Research Study on Self Curing Concrete by using Recycled Aggregate

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Abstract— We don't imagine any kind of structure without concrete in the present world. It is because of its good compressive strength and durability. The concrete needs 28 days curing to achieve the maximum strength. Lack of proper curing can badly affect the strength and durability. Self-curing concrete is one type of modern concrete, which cure itself by retaining water (moisture content) in it. Generally, in structures like columns the water in the upper part of the structure may evaporate easily when compared to the bottom part. Then structure needs some more water for proper curing. This may increase in the amount of usage of water and if proper curing is not done by the worker that may results into a failure to get the adequate results. So to avoid this self-curing concrete is introduced into the concrete structures to reduce the amount of usage of water while curing. These Concrete needs self-curing agents. The self-curing agents are used to reduce the water evaporation from concrete, and hence increase the water retention capacity of the concrete compared to conventional concrete. The use of self-curing admixtures is very important from the point of view that water resources are getting valuable every day. To achieve proper curing agents like poly ethylene glycol, wax etc. are used as a self curing agent. The main objective of proposed project work is to use the water soluble polymeric glycol as self-curing agent and to decide the optimum dosage for different conditions. In this study water retention, compacting factor and compressive strength of concrete containing self-curing agent is investigated and compared with conventional curing. Concrete weight loss with time was carried out in order to evaluate the water retention ability for different dosages of self-curing agent and for different conditions. This study includes the comparison of natural coarse aggregate and recycled coarse aggregate of different dosages of self-curing agent and for different conditions.

Keywords: Self Curing Concrete, Recycled Aggregate

I. INTRODUCTION

Curing of concrete is maintaining satisfactory moisture content in concrete during its early stages in order to develop the desired properties. However, good curing is not always practical in many cases. Several investigators explored the possibility of accomplishing self-curing concrete. Therefore, the need to develop self-curing agents attracted several researchers. The concept of self-curing agents is to reduce the water evaporation from concrete, and hence increase the water retention capacity of the concrete compared to conventional concrete

A self-curing concrete is provided to absorb water from atmosphere to achieve better hydration of cement in concrete. It solves the problem that the degree of cement hydration is lowered due to no curing or improper curing, and thus unsatisfactory properties of concrete.

A. Curing

Curing is the process of controlling the rate and extent of moisture transport from concrete during Cement hydration. It may be either after it has been placed in position (or during the manufacture of concrete products), thereby providing time for the hydration of the cement to occur. Since the hydration of cement does take time in days, and even weeks rather than hours curing must be undertaken for a reasonable period of time, if the concrete is to achieve its potential strength and durability. Curing may also encompass the control of temperature since this affects the rate at which cement hydrates. The curing period may depend on the properties required of the concrete, the purpose for which it is to be used, and the ambient conditions, i.e. the temperature and relative humidity of the surrounding atmosphere. Curing is designed primarily to keep the concrete moist, by preventing the loss of moisture from the concrete during the period in which it is gaining strength.

1) Conventional Curing Methods

Methods of curing concrete fall broadly into the following categories:

- Minimise moisture loss from the concrete, for example by covering it with a relatively impermeable membrane.
- Prevent moisture loss by continuously wetting the exposed surface of the concrete.
- Steam curing.
- Spraying on the surface with water.

B. Self-Curing

Curing of concrete is maintaining satisfactory moisture content in concrete during its early stages in order to develop the desired properties. However, good curing is not always practical in many cases. Several investigators explored the possibility of accomplishing self-curing concrete. Therefore, the need to develop self-curing agents attracted several researchers. The concept of self-curing agents is to reduce the water evaporation from concrete, and hence increase the water retention capacity of the concrete compared to conventional concrete. It was found that water soluble polymers can be used as self-curing agents in concrete. Concrete incorporating self-curing agents will represent a new trend in the concrete construction in the new millennium. Curing of concrete plays a major role in developing the concrete microstructure and pore structure, and hence improves its durability and performance. The concept of self-curing agents is to reduce the water evaporation from concrete, and hence increase the water retention capacity of the concrete compared to conventional concrete. The use of self-curing admixtures is very important from the point of view that water resources are getting valuable every day (i.e., each 1cu.m of concrete requires about 3cu.m of water for construction most of which is for curing).

C. Chemicals to Achieve Self–Curing

Some specific water-soluble chemicals added during the mixing can reduce water evaporation from and within the set concrete, making it 'self-curing.' The chemicals should have abilities to reduce evaporation from solution and to improve water retention in ordinary Portland cement matrix.

Following are the list of some chemicals which are hydrophilic in nature.

- Polyvalent alcohol
- Polyethylene glycol (peg)
- Poly-acrylic acid
- Xylitol, sorbitol
- Glycerine
- Phytosterols
- Hyaluronic acid
- Polyxyelhylene (poe)
- Sodium pyrrolidone carboxylate (pca-na),
- Stearyl alcohol
- Cetyl alcohol

D. Classification of Aggregates

For the purpose of this report, the following classifications are adopted.

1) Natural Aggregate

Construction aggregates produced from natural sources such as gravel and sand, and extractive products such as crushed rock, some of the examples are Crushed rock, Sand and gravel, Crushed river gravel.

2) Manufactured Aggregate

Aggregates manufactured from selected naturally occurring materials, by-products of industrial processes or a combination of these, some of the examples are Foamed Blast Furnace Slag (FBS), Fly Ash Aggregate, Manufactured Sand, Polystyrene Aggregate (PSA), Expanded Clays, Shale's and Slates

3) Recycled Aggregate

Aggregates derived from the processing of materials previously used in a product and/or in construction, some of the examples are Recycled Concrete Aggregate (RCA), Recycled Concrete and Masonry (RCM), Reclaimed Aggregate (RA), Reclaimed Asphalt Pavement (RAP), Reclaimed Asphalt Aggregate (RAA), Glass Cullet, Scrap Tyres, Used Foundry Sand

4) Reused by-product

Aggregates produced from by-products of industrial processes, some of the examples are Air-cooled BF Slag (BFS), Granulated BF Slag (GBS), Electric Arc Furnace Slag (EAF), Steel Furnace Slag (BOS), Fly Ash (FA), Furnace Bottom Ash (FBA), Incinerator Bottom Ash (IBA), Coal Washer Reject (CWR), Organic Materials, Crusher fines, Mine tailings.

E. Sources of Recycled Aggregate

Traditionally, Portland concrete aggregate from the demolition construction are used for landfill. But now days, Portland concrete aggregate can be used as a new material for construction usage. According to recycling of Portland Cement Concrete, recycled aggregates are mainly produced from the crushing of Portland concrete pavements and structures building. The main reason for choosing the structural building as the source for recycled aggregate is because a huge amount of crushed demolition Portland cement concrete can be produced.

F. Applications of recycled aggregate

General, applications without any processing include:

- Many types of general bulk fills
- Bank protection
- Base or fill for drainage structures
- Road construction
- Noise barriers and embankme

G. The use of recycled aggregate in concrete

The use of crushed aggregate from either demolition concrete or from hardened leftover concrete can be regarded as an alternative coarse aggregate, typically blended with natural coarse aggregate for use in new concrete. The use of 100% recycled coarse aggregate in concrete, unless carefully managed and controlled, is likely to have a negative influence on most concrete properties – compressive strength, modulus of elasticity, shrinkage and creep, particularly for higher strength concrete. Also the use of fine recycled aggregate below 2 mm is uncommon in recycled aggregate concrete because of the high water demand of the fine material smaller than 150 μm, which lowers the strength and increases the concrete shrinkage significantly. Many overseas guidelines or specifications limit the percentage replacement of natural aggregate by recycled aggregate.

In general leftover concrete aggregate can be used at higher replacement rates than demolition concrete aggregate. With leftover concrete aggregate, information will generally be known about the parent concrete – strength range and aggregate source etc., whereas for demolition concrete very little information may be known about the parent concrete, and the resulting aggregate may be contaminated with chlorides or sulphates and contain small quantities of brick, masonry or timber which may adversely affect the recycled aggregate concrete. Often the sources of material from which a recycled aggregate came (and there could be more than one source), are unknown and the variability and strength of the recycled aggregate concrete could be adversely affected in comparison with a recycled aggregate concrete where the recycled aggregate came from one source with a known history of use and known strength. It is therefore necessary to distinguish between the properties of recycled aggregate concrete made using demolition concrete aggregate and that using leftover concrete aggregate. Nevertheless, recycled aggregate concrete can be manufactured using recycled aggregate at 100% coarse aggregate replacement where the parent concrete, the processing of the recycled aggregate and the manufacture of the recycled aggregate concrete are all closely controlled. However, as target strengths increase, the recycled aggregate can limit the strength, requiring a reduction in recycled aggregate replacement.

Fig. 1.1: Recycled aggregate

A self-curing concrete is provided to absorb water from atmosphere to achieve better hydration of cement in concrete. It solves the problem that the degree of cement hydration is lowered due to no curing or improper curing, and thus unsatisfactory properties of concrete.

H. Mechanism of self-curing

Continuous evaporation of moisture takes place from an exposed surface due to the difference in chemical potentials (free energy) between the vapour and liquid phases. The polymers added in the mix mainly form hydrogen bonds with water molecules and reduce the chemical potential of the molecules which in turn reduces the vapour pressure. This reduces the rate of evaporation from the surface.

II. LITERATURE REVIEW

A. General

1) Review of self-curing concrete

a) Ravande Kishore et.al (1994) "Influence of recycled aggregate on flexural behaviour of reinforced concrete beams".

b) Wen-chen jau et.al.(2008) "Self-curing Concrete". El-Dieb A.S, et.al.(2007) "Self-curing Concrete: Water Retention, hydration and moisture transport". A.S.EL-Dieb,T.A.EL-Maaddawyand A.A.M. Mahmoud et.al.(2011)"Water-Soluble Polymers as Self-Curing Agent in Silica Fume Portland Cement Mixes".

c) Collepardi.M.,Borsoi.A, and M.Valente,et.al.(2006) "Self-Curing, Shrinkage-Free Concrete".

d) Dhir R.K.and Hewlett P.C.,et.al (1995) "Durability of 'Self-Cure' Concrete".

This paper reports the results of a series of durability tests conducted on self-cure concrete. The tests were the initial surface absorption test, the potential difference (PD) chloride diffusion test, depth of carbonation, half-cell corrosion potential and measurement of freeze / thaw resistance

III. EXPERIMENTAL PROGRAMME

A. General

The main objective of proposed project work is to use the water soluble polymeric glycol as self-curing agent and to decide the optimum dosage for different conditions. In this study water retention, compacting factor and compressive strength of concrete containing self-curing agent is investigated and compared with conventional curing. Concrete weight loss with time was carried out in order to evaluate the water retention ability for different dosages of self-curing agent and for different conditions. This study includes the comparing the natural coarse aggregate and recycled coarse aggregate of different dosages of self-curing agent and for different conditions.

Total 96 cubes, 96 cylinders, 96 prisms were casted which involves different dosages (0%, 0.5%, 1% and 2%) of self-curing agent PEG-6000 for four different mixes (Mix A1, A2 and Mix B1, B2), under different curing conditions (indoor, conventional). The compaction factor test was conducted for all mixes to know the fresh property of concrete. Compressive strength test was conducted at 7and 28 days of curing and to investigate the water retentivity capacity the cubes were weighed for every three days from the date of casting. The accuracy of the digital weighing machine used is 5 gm. Strength graph is plotted against percentage of self-curing agent; water retentivity graph is plotted for average weight loss verses number of days of curing.

In this investigation the maximum dosage of self-curing agent is restricted to 2% and minimum dosage is of 0.5% is decided as per the literature available.

B. Nomenclature for Specimen

– MIX A- normal coarse aggregate (A1- M30, A2- M40 grades)
– MIX B- recycled coarse aggregate (B1-M30, B2-M40 grades)
– O-Ordinary Portland cement (OPC)
– H-PEG 6000(Higher Molecular Weight)
– I-Indoor Curing
– W-Wet/Conventional Curing
– S.C.A-Self-Curing Agent

1) For example, sample with name A1OW represents Mix A with PEG 6000 and dosage of 0% by weight of cement subjected to wet curing.
2) Sample A1OI represents Mix A1 with PEG 6000 and dosage of 0% by weight of cement subjected to indoor curing.
3) Sample A1H1 represents Mix A1 with PEG 6000 and dosage of 1% by weight of cement subjected to indoor curing.

C. Materials used

The different materials used in this investigation are.

– Cement
– Fine Aggregate
– Coarse aggregate
– Recycled coarse aggregate
– Water
– Polyethylene glycol (PEG)

1) Cement

The cement used in the investigation was 53-grade ordinary Portland cement conforming to IS 12269-1987. It was taken from a single lot and stored properly throughout the programme. The physical properties of cement are shown in table 3.1.

Specific gravity	3.14
Initial setting time	25 min
Final setting time	600min

Table 3.1: Physical properties of cement

2) Fine Aggregate

The fine aggregate that falls in zone-II conforming to IS 383-1970 was used. The fine aggregate used was obtained from a nearby river course. The sand obtained from quarry was sieved through all the sieves (i.e. 2.36mm, 1.18mm, 600µ, 300µ and150µ). Sand retained on each sieve was filled in different bags and stacked separately for use. To obtain zone- II sand correctly, sand retained on each sieve is mixed in appropriate proportion. The physical properties of fine aggregate and proportion in which each size fraction is mixed is shown in table.3.2&3.3respectively.

Fineness modulus	2.80
Bulk density	1.37gm/cc
Specific gravity	2.60

Table 3.2: Physical Properties of fine aggregate

Sieve size (mm)	% Passing Recommended by IS:383	Adopted Grading.	(%) weight Retained	cumulative % Weight Retained	Weight Retaindin (gm)
10	100	100	-	-	-
4.75	90-100	100	-	-	-
2.36	75-100	85	15	15	150
1.18	55-90	70	15	30	150
600 µ	35-59	45	25	55	250
300 µ	8-30	10	35	90	350
150 µ	0-10	0	10	100	100

Table 3.3: Proportions of different size fractions of sand obtain zone-II sand

3) Coarse Aggregate

The coarse aggregate used from a local crushing unit having 20mm nominal size. 20mm well-graded aggregate according to IS-383 is used in this investigation. The coarse aggregate procured from quarry was sieved through all the sieves (i.e. 16mm, 12.5mm. 10mm and 4.75mm). The material retained on each sieve was filled in bags and stacked separately. To obtain 20mm well-graded aggregate, coarse aggregate retained on each sieve is mixed in appropriate proportions. The physical properties and proportions in each fraction are shown in tables respectively.

Fineness modulus	7.35
Bulk density	1.540gm/cc
Specific gravity	2.67

Table 3.4: Physical properties of coarse aggregate

Sieve size (mm)	% Passing Recommended by IS-383	Adopted grading	(%)Weight retained	Cumulative % Weight	Weight Retained In(gm)
40	100	100	-	-	-
20	95-100	100	-	-	-
16	67-82	70	30	30	1500
12	42-66	45	25	55	1250
10	25-55	30	15	70	750
4.75	0-10	0	30	100	1500

Table 3.5: Proportions for CA to obtain 20mm well- graded aggregate

4) Recycled coarse aggregate

The Recycled coarse aggregate used is from a lab crushing unit having 20mm nominal size. 20mm well-graded aggregate is used in this investigation. The Recycled coarse aggregate procured from lab was sieved through all the sieves (i.e. 16mm, 12.5mm. 10mm and 4.75mm). The material retained on each sieve was filled in bags and stacked separately. To obtain 20mm well-graded aggregate, recycled coarse aggregate retained on each sieve is mixed in appropriate proportions. The physical properties and proportions in each fraction are shown in tables respectively.

Fineness modulus	7.37
Bulk density	1325.93 kg/m3
Specific gravity	2.3

Table 3.6: physical properties of recycled coarse aggregate

Sieve size (mm/µ)	Wt. retained (gm)	Wt. passed	% Wt. retained	cumulative % Wt. retained	100-cumulative % Wt. Retained
80mm	0	5000	0	0	500
40mm	0	5000	0	0	500
20mm	1598	3402	31.96	30	340.2
10mm	3310	92	66.2	98.16	9.2
4.75mm	92	0	1.84	100	0
2.36mm	0	0	0	100	0
1.18mm	0	0	0	100	0
300 µ	0	0	0	100	0
150 µ	0	0	0	100	0
	5000			730.12	
	Fineness Modulus of Coarse Aggregate				7.3012

Table 3.7: Proportions for RCA to obtain 20mm well-graded aggregate

5) Cement

53 grade cement used to test for Properties of Cement by Using Self Curing Agent (PEG)

a) Standard Consistency of Cement

For finding out initial setting time, final setting time and soundness of cement, and strength a parameter known as standard consistency has to be used. The standard consistency of a cement paste is defined as that consistency which will permit a Vicat plunger having 10 mm diameter and 50 mm length to penetrate to a depth of 33-35 mm from the top of the mould. The apparatus is called Vicat

Apparatus. This apparatus is used to find out the percentage of water required to produce a cement paste of standard consistency. This percentage is usually denoted as P. In this study, consistency test is performed as per standard procedures using Vicat apparatus.

6) Test for Fresh Properties of Concrete

Workability Test

a) Slump Test

Slump test is the most commonly used method of measuring workability of concrete. It is not a suitable method for very wet or very dry concrete. It does not measure all factors contributing to workability. In this case study slump test is done according to IS 456-2000 Specifications.

b) Compacting Factor Test

It is more precise and sensitive than the slump test and is particularly useful for concrete mixes of very low workability as are normally used when concrete is to be compacted by vibration. Such dry concrete is insensitive to slump test.

Fig. 3.3: Compacting Factor apparatus

IV. Results and Discussions

As per Experimental programme results for different experiments were obtained. They are shown in table format or graph, which is to be presented in this chapter.

A. Studies on concrete

1) Compaction factor test

The compaction factor test is performed to calculate the compaction factor, and to know more about workability. The test results are shown in tables. The plot of the compaction factor and different dosage of PEG 6000 is shown in figures. The following are the observations on Compaction factor test.

– In case of specimens with PEG 6000 of Mix A it is clear that compaction factor for 0.5% dosage of self-curing agent is less when compared to other dosages 1% and 2%.
– In case of specimens with PEG 6000 of Mix B 1% dosage compaction factor is more compared to other dosages (1% and 2%).
– It is also clear that compaction factor is more for Mix B in 1% and 2% when compared to Mix A.
– It is also observed that in Mix the compaction factor is increased with increase of % of PEG 6000. But in Mix B it is increased from 0.5% to 1% and then it is decreased.

Percentage Dosage of PEG	Compacting Factor	
	AH	BH
0.5	0.924	0.94
1	0.932	0.996
2	0.961	0.952

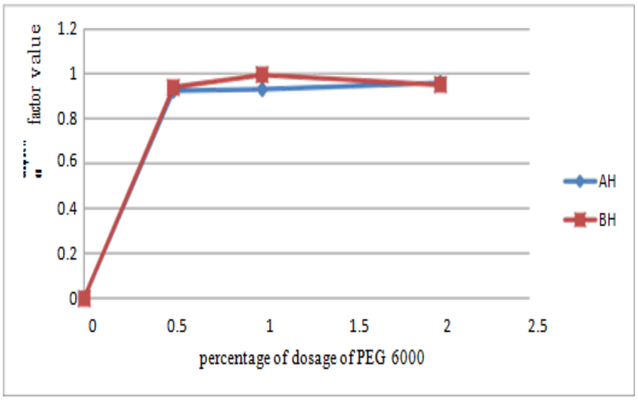

Fig. 4.1: Compaction factor for different percentages of PEG 6000

X-axis shows percentage of dosage of PEG 6000

Y-axis shows compaction factor value.

B. Water retentivity test

1) Water Retentivity Test Results for Mix A1

Concrete with high molecular weight PEG subjected to indoor curing was studied by weighing the samples at regular intervals of 3 days, with digital weighing machine of accuracy 5gms up to 28 days. The results were recorded in tables. The analysis of results or average weight loss of individual specimen is shown in tables. The average weight loss is shown in figures. The following are the observations on water retentivity of concrete.

– It is clear that 0% dosage of self-curing agent is losing more weight when compared to other dosages (0.5%, 1% and 2% of self-curing agent).
– It is also observed that 2% dosage of self-curing agent shows lower weight loss when compared to other dosages (0%, .5% and 1% of self-curing agent).

Water Retentivity Test for Mix A1 for different percentages of PEG 6000

Designation	0	3	7	10	14	20	28
A10W	8.540		8.497	8.51	8.54	8.55	8.58
A10I	8.493	8.436	8.427	8.450	8.445	8.41	8.39
A1H 0.5	8.616	8.593	8.600	8.628	8.597	8.58	8.48
A1H 1	8.561	8.538	8.541	8.560	8.525	8.50	8.49
A1H 2	8.589	8.558	8.562	8.593	8.560	8.51	8.50

Table 4.2: Average weight of cubes at different ages(kg)

Designation	0	3	7	10	14	20	28
A10W	13.07		13.02	13.02	13.02	13.1	13.0
A10I	13.1	13.05	13.03	13.50	13.01	13.1	12.8
A1H 0.5	13.02	13.0	13.18	13.18	13.12	13.1	12.8
A1H 1	13.09	13.01	13.01	13.0	13.01	13.0	12.9
A1H 2	13.2	13.11	13.12	13.09	13.12	13.11	13.1

Table 4.3: Average weight of cylinders

Designation	0	3	7	10	14	20	28
A10W	12.540		12.497	12.49	12.517	12.52	12.53
A10I	12.493	12.436	12.427	12.450	12.445	12.4	12.2
A1H 0.5	12.616	12.593	12.600	12.628	12.597	12.59	12.58
A1H 1	12.561	12.538	12.541	12.560	12.525	12.48	12.52
A1H 2	12.589	12.558	12.562	12.593	12.560	12.5	12.53

Table 4.4: Average weight of prisms at different ages(kg)

Average Weight Loss for Mix A1 for different percentage of PEG 6000

Designation	Curing Period, Days							Weight loss Ratio
	0	3	7	10	14	20	28	
A1OW	0	-0.2	-0.025	-.03	-0.035	-.029	-0.023	
A1OI	0	0.058	0.067	0.067	0.069	0.077	0.084	1
A1H 0.5	0	0.022	0.025	0.026	0.027	0.035	0.035	0.656
A1H1	0	0.023	0.028	0.03	0.032	0.040	0.025	0.641
A1H2	0	0.011	0.014	0.016	0.023	0.020	0.02	0.426

Table 4.5: Average Weight Loss for Mix A1(cubes) for different percentage of 6000

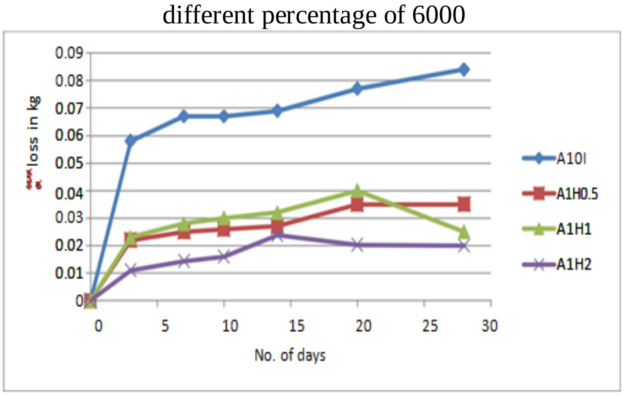

Fig. 4.2: Average Weight loss for Mix A1 (cubes) for the different dosages of PEG6000

Designation	Curing Period, Days							Weight loss Ratio
	0	3	7	10	14	20	28	
A1OW	0		-0.025		-0.035		-0.023	
A1OI	0	0.08	0.06	0.07	0.09	0.77	0.84	1
A1H 0.5	0	0.022	0.021	0.021	0.027	0.031	0.025	0.741
A1H1	0	0.023	0.023	0.033	0.032	0.041	0.020	0.541
A1H2	0	0.013	0.014	0.014	0.017	0.018	0.018	0.1

Table 4.6: Average weight Loss for MixA1(cylinders) for different percentage of PEG 6000

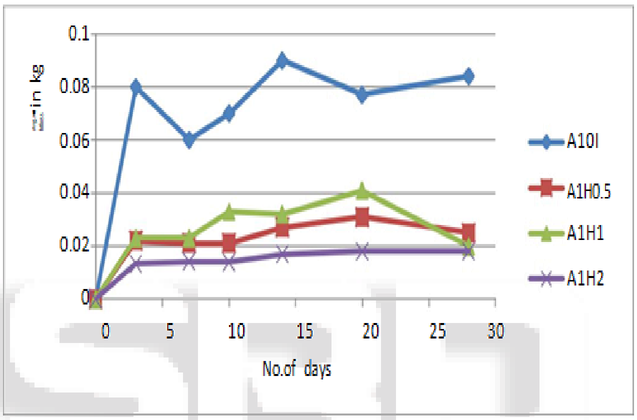

Fig 4.3: Average Weight loss for Mix A1 (cylinders) for the different dosages of PEG6000

Designation	Curing Period, Days							Weight loss Ratio
	0	3	7	10	14	20	28	
A1OW	0		-0.025		-0.035		-0.023	
A1OI	0	0.07	0.069	0.079	0.079	0.071	0.069	1
A1H 0.5	0	0.02	0.05	0.026	0.027	0.035	0.015	.57
A1H1	0	0.023	0.028	0.03	0.032	0.040	0.020	0.48
A1H2	0	0.019	0.020	0.0236	0.239	0.0250	0.025	0.3

Table 4.7: Average Weight Loss for Mix A1(prisms) for different percentage of PEG 6000

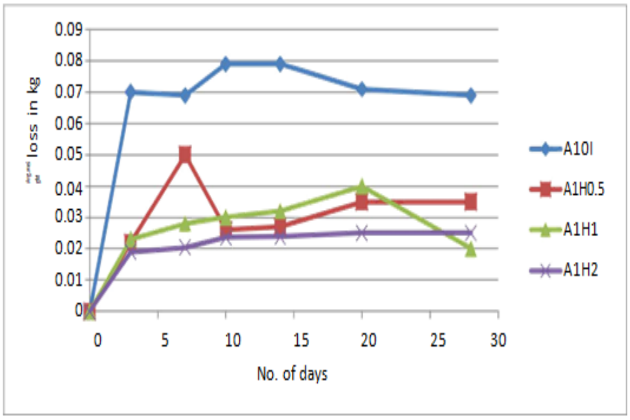

Fig 4.4: Average Weight loss for Mix A1 (prisms) for the different dosages of PEG6000

2) Water Retentivity Test Results for Mix A2

Concrete with high molecular weight PEG subjected to indoor curing was studied by weighing the samples at regular intervals of 3 days, with digital weighing machine of accuracy 5 gm up to 28 days. The results were recorded in tables. The analysis of results or average weight loss of individual specimen is shown in tables. The average weight loss is shown in figures. The following are the observations on water retentivity of concrete.

- It is clear that 0% dosage of self-curing agent is losing more weight when compared to other dosages (0.5%, 1% and 2% of self-curing agent).
- It is also observed that 1% dosage of self-curing agent shows lower weight loss when compared to other dosages (0%, .5% and 2% of self-curing agent)

Water Retentivity Test for Mix A2 for different percentages of PEG 6000

Designation	0	3	7	10	14	20	28
A20W	8.502		8.497		8.517	8.52	8.5
A20I	8.433	8.436	8.427	8.450	8.445	8.400	8.399
A2H 0.5	8.665	8.693	8.600	8.628	8.59	8.56	8.54
A2H 1	8.559	8.558	8.541	8.560	8.55	8.54	8.53
A2H 2	8.599	8.558	8.562	8.593	8.572	8.56	8.52

Table 4.8: Average weight of cubes at different ages(kg)

Designation	0	3	7	10	14	20	28
A20W	13.07		13.02	13.05	13.02	13.01	13.00
A20I	13.01	13.05	13.03	13.04	13.01	12.9	12.78
A2H 0.5	13.02	13.0	13.15	13.14	13.12	13.00	12.83
A2H 1	13.09	13.01	13.00	13.10	13.01	13.02	12.99
A2H 2	13.20	13.11	13.15	13.09	13.12	13.09	13.1

Table 4.9: Average weight of cylinders at different ages

Designation	0	3	7	10	14	20	28
A20W	12.550		12.597	12.586	12.517	12.59	12.65
A20I	12.433	12.336	12.327	12.390	12.395	12.391	12.2
A2H 0.5	12.636	12.493	12.620	12.628	12.597	12.543	12.545
A2H 1	12.541	12.538	12.511	12.560	12.525	12.523	12.500
A2H 2	12.579	12.658	12.542	12.593	12.560	12.559	12.555

Table 4.10: Average weight of prisms at different ages(kg)

Average Weight Loss for Mix A2 for different percentage of PEG 6000

Designation	Curing Period, Days							Weight loss Ratio
	0	3	7	10	14	20	28	
A20W	0		-0.025	-0.33	-0.035		-0.023	
A20I	0	0.058	0.057	0.067	0.069	0.077	0.080	1
A2H0.5	0	0.019	0.024	0.027	0.029	0.035	0.035	0.75
A2H1	0	0.023	0.018	0.20	0.022	0.025	0.025	0.61
A2H2	0	0.018	0.019	0.020	0.024	0.024	0.025	0.52

Table 4.11: Average Weight Loss for Mix A2(cubes) for different percentage of PEG 6000

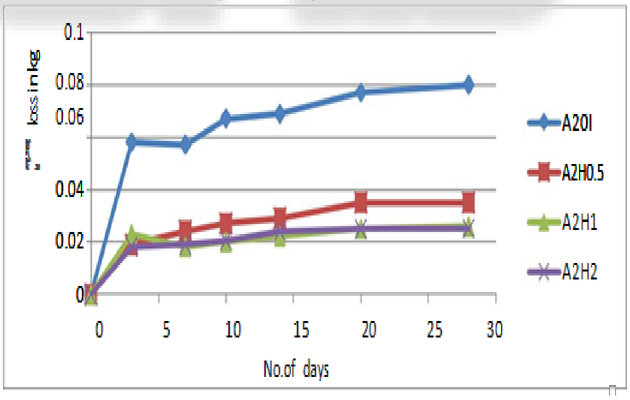

Fig. 4.5: Average Weight Loss for Mix A2 (cubes) For the Different Dosages of PEG 6000

Designation	Curing Period, Days							Weight loss ratio
	0	3	7	10	14	20	28	
A20W	0		-0.025		-0.035		0.023	
A20I	0	0.048	0.057	0.067	0.069	0.070	0.074	1
A2H 0.5	0	0.015	0.020	0.022	0.023	0.025	0.026	0.78
A2H 1	0	0.0	0.0	0.0	0.0	0.0	0.0	0.56

		2	21	19	23	26	28	
A2H 2	0	0.012	0.014	0.016	0.020	0.021	0.025	0.47

Table 4.12: Average Weight Loss for Mix A2(cylinders) for different percentage of PEG 6000

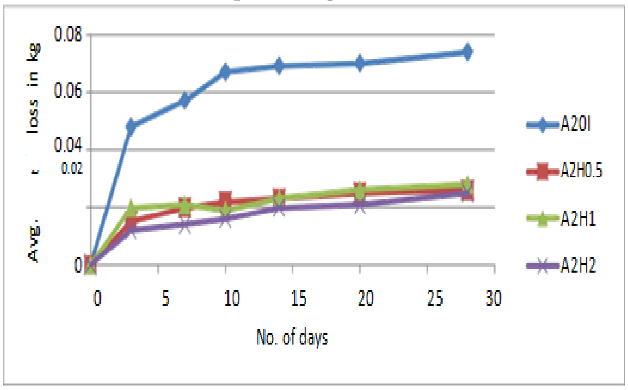

Fig. 4.6: Average Weight Loss for Mix A2 (cylinders) For the Different Dosages of PEG 6000

Designation	Curing Period, Days							Weight loss Ratio
	0	3	7	10	14	20	28	
A2OW	0		-0.025		-0.035		-0.023	
A2OI	0	0.038	0.0437	0.0457	0.049	0.0517	0.0544	1
A2H 0.5	0	0.022	0.025	0.027	0.029	0.032	0.035	0.44
A2H 1	0	0.023	0.028	0.03	0.032	0.035	0.035	0.34
A2H 2	0	0.016	0.017	0.017	0.019	0.0210	0.025	0.24

Table 4.13: Average Weight Loss for Mix A2(prisms) for different percentage of PEG 6000

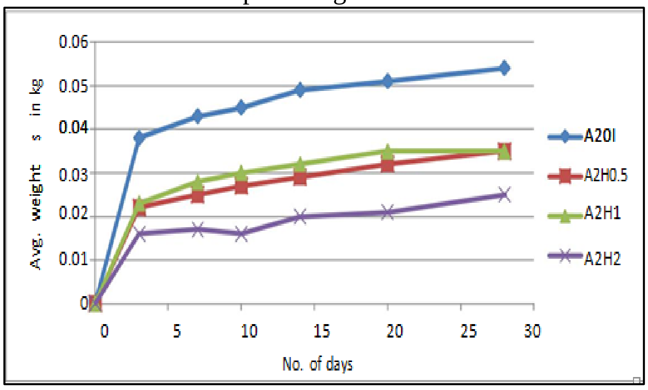

Fig. 4.7: Average Weight Loss for Mix A2(prisms) for different percentage of PEG 6000

3) Water Retentivity Test Results for Mix B 1

Concrete with high molecular weight PEG subjected to indoor curing was studied by weighing the samples at regular intervals of 3 days, with digital weighing machine of accuracy 5 gm up to 28 days. The results were recorded in tables. The average weight loss is shown in figures The analysis of results or percentage weight loss of individual specimen are shown in tables. The following are the observation on water retentivity of concrete.

1) It is clear that conventional concrete with indoor curing is losing more weight when compared to other dosages 0.5%, 1% and 2% of self-curing agent.
2) It is also clear that 2 % dosage of S.C.A result is almost nearer when compared to the dosages of conventional concrete with indoor curing. But it is not appreciable when compared with 0.5%.
3) It is also observed that 2 % dosage of S.C.A shows less weight loss when compared to other dosages.

Water Retentivity Test for Mix B1for different percentages of PEG 6000

Designation	0	3	7	10	14	20	28
B1OW	8.223		8.373		8.300		8.358
B1OI	8.230	8.147	8.135	8.141	8.110	8.143	8.137
B1H 0.5	8.219	8.114	8.124	8.114	8.114	8.115	8.085
B1H 1	8.152	8.066	8.072	8.033	8.031	8.043	8.020
B1H 2	8.129	8.059	8.059	8.011	8.014	8.013	7.990

Table 4.14: Average weight of cubes at different ages(kg)

Designation	0	3	7	10	14	20	28
B1OW	13.12		13.23		13.25	13.25	13.3
B1OI	13.21	13.2	13.18	13.18	13.12	13.1	12.8
B1H 0.5	13.09	13.08	13.07	13.08	13.05	13.05	13.01
B1H 1	13.11	13.1	13.08	13.06	13.06	13.04	13.04
B1H 2	13.11	13.09	13.07	13.08	13.08	13.07	13.07

Table 4.15: Average weight of cylinders at different ages(kg)

Designation	0	3	7	10	14	20	28
B1OW	12.59	12.6	12.6	12.61	12.639	12.659	12.96
B1OI	12.68	12.65	12.6	12.58	12.58	12.50	12.48
B1H 0.5	12.65	12.60	12.60	12.585	12.55	12.52	12.5
B1H 1	12.63	12.60	12.57	12.55	12.55	12.53	12.53
B1H 2	12.55	12.55	12.52	12.56	12.59	12.54	12.53

Table 4.16: Average weight of prisms at different ages(kg)

Designation	Curing Period, Days							Weight loss Ratio
	0	3	7	10	14	20	28	
B1OW	0		-0.5		-0.5		-0.5	

			00		17		20	
B1OI	0	0.509	0.516	0.522	0.527	0.539	0.539	1
B1H0.5	0	0.505	0.513	0.521	0.521	0.526	0.530	0.956
B1H1	0	0.508	0.508	0.509	0.510	0.515	0.520	0.735
B1H2	0	0.517	0.518	0.519	0.520	0.522	0.524	0.801

Table 4.17: Average Weight Loss for Mix B1 (cubes) for different percentage of PEG 6000

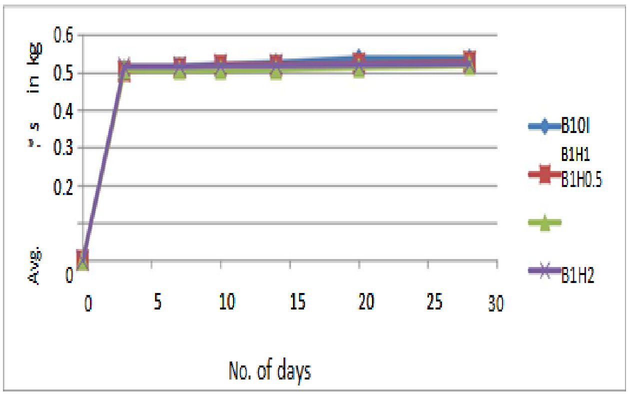

Fig. 4.8: Average Weight Loss for Mix B1 (cubes) For the Different Dosages of PEG 6000

Designation	Curing Period, Days							Weight loss Ratio
	0	3	7	10	14	20	28	
B1OW	0		-0.561		-0.537		-0.550	
B1OI	0	0.519	0.516	0.522	0.527	0.539	0.546	1
B1H0.5	0	0.505	0.515	0.521	0.524	0.526	0.530	0.732
B1H1	0	0.496	0.499	0.509	0.510	0.515	0.520	0.532
B1H2	0	0.519	0.523	0.520	0.523	0.527	0.527	0.601

Table 4.18: Average Weight Loss for Mix B1(cylinders) for different percentage of PEG 6000

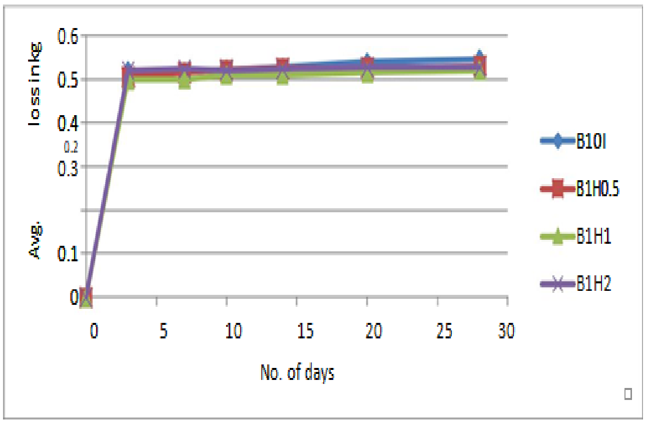

Fig. 4.9: Average Weight Loss for Mix B1(cylinders) For the Different Dosages of PEG 6000

Designation	Curing Period, Days							Weight loss Ratio
	0	3	7	10	14	20	28	
B1OW	0		-0.500		-0.517		-0.520	
B1OI	0	0.519	0.516	0.522	0.527	0.559	0.056	1
B1H0.5	0	0.505	0.513	0.521	0.519	0.516	0.520	0.730
B1H1	0	0.486	0.489	0.493	0.497	0.501	0.502	0.564
B1H2	0	0.470	0.483	0.496	0.493	0.497	0.512	0.623

Table 4.19: Average Weight Loss for Mix B1(prisms) for different percentage of PEG

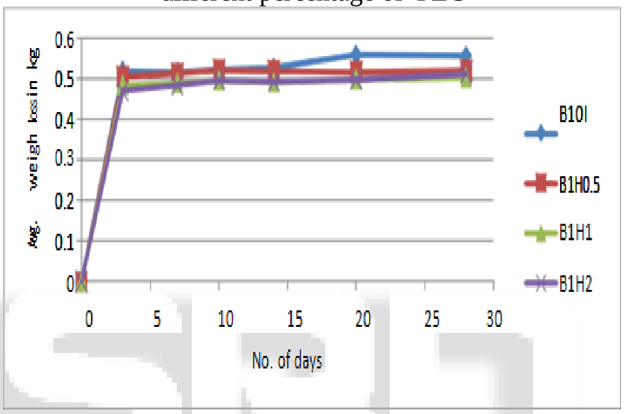

Fig. 4.10: Average Weight Loss for Mix B1 (prisms) for the Different Dosages of PEG 6000

4) Water Retentivity Test Results for Mix B 2

Concrete with high molecular weight PEG subjected to indoor curing was studied by weighing the samples at regular intervals of 3 days, with digital weighing machine of accuracy 5 gm up to 28 days. The results were recorded in table. The average weight loss is shown in fig4.10-4.13. The analysis of results or percentage weight losses of individual specimen are shown in table4.25-4.27. The following are the observation on water retentivity of concrete.

- It is clear that conventional concrete with indoor curing is losing more weight when compared to other dosages 0.5%, 1% and 2% of self-curing agent.
- It is also clear that 1 % dosage of S.C.A result is almost nearer when compared to the dosages of conventional concrete with indoor curing. But it is not appreciable when compared with 2%.

Water Retentivity Test for Mix B2 for different percentages of PEG 6000

Designation	0	3	7	10	14	20	28
B20W	8.32		8.73		8.302		8.318
B20I	8.326	8.317	8.315	8.314	8.311	8.303	8.307
B2H 0.5	8.318	8.310	8.314	8.308	8.295	8.285	8.280

B2H 1	8.418	8.415	8.413	8.401	8.403	8.403	8.402
B2H 2	8.19	8.109	8.059	8.011	8.014	8.013	7.990

Table 4.20: Average weight of cubes at different ages(kg)

Designation	0	3	7	10	14	20	28
B20W	13.36	13.45	13.46	13.47	13.49	13.56	13.60
B20I	13.29	13.25	13.19	13.19	13.09	13.01	12.98
B2H 0.5	13.35	13.28	13.26	13.25	13.25	13.20	13.15
B2H 1	13.10	13.08	13.05	13.03	12.98	12.96	12.95
B2H 2	13.09	13.05	13.03	13.01	12.91	12.85	12.90

Table 4.21: Avg weight of cylinders at different ages(kg)

Designation	0	3	7	10	14	20	28
B20W	12.54	12.59	12.61	12.63	12.65	12.70	12.73
B20I	12.48	12.41	12.38	12.26	12.23	12.19	12.15
B2H 0.5	12.49	12.47	12.39	12.35	12.33	12.31	12.30
B2H 1	12.47	12.45	12.43	12.41	12.37	12.33	12.30
B2H 2	12.43	12.40	12.35	12.30	12.30	12.28	12.27

Table 4.22: Average weight of prisms at different ages(kg)

Average Weight Loss for Mix B2 for different percentage of PEG 6000

Designation	Curing Period, Days							Weight loss Ratio
	0	3	7	10	14	20 28		
B2OW	0	-0.510	-0.500		-0.517		-0.520	
B2OI	0	0.509	0.516	0.522	0.527	0.539	0.546	1
B2H0.5	0	0.505	0.513	0.521	0.521	0.526	0.530	0.694
B2H1	0	0.486	0.498	0.509	0.510	0.515	0.520	0.436
B2H2	0	0.470	0.483	0.496	0.514	0.517	0.524	0.543

Table 4.23: Average Weight Loss for Mix B2 (cubes) for different percentage of PEG 6000

From the above table It is clear that conventional concrete with indoor curing is losing more weight when compared to other dosages 0.5%, 1% and 2% of self-curing agent.

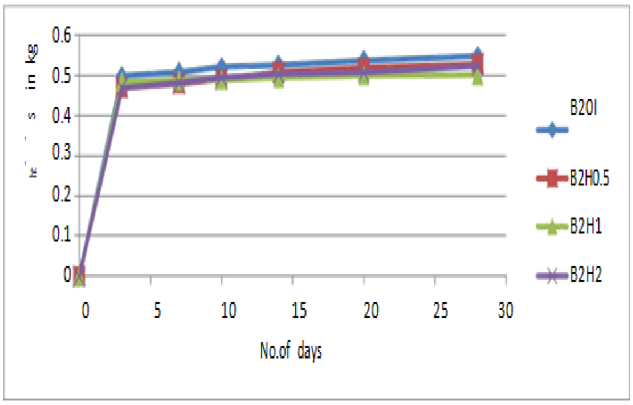

Fig. 4.11: Average Weight Loss for mixB2 (cubes) For the Different Dosages of PEG 6000

Designation	Curing Period, Days							Weight loss Ratio
	0	3	7	10	14	20	28	
B2OW	0		-0.500		-0.517		-0.520	
B2OI	0	0.50	0.51	0.52	0.527	0.53	0.549	1
B2H0.5	0	0.47	0.48	0.49	0.51	0.52	0.53	0.773
B2H1	0	0.486	0.489	0.490	0.495	0.50	0.502	0.663
B2H2	0	0.470	0.483	0.496	0.509	0.509	0.51	0.700

Table 4.24: Average Weight Loss for Mix B2(cylinders) for different percentage of PEG 6000

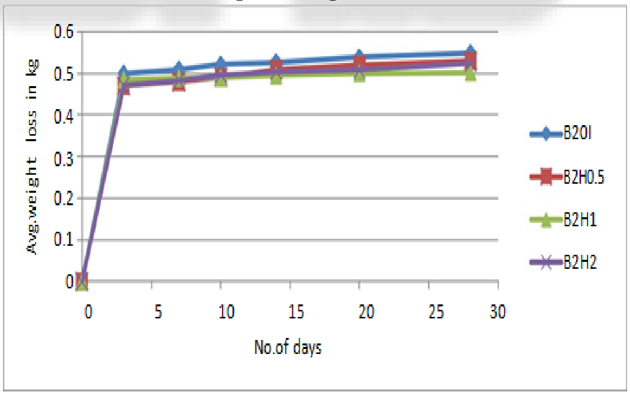

Fig. 4.12: Average Weight Loss for Mix B2 (cylinders) for the Different Dosages PEG

Designation	Curing Period, Days							Weight loss Ratio
	0	3	7	10	14	20	28	
B2OW	0		-0.500		-0.517		-0.520	
B2OI	0	0.519	0.516	0.522	0.527	0.539	0.546	1
B2H0.5	0	0.515	0.513	0.520	0.523	0.526	0.530	0.500

B2H1	0	0.486	0.498	0.509	0.510	0.515	0.520	0.423
B2H2	0	0.497	0.498	0.506	0.513	0.519	0.525	0.450

Table 4.25: Average Weight Loss for Mix B2(prisms) for different percentage of PEG6000

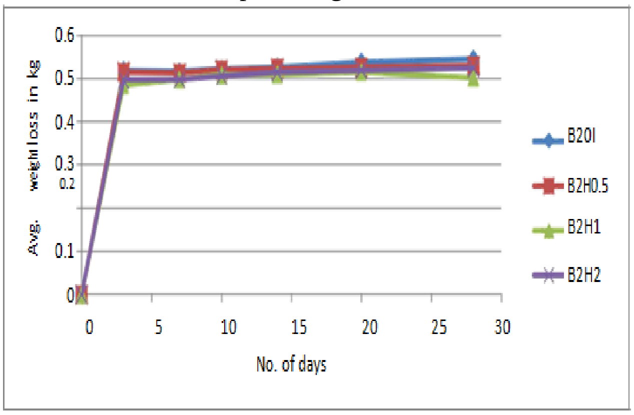

Fig. 4.13: Average Weight Loss for Mix B2 (prisms) For the Different Dosages of PEG 6000

5) Comparison of Mix A1and Mix B1

The average weight loss variation for different dosages of PEG 6000 were compared for both Mix A1 and Mix B1 for 7 days and 28 days. The following are the observations on average weight loss of concrete for indoor curing.

- The average weight loss for Mix A1 is very less when compared to Mix B1 at 7 and 28 days.
- For Mix A1 the average weight loss was more for 0% SCA at 7 days.
- The average weight loss was very less for 2% of SCA at all the ages i.e.7 and 28 days.
- The average weight loss for Mix A1 was gradually decreasing with increase of percentage of SCA.
- The average weight loss for Mix B1 was decreasing from 0% to 0.5 % and then it is increasing.
- For Mix B1 the variation of 0% and 1% SCA the average weight loss was very less and it is in fractions only.
- For Mix A1 the variation of 0% and 0.5% of SCA the average weight loss was more.
- When compare to both the mixes Mix A1 is better than Mix B1 because the average weight loss is less.

6) Comparison of Mix A2 and Mix B2

The average weight loss variation for different dosages of PEG 6000 were compared for both Mix A2 and MixB2 for 7 days and 28 days. The following are the observations on average weight loss of concrete for indoor curing.

- The average weight loss for Mix A2 is very less when compared to Mix B2 at 7 and 28 days.
- For Mix A2 the average weight loss was more for 0% SCA at 7 days.
- The average weight loss was very less for 0.5% of SCA at all the ages i.e.7 and 28 days.
- The average weight loss for Mix B2 was gradually decreasing with increase of percentage of SCA.
- The average weight loss for Mix A2 was decreasing from 0% to 0.5% and then it is increasing.
- For Mix B2 the variation of 0% and 0.5% SCA the average weight loss was very less and it is in fractions only.
- For Mix A2 the variation of 0% and 0.5% of SCA the average weight loss was more.
- When compare to both the mixes Mix A2 is better than Mix B2 because the average weight loss is less.

V. CONCLUSIONS

After the analysis of the result of the experimental programme the following conclusions were arrived for self-curing agent polyethylene glycol (PEG6000) and comparison of different aggregates are obtained.

A. Conclusion

1) Due to the use of PEG6000

- The workability of concrete with low w/c ratio has significant effect due to higher molecular weight polyethylene glycol (PEG6000).
- Water retention of the concrete with low w/c ratio in conjunction has significant effect due to addition of higher molecular weight polyethylene glycol(PEG6000).
- The compressive strength of concrete with lower w/c ratio and with higher dosage of polyethylene glycol (PEG6000) is beneficial.
- The use of higher molecular weight polyethylene glycol (PEG6000) with higher w/c ratio is not beneficial.
- Effectiveness of self-curing concrete is affected by w/c ratio and percentage dosages of self-curing agent.
- Water retention of concrete mixes incorporating self-curing agent is higher compared to conventional concrete mixes.
- The compressive strength of concrete with low w/c ratio has significant effect due to change in curing regime.
- The mix which shows lower weight loss need not give higher compressive strength.
- Water retention of concrete with lower w/c ratio incorporating higher molecular weight polyethylene glycol (PEG 6000) with lower dosage is more beneficial.
- Water retention of concrete with higher w/c ratio incorporating self-curing agent is not beneficial.
- The compressive strength of concrete with low w/c ratio and lower dosage of self-curing agent is more beneficial.
- The compressive strength of concrete with high w/c ratio incorporating with self-curing agent is not effective

B. Scope for future studies

- The effect of self-curing agent on the microstructure and pore size distribution of the self-curing concrete requires additional study.
- Structural properties, shrinkage characteristics, creep characteristics of self-curing concrete need to be investigate.
- Absorptivity and durability studies for sulphate salts and chloride induced corrosion on self-curing concrete need to investigate.

- Performance of the self-curing agent is affected by the mix proportions, mainly the cement content and the w/c ratio.
- Mix design procedures for development of self-curing concrete and fibre reinforced self-curing concrete are to established.
- The effect of using higher w/c ratios, different cement types, and supplementary cementing materials (SCM), such as silica fume fly ash and ground granulated blast slag on water retention, hydration and moisture transport of the self-curing concrete needs further investigation.
- Effect of super-plasticizers and viscosity modifying agent on self-curing properties for high strength concrete (above M70) needs further investigation.
- Further in depth investigation is to done for choosing optimum dosage of self-curing agent in strength and durability point of view.
- Further investigation is to be done on different hydrophilic polymers for selecting S.C.A w.r.t strength and durability of concrete.
- Further investigation on effect of relative humidity on water absorption and strength characteristics or different S.C.A has to be carried.
- Study on rate of gain of strength and rate of hydration in concrete is to be carried.
- Study on use of light weight aggregate and recycled aggregate is to be carried which possess more absorption capacities.
- Research on self-curing-consolidating (compacting) concrete is to be done which can rule the future concrete industry.

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