Self Curing for High Strength Concrete

Krishna Rao S
Department of Civil Engineering
V R Siddhartha Engineering College
Vijayawada, India

Asha S K
Department of Civil Engineering
V R Siddhartha Engineering College
Vijayawada, India

***Abstract*: Concrete requires curing to continue with the hydration process. Self-curing concrete is one of the special concretes in mitigating insufficient curing due to human negligence paucity of water in arid areas, inaccessibility of structures in difficult terrains and in areas where the presence of fluorides in water will badly affect the characteristics of concrete. The present study involves the use of polyethylene glycol which acts as a self curing compound. The most important aspect is that this compound is expected to maintain maximum water retention there by contributing to full hydration. The parameters in the study include grade of concrete, type and dosage of polyethylene glycol, curing conditions and age of curing. The present involves the two types of self curing compounds PEG 4000, PEG 200 with dosage of 0.1%, 0.5%, 1% for M70 grade of concrete. Weight loss and compressive strength, flexural strength, split tensile strength, and durability tests were determined as a performance benchmark for the investigated curing compounds. It was reported from the study that higher dosage (1%), higher molecular weight (4000) based PEG compounds act as better curing compounds in higher grade concretes compared to other self curing compound.**

Keywords - Self desiccation, Hydrophilic compound, Water retention, Compressive strength, Internal sealing, flexural strength, split tensile strength, acid test, sorptivity test.

1. INTRODUCTION

Proper curing of concrete structures is important to meet performance and durability requirements. In conventional curing this is achieved by external curing applied after mixing, placing and finishing. The development of concrete has brought several challenges to the engineers to improve the performance characteristics: strength and durability. One of major considerations in achieving this is gaining control on water. The water supplied during mixing in concrete is needed to hydrate the cement to achieve the required rheological properties in mixing, transportation, placing and compacting. One of the most important aspects in hydration is the need to maintain relative humidity of around 100%. Decrease in relative humidity will cause self desiccation or chemical shrinkage at micro level. To prevent this problem, it is recommended to make available, embedded water for curing. Self-curing or internal curing is a technique that can be used to provide additional moisture in concrete for more effective hydration of cement and reduced self-desiccation. 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.

2.EXPERIMENTAL PROGRAMME

2.1 MATERIALS

Cement used in the investigation was 53 Grade Ordinary Portland cement confirming to IS: 12269 [18]. The specific gravity of cement was 3.14. the initial setting time of cement is 40 min and final setting time is 560 min. The fine aggregate was conforming to Zone-2 according to IS: 383 [19]. The fine aggregate used was obtained from a nearby river source. The specific gravity was 2.65, while the bulk density of sand was 1400 kg/m^3. Crushed granite was used as coarse aggregate. The coarse aggregate was obtained from a local crushing unit having 20mm nominal size, well graded aggregate according to IS: 383[19]. The specific gravity was 2.8, while the bulk density was 1600kg/m^3. Potable water was used in the experimental work for both mixing and curing companion specimens. High range water reducing admixture confirming to ASTM C94 [20] commonly called as super plasticizers was used for improving the flow or workability for decreased water-cement ratio without sacrifice in the compressive strength. These admixtures when they disperse in cement agglomerates significantly, decreases viscosity of the paste forming a thin film around the cement particles. In the present investigation, water-reducing admixture glinium B233 obtained from BASF Chemicals was used. Polyethylene glycols of low molecular (200) and high molecular weights (4000) were used in the study.

3.EXPERIMENTAL INVESTIGATION

A total of 72 standard cubes of dimensions 150mm × 150mm × 150mm were cast with two hydrophilic compounds (PEG 4000, PEG 200) and grade of concrete is M70. Water retention test was carried out to study the moisture loss at the end of 3, 7, 10, 14, 21 and 28days. Compressive strength was determined at the end 7, 14 and 28 days curing. After fixation of dosage a total of 24 beams and 24 cylinders of dimensions 100mm×100mm×500mm and 300mm×150mm are casted using the optimum dosage of self curing compound. Flexural strength and split tensile strength test was determined at 7, 14, 28 days. A total of 48 cubes of dimensions 100mm×100mm are casted for acid attack test and sorptivity test.

3.1 Water retention test

The resources of water molecules in concrete, particularly when subjected to indoor curing is extremely important for curing of concrete. The curing compounds added during the mixing time act as internal sealing agents, by filling cracks, voids, which decrease the self desiccation and progress the hydration of concrete. The retention of water in concrete was monitored by weighing the concrete cubes at regular intervals. The weight of three similar specimens was taken on an electronic balance of accuracy 0.1 grams and an average of three specimens was taken for further analysis.

3.2 Compressive Strength test

The cube specimens were tested in a standard compression testing machine of capacity 200 Tons. The axes of the specimens were carefully aligned at the center of the loading frame. The load applied was increased continuously at a constant rate until the resistance of the specimen to increasing load breaks down and could no longer sustain. The maximum load applied on the specimen was recorded. The rate of loading was adopted as per IS 516 [21].

3.3 flexural strength test

The cube specimens were tested in a universal testing machine of 40 tons for two-point loading to create a pure bending. The two point bending load applied was increased continuously at a constant rate until the specimen breaks down and no longer can be sustained. The maximum load applied on specimen was recorded. The modulus of rupture depends on where the specimen breaks along the span.

3.4 Split tensile strength test

The cylinder specimens were tested on compression testing machine of capacity 3000KN.The bearing surface of machine was wiped off clean and looses other sand or other material removed from the surface of the specimen. The load applied was increased continuously at a constant rate until the resistance of the specimen to the increasing load breaks down and no longer can be sustained. The maximum load applied on specimen was recorded.

3.5 Acid test

The chemical resistance of the concrete was studied through chemical attack by immersing them in an acid solution. 3 specimens of each batch of concrete were immersed in 5% HCl. The mass, diagonal dimensions values are measured at 3, 7, 10, 14, 21, 28 days of immersion. Compressive strength is measured at 7days, 14days and 28days of immersion. In the present investigation, the “Acid Durability Factors” are derived directly in terms of relative strengths. The relative strengths are always compared with respect to the 28 days value (i.e. at the start of the test).

3.6 Sorptivity test

The water permeability action of concrete was studied by sorptivity test. The cubes are casted with the size of 10mm×10mm. Afetr that wax is applied on all sides and they were placed in a recipient in contact with a level of water capable to submerge them about 5 mm. The weights are taken at every 10 min, 20min, 30min, 40min, 1hr, 90 min, 2hr, 3hr, 4hr, 5hr, 6hr.

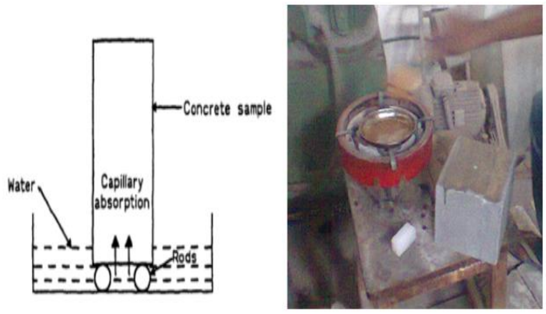


Fig 1: Sorptivity test

4. RESULTS & DISCUSSION

4.1 Water retention test

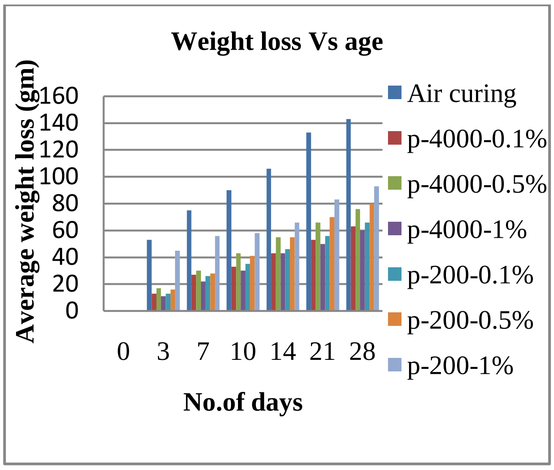
While using this test we are observed that the smallest weight loss of a cube at 3 days to 28 days. The graph between average weight loss and age of curing for PEG 4000 and PEG 200 are drawn below. In this test the smallest average weight loss occured at PEG 4000-1% because this dosage had low permeability compared to other dosages.


Fig 2: Water retentivity test

Table 1: average weight losses

	Number of days						
Grade	0	3	7	10	14	21	28
Air curing	0	53	75	90	106	133	143
P-4000-0.1%	0	13	27	33	43	53	63
P-4000-0.5%	0	17	30	43	55	66	76
P-4000-1%	0	11	22	30	43	50	60
P-200-0.1%	0	13	26	35	46	56	66
P-200-0.5%	0	16	28	41	55	70	80
P-200-1%	0	45	56	58	66	83	93

Graph 1: age versus weight loss



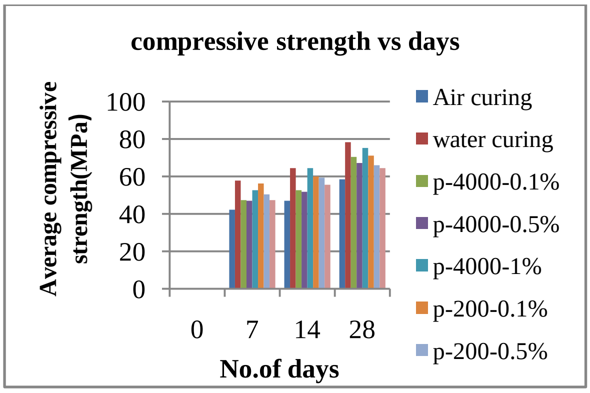
4.2 Compressive strength test

In this test the highest average compressive strength occured at PEG 4000-1% because the voids are mostly filled in that dosage. The graph between age of curing and compressive strength test results for PEG 200 and PEG 4000 are drawn below.

Table 2: average compressive strength test results

Grade	7 days (N/mm^2)	14 days (N/mm^2)	28 days (N/mm^2)
Air curing	42.22	46.96	58.51
Water curing	57.77	64.44	78.22
P-4000-0.1%	47.4	52.59	70.36
P-4000-0.5%	46.96	51.85	67.1
P-4000-1%	52.59	64.44	75.25
P-200-0.1%	56.29	60	71.11
P-200-0.5%	50.37	59.25	65.92
P-200-1%	47.4	55.5	64.44

Graph 2: age versus compressive strength



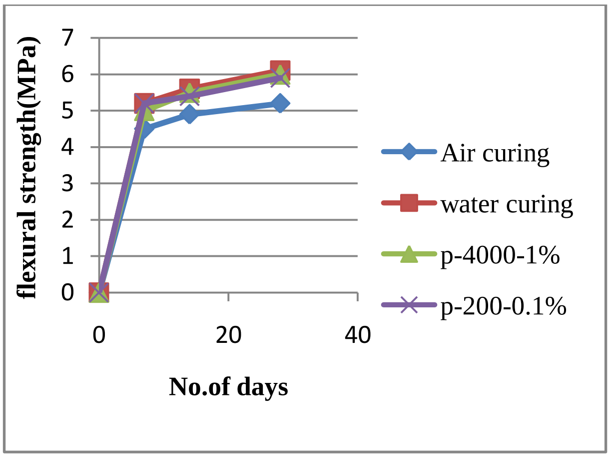
4.3 Flexural strength test

After fixation of dosage beams are casted while using the optimum dosage. In this test the average flexural strength observed at PEG 4000-1%. The graph between age of curing and flexural strength test results for PEG 200 and PEG 4000 are given below.

Table 3: average flexural strength test results

Grade	7 days (N/mm^2)	14 days (N/mm^2)	28 days (N/mm^2)
Air curing	4.5	4.9	5.2
Water curing	5.2	5.6	6.1
P-4000-1%	5	5.5	6
P-200-0.1%	5.2	5.4	5.9

Graph 3: age versus flexural strength



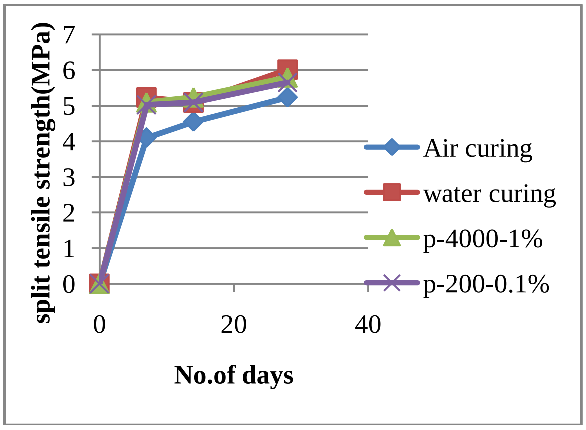
4.4 Split tensile strength test

This test procedure was same as that flexural strength. In this test the average split tensile strength observed at PEG 4000-1%The graph between age of curing and split tensile strength test results for PEG 200 and PEG 4000 are shown below.

Table 4: average split tensile strength test results

Grade	7 days (N/mm^2)	14 days (N/mm^2)	28 days (N/mm^2)
Air curing	4.1	4.55	5.23
Water curing	5.23	5.09	6.01
P-4000-1%	5.09	5.23	5.79
P-200-0.1%	5.02	5.09	5.65

Graph 4: age versus split tensile strength



4.5 Acid attack factor test

The test was conducted on moulds of size:10mm×10mm. In this test the diagonal dimensions are taken at 3 days, 7 days, 10 days, 14 days, 21 days, 28 days. The graph between average acid attack factor and number days are given below.

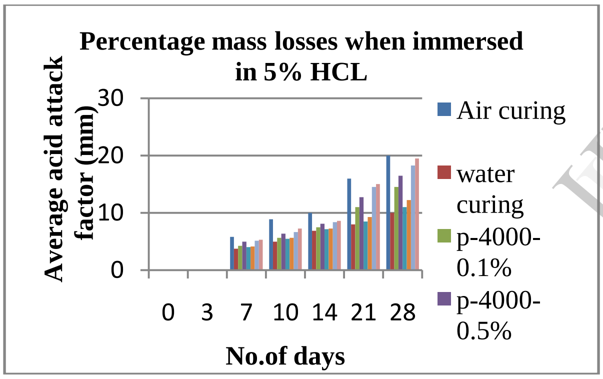
Fig 3: acid attack factor test

Table 5: Average acid attack factor test results

Grade	Number of days					
	0	3	7	10	14	21	28
Air curing	0	0	5.8	8.87	10	16	20
Water curing	0	0	3.7	5	6.87	8	10
P-4000-0.1%	0	0	4.2	5.62	7.5	11	14.5
P-4000-0.5%	0	0	5	6.37	8.12	12.7	16.5
P-4000-1%	0	0	4	5.5	7.12	8.5	11
P-200-0.1%	0	0	4.1	5.62	7.25	9.25	12.2
P-200-0.5%	0	0	5.1	6.62	8.37	14.5	18.2
P-200-1%	0	0	5.3	7.25	8.62	15	19.5

(All dimensions are in mm)

Graph 5: age versus AAF



4.6 Acid durability factor test

With this test percentage loss of strengths are determined at 7 days, 14 days, 28 days when immersed in 5% HCL. The cube dimensions are 10mm×10mm. The test results are shown below.

Table 6: % loss of strength and age

Grade	7 days	14 days	28 days
Air curing	23.497	34.89	41.40
Water curing	9.90	14.77	18.42
P-4000-0.1%	13.37	18.78	26.90
P-4000-0.5%	14.83	19.09	27.61
P-4000-1%	10.14	13.93	19.00
P-200-0.1%	8.92	14.28	19.64
P-200-0.5%	16.20	23.42	29.20
P-200-1%	20.19	26.10	33.49

Graph 6: age versus %loss of strength

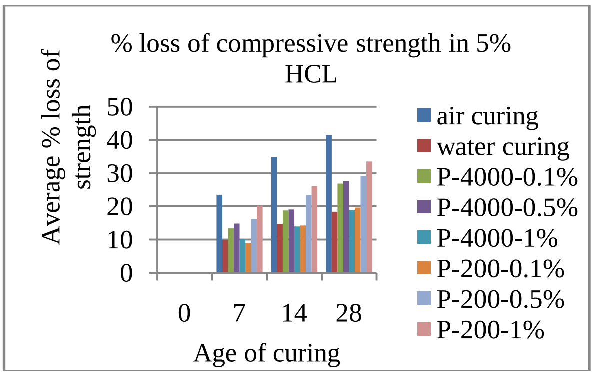
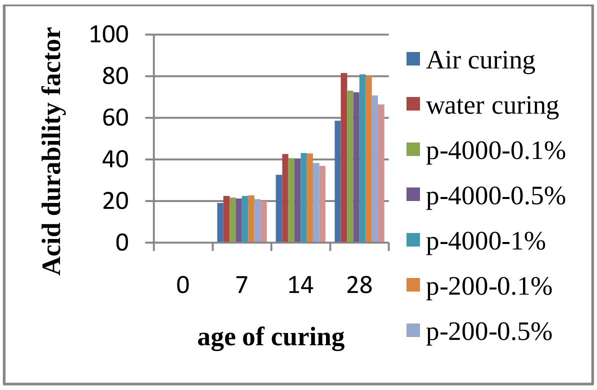


Table 7: acid durability factor values

Grade	7 days	14 days	28 days
Air curing	19.12	32.55	58.59
Water curing	22.52	42.61	81.57
P-4000-0.1%	21.62	40.60	73.09
P-4000-0.5%	21.29	40.45	72.38
P-4000-1%	22.46	43.03	80.99
P-200-0.1%	22.76	42.85	80.35
P-200-0.5%	20.94	38.28	70.79
P-200-1%	19.95	36.94	66.50

Graph 7: Age Versus ADF



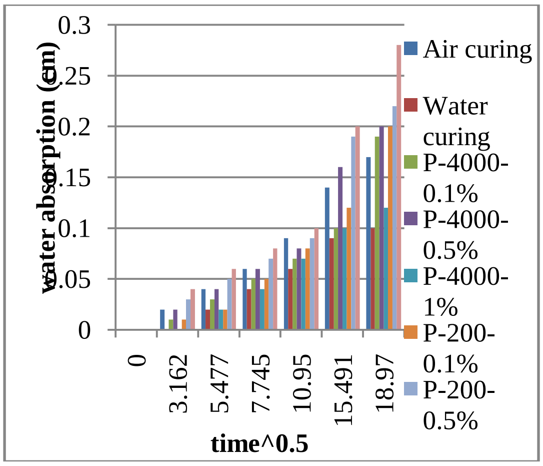
4.7 Sorptivity test

The test results and graph between t^0.5 and water absorption (w) values are shown below.

Table 8:average water absoption values (w) in cm

Grade	0 min	10 min	30 min	60 min	120 min	240 min	360 min
Air curing	0	0.02	0.04	0.06	0.09	0.14	0.17
Water curing	0	0	0.02	0.04	0.06	0.09	0.1
P-4000-0.1%	0	0.01	0.03	0.05	0.07	0.1	0.19
P-4000-0.5%	0	0.02	0.04	0.06	0.08	0.16	0.2
P-4000-1%	0	0	0.02	0.04	0.07	0.1	0.12
P-200-0.1%	0	0.01	0.02	0.05	0.08	0.12	0.2
P-200-0.5%	0	0.03	0.05	0.07	0.09	0.19	0.22
P-200-1%	0	0.04	0.06	0.08	0.1	0.2	0.28

Graph 7: time versus water absorption



CONCLUSIONS

1. High grade concrete with polyethylene glycol in indoor curing with 1% dosage (by weight of cement) has minimum weight loss when compared to the 0%, 0.1%, 0.5%, dosages.

2. For compressive strength test the average value for 28 days was found to be 75.22N/mm^2. For tensile strength test the average value for 28 days was found to be 6N/mm^2. For split tensile strength the average value for 28 days was found to be 5.79N/mm^2.

3. In acid attack factor test the smallest average percentage mass losses for 28 days when immersed in 5% HCL obtained at PEG 4000-1%.

4. In acid durability factor test smallest % loss of strength and highest ADF obtained at the dosage of PEG 4000-1% @ 28 days.

5.In sorptivity test the smallest average water absorption obtained at PEG 4000-1% @ 6hrs.

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