

In the experimental investigation Ordinary Portland cement (53 grades) of 28th day compressive strength N/mm2 was used. The cement procured was tested for physical properties in accordance with IS: 4031-1988.

8.1.1.Test results of Cement:

Sl .no	tests	Results
1	Consistency	30%
2	Fineness	2%
3	Initial setting time	100min
4	Final setting time	2h 20min
5	Specific gravity	3.15

Table 3: Test results on cement

8.2. Fine Aggregate:

Fine aggregate (river sand) obtained from local market was used in this study. The physical properties of fine aggregate such as specific gravity, fineness modulus, porosity, void ratio etc., are determined in accordance with IS: 2368-1963.

8.2.1. Test Results of Sand:

Sl.no	tests	Results
1	Sieve analysis of sand	ZONE-III
2	Moisture content	2%
3	Bulk age of sand	8.667
4	Silt content time	2.73%
5	Specific gravity	2.66

Table 4: Test results on sand

8.3. COARSE AGGREGATE:

The properties of coarse aggregate like size of aggregate, shape, grading, surface texture etc. play an important role in workability and strength of concrete.

8.3.1. Test results of Coarse Aggregate:

Sl .no	tests	results
1	Specific gravity of coarse aggregates 20mm	2.88
2	Specific gravity of coarse aggregates 12.5mm	2.80
3	Water absorption of 20mm coarse aggregates	0.5%
4	Water absorption of 12.5mm coarse aggregates	0.48%

Table 5: test results on coarse aggregates

8.4. Sodium Naphthalene Formaldehyde (SNF) powder:

SNF has high purity which makes it cement particles with high dispersancy, low foaming, high rang water reducing and obvious strengthening so that we can accelerate project mould turnover and construction speed. SNF is a high rangconcrete admixture of concrete cast-in-place, prefabricating, pump and curing. Its specific gravity was 1.210.

Fig 2 : Sodium Naphthalene Formaldehyde (SNF) powder

S.No.	Item	Specifications
1	Appearance	Yellow beige powder
2	Fluidness (mm)	250 min
3	Water exudation rate	90% max
4	Gas content	3.0% max
5	Solid content	93% min
6	Cl	0.3% max
7	PH value	7-9
8	Sodium sulphate	5% max

Table 6: Characteristics of SNF powder

8.5.Polyethylene glycol 4000 (PEG 4000):

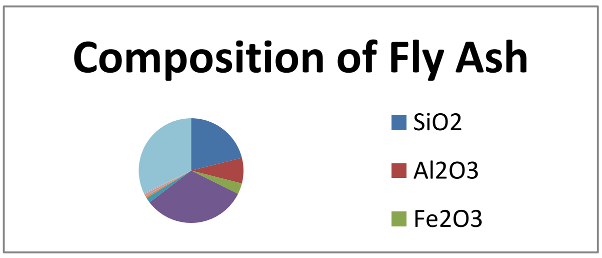
The condensed polymer of ethylene oxide and water is polyethylene glycol. PEG 600 is used in this study where 600 is the molecular weight. It has general formula H (OCH2CH2) nOH. They soluble in water. It is nontoxic, odorless, non-volatile and non-irritating. It has wide variety of uses in medicine

S.No	Properties	Specifications
1	Physical form	Waxy solid
2	Average number of repeating oxyethylene units	90
3	Range of average molecular weight	3600-4400
4	Range of average Hydroxyl number	25-32
5	Density	1.093
6	Melting or freezing range	53-59
7	Solubility in water at 20^{0}C	66%
8	Viscosity at 100^0 C,cSt	140.4
9	Heat of fusion, Cal/g	45

Table 7: Characteristics of Polyethylene glycol

FLY ASH:

The burning of harder, older anthracite and bituminous coal typically produces Class F fly ash. This fly ash is pozzolanic in nature and contains less than 20% lime (CaO). Possessing pozzolanic properties, the glassy silica and alumina of Class F fly ash require a cementing agent, such as Portland cement, quicklime, or hydrated lime, with the presence of water to react and produce cementitious compounds.



Graph 4: Composition Of Fly Ash

9. Mix Design

9.1. Details of materials:

a) Grade of concrete – M40
b) Type of cement – OPC 53 grade
c) Maximum nominal size of coarse aggregate – 20mm
d) Exposure condition – Severe
e) Degree of Supervision – good
f) Type of aggregate – Angular aggregate
Assuming state of surface to be SSD (Surface Saturated Dry state)
Specific gravity of OPC- 3.15
Specific gravity of Natural Sand – 2.67
Chemical admixture-super plasticizer
Specific gravity of coarse aggregate - 2.88
Water absorption of sand-2%.
Water absorption of coarse aggregate-0.5%.
Free moisture content of sand-2%.
Free moisture content of coarse aggregate-nil

S.NO	INGREDIENT	QUANTITY
1	Cement	492.5 kg/m^3
2	Fine aggregates	579.99 kg/m^3
3	Course aggregates	1214.4 kg/m^3
4	Water	197 liters

Table 8: Mix proportions

10. TESTS ON CONCRETE

10.1. Workability of concrete:

Fig 3: Slump cone Apparatus

S.no	W/C ratio	% of self curing concrete	Slump (mm)
1	0.40	0	100
2	0.40	1	130
3	0.40	1.5	146
4	0.40	2	153
5	0.40	2.5	175
6	0.40	3	220

Table 9: Slump Values of SNF Powder and PEG 4000

10.2. Compaction factor test:

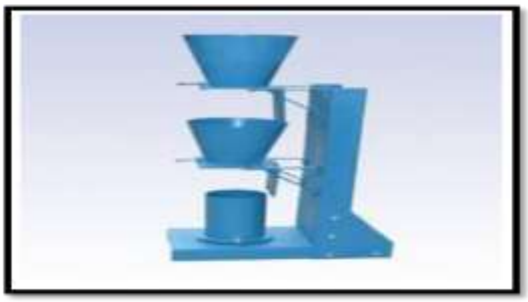


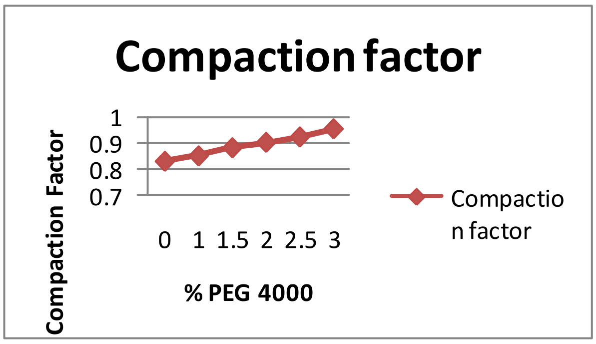
Fig 4: Compaction Factor Apparatus

Compacting factor = (Weight of partially compacted concrete) / (Weight of fully compacted concrete)

10.2.1.TEST RESULTS:

% of PEG 4000	Weight of partially compacted concrete (w_1)	Weight of fully compacted concrete (w_2)	Compacting factor=w_1/w_2
0	16.932	20.4	0.83
1	16.793	19.605	0.85
1.5	16.853	19.001	0.88
2	16.890	18.60	0.90
2.5	16.990	18.450	0.92
3	16.891	17.780	0.95

Table 10: Compaction Factor test results



Graph 5: Compaction factor for various percentages of quarry dust

11.TESTS ON HARDENED CONCRETE

Concrete is a mixture of cement, water, fine aggregate and coarse aggregate. Normally concrete is strong in compression and weak in tension. In the design of concrete structures, engineers usually refer to the hardened state properties like compressive strength, flexural strength and split tensile strength of concrete.

11.1. Compression test:

Fig 5: Compression test

11.1.1. CONCRETE WITH 0% of PEG 4000 as admixture [Cubes]:

Size of cube = 0.15m x 0.15m x 0.15m

Trial no	Load (KN)		
	7 days	14 days	21 days
1	311.0	420	510
2	303.25	408.5	493.75
3	297	400	515
Average	303.75	409.5	506.25

Table 11: Compressive Strength of 0% PEG 4000 as admixture

Time of curing	Average load (N)	Area (mm^2)	Compressive Strength (N/mm^2)
7 Days	303.75	22.5	13.5
14 Days	409.5	22.5	18.2
28 Days	506.25	22.5	22.5

11.1.2.CONCRETE WITH 1% of PEG 4000 as admixture [Cubes]:

Size of cube = 0.15m x 0.15m x 0.15m

Trial No	Load (KN)		
	7 days	14 days	21 days
1	324	410	540
2	330.7	400.85	530
3	320	419	550
Average	324.9	409.95	540

Table 12: Compressive Strength of 1% PEG 4000 as admixture

Time of curing	Average load (N)	Area (mm^2)	Compressive Strength (N/mm^2)
7 Days	324.9	22.5	14.44
14 Days	409.95	22.5	18.22
28 Days	540	22.5	24

11.1.3. CONCRETE WITH 1.5% of PEG 4000 as admixture [Cubes]:

Size of cube = 0.15m x 0.15m x 0.15m

Trial no	Load (KN)		
	7 days	14 days	21 days
1	165	220	280
2	154.25	225	277
3	160	230	286.75
Average	159.75	225	281.25

Table 13: Compressive Strength of 1.5% PEG 4000 as admixture

Time of curing	Average load	Area (mm^2)	Compressive Strength (N/mm^2)
7 Days	159.75	22.5	7.1
14 Days	225	22.5	10
28 Days	281.25	22.5	12.5

11.1.4. CONCRETE WITH 2% of PEG 4000 as admixture [Cubes]:

Size of cube = 0.15m x 0.15m x 0.15m

Trial no	Load (KN)		
	7 days	14 days	21 days
1	116	207	265.05
2	97	214.51	266.7
3	111	215	258
Average	108	212.17	263.25

Table 14: Compressive Strength of 2 % PEG 4000 as admixture

Time of curing	Average load	Area (mm^2)	Compressive Strength (N/mm^2)
7 Days	108	22.5	4.8
14 Days	212.17	22.5	9.43
28 Days	263.25	22.5	11.7

11.1.5. CONCRETE WITH 2.5% of PEG 4000 as admixture [Cubes]:

Size of cube = 0.15m x 0.15m x 0.15m

Trial no	Load (KN)		
	7 days	14 days	21 days
1	90	194	225
2	93	200	220
3	100.5	193.25	230
Average	94.5	195.75	225

Table 15: Compressive Strength of 2.5% PEG 4000 as admixture

Time of curing	Average load	Area (mm^2)	Compressive Strength (N/mm^2)
7 Days	94.5	22.5	4.2
14 Days	195.75	22.5	87
28 Days	225	22.5	10

11.1.6.CONCRETE WITH 3% of PEG 4000 as admixture [Cubes]:

Size of cube = 0.15m x 0.15m x 0.15m

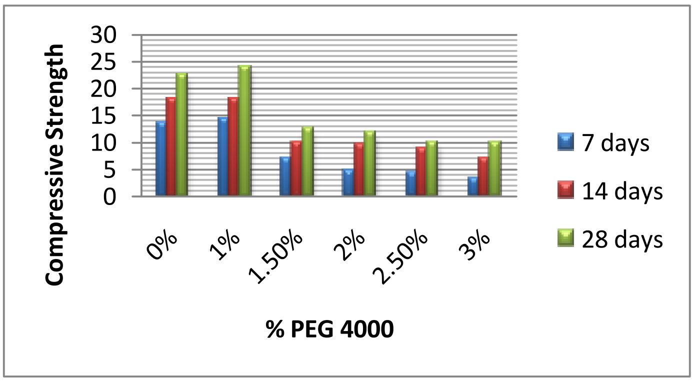
Trial no	Load (KN)		
	7 days	14 days	21 days
1	75	165.25	218.25
2	77.75	150	215.25
3	70	157.25	228
Average	74.25	157.5	220.5

Table 16: Compressive Strength of 3% PEG 4000 as admixture

Time of curing	Average load	Area (mm^2)	Compressive Strength (N/mm^2)
7 Days	74.25	22.5	3.3
14 Days	157.5	22.5	7
28 Days	220.5	22.5	9.8

The compressive strength results of PEG 4000 concrete (cubes) obtained at age of 28 days is

1. For 0% PEG 4000Concrete = 22.5 N/mm^2.
2. For 1% PEG 4000Concrete = 24 N/mm^2.
3. For 1.5% PEG 4000Concrete = 12.5 N/mm^2.
4. For 2% PEG 4000Concrete = 11.7N/mm^2.
5. For 2.5% PEG 4000Concrete = 10.0 N/mm^2.
6. For 3% PEG 4000Concrete = 9.8 N/mm^2.



Graph 6: Compressive strength of concrete

12.SPLIT-TENSILE STRENGTH:

This test is done to determine the Split-Tensile strength of concrete specimens as per IS: 516- 1959. The splitting test is carried out on a standard cylinder specimen by applying a line load along the vertical diameter.

12.1.CONCRETE WITH 0% of PEG 4000 as admixture [Cylinders]:

Size of cylinder = 0.15m dia x 0.30m high

Trial no	Load (KN)		
	7 days	14 days	21 days
1	105.4	115	134
2	111.2	106.25	140.18
3	106.2	116.25	140
Average	107.6	112.5	138.06

Table 17: Split Tensile Strength of 0% PEG 4000 as admixture

Time of curing	Average load (N)	Area (mm^2)	Split Tensile Strength (N/mm^2)
7 Days	107.6	70.8	1.52
14 Days	112.5	70.8	1.59
28 Days	138.03	70.8	1.95

12.2.CONCRETE WITH 1% of PEG 4000 as admixture [Cylinders]:

Size of cylinders = 0.15m dia x 0.30m high

Trial No	Load (KN)		
	7 days	14 days	21 days
1	114	120	140
2	115	124.2	142
3	114.8	123	142.8
Average	114.6	122.4	141.6

Table 18: Split Tensile Strength of 1% PEG 4000 as admixture

Time of curing	Average load (N)	Area (mm^2)	Split Tensile Strength (N/mm^2)
7 Days	114.6	70.8	1.62
14 Days	122.4	70.8	1.73
28 Days	141.6	70.8	2.00

12.3.CONCRETE WITH 1.5% of PEG 4000 as admixture [Cylinders]:

Size of cylinder = 0.15m dia x 0.30m high

Trial no	Load (KN)		
	7 days	14 days	21 days
1	96	100	123
2	94.61	101.33	124.57
3	94	102.39	122
Average	94.87	101.24	123.19

Table 19: Split Tensile Strength of 1.5% PEG 4000 as admixture

Time of curing	Average load	Area (mm^2)	Split Tensile Strength (N/mm^2)
7 Days	94.87	70.8	1.34
14 Days	101.24	70.8	1.43
28 Days	123.19	70.8	1.74

12.4.CONCRETE WITH 2% of PEG 4000 as admixture [Cylinders]:

Size of cylinder = 0.15m dia x 0.30m high

Trial no	Load (KN)		
	7 days	14 days	21 days
1	94	97.99	121.41

2	92.12	99.37	119.45
3	90	100	120.22
Average	92.04	99.12	120.36

Table 20: Split Tensile Strength of 2 % PEG 4000 as admixture

Time of curing	Average load	Area (mm^2)	Split Tensile Strength (N/mm^2)
7 Days	92.04	70.8	1.30
14 Days	99.12	70.8	1.40
28 Days	120.36	70.8	1.70

12.5.CONCRETE WITH 2.5% of PEG 4000 as admixture [Cylinders]:

Size of cylinder = 0.15m dia x 0.30m high

Trial no	Load (KN)		
	7 days	14 days	21 days
1	90.55	97.853	117.83
2	88.11	98.979	116.86
3	91.08	96.28	120
Average	89.916	97.704	118.23

Table 21: Split Tensile Strength of 2.5% PEG 4000 as admixture

Time of curing	Average load	Area (mm^2)	Split Tensile Strength (N/mm^2)
7 Days	89.916	70.8	1.27
14 Days	97.704	70.8	1.38
28 Days	118.23	70.8	1.67

12.6.CONCRETE WITH 3% of PEG 4000 as admixture [Cylinders]:

Size of cylinder = 0.15m dia x 0.30m high

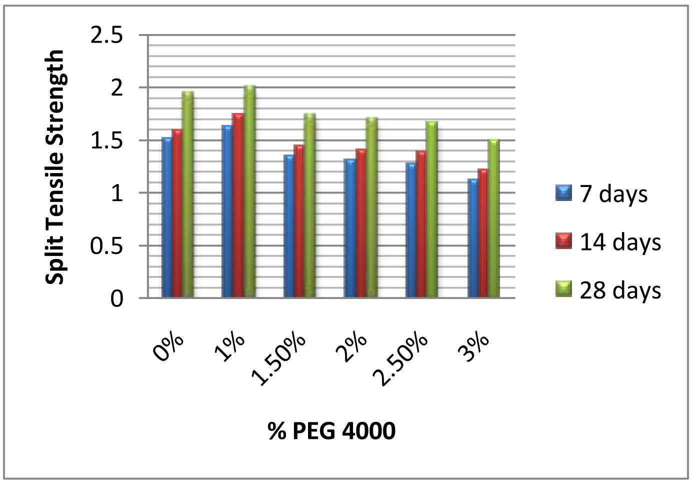
Trial no	Load (KN)		
	7 days	14 days	21 days
1	78.938	85	106.4
2	80	84.88	107.2
3	78.95	85	105
Average	79.296	84.96	106.2

Table 22: Split Tensile Strength of 3% PEG 4000 as admixture

Time of curing	Average load	Area (mm^2)	Split Tensile Strength (N/mm^2)
7 Days	79.296	70.8	1.12
14 Days	84.96	70.8	1.20
28 Days	106.2	70.8	1.50

The split tensile strength results of PEG 4000 concrete (cylinders) obtained at age of 28 days is

1. For 0% PEG 4000Concrete = 1.95 N/mm^2.
2. For 1% PEG 4000Concrete = 2.00 N/mm^2.
3. For 1.5% PEG 4000Concrete = 1.74 N/mm^2.
4. For 2% PEG 4000Concrete = 1.70 N/mm^2.
5. For 2.5% PEG 4000Concrete = 1.67 N/mm^2.
6. For 3% PEG 4000Concrete = 1.50N/mm^2.



Graph 7: Split Tensile Strength of concrete

13. CONCLUSIONs

The following conclusions were drawn from this study.

- The strength of the specimen with 1% of PEG4000 increased when compared to the conventional specimen with M40.
- From the 7 days, compressive strength results in the specimen with 1% of PEG4000 increased with a conventional specimen with M40 by 0.06963%.

From the 14 days, compressive strength results in the specimen with 1% of PEG4000 increased with a conventional specimen with M40 by 0.01099%.

From the 28 days, compressive strength results in the specimen with 1% of PEG4000 increased with a conventional specimen with M40 by 7.00%.

- From the 7 days splitting tensile strength results, the specimen with 1 % of PEG4000 increased with conventional specimen with M40 by 0.06578%.

From the 14 days splitting tensile strength results, the specimen with 1 % of PEG4000 increased with conventional specimen with M40 by 0.08805%.

- From the 28 days splitting tensile strength results, the specimen with 1% of PEG4000 increased with a conventional specimen with by 0.02564%.
- From 7 days flexural tensile strength results the specimen with 1% of PEG4000 decreased with a conventional specimen with M40 by 37.57%.

From 14 days flexural tensile strength results the specimen with 1% of PEG4000 decreased with a conventional specimen with M40 by 40.26%.

• From 28 days flexural tensile strength results the specimen with 1% of PEG4000 decreased with a conventional specimen with M40 by 45.65%

14. REFERENCES

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