An Experimental investigation on durabilities of self curing concrete with silica fume using different chemical agents

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Abstract — *From early times upto present day construction field is facing lot of problems, one of them is based on water. Atleast one third of water is required for construction. Growing water scarcity is now one of the leading challenges for sustainable development. An estimate by a global consultancy states that one lakh square feet of construction consumes over nine thousand million litre of water. Curing plays a vital role in the development of concrete durability. To avoid this water scarcity problem, Self curing was initiated. Many researchers have tested in mechanical properties of self curing of concrete but we predominantly look for durability of self curing concrete with silica fumes incorporating with different chemical agents like Poly Ethylene Glycol 6000 (PEG 6000) and Sodium Polyacrylate to avoid shrinkage effect. The grade of cement used was M30. The self curing agent of Poly Ethylene Glycol 6000 and Sodium Polyacrylate for dosages ranging from 0.20%, 0.30% & 0.40% related to the weight of cement. Partial replacement of cement with silica fumes with 5% and 10% to increase the properties of concrete. The ideal mix ratio was taken for casting of reinforced concrete beam and to analysis the strength and durability properties were captured with self curing concrete and conventional concrete.*

Keywords: Concrete, Self Curing, Silica fume, Sodium Polyacrylate, Poly Ethylene Glycol 6000, Mechanical properties and Durability.

I. INTRODUCTION

Concrete is a composite material made up of fine and course aggregate bonded together with a cement paste. It is one of the most widely used durable materials. Structures which are made of concrete materials have a long life service. To achieve desire strength and durability properties of concrete minimum seven days of curing is required for conventional concrete. Self curing is also called as internal curing, it is a modern technique which ease itself by preserving water in it. The ACI: 308 code states that “Internal curing refers to the process by which the hydration of cement occurs because of the availability of additional internal water that is not part of the mixing water” [1].

2. Literature Review

Rayees Ali khana[2], usage of water quantity is minimized than the conventional curing method. The conventional specimen and self cured specimen with ideal percentage of 0.3% of calcium lignosulfonate reasoned as an ideal percentage for desired mechanical properties. The durability test under saline environment is resulted in loss of strength. **R. Gobi [3],** this paper focus on flexural behavior of self

compacting self curing concrete (SCSCC) using light weight expanded clay aggregate(LECA) and fly ash aggregate (FAA) self curing by inclusion of light weight fine aggregate under saturated surface dry (SSD) to enhance the strength and durability of concrete and to maintain its saturated condition. The aggregate is replaced in 0% to 20% at 5% interval in volume of LECA and FAA for mix concrete. **Prakash Mandiwal [4],** in this paper they focuson durability, compressive and tensile strength properties. The idea used in this research work is PEG-400 with the replacement of cement in different percentages of 1.6 & 2.4 for M20 & M25 concrete the maximum tensile strength achieved in PEG-400 is 1.6 and 2.4 respectively. For durability test against acid attack, PEG-400 agent is not used in conventional concrete. The loss in compressive strength for M20 & M25 is 11.35 and 12.24 respectively. **D.S. Vijayan [5],** in this paper found that the compressive strength hardly at all greater than the compressive strength of conventional concrete using 1% of PEG-1500. The river sand was replaced with manufactured sand (M-Sand) by 50% and 100%. The concept introduced for self curing of concrete is PEG (1500) is 0.3% by the weight of cement with replacement of M. sand using different grade of concrete. **Aegula Shravan Kumar [6],** shows that the incorporation of PEG-600 by the weightof cement in 0.3%, 0.6%, 1% and 2%. It helps in hydration while using of PEG-600 in conventional and also helps to bring up agents of detergents, lubricants and plasticizers of concrete and increase in strengthcriteria. **Rayees Ali khana [7],** this paper deals with varieties of fresh and hardened concrete specimens and also finding with the self curing reagents as PEG-400 with flyash and GGBFS in different distributions. These results for the differentcombination of proportions with the swap of M.sand with river sand with ordinary self curing concrete in grade of M30.**S. Sowdambikai [8],** focus on awareness and effect of self curing with agent as PEG in different prospects and also in several dimensions of 0.5%, 1%, 1.5% and 2% by theweight of cement. Finally resulting in regression coefficients of 0.971 and 0.891 present a inter relationship among properties. **Khushpreetsingh [9],** focus on benefits of self desiccation and improve concrete characteristics PEG-400 used for cement which helps to reduce self desiccation and to improve mechanical properties, retains the water for hydration of cement in concrete when compared with conventional concrete. **Rayees Ali khana [10],** aim is to evaluate the use of PEG as self curing agent. The benefit of PEG is more significant where there is no source of water. PEG is used in various proportions of 0.22%, 0.5%, 0.75% and 1% in M40 grade of concrete for standard curing days. Durability test are carried out under various scale, better result is at 0.5% of PEG when comparing with conventional concrete.**T. Amutha[11],** the objective of the research is to investigate the strength characteristics of self curing concrete with silica fume incorporating with Peg-6000 (0.2%, 0.3% and 0.4%), SAP (0.2%, 0.3% and 0.4%) and silica fume (5% and 10%) to avoid shrinkage effect and to improve properties of concrete. The effect variation in strength parameters, elastic properties and shrinkage ie. compressive strength were carried out for different dosages of self curing agents and shrinkage reducing agent PEG-6000 to reduce early-age shrinkage and at the same time to maintain the mechanical properties and durability of concrete and also to analyze the deflection of the beams. **Amrin Sulthana [12],** In this research, the strength parameters of M20 grade self- curing concrete is compared with that of conventional concrete. Mechanical properties of self-curing concrete and conventional concrete such as compressive strength and split tensile strength are tested and compared. The concept of self- curing is used to reduce the evaporation of water from the concrete and to increase the water retaining capacity of the concrete. Self-curing agents such as Paraffin wax and Sodium Polyacrylate are used. These elements prevent the evaporation of water from the concrete. Sodium Polyacrylate also aids in absorption of the moisture to compensate the loss of water due to the heattextile in water soluble. It is added at 0.4% to the weight of cement. Paraffin wax is applied externally after the casting of concrete. River sand is completely replaced

by manufactured sand. The experiment focused on testing the mechanical properties of the self- curing concrete prepared using different methods and compare the results with that of conventional concrete. **GajendraRaghuvanshi [13],** this research is to improve its durability and performance. The use of self-curing admixtures is very important from the point of view that saving of water is a necessity everyday (each $1m^3$ of concrete requires $3m^3$ of water in a construction, most of which is used for curing). Keeping importance to this, an attempt has been made to develop self-curing concrete by using water-soluble Polyethylene Glycol as self-curing agent. The function of self-curing agent is to reduce the water evaporation from concrete, and hence they increase the water retention capacity of concrete compared to the conventionally cured concrete. polyethylene glycol (PEG) of molecular weight 400 (PEG-400) for dosages of 0%, 0.5%,1% and 2% by weight of cement added to mixing water in the concrete. Comparative studies were carried out for compressive strength for conventional and self-cured concrete mixture of M20, M30 and M40 grades at standard ages (7, 14 and 28 days). It was also found that 1% dosage of PEG-400 by weight of cement was optimum for M20 and M30 grade of concrete while 0.5 %dosage of PEG-400 was optimum for M40 grade concrete for achieving maximum strength without compromising workability. **K. Dasthagiri [14],** in this research a look at use of shrinkage lowering admixture polyethylene glycol (PEG 400) in concrete that enables in self curing. Inside the present study Pottery powder 5% may be replaced in cement and PEG 400 may be changed with the resource of the load of water with various proportions 0.5%, 1%, 1.5% and 2% in M25 grade of concrete. self curing agent and pottery powder on the Mechanical properties like Compressive strength, split tensile strength and Flexural strength and the durable properties like Permeability test and rapid Chloride Permeability test can be accomplished. And the comparative study of normal curing concrete and Self curing concrete of M25 grade**. S. Karthiga [15],** in this research it was found that water soluble polymers can be used as self-curing agents in concrete. Concrete incorporating self-curing agents willpoint of view that the water resources are getting valuable everyday (i.e., each $1m^3$ of concrete require about $3m^3$ of water for construction, Most of which is for curing. In this study the mechanical properties and durability properties of self-curing at different mechanical and durability characteristics.Percentages (0.25%, 0.5%, 0.75%, 1%)of poly ethylene glycol for M40grade were evaluated for 7days, 14 days, and 28 days, and compared with conventional concrete specimen and it is found that 0.5% of PEG produced better results comparing conventional concrete. Durability properties also show better results at 0.5% of PEG comparing conventional concrete. Therefore the optimum percentage of PEG 400 for M40 grade is 0.5%. **U. Sindhu Vaardini [16],** in this research experimental investigations on durability properties of SCC with 20 different mixproportions, containing various percentages of filler materials like Limestone Powder and Marble Powder, along with the mineral admixtures like Fly ash and Silica Fume. The durability properties for all the 20 mixes of SCC was carried out by conducting the Rapid Chloride Penetration Test (RCPT), Saturated Water Absorption Test, Acid Resistance Test, Sulphate Resistance Test, Water Permeability Test and Salt Water Resistance Test. From the experimental study, it is observed that the SCC mix with equal proportions F (10%), SF (10%), LP (10%) and MP (10%), exhibit better performance than the control mix in terms of strength and durability characteristics and thus it is concluded that the addition of mineral admixtures and filler materials have a pivotal role in the development of strength and durability aspects of SCC. **Rampradheep G S [17],** In this paper the self-curing cement was thrown for M20 with Poly ethylene glycol (PEG) as a curing operator. Determination of mass misfortune and quality crumbling against weakened Hydrochloric corrosive (HCl), fast chloride infiltration test.

3. Research Significance

The aim of this research is to compare the efficiency of self curing concrete with silica fume using PEG-6000 and Sodium polyacrylate. So that the amount of water used for construction can be reduced. Autogeneous shrinkage is diminished by using an internal curing agent and it act as a reservoir for the concrete curing. It supplies water to the concrete for hydration reaction from inside. Internal curing agent is also used to reduce the early age of cracking in concrete by supplying water regularly for hydration of concrete. In this research, things to be determined are ideal percentage of PEG6000, flexural behavior, mechanical and durability properties of self curing concrete. The significance of this project is to furnish sufficient data for the researchers and engineers for concerning the utilization of PEG 6000 in the water scarcity area, where the water to took up for curing process is difficult. PEG 6000 is a water soluble polymer which helps to reduce self desiccation and to improve conventional concrete.

4. Scope

To investigate the durability properties of self curing concrete with silica fume using different chemical agents like poly ethylene glycol 6000, sodium polyacrylate in various proportions. To reduce shrinkage effect and water usage of curing. To compare flexural strength of reinforced concrete beam with immersed curing concrete and self curing concrete using various PEG 6000 and sodium polyacrylate.

5. Mechanism of curing

- In process of hydration, a vital role is played by self curing agents such as sodium polyacrylate and poly ethylene glycol 6000.
- While hydration process in concrete it reduce evaporation.
- Sodium polyacrylate and PEG 6000 contains high water retention capacity.
- Self desiccation to reduce in disjoining pressure and dehydration.
- Void formation in conventional concrete due to improper curing.
- No evaporation loss during the hydration process because curing is done by internal agents.
- Increase the hydration process C-S-H gel formation and achieve the strength without any autogenous shrinkage.

6. Research Methodology

The technique used to analyze the proposed work procedure as follows.

1. Design of concrete mix as per IS: 10262-2009
2. Incorporation of different dosage percentages of agents as PEG 6000 and sodium polyacrylate.
3. Casting of concrete cubes
4. Testing on cube specimens

7. Materials used and their properties

7.1. Cement

The ordinaryPortland cement 53- ultratech cement is conforming to IS – 12269 – 1987 [18] cement was used in entire investigation. The specific gravity of cement is **3.165**

7.2. Fine aggregate

Normally available natural river sand of size is below 4.75mm according to zone II of IS: 383 – 1970 [19]. The Sand has taken from SH Infra, Coimbatore. The specific gravity of cement is **2.617.**

7.3. Coarse aggregate

In this research, coarse aggregate size is 20mm and various test has been carried out for coarse aggregate to determine the different physical properties as per IS: 383 – 1970 [20]. The Coarse aggregate has taken from Sri Maruthi traders, Coimbatore. The specific gravity of Coarse aggregate is **2.899.**

7.4. Reinforcement details

For reinforced concrete beam, high yield strength deformed bars of size 12mm bars were used for longitudinal reinforcement and 8mm bars were used for lateral ties [21].

7.5. Water

Water is a fundamental ingredient of making concrete and as well as designed concrete mixture and for curing. The used water is potable and free from acidic and alkaline substance or any other materials that may cause harmfulness or damage to the concrete.

7.6. Silica fume:

Silica fume is also known as micro silica, is an amorphous (non crystalline polymorph silicon dioxide). It is an ultrafine powder collected by as a by-product of silicon. Based on IS: 456 [22], silica fume is usually used in proportion of 5% 10% of cement content mix. For this research, silica fume is commercially takenfrom San Marketing, Coimbatore. The specific gravity of **Silica fume** is **2.28**

7.7. Poly Ethylene Glycol – 6000

Poly Ethylene Glycol – 6000 is used as internal curing agent. It is a condensation polymer of ethylene oxide and water. By using this product for this research, the output result shows as

Table – 1

Sl. No.	Material	Dryweight (Gms)	Saturated weight (Gms)	Water absorption
1	PEG 6000	25	1525	61 times

7.8. Sodium polyacrylate:

Sodium polyacrylate is also known as waterlock, and also called as slush powder.Super absorbent polymer has ability to absorb 100 to weight of partially compacted to fully compacted concrete mortar.

- It is odorless and in grainy white powder. 300 times its mass in water. It is a chemical polymer SAP act as self curing agent in concrete.
- The chemical formula is $[-Ch_2-Ch(CO_2na)-]_{n.}$
- It appears in white powder. It takes up water as much as 400 to 500 times its dry size and swells to form a polymeric gel.

- Particle size – 85-50 mesh
- pH value – 6-7
- Percentage of moisture – ≤5

Table – 2

Sl. No.	Material	Dry weight (Gms)	Saturated weight (Gms)	Water absorption
1	Sodium polyacrylate	25	2800	112 times

8. Mechanism

Sodium polyacrylate and polyethylene glycol are the self curing agents, that play a vital role in hydration process. Using this self curing agent can reduce evaporation in concrete during hydration. Sodium polyacrylate retain large amount of water. It occurs only because of osmotic pressure [i.e. Movement of water when a semi permeable membrane separate solution from pure water]. Sodium polyacrylate absorb water continuously until there appears an equal pressure of water in both in and out molecule.

9. XRF analysis for silica fume

X-Ray fluorescence is a non-destructive analytical technique used to determine the elemental composition of selected samples. XRF results are analyzed from Emerald Testing, Coimbatore shows that silica content is more about of **91.93**. So it suits for concrete

10. SEM analysis for silica fume

Scanning Electron Microscope is widely used to investigate the micro structure surface of topography and composition of the selected sample SEM image results as appearance of agglomerated circle ball structure that absorbs the water about its capacity and act as an internal curing agent. While compacting the fresh concrete it does not allow water to squash out hold the water until hydration process occur.

11. SEM analysis for Sodium Polyacrylate

Scanning Electron Microscope is widely used to investigate the information about the surface topography and composition of the selected. The structure of this image is like cluster of spherical ball which that absorbs the water about it capacity and reacts as a internal curing agent.

12. EXPERIMENTAL WORK AND RESULTS

12.1. Slump cone test and compaction factor test

Slump cone is the most commonly used method for analyzing the measuring consistency of fresh concrete. Compaction factor test is the workability test for concrete as per IS: 1199 - 1959 and it is carried out by the ratio by the ratio of weight of partially compacted to fully compacted concrete.

Fig – 1
Slump cone

Fig – 2
Compaction Factor Test

Table – 3
Slump cone test and compaction factor

Sample	Percentage		Slump cone	Compaction factor
Conventional Concrete	-		52	0.89
Sodium Polyacrylate	5%	0.2	38	0.87
		0.3	47	0.93
		0.4	53	0.96
PEG 6000		0.2	52	0.90
		0.3	53	0.94
		0.4	57	0.92
Sodium Polyacrylate	10%	0.2	49	0.91
		0.3	50	0.95
		0.4	**55**	**0.97**
PEG 6000		0.2	54	0.92
		0.3	55	0.95
		0.4	**59**	**0.96**

12.2. Compressive strength

The most common of all test for harden concrete is compressive strength test. The specimen is processed in standard aspect including curing for specified period (90 days) which results in capability quality of

concrete. The concrete cube specimens were tested on compressive testing machine under UTM. The dimension of concrete cube mold of size is 150mm x 150mm x 150mm. This test is carried out by various percentage of PEG-6000 and sodium polyacrylate with addition of 5% and 10% of silica fume.

Fig – 4
Casting of concrete cube

Fig – 5
Curing of concrete cube

Fig – 5
Testing of concrete cube

Table – 4

In conventional concrete

Day at test is conducted	**Compressive strength (N/mm^2)**
7 days	23.38
28 days	30.84
90 days	38.77

Table – 5
Compressive strength test on cube using silica fume

Sample	%	Compressive strength (N/mm^2) test days		
		7 days	**28 days**	**90 days**
Sodium Polyacrylate& Silica fume 5%	0.2	18.25	28.47	36.97
	0.3	22.15	30.58	37.20
	0.4	24.85	32.33	37.05
PEG 6000 & Silica fume 5%	0.2	18.99	29.67	36.22
	0.3	23.96	31.11	37.18
	0.4	24.85	33.18	37.87
Sodium Polyacrylate& Silica fume 10%	0.2	26.78	33.15	35.98
	0.3	**27.98**	**34.68**	**37.88**
	0.4	25.98	35.08	38.27
PEG 6000 & Silica fume 10%	**0.2**	**28.15**	**35.88**	**38.75**
	0.3	25.77	33.99	38.15
	0.4	24.87	34.87	37.85

12.3. Split tensile strength

Split tensile strength is used to determine the tensile strength of concrete indirectly. It is carried out by using a cylinder specimen with a diameter of 150mm and height of 300mm. The specimen is placed horizontally in compressive testing machine. The test is carried out in 28 days with different percentages of PEG – 6000 and SAP using 5% and 10% of silica fume.

Table – 6

Split tensile strength test on cube in conventional concrete

Day at test is conducted	Split tensile strength (N/mm^2)
7 days	2.78
28 days	3.29

Table – 7
Split tensile strength test on cube

Sample	%	Split tensile strength (N/mm^2) test days
		28 days
Sodium Polyacrylate& Silica fume 5%	0.2	2.88
	0.3	2.98
	0.4	3.15
PEG 6000 & Silica fume 5%	0.2	2.97
	0.3	3.18
	0.4	3.28
Sodium Polyacrylate& Silica fume 10%	0.2	3.59
	0.3	3.27
	0.4	**3.84**
PEG 6000 & Silica fume 10%	0.2	3.48
	0.3	3.37
	0.4	**3.67**

12.4. FLEXURALSTRENGTHTEST

After the curing period the specimen is taken outfrom the curing tank and wiped clean. The dimension of the specimen and the weight of the specimens were noted down with accuracy. The beam testing machineshould be provided with two rollers 38 mm diameter onwhich the specimen is placed and the rollers are spaced such that the distance between two rollers should be 333.34 mm. The load is applied through two similar rollers mounted at the third point of the supporting span, i.e., 333.34 mm centre to centre. The load is divided equally between the two –point loading rollers are mounted in such a manner that the load is applied axially and without subjecting to any torsion stresses.

Flexural strength = PL/BD2

Where P = ultimate load,

L = Length of the specimen,

B = Breadth of the specimen,

D = depth of the specimen

Length = 1200m mm,

Breadth = 100 mm,

Depth =150 mm,

d = 120 mm

a = 333.33 mm.

The beam is cast with nos of 10 mm dia bar for main reinforcement and 8 mm dia for vertical stirrups spacing of 140 mm c/c

BEAM SUBJECTED TO TWO POINT LOADING $y = wa/24EI(3L^2 -4a^2)$

Experimental result

1. In Conventional RC beam

RC beam size is 1200mm x 100mm x 150mm. The load is applied upto 5 tonne, the deflection in right side is 2.07mm, the deflection in left side is 2.15mm and the deflection in middle is 1.94mm.

Table – 8

Load (tonne)	Left			Middle	Right		
	Division		Deflection (mm)	Digital dial gauge(mm)	Division		Deflection (mm)
	Inner	Outer			Inner	outer	
0	9	0	0	0	3	0	0
0.5	9	14	0.14	0.12	3	8	0.08
1	9	24	0.24	0.44	3	17	0.17
1.5	9	45	0.45	0.78	3	63	0.63
2	10	12	1.12	0.98	4	18	1.18
2.5	10	35	1.35	1.02	4	27	1.27
3	10	48	1.48	1.23	4	56	1.56
3.5	10	76	1.76	1.42	4	84	1.84
4	10	98	1.98	1.67	4	97	1.97
4.5	**11**	**08**	**2.08**	**1.98**	**5**	**6**	**2.06**
5	11	38	2.38	2.04	5	32	2.32
5.5	11	59	2.59	2.67	5	68	2.68
6	11	64	2.64	3.01	5	89	2.89
6.5	12	9	3.09	3.45	6	12	3.12
7	12	34	3.34	3.76	6	36	3.36
7.5	13	79	4.79	4.52	6	48	3.48
8	14	06	5.06	4.86	6	79	3.79
8.48	**14**	**12**	**5.12**	**5.34**	**7**	**66**	**4.66**

2. In Self Curing Beam Using 10% Silica Fume and Sodium Polyacrylate

The load is applied upto 5 tonne, the deflection in right side is 2.25mm, the deflection in left side is 2.17mm and the deflection in middle is 1.52mm.

Table – 9

Load (tonne)	Left			Middle Digital dial gauge (mm)	Right		
	Division		Deflection (mm)		Division		Deflection (mm)
	Inner	Outer			Inner	outer	
0	2	0	0	0	11	0	0
0.5	2	26	0.26	0.24	11	07	0.07
1	2	48	0.48	0.45	11	21	0.21
1.5	2	67	0.67	0.76	12	03	1.03
2	3	12	1.12	0.81	12	34	1.34
2.5	3	68	1.68	1.02	12	71	1.71
3	3	74	1.74	1.45	12	92	1.92
3.5	**3**	**98**	**1.98**	**1.98**	**13**	**10**	**2.10**
4	4	05	2.05	2.12	13	37	2.37
4.5	4	25	2.25	2.66	13	78	2.78
5	4	88	2.88	2.98	13	94	2.94
5.5	5	6	3.06	3.78	14	22	3.22
6	6	24	4.24	4.78	15	34	4.34
6.5	7	38	5.38	5.76	16	18	5.18
7.21	**8**	**03**	**6.03**	**6.01**	**17**	**42**	**5.42**

3. In Self Curing RC Beam using 10% Silica fume and PEG 6000

The load is applied upto 5 tonne, the deflection in right side is 2.82mm, the deflection in left side is 2.63mm and the deflection in middle is 1.88mm.

Table – 10

Load (tonne)	Left			Middle Digital dial gauge (mm)	Right		
	Division		(mm)		Division		(mm)
	Inner	Outer			Inner	outer	
0	16	0	0	0	4	0	0
0.5	16	12	0.12	0.04	4	05	0.05
1	16	21	0.21	0.13	4	29	0.29
1.5	16	42	0.42	0.24	4	35	0.35
2	16	57	0.57	0.48	4	47	0.47
2.5	17	19	1.19	0.76	4	82	0.82
3	17	38	1.38	1.03	4	91	0.91
3.5	17	49	1.49	1.25	5	3	1.03
4	17	56	1.56	1.44	5	17	1.17
4.5	17	78	1.78	1.56	5	32	1.32
5	**18**	**03**	**2.03**	**1.98**	**5**	**57**	**1.57**
5.5	18	38	2.38	2.48	5	84	1.84
6	18	79	2.79	2.97	6	13	2.13
6.5	19	14	3.14	3.62	6	76	2.76
7	19	32	3.32	3.98	6	84	2.84
7.5	19	58	3.58	4.34	7	27	4.27
8	19	67	3.67	4.81	7	48	4.48
8.5	20	92	4.92	5.16	8	24	5.24
9.14	**21**	**42**	**5.42**	**5.76**	**8**	**48**	**5.48**

Table 11 Result Comparison for Conventional and SC beam

Beam Specimen	Initial Crack Load (Tonne)	Ultimate Load (Tonne)	Maximum Deflection (mm)	Ultimate Moment (kNm)	Flexural Strength N/mm^2	Flexural rigidity Nmm^2
Conventional Beam	4.5	8.48	5.34	28.26	44.36	$4.96x10^{11}$
Self Curing Beam SPA	3.5	6.84	3.56	22.76	35.77	$3.79x10^{11}$
PEG 6000	**5**	**9.14**	**5.76**	**30.46**	**47.80**	**$6.9x10^{11}$**

5. **DRYING SHRINKAGE TEST**

This test method describes the procedure for determining the drying shrinkage or change in length of concrete specimen due to changes in moisture content. A length measuring apparatus incorporating a dial gauge capable of measuring the length accurately to 0.005 mm. The mould size 0f 200 mm x 100 mm x 100 mm. Length comparator measures the initial drying shrinkage of concrete. Drying oven capable of maintaining a temperature of 50±10. The initial drying shrinkage or drying shrinkage is calculated as the difference between the original wet measurement and the dry measurement expressed as a percentage of dry length. According to IS 6441 part 2 shrinkage limits should be 0.007%.

Initial drying shrinkage = [(original wet measurement – dry measurement)/Original length] *100

Table:12 Drying shrinkage result

Sample	Leastcount: 0.01mm Length of the specimen in 200 mm		
	Length of the member	**Shrinkage Value**	**Initial drying shrinkage**
Conventional concrete	19.45cm	0.87 cm	0.0009%
Self curing concrete			
PEG6000 (0.3 % & 10%SF)	19.987cm	0.01213 cm	0.00035 %
SPA (0.2% & 10%SF)	19.9868 cm	0.01320 cm	0.00085%

6. Water Absorption

Water absorption test was done affirming to ASTMC_64297. Initially the mortar specimens were dried absolutely to expel dampness by using Hot air oven for duration of 24 hours. The samples were taken out from the oven and their initial weights were noted as W0 (kg).The samples were immersed into water not less than a period of 48 hours. The final weight of the samples W1 (kg) was recorded after taking out the immersed samples from water. The rate of water absorption is calculated by using the following expression.

Rate of water absorption=$(W1-W0)/W0\times100$

Table – 11
Water absorption test

Sample	Percentage		Heating Weight of concrete cube(kg)		Absorption	
			Before	After	After immersion (W1)	Water absorption (%)(W0)
Conventionalconcrete	-		8.78	8.67	8.98	3.57
Self curing concrete						
Sodium polyacrylate with silica fume	5%SF	0.2	8.29	8.17	8.48	3.79
		0.3	8.382	8.22	8.52	3.65
		0.4	8.37	8.09	8.35	3.21
PEG6000 with silica fume		0.2	8.29	8.27	8.6	3.99
		0.3	8.44	8.15	8.44	3.56
		0.4	8.39	8.11	8.39	3.45
Sodium polyacrylate with silica fume	10%SF	0.2	8.29	8.38	8.61	2.74
		0.3	**8.47**	**8.19**	**8.69**	**3.54**
		0.4	8.92	8.16	8.54	4.66
PEG6000 with silica fume		**0.2**	**8.37**	**8.32**	**8.61**	**3.49**
		0.3	8.49	8.22	8.47	3.04
		0.4	8.37	8.16	8.44	3.43

Thus it results with the taken specimen using Sodium polyacrylate and PEG6000 with silica fume are resulting nearly with the standard absorption value.

7. WATER PERMEABILITY TEST

Permeability of concrete is the most important aspect while handling with durability. The test was carried in 150 mm cube specimens at the age of 28 days. The specimens were surface dried and the dimensions measured to the nearest 0.5 mm. The cubes were clamped between two flanges with spherical circular gaskets. The water, under controlled pressure of 50 kg/cm2, is then applied to the surface of the concrete specimen. A constant 50 kg/cm2 pressure head of water was applied to the inflow side of the permeability cell and the pressure throughout the test was continuously monitored. The duration of the test was 48 hours. It was ensured that the permeability apparatus was filled with de-aired water and contains no air pockets or bubbles. The penetration of water was measured, after the testing period, by breaking the

specimens. The water permeability of the developed SCC mixes was evaluated by measuring the water penetration depth that is a reliable indirect assessment of the water permeability of concrete.

Table - 12

Sample	**Depth of penetration (d in cm)**	
Conventional concrete	0.45	
Sodium polyacrylate with 5% of silica fume	0.2	1.25
	0.3	3.86
	0.4	4.99
PEG 6000 with 5% of silica fume	0.2	1.65
	0.3	3.02
	0.4	4.82
Sodium polyacrylate with 10% of silica fume	0.2	1.84
	0.3	5.87
	0.4	9.81
PEG 6000 with 10% of silica fume	0.2	1.55
	0.3	4.97
	0.4	8.48

8. **Rapid Chloride Penetration Test**

The procedure of this test method for measuring the resistance of concrete to chloride ion penetration has no bias because the value of this resistance can be defined only in terms of a test method. The method relies on the results from a test in which electrical current passes through a concrete sample during a six-hour exposure period. The interpretation is that the larger the Coulomb number or the charge transferred during the test, the greater the permeability of the sample. The more permeable the concrete, the higher the coulombs; the less permeable the concrete, the lower the coulombs. The method has shown good correlation with chloride tests. The following formula, based on the trapezoidal rule can be used to calculate the average current flowing through one cell.

$Q = 900(I0+2I30+2I60+2I90+2I120+\ldots+ 2I300+ 2I330+ I360)$

Where, Q = current flowing through one cell (coulombs)

I0 = Current reading in amperes immediately after voltage is applied and

It = Current reading in amperes at t minutes after voltage is applied the rating of chloride permeability according to ASTM C 1202-97

Table - 13

Charge passing in coulombs	**Chloride permeability rating**
Greater than 4000	High
2001 to 4000	Moderate
1001 to 2000	low
100 to 1000	Very low
Less than 100	Negligible

Table – 14

RCPT test result

Sample	**Specimen**	**Charge passed (Coulombs))**	
		28 days	**60 days**
Sodium poly acrylate with 10% of silica fume	**S1**	**2687**	**2314**
	S2	3698	3247
	S3	3856	3574
PEG 6000 with 10% of silica fume	S1	3498	3286
	S2	**2918**	**2173**
	S3	3498	3286

III. Conclusion

The results of various tests carried out on for concrete durability characteristics such as saturated water absorption, water permeability, water absorption, shrinkage test, flexural strength measurement are reported. The influence of admixtures on various durability characteristics were analyzed and reported. The optimum combinations of admixtures were also found out.

The saturated water absorption of self curing concrete mixes containing silica fume was lower when compared with that of the concrete mixes without silica fume. From the test results, it is observed that the lowest value of charge passed was obtained for the mix Sodium polyacrylate with 5% of silica fume in 0.2 dosage which signifies that it is less permeable.

In durability test the result for all mixes proportions considered in this research, it is observed that there is no much variation in the permeability properties and which indicate that there would not be much significant variation in the water absorption and permeability of the mixes.

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